BURNS McDONNELL

Application to the South Dakota Public Utilities Commission for a Facility Permit

Dakota Range I, LLC and Dakota Range II, LLC

Dakota Range Wind Energy Facility

January 2018

EXHIBIT A-1

Application to the South Dakota Public Utilities Commission for a Facility Permit

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Dakota Range Wind Energy Facility

Codington and Grant Counties, South Dakota

January 2018

prepared by

Burns & McDonnell Engineering Company, Inc.

Centennial, Colorado

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
ADT	Average Daily Traffic
AMSL	above mean sea level
APE	area of potential effects
Apex	Apex Clean Energy Holdings, LLC
Applicant	Dakota Range I, LLC and Dakota Range II, LLC
ARSD	Administrative Rules of South Dakota
BBCS	Bird and Bat Conservation Strategy
BCC	Birds of Conservation Concern
BGEPA	Bald and Golden Eagle Protection Act
BMPs	Best Management Practices
CMWS	composite mean wind speeds
Commission	South Dakota Public Utilities Commission
CRMMP	Cultural Resources Monitoring and Management Plan
CWA	Clean Water Act
Dakota Range	Dakota Range I, LLC and Dakota Range II, LLC
dB	decibel
dBA	A-weighted decibels
ECPG	Eagle Conservation Plan Guidance
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration

Abbreviation	Term/Phrase/Name
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
GW	gigawatts
HAPET	Habitat and Population Evaluation Team
HPA	High Probability Area
Hz	Hertz
IPaC	Information for Planning and Conservation
Ksat	saturated hydraulic conductivity
kV	kilovolt
m/s	meters per second
MBTA	Migratory Bird Treaty Act
MERRA	Modern Era Retrospective-Analysis for Research and Application
met	meteorological
Mg/L	milligrams per liter
MISO	Midcontinent Independent System Operator, Inc.
MVA	megavolt-ampere
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NNRP	NCEP/NCAR Reanalysis Project
NPS	National Park Service

Abbreviation	Term/Phrase/Name
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRI	Nationwide Rivers Inventory
NWI	National Wetland Inventory
NWP	Nationwide Permit
O&M	operations and maintenance
PEM	Palustrine Emergent Wetlands
PGA	peak ground acceleration
Project	Dakota Range Wind Project
PSA	Purchase and Sale Agreement
PSS	Palustrine Scrub/Shrub Wetlands
PTC	Production Tax Credit
PVRR	present value of revenue requirement
RD	rotor diameter
RPS	renewable portfolio standard
RUSLE	Revised Universal Soil Loss Equation
SCADA	supervisory control and data acquisition
SDARC	South Dakota Archaeological Research Center
SDCL	South Dakota Codified Laws
SDDENR	South Dakota Department of Environment and Natural Resources
SDDLR	South Dakota Department of Labor and Regulation
SDDOA	South Dakota Department of Agriculture

Abbreviation	Term/Phrase/Name
SDDOT	South Dakota Department of Transportation
SDGFP	South Dakota Game, Fish, and Parks
SDGS	South Dakota Geological Survey
SDPUC	South Dakota Public Utilities Commission
SGCN	South Dakota Species of Greatest Conservation Need
SHPO	State Historic Preservation Office
SLM	sound level meter
SWO	Sisseton-Wahpeton Oyate
SWPPP	Storm Water Pollution Prevention Plan
TMDL	total maximum daily load
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WEG	Wind Energy Guidelines
WES	Wind Energy Systems

1.0 INTRODUCTION

Dakota Range I, LLC and Dakota Range II, LLC (together Dakota Range or Applicant) are requesting an Energy Facility Permit from the South Dakota Public Utilities Commission (Commission or SDPUC) for an up to 302.4-megawatt (MW) wind energy conversion facility to be located in Grant County and Codington County, South Dakota, known as the Dakota Range Wind Project (Project).

The Project would be situated within an approximately 44,500-acre Project Area (Figure 1 in Appendix A), and the total installed capacity of the Project would not exceed 302.4 MW. Project components would include:

- Up to 72 wind turbine generators;
- Access roads to turbines and associated facilities;
- Underground 34.5-kilovolt (kV) electrical collector lines connecting the turbines to the collection substation;
- Underground fiber-optic cable for turbine communications co-located with the collector lines;
- A 34.5 to 345-kV collection substation;
- Up to 5 permanent meteorological (met) towers;
- An operations and maintenance (O&M) facility; and
- Additional temporary construction areas, including laydown and batch plant areas.

The Project would interconnect to the high-voltage transmission grid via the Big Stone South to Ellendale 345-kV transmission line, which crosses the Project site. A new 345-kV interconnection switching station connecting to the Big Stone South to Ellendale line will be constructed, owned, and operated by Otter Tail Power Company and Montana Dakota Utilities. Dakota Range would construct and own a 345-kV interconnection facility connecting a new collection substation and the interconnection switching station. Because the interconnection facility is less than 2,640-feet long, does not cross any public highways, and does not require the use of eminent domain, it falls outside the Commission's jurisdiction and has been permitted locally.

Both the Dakota Range I and Dakota Range II entities are Delaware limited liability companies and wholly owned indirect subsidiaries of Apex Clean Energy Holdings, LLC (Apex). Apex is an independent renewable energy company based in Charlottesville, Virginia. Apex has one of the nation's largest, most diversified portfolios of renewable energy resources, capable of producing more than 14,000 MW of clean electricity. Apex offers comprehensive in-house capabilities, including site origination, financing, construction, and long-term asset management services, and works with corporations, utilities, and government entities, including Northern States Power Company d/b/a Xcel Energy, AEP, Southern Power, IKEA, the U.S. Army, and Steelcase. Apex has the experience, skills, personnel, and proven capability to successfully manage the development, financing, construction, and operation of wind projects. Apex has brought 2,200 MW online since 2012, and operating assets under management are nearly 1 gigawatts (GW) as of the first quarter of 2018.

2.0 PROJECT DEVELOPMENT SUMMARY

Apex acquired the Dakota Range Project from a small local developer, Wahpeton Wind, in March 2015. At the time of acquisition, the Project consisted of approximately 10,000 acres under lease. Since March 2015, the Applicant has undertaken extensive development activities, consisting of landowner outreach and easement acquisition, detailed studies of resources in the Project Area, coordination with resource agencies, county permitting, design and refinement of the Project layout, and entering into a purchase agreement for the Project. Following is a summary of these activities:

Community Outreach and Land Acquisition – The Applicant began meeting with landowners in March 2015. Community outreach meetings were held on January 19, 2016; August 2, 2016; February 1, 2017; February 15, 2017; and February 21, 2017. At the time of the March 2015 Project acquisition from Wahpeton Wind, approximately 20 percent of the current Project Area was under lease. Additional easement acquisitions for the remaining Project Area began in March 2015 and were completed in May 2017.

Agency Coordination – The Applicant conducted coordination with various agencies throughout Project planning and development. The Applicant conducted wildlife coordination meetings with the U.S. Fish and Wildlife Service (USFWS) and South Dakota Game, Fish and Parks (SDGFP) on August 12, 2015; March 28, 2017; and September 25, 2017, to agree on study plans and discuss impact avoidance and minimization measures. A Cultural Resources Monitoring and Management Plan (CRMMP) was developed for the Project in coordination with the South Dakota State Historic Preservation Office (SHPO). Coordination meetings with SHPO were held on June 13, 2017, and August 29, 2017. Furthermore, the Applicant has engaged in ongoing coordination with the Sisseton-Wahpeton Oyate (SWO) regarding impact avoidance for sensitive tribal resources. Agency coordination is discussed in Section 27.2.

Environmental Analysis – The environmental studies and field surveys conducted for the Project are summarized in Table 2-1.

Table 2-1: Environmental Studies and Surveys for the Dakota Range Project

Study	Dates	Status
Microwave beam path study	November 2015	Complete
Raptor nest surveys	April 2016; April 2017	Complete
Avian use surveys	December 2015 – May 2017 (winter and spring)	Complete

Study	Dates	Status
Grouse lek surveys	April-May 2016; April-May 2017	Complete
Dakota skipper/Poweshiek skipperling habitat survey	June 2016; June 2017	Complete
Level I cultural resources records search	June 2017	Complete
Level III intensive cultural resources survey of High Probability Areas within Project disturbance footprint (in accordance with CRMMP)	December 2017	Field survey complete; analysis results pending
Additional cultural resources survey for sensitive tribal resources in coordination with SWO	Initiated in December 2017	Ongoing
Historical/Architectural Survey	November 2017	Complete
Wetland and Stream Delineation	September 2017	Complete
Noise modeling	December 2017	Complete
Shadow flicker analysis	December 2017	Complete

County Permitting – The Applicant conducted pre-application meetings with Grant and Codington County in February and March 2017, submitted Conditional Use Permit applications for the Project in May 2017, and received unanimous board approvals in June 2017. County permitting is discussed in Chapter 17.0.

Purchase Agreement – In September 2017, Northern States Power Company, d/b/a Xcel Energy, entered into a Purchase and Sale Agreement (PSA) with Apex Clean Energy to acquire the Dakota Range I, LLC and Dakota Range II, LLC entities, which own the Project.

Project Design – The results of the various studies and coordination activities listed above have been used to inform the site layout and design of the Project. Final micrositing of Project facilities will occur in 2018, based on the results of the completed cultural resource investigations, geotechnical analysis, and final engineering design. The remaining study work is not anticipated to affect the environmental analysis set forth in this Application, nor will it prevent the Project from meeting all applicable local, State and Federal permitting requirements.

3.0 FACILITY PERMIT APPLICATION

In accordance with South Dakota Codified Laws (SDCL) Chapter 49-41B and Administrative Rules of South Dakota (ARSD) Chapter 20:10:22, the Application provides information on the existing environment, potential Project impacts, and proposed avoidance, minimization, and/or mitigation measures for the following resources:

- Physical (geology, economic deposits, soils; see Chapter 12.0);
- Hydrology (surface water and groundwater; see Chapter 13.0);
- Terrestrial ecosystems (vegetation, wetlands, wildlife, threatened and endangered species; see Chapter 14.0);
- Aquatic ecosystems (see Chapter 15.0);
- Land use (agriculture, residential, displacement, sound, aesthetics, electromagnetic interference, safety and health, real estate values; see Chapter 16.0);
- Water quality (see Chapter 18.0);
- Air quality (see Chapter 19.0); and
- Communities (socioeconomics, transportation and emergency response, cultural resources; see Chapter 21.0)).

Based on the analysis completed by Dakota Range, the Project is not expected to have significant impacts on the environment. Approximately 65 acres of total disturbance is expected during the life of the Project. This represents less than 0.2 percent of the total acreage within the Project Area, and disturbances would be dispersed throughout the Project Area.

The Project has avoided locating facilities in wetland areas, to the extent possible. Wind turbines and access roads are generally located in upland areas, avoiding low-lying wetlands and drainage ways. As the design details for Project infrastructure are finalized, any wetland impacts would be identified to ensure compliance with Section 404 of the Clean Water Act (CWA).

The majority of land proposed to be directly affected by construction of the Project is cropland. Construction of Project facilities in cropland or grassland is not expected to negatively affect terrestrial ecosystems. Best Management Practices (BMPs) would be utilized to avoid or reduce impacts to the vegetation and water resources of the Project Area during construction. Because the Project avoids USFWS Grassland, Conservation, or Wetland Easements, there is no federal nexus for the Project that would require National Environmental Policy Act review.

Six species listed as threatened or endangered under the Federal Endangered Species Act (ESA) have the potential to occur in the Project Area and include: Dakota skipper (*Hesperia dacotae*), Poweshiek skipperling (*Oarisma poweshiek*), northern long-eared bat (*Myotis septentrionalis*), red knot (*Calidris canutus rufa*), whooping crane (*Grus americana*), and Topeka shiner (*Notropis topeka*). Wildlife studies and coordination with USFWS and SDGFP determined the Project to have a low risk of impacts to threatened or endangered species (see Section 14.3.2).

Existing land uses are not anticipated to be significantly changed or impacted by the Project. Sound from the Project construction activities would be temporary. Once the Project were operational, sound from the turbines and other facilities would be limited per applicable county requirements: (1) Grant County – 50 A-weighted decibels (dBA) at sound receptors (i.e., off-site residences, businesses, and buildings owned and/or maintained by a governmental entity); or (2) Codington County – 50 dBA at the property line of sound receptors (i.e., off-site residences, businesses, and buildings owned and/or maintained by a governmental entity). A sound level modeling study was completed for the Project to confirm compliance with these standards (see Section 16.3.2).

Construction activities for this Project would be short-term, and no negative impact to the socioeconomics of the area is expected. Project construction is anticipated to provide economic benefits to businesses in the region.

During Project construction, fugitive dust emissions would increase due to vehicle and equipment traffic in the area. The additional particulate matter emissions would not exceed the National Ambient Air Quality Standards (NAAQS). The wind turbines would not produce air emissions during operation.

Cultural resource Level I records review for the Project Area identified previously recorded archaeological and historic resources located within or near the Project Area. Level III intensive cultural resources surveys of High Probability Areas within the Project disturbance footprint were completed in December 2017. Additional surveys for sensitive tribal resources are being completed in coordination with the SWO. The Applicant would avoid direct impacts to identified cultural resources as defined in the CRMMP and in coordination with the SWO.

Additional avoidance and minimization measures proposed for the Project include:

- Wind turbines will be illuminated as required by Federal Aviation Administration (FAA) regulations and recommendations;
- Existing roads will be used for construction and maintenance where possible;

- Access roads created for the Project will be located to limit cuts and fills;
- Temporarily disturbed uncultivated areas will be reseeded with certified weed-free seed mixes to blend in with existing vegetation;
- BMPs will be used during construction to control erosion and prevent or reduce impacts to drainage ways and streams by sediment runoff from exposed soils in accordance with the Storm Water Pollution Prevention Plan (SWPPP);
- The Applicant will avoid impacts to land held for conservation purposes via USFWS Wetland and Grassland Easements;
- Construction activities will be limited in accordance with SDGFP recommendations to minimize impacts to grouse leks;
- The Applicant will avoid impacts to native grasslands to the extent practicable;
- The Applicant will meet or exceed setbacks, conditions, and siting standards required by State and local governing bodies where the wind turbines are located; and
- The Project will meet the Grant and Codington County noise requirements set forth above;
- The Project will meet the voluntary commitment of limiting shadow flicker to 30 hours per year or less at off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.

In this Application, the Applicant has addressed each matter set forth in SDCL Chapter 49-41B and in ARSD Chapter 20:10:22 (Energy Facility Siting Rules) related to wind energy facilities. Included with this Application is a Completeness Checklist (Table 4-1) that sets forth where in the Application each rule requirement is addressed.

Pursuant to SDCL 49-41B-22, the information presented here establishes that:

- The proposed wind energy facility complies with applicable laws and rules;
- The facility will not pose a threat of serious injury to the environment or to the social and economic condition of inhabitants in, or near, the Project Area;
- The facility will not substantially impair the health, safety, or welfare of the inhabitants; and
- The facility will not unduly interfere with the orderly development of the region, having given consideration to the views of the governing bodies of the local affected units of government.

4.0 COMPLETENESS CHECKLIST

The contents required for an application with the Commission are described in SDCL 49-41B and further clarified in ARSD 20:10:22:01(1) et seq. The Commission submittal requirements are listed in Table 4-1 with cross-references indicating where the information can be found in this Application.

Table 4-1: Completeness Checklist

SDCL	ARSD	Required Information	Location
49-41B-22	N/A	**Applicant's burden of proof.** The applicant has the burden of proof to establish that: (1) The proposed facility will comply with all applicable laws and rules; (2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area; (3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and (4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government	Chapter 3.0
49-41B-11(1-12)	20.10.22.05	**Application contents.** The application for a permit for a facility shall contain the applicable information specified in §§ 20:10:22:06 to 20:10:22:25, inclusive, 20:10:22:36, and 20:10:22:39. If the application is for a permit for an energy conversion facility, it shall also contain the information specified in §§ 20:10:22:26 to 20:10:22:33, inclusive. If the application is for a permit for a transmission facility as defined in SDCL subdivision 49-41B-2.1(1), it shall also contain the information in §§ 20:10:22:34 and 20:10:22:35. If the application is for a permit for a transmission facility as defined in SDCL subdivision 49-41B-2.1(2), it shall also contain the information in §§ 20:10:22:37 and 20:10:22:38. If the application is for a permit for a wind energy facility, it shall also contain the information in §§ 20:10:22:33.01 and 20:10:22:33.02. The application for a permit for a facility shall contain a list of each permit that is known to be required from any other governmental entity at the time of the filing. The list of permits shall be updated, if needed, to include any permit the applicant becomes aware of after filing the application. The list shall state when each permit application will be filed. The application shall also list each notification that is required to be made to any other governmental entity.	Chapters 5.0-28.0
49-41B-11(1)	20:10:22:06	**Names of participants required.** The application shall contain the name, address, and telephone number of all	Chapter 5.0

SDCL	ARSD	Required Information	Location
		persons participating in the proposed facility at the time of filing, as well as the names of any individuals authorized to receive communications relating to the application on behalf of those persons.	
49-41B-11(7)	20:10:22:07	**Name of owner and manager.** The application shall contain a complete description of the current and proposed rights of ownership of the proposed facility. It shall also contain the name of the project manager of the proposed facility.	Chapter 6.0
49-41B-11(8)	20:10:22:08	**Purpose of facility.** The applicant shall describe the purpose of the proposed facility.	Chapter 7.0
49-41B-11(12)	20:10:22:09	**Estimated cost of facility.** The applicant shall describe the estimated construction cost of the proposed facility	Chapter 8.0
49-41B-11(9)	20:10:22:10	**Demand for facility.** The applicant shall provide a description of present and estimated consumer demand and estimated future energy needs of those customers to be directly served by the proposed facility. The applicant shall also provide data, data sources, assumptions, forecast methods or models, or other reasoning upon which the description is based. This statement shall also include information on the relative contribution to any power or energy distribution network or pool that the proposed facility is projected to supply and a statement on the consequences of delay or termination of the construction of the facility.	Chapter 7.0
49-41B-11(2)	20:10:22:11	**General site description.** The application shall contain a general site description of the proposed facility including a description of the specific site and its location with respect to state, county, and other political subdivisions; a map showing prominent features such as cities, lakes and rivers; and maps showing cemeteries, places of historical significance, transportation facilities, or other public facilities adjacent to or abutting the plant or transmission site.	Chapter 9.0 Figures 1, 10, 12, and 13 Appendix M
49-41B-11(6); 49-41B-21; 34A-9-7(4)	20:10:22:12	**Alternative sites.** The applicant shall present information related to its selection of the proposed site for the facility, including the following: (1) The general criteria used to select alternative sites, how these criteria were measured and weighed, and reasons for selecting these criteria; (2) An evaluation of alternative sites considered by the applicant for the facility; (3) An evaluation of the proposed plant, wind energy, or transmission site and its advantages over the other alternative sites considered by the applicant, including a discussion of the extent to which reliance upon eminent domain powers could be reduced by use of an alternative	Chapter 10.0

SDCL	ARSD	Required Information	Location
		site, alternative generation method, or alternative waste handling method.	
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:13	**Environmental information.** The applicant shall provide a description of the existing environment at the time of the submission of the application, estimates of changes in the existing environment which are anticipated to result from construction and operation of the proposed facility, and identification of irreversible changes which are anticipated to remain beyond the operating lifetime of the facility. The environmental effects shall be calculated to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction. The applicant shall provide a list of other major industrial facilities under regulation which may have an adverse effect on the environment as a result of their construction or operation in the transmission site, wind energy site, or siting area.	Chapters 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 18.0, 19.0, and 21.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:14	**Effect on physical environment.** The applicant shall provide information describing the effect of the proposed facility on the physical environment. The information shall include: (1) A written description of the regional land forms surrounding the proposed plant or wind energy site or through which the transmission facility will pass; (2) A topographic map of the plant, wind energy, or transmission site; (3) A written summary of the geological features of the plant, wind energy, or transmission site using the topographic map as a base showing the bedrock geology and surficial geology with sufficient cross-sections to depict the major subsurface variations in the siting area; (4) A description and location of economic deposits such as lignite, sand and gravel, scoria, and industrial and ceramic quality clay existent within the plant, wind energy, or transmission site; (5) A description of the soil type at the plant, wind energy, or transmission site; (6) An analysis of potential erosion or sedimentation which may result from site clearing, construction, or operating activities and measures which will be taken for their control; (7) Information on areas of seismic risks, subsidence potential and slope instability for the plant, wind energy, or transmission site; and	Chapter 12.0 Figures 6, 7a, 7b, 8, and 9

SDCL	ARSD	Required Information	Location
		(8) An analysis of any constraints that may be imposed by geological characteristics on the design, construction, or operation of the proposed facility and a description of plans to offset such constraints.	
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:15	**Hydrology.** The applicant shall provide information concerning the hydrology in the area of the proposed plant, wind energy, or transmission site and the effect of the proposed site on surface and groundwater. The information shall include: (1) A map drawn to scale of the plant, wind energy, or transmission site showing surface water drainage patterns before and anticipated patterns after construction of the facility; (2) Using plans filed with any local, state, or federal agencies, indication on a map drawn to scale of the current planned water uses by communities, agriculture, recreation, fish, and wildlife which may be affected by the location of the proposed facility and a summary of those effects; (3) A map drawn to scale locating any known surface or groundwater supplies within the siting area to be used as a water source or a direct water discharge site for the proposed facility and all offsite pipelines or channels required for water transmission; (4) If aquifers are to be used as a source of potable water supply or process water, specifications of the aquifers to be used and definition of their characteristics, including the capacity of the aquifer to yield water, the estimated recharge rate, and the quality of groundwater; (5) A description of designs for storage, reprocessing, and cooling prior to discharge of heated water entering natural drainage systems; and (6) If deep well injection is to be used for effluent disposal, a description of the reservoir storage capacity, rate of injection, and confinement characteristics and potential negative effects on any aquifers and groundwater users which may be affected.	Chapter 13.0 Figure 10
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:16	**Effect on terrestrial ecosystems.** The applicant shall provide information on the effect of the proposed facility on the terrestrial ecosystems, including existing information resulting from biological surveys conducted to identify and quantify the terrestrial fauna and flora potentially affected within the transmission site, wind energy site, or siting area; an analysis of the impact of construction and operation of the proposed facility on the terrestrial biotic environment, including breeding times and places and pathways of migration; important species; and planned measures to	Chapter 14.0

SDCL	ARSD	Required Information	Location
		ameliorate negative biological impacts as a result of construction and operation of the proposed facility.	
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:17	**Effect on aquatic ecosystems.** The applicant shall provide information of the effect of the proposed facility on aquatic ecosystems, and including existing information resulting from biological surveys conducted to identify and quantify the aquatic fauna and flora, potentially affected within the transmission site, wind energy site, or siting area, an analysis of the impact of the construction and operation of the proposed facility on the total aquatic biotic environment and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.	Chapter 15.0
49-41B-11(2,11); 49-41B-22	20:10:22:18	**Land use.** The applicant shall provide the following information concerning present and anticipated use or condition of the land: (1) A map or maps drawn to scale of the plant, wind energy, or transmission site identifying existing land use according to the following classification system: (a) Land used primarily for row and nonrow crops in rotation; (b) Irrigated lands; (c) Pasturelands and rangelands; (d) Haylands; (e) Undisturbed native grasslands; (f) Existing and potential extractive nonrenewable resources; (g) Other major industries; (h) Rural residences and farmsteads, family farms, and ranches; (i) Residential; (j) Public, commercial, and institutional use; (k) Municipal water supply and water sources for organized rural water systems; and (l) Noise sensitive land uses; (2) Identification of the number of persons and homes which will be displaced by the location of the proposed facility; (3) An analysis of the compatibility of the proposed facility with present land use of the surrounding area, with special attention paid to the effects on rural life and the business of farming; and (4) A general analysis of the effects of the proposed facility and associated facilities on land uses and the planned measures to ameliorate adverse impacts.	Chapters 16.0 and 21.0 Figure 12

SDCL	ARSD	Required Information	Location
49-41B-11(2,11); 49-41B-28	20:10:22:19	**Local land use controls.** The applicant shall provide a general description of local land use controls and the manner in which the proposed facility will comply with the local land use zoning or building rules, regulations or ordinances. If the proposed facility violates local land use controls, the applicant shall provide the commission with a detailed explanation of the reasons why the proposed facility should preempt the local controls. The explanation shall include a detailed description of the restrictiveness of the local controls in view of existing technology, factors of cost, economics, needs of parties, or any additional information to aid the commission in determining whether a permit may supersede or preempt a local control pursuant to SDCL 49-41B-28.	Chapter 17.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:20	**Water quality.** The applicant shall provide evidence that the proposed facility will comply with all water quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.	Chapter 18.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:21	**Air quality.** The applicant shall provide evidence that the proposed facility will comply with all air quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.	Chapter 19.0
49-41B-11(3)	20:10:22:22	**Time schedule.** The applicant shall provide estimated time schedules for accomplishment of major events in the commencement and duration of construction of the proposed facility.	Chapter 20.0
49-41B-11(11); 49-41B-22	20:10:22:23	**Community impact.** The applicant shall include an identification and analysis of the effects the construction, operation, and maintenance of the proposed facility will have on the anticipated affected area including the following: (1) A forecast of the impact on commercial and industrial sectors, housing, land values, labor market, health facilities, energy, sewage and water, solid waste management facilities, fire protection, law enforcement, recreational facilities, schools, transportation facilities, and other community and government facilities or services; (2) A forecast of the immediate and long-range impact of property and other taxes of the affected taxing jurisdictions; (3) A forecast of the impact on agricultural production and uses; (4) A forecast of the impact on population, income, occupational distribution, and integration and cohesion of communities; (5) A forecast of the impact on transportation facilities;	Chapter 21.0

SDCL	ARSD	Required Information	Location
		(6) A forecast of the impact on landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance. The information shall include the applicant's plans to coordinate with the local and state office of disaster services in the event of accidental release of contaminants from the proposed facility; and (7) An indication of means of ameliorating negative social impact of the facility development.	
49-41B-11(4)	20:10:22:24	**Employment estimates.** The application shall contain the estimated number of jobs and a description of job classifications, together with the estimated annual employment expenditures of the applicants, the contractors, and the subcontractors during the construction phase of the proposed facility. In a separate tabulation, the application shall contain the same data with respect to the operating life of the proposed facility, to be made for the first ten years of commercial operation in one-year intervals. The application shall include plans of the applicant for utilization and training of the available labor force in South Dakota by categories of special skills required. There shall also be an assessment of the adequacy of local manpower to meet temporary and permanent labor requirements during construction and operation of the proposed facility and the estimated percentage that will remain within the county and the township in which the facility is located after construction is completed.	Chapters 21.0 and 22.0
49-41B-11(5)	20:10:22:25	**Future additions and modifications.** The applicant shall describe any plans for future modification or expansion of the proposed facility or construction of additional facilities which the applicant may wish to be approved in the permit.	Chapter 23.0
49-41B-35(3)	20:10:22:33.01	**Decommissioning of wind energy facilities.** Funding for removal of facilities. The applicant shall provide a plan regarding the action to be taken upon the decommissioning and removal of the wind energy facilities. Estimates of monetary costs and the site condition after decommissioning shall be included in the plan. The commission may require a bond, guarantee, insurance, or other requirement to provide funding for the decommissioning and removal of a wind energy facility. The commission shall consider the size of the facility, the location of the facility, and the financial condition of the applicant when determining whether to require some type of funding. The same criteria shall be used to determine the amount of any required funding.	Chapter 24.0
49-41B-11(2,11)	20:10:22:33.02	**Information concerning wind energy facilities.** If a wind energy facility is proposed, the applicant shall provide the following information:	Chapter 25.0 and 26.0

SDCL	ARSD	Required Information	Location
		(1) Configuration of the wind turbines, including the distance measured from ground level to the blade extended at its highest point, distance between the wind turbines, type of material, and color; (2) The number of wind turbines, including the number of anticipated additions of wind turbines in each of the next five years; (3) Any warning lighting requirements for the wind turbines; (4) Setback distances from off-site buildings, right-of-ways of public roads, and property lines; (5) Anticipated noise levels during construction and operation; (6) Anticipated electromagnetic interference during operation of the facilities; (7) The proposed wind energy site and major alternatives as depicted on overhead photographs and land use culture maps; (8) Reliability and safety; (9) Right-of-way or condemnation requirements; (10) Necessary clearing activities; (11) Configuration of towers and poles for any electric interconnection facilities, including material, overall height, and width; (12) Conductor configuration and size, length of span between structures, and number of circuits per pole or tower for any electric interconnection facilities; and (13) If any electric interconnection facilities are placed underground, the depth of burial, distance between access points, conductor configuration and size, and number of circuits.	
49-41B-22	20:10:22:36	**Additional information in application.** The applicant shall also submit as part of the application any additional information necessary for the local review committees to assess the effects of the proposed facility pursuant to SDCL 49-41B-7. The applicant shall also submit as part of its application any additional information necessary to meet the burden of proof specified in SDCL 49-41B-22.	Chapter 27.0
49-41B-11	20:10:22:39	**Testimony and exhibits.** Upon the filing of an application pursuant to SDCL 49-41B-11, an applicant shall also file all data, exhibits, and related testimony which the applicant intends to submit in support of its application. The application shall specifically show the witnesses supporting the information contained in the application.	Chapter 28.0 and Appendices

5.0 NAMES OF PARTICIPANTS (ARSD 20:10:22:06)

ARSD 20:10:22:06. Names of participants required. *The application shall contain the name, address, and telephone number of all persons participating in the proposed facility at the time of filing, as well as the names of any individuals authorized to receive communications relating to the application on behalf of those persons.*

The Applicants' full names, business address, and business telephone number are:

- Dakota Range I, LLC and Dakota Range II, LLC
  c/o Apex Clean Energy Holdings, LLC
  310 4th Street NE, Suite 200
  Charlottesville, VA 22902
  (434) 220-7595

Individuals who are authorized to receive communications relating to the Application on behalf of the Applicant include:

- Mark Mauersberger
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  Apex Clean Energy Holdings, LLC
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6.0 NAME OF OWNER AND MANAGER (ARSD 20:10:22:07)

ARSD 20:10:22:07. Name of owner and manager. *The application shall contain a complete description of the current and proposed rights of ownership of the proposed facility. It shall also contain the name of the project manager of the proposed facility.*

Dakota Range I, LLC and Dakota Range II, LLC (Dakota Range) are Delaware limited liability companies and wholly owned indirect subsidiaries of Apex Clean Energy Holdings, LLC. The two entities will jointly own, manage, and operate the Project and, between them, hold the land rights and interconnection requests necessary to facilitate development of the Project as proposed. Each entity has obtained a Certificate of Authority from the South Dakota Secretary of State to conduct business in South Dakota. As limited liability companies, sole-member managed by Apex Clean Energy Holdings, LLC, Dakota Range does not have officers and directors. Mark Mauersberger, Senior Development Manager, Apex Clean Energy Holdings, LLC, is managing development of the Project.

7.0 PURPOSE OF, AND DEMAND FOR, THE WIND ENERGY FACILITY (ARSD 20:10:22:08, 20:10:22:10)

ARSD 20:10:22:08. Purpose of facility. *The applicant shall describe the purpose of the proposed facility.*

ARSD 20:10:22:10. Demand for facility. *The applicant shall provide a description of present and estimated consumer demand and estimated future energy needs of those customers to be directly served by the proposed facility. The applicant shall also provide data, data sources, assumptions, forecast methods or models, or other reasoning upon which the description is based. This statement shall also include information on the relative contribution to any power or energy distribution network or pool that the proposed facility is projected to supply and a statement on the consequences of delay or termination of the construction of the facility.*

Electricity generated by the Project would interconnect to the high-voltage transmission grid via a switching station connected to the Big Stone South to Ellendale 345-kV transmission line, which crosses the Project site. Apex Clean Energy Holdings, LLC currently owns the Dakota Range entities and is overseeing development of the Project. Northern States Power Company, d/b/a/ Xcel Energy, has entered into a Purchase and Sale Agreement with Apex Clean Energy Holdings, LLC to acquire the Dakota Range I, LLC and Dakota Range II, LLC entities, which own the Project. The PSA will be finalized after the completion of certain development milestones, including acquisition of an Energy Facility Permit from the Commission for the Project. Xcel Energy is a utility company operating in South Dakota, Minnesota, North Dakota, Colorado, Michigan, New Mexico, Texas, and Wisconsin. Xcel Energy's need for the Project is discussed further below.

Though Xcel will own the Project entities, and therefore the electricity produced, the specific electrons generated by the Project would be utilized as needed on the Midcontinent Independent System Operator, Inc. (MISO) regional grid and cannot be tracked to their exact delivery location or final use. The electricity generated by the Project would help MISO operators meet electricity demand in both the immediate and surrounding MISO control area. This Project would also provide zero-emission cost electricity to the grid, as well as firm price stability due to the availability of a renewable resource that would replace the need for ongoing fuel costs. Demand for this power and the benefits it provides are discussed in Section 7.2.

Additionally, Dakota Range would provide a variety of local benefits. During construction, a typical 300-MW wind project such as this Project typically generates an immediate need for up to 300 temporary construction jobs over 9 months. Construction and operation of a typical 300-MW wind project results in the injection of millions of dollars into the local economy throughout the life of the Project. These investments would be seen throughout the community, including at hotels, restaurants, gas stations, auto repair companies, tire companies, grocery stores, and countless other local businesses. During operation, the Project would employ approximately 10 full-time personnel as facility managers, site managers, and turbine technicians. Furthermore, the Project represents approximately a $400 million investment in Grant and Codington Counties. Dakota Range would pay taxes on the Project, which would significantly increase the revenue available for a variety of local needs.

7.1 Wind Resources Areas

The Applicant has retained the services of Vaisala, LLC to perform a Wind Energy Due Diligence report for Dakota Range. To obtain an accurate representation of the wind resource within the Project Area, Vaisala performed a comprehensive analysis using the following data:

- Onsite data collected at the Project's nine meteorological towers;
- Long-term correlation from NASA's Modern Era Retrospective-Analysis for Research and Application (MERRA), European Centre for Medium-Range Weather Forecasts Re-Analysis (ERA), and National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) Reanalysis Project (NNRP) upper-air data points;
- Project Area topographic and land cover data;
- Up to 72 potential turbine locations within the Project Area;
- Power curve from the Vestas V136-4.2 MW turbine at an 82-meter hub height; and
- State and County standards and setbacks.

Based on data collected, wind speeds are highest in November and December and lowest in July and August. Composite mean wind speeds (CMWS) are generally above 9 meters per second (m/s) during winter, spring and fall, but fall below 9 m/s during the months of July, August, and September. Wind speeds at hub height generally fall off in the morning as solar warming causes increased mixing of the winds at different levels aboveground. After sunset, less mixing occurs and the winds at hub height will tend to increase.

Vaisala compared the onsite data to long-term wind data near Dakota Range. The analysis showed that daily correlation coefficients of the towers average about 0.87 to all reference stations. This high correlation lends confidence to the assessment in that the site-specific data can accurately be placed in a long-term climatological context. The Project is classified as an IEC Classification Class II wind site. IEC Classifications are a set of design requirements that ensure wind turbines are engineered against damage from hazards within their planned lifetime. An IEC Class II wind site has an annual average wind speed at the hub height greater than 8.5 m/s and less than 10 m/s.

7.2 Renewable Power Demand

Regional demand for wind energy can be seen in utilities' Resource Plan filings. Xcel's most recent Minnesota Resource Plan shows a demand for 1,800 MW of new wind energy generation by 2026.[1] Otter Tail Power Company's ten-year plan listed 200 MW of new wind energy generation to be acquired by 2020.[2] Otter Tail Power Company's Integrated Resource Plan filed in Minnesota shows demand for an additional 200 MW of wind by 2023. Beyond demand from utilities, non-traditional power buyers, such as Google, IKEA, Apple, eBay, Facebook, General Motors, Johnson & Johnson, Kellogg's, Microsoft, Nike, and Wal-Mart, have shown demand for renewable energy such as wind energy to meet commitments to use 100 percent renewable energy.[3]

Beyond the market for wind energy, the public has also shown support for the use of renewable energy. According to a Gallup National poll in March 2017, 71 percent of Americans are in favor of "emphasiz[ing] the development of alternative energy such as wind and solar power" compared to 23 percent in favor of emphasizing production of oil, gas, and coal (Gallup, Inc., 2017).

This support can also be seen in legislation throughout the nation. Twenty-nine states, including South Dakota, have adopted renewable portfolio standards (RPSs). These standards require utilities to sell a specified percentage or amount of renewable electricity annually. In addition to these twenty-nine states with RPSs, eight states and two territories have set renewable energy goals. Dakota Range would provide a new source of low cost energy for South Dakota and the United States, helping the Nation move towards the goal of energy independence while reducing pollution and carbon emissions.

The cost of energy from wind has declined by over 66 percent in the past 7 years (Lazard, 2016), and new wind energy projects provide some of the lowest cost energy in the Nation. This low-cost energy is in demand not only from utilities, but also non-traditional power buyers such as major independent corporations. The demand for the Dakota Range Project has been shown by Xcel contracting with Apex Clean Energy to purchase the Dakota Range entities and Project.

Xcel has submitted an application to the North Dakota Public Service Commission for an Advance Determination of Prudence regarding its acquisition of the Dakota Range entities and, thereby, to build, own, and operate the Project. Xcel states in its application that "Dakota Range may be one of the last

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[1] *Supplement to Xcel Energy's 2016-2030 Upper Midwest Resource Plan*, Attachment C, Northern States Power Company, Case No. E002/RP-15-21, at 2.
[2] *South Dakota Ten-Year Biennial Plan,* June 2016, Otter Tail Power Company.
[3] RE100, at http://there100.org/re100.

projects available to us that will have this level of transmission certainty for quite some time" and that "even when using conservative assumptions, Dakota Range will provide benefits to our customers by driving down the overall system cost of fuel" (Northern States Power Company, 2017).[4]

In support of its application, Xcel conducted a Strategist analysis for the addition of Dakota Range into its portfolio and found that at base projections the Project provides a $182 million-dollar system-wide present value of revenue requirement (PVRR) savings over the life of the Project, and that the savings could reach as high as $274 million under high gas price assumptions.[5] Furthermore, Xcel states that due to the addition of the Project to their portfolio, "there will be periods of time where the generation on our system exceeds our native load serving requirement. During these periods, we are likely to make energy sales into the MISO market. Revenues from those sales will be credited to customers through our Fuel Cost Rider."[6] Beyond savings for Xcel's customers, their sale of energy into the MISO market will displace the sale of more expensive energy into the MISO market, benefitting the whole region. Xcel goes on to state in this application that "the levelized costs of the proposed Project are more than offset by the value of avoided generation costs."[7] These analyses were all factors in Xcel's decision to enter into a PSA for the Project, and demonstrate that demand exists for this Project.

7.3 Consequences of Delay

If the Dakota Range project is delayed, the Project's benefits would be greatly reduced. Dakota Range must be constructed by the end of 2021 to receive a 1.92-cents per kilowatt hour Production Tax Credit (PTC). If the Project does not reach operation until 2022, the Project may not qualify for a PTC, or would qualify for only a 1.44-cents per kilowatt hour PTC. As scheduled, Dakota Range is expected to provide a $182 million-dollar system-wide present value of revenue requirement savings over the life of the Project. Xcel has scheduled Dakota Range to reach operation in 2021 to ensure the Project qualifies for the 1.92-cents per kilowatt hour PTC and to provide savings to its customers through the Project's low cost of energy. Delay could force Xcel to re-analyze its source of new generation, removing significant savings for Xcel's customers and guaranteeing a higher cost of energy.

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[4] A*pplication for Advance Determination of Prudence*, Northern States Power Company, Case No. PU-17-372, at 1.
[5] A*pplication for Advance Determination of Prudence*, Resource Planning Testimony, Northern States Power Company, Case No. PU-17-372, at 19.
[6] *Id.*
[7] A*pplication for Advance Determination of Prudence*, Northern States Power Company, Case No. PU-17-372, at 16.

8.0 ESTIMATED COST OF THE WIND ENERGY FACILITY (ARSD 20:10:22:09)

ARSD 20:10:22:09. Estimated cost of facility. *The applicant shall describe the estimated construction cost of the proposed facility.*

The current estimated capital cost of the Project is approximately $380 million based on indicative construction and wind turbine pricing cost estimates for the proposed Vestas V136-4.2 MW turbine layout. This estimate includes lease acquisition; permitting, engineering, procurement, and construction of turbines, access roads, underground electrical collector system, Project collection substation, interconnection facilities, O&M facility, supervisory control and data acquisition (SCADA) system, and meteorological towers; and project financing. Capital costs could fluctuate as much as 20 percent for the Project, dependent on final micrositing and MISO interconnection costs.

9.0 GENERAL SITE AND PROJECT COMPONENT DESCRIPTION (ARSD 20:10:22:11)

ARSD 20:10:22:11. General site description. *The application shall contain a general site description of the proposed facility including a description of the specific site and its location with respect to state, county, and other political subdivisions; a map showing prominent features such as cities, lakes and rivers; and maps showing cemeteries, places of historical significance, transportation facilities, or other public facilities adjacent to or abutting the plant or transmission site.*

The Project would be located on approximately 44,500 acres of land in Codington and Grant Counties north of Watertown, South Dakota. Table 9-1 shows the sections that intersect the Project Area.

Table 9-1: Sections that Intersect the Project Area Boundary

County	Township	Range	Sections
Codington	118N	52W	1-4, 10-12
	119N	51W	5-6, 19
	119N	52W	1-4, 8-17, 21-24, 26-28, 31-36
	119N (A)	51W (A)	6
	120N (A)	51W (A)	30-31
	120N (A)	52W (A)	25, 36
Grant	120N	51W	6-8, 17-22, 27-29, 33
	120N	52W	1-2, 10-15, 22-24, 26-28, 33-35
	120N (A)	51W (A)	4-9, 3, 18-19, 10
	120N (A)	52W (A)	1-4, 9-15, 22-24
	121N (A)	51W (A)	27-28, 31-33
	121N	52W	34-36

(A) = Township duplicate

Figure 1 shows the locations of the State, county, and town boundaries; lakes and rivers; railroads; and major highways and roads with respect to the Project Area. Figure 12 shows the locations of cemeteries, places of historical significance, and other community facilities (i.e., schools, religious facilities) within or near the Project Area. There are no active transportation facilities (i.e., airports) other than roads and railroads within or adjacent to the Project Area.

9.1 Wind Farm Facility

The Project would consist of up to 72 wind turbines with an aggregate nameplate capacity of up to 302.4 MW. The Project would also include underground electric collector lines, a central collection substation, an interconnection switching station, an O&M facility, access roads connecting to turbines and associated facilities, up to five permanent meteorological towers, and a SCADA system (installed with the collector lines and interconnection facility). A 345-kV interconnection facility will also be constructed between the collection substation and the interconnection switching station. Figure 2 shows the proposed layout of the Project facilities. Table 9-2 lists the sections within the Project Area containing proposed wind farm facilities.

Table 9-2: Sections Containing Wind Farm Facilities

County	Township	Range	Sections
Codington	119N	51W	5-6
	119N	52W	1-3, 11-14, 23-24
Grant	120N	51W	6-7, 17-21, 27-28
	120N	52W	1-2, 10-15, 22-24, 26-27, 34-35
	120N (A)	51W (A)	4-9
	120N (A)	52W (A)	12
	121N (A)	51W (A)	31-33
	121N	52W	34-36

(A) = Township duplicate

Figure 2 shows the 72 proposed primary wind turbine locations, as well as the 25 proposed alternate turbine locations. No more than 72 turbines will be built. As a result of final micrositing, minor shifts in the turbine locations may be necessary to avoid newly identified cultural resources (cultural resource studies in coordination with the SWO are ongoing), or due to geotechnical evaluations of the wind turbine locations, landowner input, or other factors. Therefore, the Applicant requests that the permit allow turbines to be shifted within 500 feet of their current proposed location, so long as specified noise and shadow flicker thresholds are not exceeded, cultural resource impacts are avoided or minimized per the CRMMP, environmental setbacks are adhered to as agreed upon with USFWS and SDGFP, and wetland impacts are avoided to the extent practicable. If turbine shifts are greater than 500 feet, exceed the noted thresholds, or do not meet the other limitations specified, the Applicant would either use an alternate turbine location or obtain Commission approval of the proposed turbine location change. Twenty-five alternate turbine locations are proposed to hedge against additional turbine locations becoming necessary during final micrositing. Furthermore, these additional locations provide layout flexibility to hedge against potential capacity factor reductions in cases where a necessary turbine shift within 500 feet of its original location lowers the capacity factor greater than activating an alternate location. This number of alternate turbine locations prevents unforeseen findings from reducing the size of the project or from significantly injuring the productivity of the project. In all cases, the final turbine locations constructed will adhere to all applicable local, State, and Federal regulations and requirements.

Figure 2 also shows the proposed access road and underground collection system locations. As a result of final micrositing and the utility coordination needed to facilitate Project interconnection, shifts in the access roads and collector system, as well as changes in the locations of the O&M facility, Project substation, concrete batch plant, and laydown/staging areas, may be necessary. Therefore, the Applicant requests that the permit allow those facilities to be modified, as needed, so long as the new locations are on land leased for the Project, cultural resources and environmental setbacks are retained, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met.

9.2 Turbines

Each wind turbine consists of three major components: the tower, the nacelle, and the rotor. These components are mounted on a concrete foundation, also known as a turbine pad, to provide structural support to the assembled turbine. The nacelle sits atop the tower, and the rotor hub is mounted on a drive shaft that is connected to the gearbox and generator contained within the nacelle.

Turbine Type: The proposed turbine that would be utilized for the Project is the Vestas V136-4.2 MW turbine at an 82-meter hub height and 136-meter rotor diameter (RD). Figure 3 is a diagram depicting hub height and RD. Table 9-3 identifies the wind turbine characteristics for this turbine model.

Table 9-3: Wind Turbine Characteristics

Manufacturer	Model	Rotor Diameter	Hub Height	Generator Nameplate Capacity
Vestas	V136-4.2MW	136 meters	82 meters	4.2 MW

Tower: The tubular towers proposed for the Project would be conical steel structures. Each tower has a lockable access door, internal lighting, and an internal ladder and lift to access the nacelle. In accordance with FAA regulations, the towers would be painted off-white to minimize visual impact.

Nacelle: The main mechanical and electrical components of the wind turbine are housed in the nacelle. The nacelle is mounted on a sliding ring that allows it to rotate, or “yaw,” into the wind to maximize energy capture. The nacelle components include the drive train, gearbox, generator, and generator step-up transformer. The nacelle is housed in a steel-reinforced fiberglass shell that protects internal machinery from the environment. The housing is designed to allow for adequate ventilation to cool internal machinery. It is externally equipped with an anemometer and a wind vane to measure wind speed and direction. The generated electricity is conducted through cables within the tower to a switch enclosure mounted at the base of the turbine tower. Attached to the top of select nacelles, per FAA specifications, would be a single, medium-intensity aviation warning light. These would be red flashing lights that would be operated in accordance with FAA requirements. The FAA determines lighting specifications and determines which turbines must be equipped with lights.

Rotor: A rotor assembly is mounted on the drive shaft and operates upwind of the tower. Electric motors within the rotor hub vary the pitch of each blade according to wind conditions to maximize turbine efficiency at varying wind speeds.

9.3 Access Roads

Existing public roads, private roads, and field paths are being utilized to access the Project. The existing roads may require improvements before, during, or following construction. Where necessary, new access roads would be constructed between existing roadways and Project components. The new and improved access roads would be all-weather, gravel surfaced, and generally 16 feet in width. During construction, some of the access roads would be widened to accommodate movement of the turbine erection crane, with temporary widths generally not exceeding 50 feet.

Separate access may be required for the cranes used to erect the wind turbines. In such cases, temporary crane paths would be constructed between turbine locations. Following completion of construction, the temporary crane paths would be removed and the area restored, to the extent practicable.

The final access road design would be dependent on geotechnical information obtained during the engineering phase. It is anticipated that the access road network for the Project would include approximately 19 to 23 miles of new private roads. For purposes of calculating access road impacts in this Application, the Applicant has conservatively assumed approximately 140 acres of temporary disturbance and 45 acres of disturbance during the life of the Project for access roads. Final turbine placement would determine the amount of roadway and disturbance for the Project.

9.4 Underground Electrical Collector Lines

The electrical collector lines would consist of an underground cable system between the collection substation and the individual turbine locations. The collector system would be designed for operation at 34.5 kV. The collector lines would be installed in a trench at least 30 inches below the ground to avoid potential impact from the existing land uses. A fiber-optic cable and an additional separate ground wire would also be installed with the collector system. The fiber-optic cable would be used for telemetry, control, and communication purposes. Above-ground junction boxes would be installed as required for connections or splices. For purposes of calculating temporary impacts in this application, the Applicant has conservatively assumed approximately 160 acres of total temporary disturbance from underground collector system construction. The Applicant assumes that some of the construction disturbance for the underground collector system would be shared with construction disturbance for access roads where these facilities overlap. Ground disturbance impacts during the operational life of the Project are assumed to be approximately 0.03 acre for the above-ground junction boxes.

9.5 Collection Substation

The collection substation would be located generally in the center of the Project footprint and would consist of two substation transformers, circuit breakers, switching devices, auxiliary equipment, a control enclosure containing equipment for proper control, protection, monitoring, and communications, and associated equipment and facilities. The principal function of the substation is to increase the voltage from the collector system (34.5 kV) to the voltage of the transmission line (345 kV), which would transport the electricity of the entire Project to the MISO grid via the interconnection switching station. The collection substation would be located within a fenced area. The fence would be designed in accordance with industry standards to provide safety and security.

Up to 10 acres of land would be purchased to facilitate construction and operation of the collection substation. The final location of the collection substation depends on the location of the interconnection switching station, which, as discussed below in Section 9.6, will be determined by Otter Tail Power Company in Q1 2018. Four potential substation locations, as shown on Figure 2, are currently being evaluated. The collection substation, whether ultimately located at one of the four locations under evaluation or elsewhere within the Project Area, would be sited so that the transmission facility between the collection substation and the interconnection switching station is less than a 0.5-mile in length and so that it does not cross any public roads. As discussed in Section 9.1, the Applicant requests that the permit allow Project facilities, including the collection substation, to be modified, as needed, so long as the new locations are on land leased for the Project, cultural resource impacts are avoided or minimized per the CRMMP, environmental setbacks are adhered to as agreed upon with USFWS and SDGFP, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met.

9.6 Interconnection Facilities and Switching Station

Associated with the Project would be an interconnection switching station. This switching station would occupy a fenced area and would be situated within the Project footprint, adjacent to the under-construction Big Stone South to Ellendale 345-kV transmission line. The switching station would serve as the electrical interconnection between the Project and the MISO grid. The switching station would consist of 345-kV circuit breakers, disconnect switches, bus conductors, auxiliary equipment, and a control enclosure containing equipment for proper control, protection, monitoring, and communications. The switching station would be located within a fenced area. The fence would be designed in accordance with industry standards to provide safety and security.

Potential locations for the interconnection switching station have been determined through coordination between Dakota Range and Otter Tail Power Company, the owner and operator of the Big Stone South to Ellendale 345-kV transmission line. Otter Tail Power Company will identify the interconnection switching station location in Q1 2018 after the necessary interconnection agreement documentation has been signed. Otter Tail Power Company will be responsible for the construction and operation of the switching station. The interconnection switching station will utilize approximately 10 acres, but the parcel will consist of up to 40 acres for future expansion or upgrades that the MISO system may need.

Dakota Range would construct a 345-kV interconnection facility connecting the collection substation and the interconnection switching station. Because the interconnection facility is less than 2,640-feet long, does not cross any public highways, and does not require the use of eminent domain, it falls outside the Commission's jurisdiction and has been permitted locally.

9.7 Meteorological Towers

Up to five permanent met towers would be installed as part of the Project. These met towers are used to obtain wind data for performance management once the Project is operational. The met towers would be self-supporting with heights not to exceed the hub height of the wind turbines. The permanent met towers would be marked and lighted as specified by the FAA. Each meteorological tower would result in a permanent impact of approximately 42 feet by 42 feet (0.3 acre).

9.8 O&M Facility

An O&M facility would be constructed within the Project Area at a location well-suited for access to the turbines, as well as the substation and switching station. One potential O&M facility location, as shown on Figure 2, is currently being evaluated. As discussed in Section 9.1, the Applicant requests that the permit allow the O&M facility location to be modified, as needed, so long as the final location is on land leased for the Project, cultural resource impacts are avoided or minimized per the CRMMP, environmental setbacks are adhered to as agreed upon with USFWS and SDGFP, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met. The facility would comprise a single- or two-story, 7,000 to 10,000 square-foot building, which would house operating personnel, offices, operations and communication equipment, parts storage and maintenance activities, and a vehicle parking area. An area for outdoor storage of larger equipment and materials would also be included within a fenced area for safety and security.

For purposes of calculating temporary impacts in this Application, the Applicant has assumed approximately 5 acres of total temporary disturbance from O&M facility construction. After construction, total permanent disturbance from the O&M facility, including parking, would be approximately 5 acres. Dakota Range would purchase up to 5 acres to facilitate construction and use of the O&M facility.

Station power for Dakota Range facilities would be provided through the Project interconnection. Back-up power for the Dakota Range substation would be provided by the local electrical cooperative(s), providing power to operate communications, relaying, and control systems, indefinitely.

9.9 SCADA System

The Project's design includes safety and control mechanisms. These mechanisms are generally monitored using a Supervisory Control and Data Acquisition ("SCADA") system. Each turbine is connected to the SCADA system via fiber-optic cable, which allows the turbines to be monitored in real time by the O&M staff. The SCADA system also allows the Project to be remotely monitored, thus increasing Project oversight, as well as the performance and reliability of the turbines. Not only would the local O&M office have full control of the wind turbines, but a 24/7 remote operations facility would also have control of the individual turbines. These two teams coordinate to ensure that the wind turbines operate safely and efficiently.

A third mechanism for safety and control is the turbines themselves. Each turbine monitors the wind speed and direction to ensure its current position is most efficient to produce electricity. This data is also used for feathering the blades; applying the brakes in high wind speeds or if there is ice build-up on the blades; and to tell the turbine when the wind is strong enough to begin turning the generator and producing electricity at the "cut-in" wind speed.

9.10 Construction

Once the Facility Permit is approved and other county, state, and Federal approvals are obtained, the Applicant would complete engineering-scale design of the access roads, construction areas, turbine foundations, and the electrical components. Construction of the on-site roads, tower foundations, and substation would take approximately 8 to 10 months. The actual installation of the turbines would take approximately 2 to 3 months. Figure 4 shows a typical site layout during construction. Collector lines would be installed by trenching or, if necessary based on site conditions, by other non-trenching means (e.g., directional boring). For collection system trenching during construction, Dakota Range personnel and its contractors would remove topsoil prior to trenching and restore topsoil after trenching is complete. The contractor would typically decompact up to 10 inches below grade for crane paths post construction. Per agreement with the SWO, tribal resources will be marked in advance of construction to avoid unintentional impacts. For road construction, topsoil will be removed and stockpiled in the temporary construction area. If necessary for drainage and access, temporary culverts and field approaches will be installed. For turbine foundation installation, topsoil and subsoil will be removed, separated, and stockpiled at each turbine site. After construction, the subsoil and topsoil will be restored over the spread footer concrete foundation. All temporary construction areas will be restored after construction, including removing gravel, decompacting subsoil, and replacing removed topsoil. Where necessary, temporary and permanent stabilization measures will be implemented, including mulching, seed with appropriate seed mix, and installing slope breakers.

Dakota Range personnel and its contractors would confer and coordinate closely with the South Dakota Department of Transportation (SDDOT) and Codington and Grant Counties to manage construction traffic and safely deliver the various turbine components. Highway Access and Utility Permits would be obtained from the SDDOT prior to construction, and contractors would be required to obtain any necessary overheight or overweight haul permits. County road permits required for right-of-way occupancy, utility crossings, road approaches, and overweight loads would be obtained from Codington and Grant Counties prior to construction.

9.11 Operation

The Project would be operated and maintained by a team of approximately 10 personnel, including facility managers, a site manager, and a certified crew of technicians. This team would be at the Project site or O&M facility during normal business hours and would perform routine checks, respond to issues, and optimize the performance of the wind farm. The team would also have specified personnel on-call 24 hours per day, seven days per week, should an issue arise outside of normal business hours. The on-site team will work in coordination with off-site operations staff at a Remote Operation Control Center in accordance with FERC guidelines. This off-site team will assist in identifying turbines operating at non-peak efficiency, helping on-site staff quickly locate turbines with potential operating issues so they can be quickly resolved to ensure safety and optimal performance of the wind farm. The on-site team will also conduct frequent visual assessments of the wind turbines to check for issues that are not impacting performance of the wind farm. A plan for addressing emergency incidents will be in place, and is discussed in Section 21.3.3.

During operations, the O&M staff would perform scheduled, preventive maintenance on the turbines. This is typically done in conjunction with representatives from the turbine manufacturer for the first 1 to 3 years. Turbine inspections are conducted and recorded twice a year. Once a year, maintenance is conducted on the turbine for 10 hours with a crew of 3 technicians. The other annual maintenance is a 36-hour inspection with a crew of 3 technicians. During these inspections, the entire turbine is inspected, including bolt torque checks, lubrication and filter changes, electrical inspections, pitch calibrations, amongst other tasks. The on-site operations team also drives throughout the Project on a daily basis conducting unrecorded visual inspections on the Project.

10.0 ALTERNATE SITES AND SITING CRITERIA (ARSD 20:10:22:12)

ARSD 20:10:22:12. Alternative sites. *The applicant shall present information related to its selection of the proposed site for the facility, including the following:*
(1) The general criteria used to select alternative sites, how these criteria were measured and weighed, and reasons for selecting these criteria;
(2) An evaluation of alternative sites considered by the applicant for the facility;
(3) An evaluation of the proposed plant, wind energy, or transmission site and its advantages over the other alternative sites considered by the applicant, including a discussion of the extent to which reliance upon eminent domain powers could be reduced by use of an alternative site, alternative generation method, or alternative waste handling method.

Following is a description of the general Project location site selection process, a discussion of the turbine and site configuration alternatives considered for the Project, and a summary of the siting criteria applied to the Project.

10.1 General Project Location Selection

Apex acquired approximately 10,000 acres under lease from a different developer, Wahpeton Wind, in March 2015. Apex pursued this sale due to MISO transmission availability, which was scarce throughout South Dakota. Because the Dakota Range Project was acquired after initial site selection, and a specific area was offered for sale, Apex was not involved in considering broader alternative locations. However, after Apex acquired Dakota Range, Apex and Dakota Range analyzed potential alternatives for expansion of the initial site. A number of constraints limited the area within which the initial site could be expanded. Specifically, Apex and Dakota Range identified constraints to the south, east and north due to competing wind farm leases. Additionally, Apex and Dakota Range identified USFWS Grassland Easements to the north and east that they wanted to avoid. Constraints further west existed due to diminishing wind speeds west of the initial site. Given the constraints noted, Dakota Range ultimately sought to acquire leases from landowners in the immediate vicinity of the initial site, with new leases signed primarily within 5-7 miles of existing leases with the goal of connectivity to the initial site acquired.

In addition to existing constraints, Apex considered a number of factors in selecting the final Project site, including:

- The site has strong wind speeds for both the region as a whole and the immediate area, which is key for development of a competitive, economically viable wind project.
- The site is in close proximity to the Big Stone South to Ellendale 345-kV transmission line that is currently under construction and would run through the Project boundary. Having direct access to available transmission minimizes the interconnection infrastructure needed, and helps reduce overall Project costs.

- The Project is compatible with the existing land uses, which are primarily agricultural (i.e., crop production, pasture land, hay production). Wind development is particularly compatible with agricultural land because the existing uses can continue around the wind energy facility. As a result, wind development allows landowners to diversify their operations with minimal disruption to existing agricultural uses.
- The proposed Project has received strong support from landowners in the Project Area, as well as the surrounding community. Dakota Range gained its support by establishing long-term relationships within the community. In return, landowners voluntarily signed wind leases in order to make the Project a reality.
- Through preliminary desktop analysis, site-specific field studies, and ongoing coordination with agencies, such as the USFWS and SDGFP, the Project was able to avoid or minimize potential adverse impacts to cultural resources, wetlands, grasslands, and wildlife species of concern. Given the need to acquire an Energy Facility Permit for the Project, and to comply with applicable federal and state permitting requirements, minimal impacts to existing resources is key to enabling Project development.

10.2 Site Configuration Alternatives

The proposed layout of 72 turbines reflects an optimal configuration to best capture wind energy within the Project Area, while avoiding impacts to residences, known cultural resources, wetlands, grasslands, and sensitive species and their habitats. A previous site configuration, which included 158 turbine locations, was submitted and permitted at the County level in May 2017 (see Chapter 17.0 for a discussion of County permitting). However, for market and wind resource suitability reasons, it was determined that Dakota Range would utilize a 4.2-MW turbine rather than a 2.0-MW turbine, as previously contemplated. This reduced the number of primary turbine positions in the layout from 150 to 72 and reduced the total footprint of turbines. Rather than spanning the whole Project Area boundary, the turbines are now primarily located in the northeast portion of the Project Area to maximize the available wind resource. As discussed in Section 9.1, final micrositing could result in minor turbine adjustments. However, the final Project layout will comply with all applicable local, State, and Federal requirements, including the state and local requirements and/or commitments set forth in Table 10-1 below. The buildable area for turbines, after taking into account the setbacks in Table 10-1 as well as further environmental setbacks (see Figure 11), is visually depicted on the siting constraints map provided as Figure 5.

Table 10-1: Dakota Range Siting Requirements/Commitments

Category	Requirements/Commitments
State Requirements	
Setbacks	Turbines shall be set back at least 500 feet or 1.1 times the height of the tower, whichever is greater, from any surrounding property line (SDCL 43-13-24).
Codington County	
Setbacks	- 1,000 feet from existing off-site residences, businesses, churches, and buildings owned and/or maintained by a government entity. - 500 feet from on-site or lessor's residence. - 110% the height of the wind turbines from the centerline of public roads. - 110% the height of the wind turbines from any property line unless a wind easement has been obtained from adjoining property owner.
Noise	Noise level shall not exceed 50 dBA average A-weighted sound pressure including constructive interference effects at the property line of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.
Turbine Spacing	The turbines shall be spaced no closer than three rotor diameters (RD) within a string. If required during final micro siting of the turbines to account for topographic conditions, up to 10 percent of the towers may be sited closer than the above spacing, but the permittees shall minimize the need to site the turbines closer.
Grant County	
Setbacks	- 1,000 feet from existing off-site residences, businesses, churches, and buildings owned and/or maintained by a government entity. - 500 feet from on-site or lessor's residence. - 110% the height of the wind turbines from the centerline of public roads. - 110% the height of the wind turbines from any property line unless a wind easement has been obtained from adjoining property owner.
Noise	Noise level shall not exceed 50 dBA average A-weighted sound pressure including constructive interference effects at the perimeter of the principal and accessory structures of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.
Turbine Spacing	The turbines shall be spaced no closer than three RD within a string. If required during final micro siting of the turbines to account for topographic conditions, up to 10 percent of the towers may be sited closer than the above spacing but the permittees shall minimize the need to site the turbines closer.
Voluntary	
Shadow Flicker	Facility will not exceed a maximum of 30 hours of shadow flicker per year at any existing non-participating residence, business, or building owned and/or maintained by a governmental entity, unless otherwise agreed to by the landowner.
Punished Woman's Lake	The turbines will be set back 2 miles from the shoreline of Punished Woman's Lake.

10.3 Lack of Reliance on Eminent Domain Powers

Dakota Range will not use eminent domain powers to acquire easements for the wind energy facility. All land rights required for the wind energy facility were obtained through voluntary leases with property owners. Private land and public road rights-of-way would be used for all facilities. Further, the Applicant will coordinate with Federal, State, and local agencies to obtain appropriate permits for the Project. Thus, selection of an alternative site would not reduce reliance on eminent domain powers.

11.0 ENVIRONMENTAL INFORMATION (ARSD 20:10:22:13)

ARSD 20:10:22:13. Environmental information. *The applicant shall provide a description of the existing environment at the time of the submission of the application, estimates of changes in the existing environment which are anticipated to result from construction and operation of the proposed facility, and identification of irreversible changes which are anticipated to remain beyond the operating lifetime of the facility. The environmental effects shall be calculated to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction. The applicant shall provide a list of other major industrial facilities under regulation which may have an adverse effect on the environment as a result of their construction or operation in the transmission site, wind energy site, or siting area.*

Chapters 12.0 through 16.0 and Chapters 18.0, 19.0, and 21.0 provide a description of the existing environment at the time of the Application submittal, the potential changes to the existing environment that are anticipated as a result of Project construction and operation, and the irreversible changes that are anticipated to remain beyond the operational lifetime of the facility. These chapters also identify the avoidance, minimization, and mitigation measures that will be implemented for the Project. Table 11-1 identifies the ground disturbance impacts (both temporary impacts during construction and operational impacts during the life of the Project) assumed for the Project.

Table 11-1: Summary of Dakota Range Ground Disturbance Impacts

Project Component	Construction Impacts (Temporary)		Operational Impacts (Long-Term)	
	Dimensions	*Total Acreage*	*Dimensions*	*Total Acreage*
Turbines	150-foot radius	117 acres	25-foot radius	4 acres
Access roads	50-foot wide	140 acres	16-foot wide	45 acres
Crane paths	50-foot wide	210 acres	N/A	N/A
Collector lines	30-foot wide	160 acres	10-foot by 5-foot junction box	0.03 acre
Collection substation	10 acres	10 acres	10 acres	10 acres
Met towers	50-foot by 50-foot area	0.3 acres	42-foot by 42-foot area	0.3 acres
O&M facility	5 acres	5 acres	5 acres	5 acres
Laydown/staging/ batch plant areas	10 acres	10 acres	N/A	N/A
	Total:	**647 acres**	**Total:**	**65 acres**

There are no other operating energy conversion facilities, existing or under construction, or other major industrial facilities under regulation within or adjacent to the Project Area. As such, construction and operation of the Dakota Range Project would not result in cumulative effects on resources in the area from siting the Project in combination with other energy conversion or major industrial facilities.

12.0 EFFECT ON PHYSICAL ENVIRONMENT (ARSD 20:10:22:14)

ARSD 20:10:22:14. Effect on physical environment. *The applicant shall provide information describing the effect of the proposed facility on the physical environment. The information shall include:*
(1) A written description of the regional land forms surrounding the proposed plant or wind energy site or through which the transmission facility will pass;
(2) A topographic map of the plant, wind energy, or transmission site;
(3) A written summary of the geological features of the plant, wind energy, or transmission site using the topographic map as a base showing the bedrock geology and surficial geology with sufficient cross-sections to depict the major subsurface variations in the siting area;
(4) A description and location of economic deposits such as lignite, sand and gravel, scoria, and industrial and ceramic quality clay existent within the plant, wind energy, or transmission site;
(5) A description of the soil type at the plant, wind energy, or transmission site;
(6) An analysis of potential erosion or sedimentation which may result from site clearing, construction, or operating activities and measures which will be taken for their control;
(7) Information on areas of seismic risks, subsidence potential and slope instability for the plant, wind energy, or transmission site; and
(8) An analysis of any constraints that may be imposed by geological characteristics on the design, construction, or operation of the proposed facility and a description of plans to offset such constraints.

The following sections describe the existing physical environment within the Project Area, the potential effects of the proposed Project on the physical environment, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

12.1 Geological Resources

The existing geological resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

12.1.1 Existing Geological Resources

This section describes the regional landforms, surficial geology, bedrock geology, economic deposits, seismic risk, and subsidence potential within the Project Area.

12.1.1.1 Regional Landforms/Surficial Geology

The topography within the Project Area is generally characterized by gently rolling hills. Relief within the Project Area is low with site elevations ranging from approximately 1,800 to 2,050 feet above mean sea level (AMSL). Within the Project Area, perennial streams and drainages bisect the terrain. The majority of the Project Area drains southwest into the Big Sioux River via the Indian River, Soo Creek, Mahoney Creek, and Mud Creek. Drainage of the northeastern portion of the Project Area is east into the Minnesota River via the South Fork Whetstone River. Figure 6 is a topographic map of the Project Area.

The Project Area is located within the Central Lowland province of the Interior Plains physiographic region. The Central Lowland province is characterized by flat lands and geomorphic remnants of glaciation (National Park Service [NPS], 2015a). The Central Lowlands were subject to repeated Pleistocene glaciations. Underlying glacial deposits are largely horizontal Paleozoic sandstones, shales, limestones, conglomerates, and coals.

The following surficial geologic units are mapped within the Project Area (South Dakota Geological Survey [SDGS], 2004a):

- Qal - Alluvium (Quaternary) – Clay- to boulder-sized clasts with locally abundant organic material. Thickness up to 75 feet (23 meters).
- Qlo - Outwash, undifferentiated (Upper Wisconsin) – Heterogeneous sand and gravel with minor clay and silt, of glaciofluvial origin, including outwash plains, kames, kame terraces, and other undifferentiated deposits. Thickness up to 30 feet (9 meters).
- Qlot - Outwash, terrace (Upper Wisconsin) – Heterogeneous clay to gravel of glaciofluvial origin. Thickness up to 60 feet (18 meters).
- Qlov - Outwash, valley train (Upper Wisconsin) – Heterogeneous silt to gravel. Confined to valleys of glaciofluvial origin. Thickness up to 60 feet (18 meters).
- Qlt - Till, moraine (Upper Wisconsin) – Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. Exhibits a distinctive weathered, dissected surface. Typically overlain by up to 10 feet (3 meters) of loess. Thickness up to 150 feet (46 meters).
- Qlte - Till, end moraine (Upper Wisconsin) – Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by elevated linear ridges with hummocky terrain locally at former ice sheet margins. Composite thickness of all Upper Wisconsin till may be up to 300 feet (91 meters).
- Qltg - Till, ground moraine (Upper Wisconsin) – Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by smooth, rolling terrain. Composite thickness of all Upper Wisconsin till may be up to 300 feet (91 meters).

Figure 7a illustrates the surficial geology within the Project Area, and Figure 7b is a geologic cross section of the Project Area.

12.1.1.2 Bedrock Geology

The uppermost bedrock unit underlying the entire Project Area is the Pierre Shale (Figure 8). The Pierre Shale, is an Upper Cretaceous-aged blue-gray to dark-gray, fissile to blocky shale with persistent beds of bentonite, black organic shale, and light-brown chalky shale (SDGS, 2004b). The Pierre Shale contains minor sandstone, conglomerate, and abundant carbonate and ferruginous concretions, with thickness up to 1,000 feet (205 meters).

12.1.1.3 Economic Deposits

Commercially viable mineral deposits within Codington and Grant Counties are limited to sand, gravel, and construction aggregates. Information from the South Dakota Department of Environment and Natural Resources (SDDENR) Minerals and Mining Program and a review of the U.S. Geological Survey (USGS) 7.5-minute quadrangle mapping indicates that a sand and gravel quarry was developed in the southern part of the Project Area, but it has been inactive since 1995. The nearest active gravel quarries are approximately 10 miles north and 11 miles southwest of the Project Area (SDDENR, 2017a).

A review of information from the SDDENR Oil and Gas Initiative Program reveals that the majority of current and historic oil and gas development in South Dakota occurs in the western half of the State. The Project Area does not lie within an identified oil and gas field, and there are no active or historical oil and gas developments within or near the vicinity of the Project Area (SDDENR, 2017b).

12.1.1.4 Seismic Risks

The risk of seismic activity in the vicinity of the Project Area is low. The USGS Earthquake Hazards Program estimates less than 1 percent chance of damage from earthquakes in 2017 (USGS, 2017a). Further, the 2014 USGS National Seismic Hazard Map indicates the peak ground acceleration (PGA) with a 2 percent chance of exceedance in 50 years is 0.02 to 0.04 g (USGS, 2017a). According to the SDGS, no earthquakes have been recorded in Codington or Grant County from 1872 to 2013 (SDGS, 2013). However, a magnitude 3.7 earthquake was recorded approximately 40 miles northeast of the Project Area in 1995. Available geologic mapping and information from the USGS Earthquake Hazards Program do not indicate any active or inactive faults within the Project Area (USGS, 2017b).

12.1.1.5 Subsidence Potential

The risk for subsidence within the Project Area is considered negligible. The Pierre Shale bedrock is not known to exhibit karst topography or contain layers or members susceptible to dissolution by water. No historic underground mining operations, which could lead to subsidence potential, exist within the Project Area.

12.1.2 Geological Resources Impacts/Mitigation

The geological conditions, including geologic formations, seismic risk, and subsidence potential, within the Project Area are favorable and are not anticipated to control or impact construction or operation of the Project. Excavation would be required to install the turbine tower foundations, and trenching would be required to install collector lines. Prior to construction, geotechnical borings would be performed at all wind turbine locations to develop the specific design and construction parameters. Laboratory testing of soil samples obtained from the site and geophysical surveys would be performed to determine the engineering characteristics of the site subgrade soils. If necessary, modifications to roadway and foundation subgrade design would be made to account for specific site conditions. As discussed in Chapter 24.0, the facility would be decommissioned after the end of the Project's operating life. Facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. After decommissioning of the Project is complete, the portions of underground facilities that have been abandoned in place would remain beyond the operational lifetime of the facility. However, these remaining facilities would not result in irreversible changes to the underlying geological conditions of the Project Area.

Due to the lack of developed or potential economic mineral resources within the Project Area, construction and operation of the proposed facility poses no impact to economic mineral resources. Therefore, no mitigation is required for impacts to mineral resources.

12.2 Soil Resources

The existing soil resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

12.2.1 Existing Soil Resources

This section describes the existing soil types, erosion potential and slopes, and prime farmland soils within the Project Area.

12.2.1.1 Soil Types

The soils within the Project Area primarily consist of loams, silty loams, and silty clay loams derived mostly from glacial till, alluvium, and the underlying Pierre Shale bedrock. The soils in the Project Area are not highly susceptible to erosion and are generally conducive to crop production (Natural Resources Conservation Service [NRCS], 2017). Nearly all the soils within the Project Area have the potential to be highly corrosive to buried steel, while less than half of the soils within the Project Area have the potential to be moderately corrosive to concrete. The majority of soils in the Project Area are well drained, and only approximately 6 percent of the soils have a significant hydric component (30 to 100 percent of the soil is hydric). Approximately 11 percent of the soils are considered to have a high potential for frost action (NRCS, 2017). Table 12-1 lists the soil types comprising more than 1 percent of the Project Area and the characteristics of these soils, and Figure 9 illustrates the soil types and distributions within the Project Area.

Table 12-1: Soil Types Within the Project Area

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
Z192B (Vienna-Brookings complex, coteau, 1 to 6 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Silt loam	Loess over loamy till	Well drained	Greater than 201	8,781	19.73%
Z192A (Vienna-Brookings complex, coteau, 0 to 2 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Silt loam	Loess over loamy till	Well drained	Greater than 201	7,193	16.16%
Z171A (Renshaw-Fordville loams, coteau, 0 to 2 percent slopes)	Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls	Loam	Alluvium over outwash	Somewhat excessively drained	Greater than 201	4,518	10.15%
Z199B (Vienna-Barnes-Forestville loams, 1 to 6 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Loam	Loess over loamy till	Well drained	Greater than 201	3,062	6.88%
Z194B (Barnes clay loam, coteau, 2 to 6 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Clay loam	Loamy till	Well drained	Greater than 201	2,419	5.43%
Z141B (Barnes-Svea loams, coteau, 1 to 6 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Loam	Loamy till	Well drained	Greater than 201	1,564	3.51%

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
Z153A (Lamoure-Rauville silty clay loams, channeled, 0 to 2 percent slopes, frequently flooded)*	Fine-silty, mixed, superactive, calcareous, frigid Cumulic Endoaquolls	Silty clay loam	Silty alluvium	Poorly drained	Greater than 201	1,523	3.42%
Z173B (Renshaw-Sioux complex, 2 to 6 percent slopes)	Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls	Loam	Loamy alluvium over outwash	Somewhat excessively drained	Greater than 201	1,499	3.37%
Z142C (Barnes-Buse-Svea loams, coteau, 2 to 9 percent slopes)*	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Loam	Loamy till	Well drained	Greater than 201	1,276	2.87%
Z145D (Buse-Barnes loams, coteau, 2 to 15 percent slopes, very stony)	Fine-loamy, mixed, superactive, frigid Typic Calciudolls	Loam	Loamy till	Well drained	Greater than 201	951	2.14%
Z143C (Barnes-Buse loams, coteau, 6 to 9 percent slopes)	Fine-loamy, mixed, superactive, frigid Calcic Hapludolls	Loam	Loamy till	Well drained	Greater than 201	950	2.13%
Z117A (McKranz-Badger silty clay loams, 0 to 2 percent slopes)	Fine-silty, mixed, superactive, frigid Aeric Calciaquolls	Silty clay loam	Loess over loamy till	Somewhat poorly drained	Greater than 201	932	2.09%

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
Z159A (Divide loam, 0 to 2 percent slopes, occasionally flooded)	Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Aeric Calciaquolls	Loam	Loamy alluvium over outwash	Somewhat poorly drained	Greater than 201	840	1.89%
Z190A (Brookings silty clay loam, 0 to 2 percent slopes)	Fine-silty, mixed, superactive, frigid Pachic Hapludolls	Silt clay loam	Loess over fine-loamy till	Moderately well drained	Greater than 201	672	1.51%
Z171B (Renshaw-Fordville loams, coteau, 2 to 6 percent slopes)	Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Calcic Hapludolls	Loam	Alluvium over outwash	Somewhat excessively drained	Greater than 201	544	1.22%

Source: NRCS, 2017 *designates hydric soil

12.2.1.2 Erosion Potential and Slopes

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. The soils in the Project Area are moderately susceptible to erosion and have K Factors ranging from 0.10 to 0.32, with the majority between 0.24 and 0.32. Slopes in the Project Area range from 0 to 40 percent, with the majority of slope at 1 to 6 percent.

12.2.1.3 Prime Farmland Soils

NRCS farmland classifications include “prime farmland” (land that has the best combination of physical and chemical characteristics for the production of crops), “farmland of statewide importance” (land other than prime farmland that has a good combination of physical and chemical characteristics for the production of crops), and “not prime farmland” (land that does not meet qualifications for prime farmland), among other classifications. Much of the farmland in the Project Area is classified as either “prime farmland” (59 percent) or “farmland of statewide importance” (10 percent). Approximately 16 percent is categorized as “not prime farmland.” The remaining 15 percent is divided among “prime farmland” categories with stipulations. Farmland types within the Project Area are shown in Table 12-2.

Table 12-2: Farmland Types Within the Project Area

Farmland Type	Area (acres)	Percentage of Project Area
Prime farmland	26,464	59%
Farmland of statewide importance	4,222	10%
Not prime farmland	6,974	16%
Prime farmland if drained	1,517	3%
Prime farmland if irrigated	5,336	12%
Total	44,513	100%

12.2.2 Soil Resources Impacts/Mitigation

The following sections describe the potential effects of the proposed Project on soil resources. Where applicable, planned measures to avoid, minimize, or mitigate impacts are noted.

12.2.2.1 Potential for Impacts to Soil Resources

Construction of up to 72 wind turbine foundations, access roads, collector lines, substation, and O&M facilities would result in approximately 647 acres of temporary disturbance and approximately 65 acres of permanent impacts (see Table 11-1) to surface soils within the Project Area. During construction, existing vegetation would be removed in the areas associated with the proposed Project components, potentially increasing the risk of erosion, which is discussed in more detail below. Potential impacts to agricultural soils from the Project, and associated mitigation measures, are discussed in Section 21.2.2. As discussed in Chapter 24.0, the facility would be decommissioned after the end of the Project's operating life. Facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. Disturbed surfaces would be graded, reseeded, and restored as nearly as possible to their preconstruction conditions. After decommissioning of the Project is complete, no irreversible changes to soil resources would remain beyond the operating life of the Project.

12.2.2.2 Erosion, Slope Stability, and Sedimentation

The Applicant will design the Project layout to limit construction cut and fill work and limit construction in steep slope areas. Wind turbines are generally located at higher elevations to maximize exposure to wind and to avoid steep slope areas for foundation installation. The current layout has sited access roads to avoid steep slopes as much as possible, and the underground collector lines similarly avoid crossing steep ravines whenever feasible.

Surface disturbance caused by construction of the wind turbines and infrastructure improvements would result in the soil surface becoming more prone to erosion. Another potential issue is soil compaction, which can occur by use of heavy equipment. Silt and clay soils are especially susceptible to this. Measures to reduce impacts to soils would be implemented during construction. These may include the use of erosion and sediment control during and after construction, noxious weed control, segregating topsoil from subsurface materials, reseeding of disturbed areas, the use of construction equipment appropriately sized to the scope and scale of the Project, ensuring access road grades fit closely with the natural terrain, proper on-site disposal of soil cuttings from turbine foundation construction and maintaining proper drainage.

Construction of the Project would require coverage under the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. A condition of this permit is the development and implementation of a SWPPP. The SWPPP would be developed during civil engineering design of the Project and would prescribe BMPs to control erosion and sedimentation. The BMPs may include use of silt fences, straw wattles, erosion control blankets, temporary storm water sedimentation ponds, re-vegetation, or other features and methods designed to control storm water runoff and mitigate erosion and sedimentation. The BMPs would be implemented to reduce the potential for impacts to drainage ways and streams by sediment-laden runoff. During the facility design life, storm water volume and flow erosion rates are not anticipated to increase from those of pre-development conditions.

13.0 EFFECT ON HYDROLOGY (ARSD 20:10:22:15)

ARSD 20:10:22:15. Hydrology. *The applicant shall provide information concerning the hydrology in the area of the proposed plant, wind energy, or transmission site and the effect of the proposed site on surface and groundwater. The information shall include:*
(1) A map drawn to scale of the plant, wind energy, or transmission site showing surface water drainage patterns before and anticipated patterns after construction of the facility;
(2) Using plans filed with any local, state, or federal agencies, indication on a map drawn to scale of the current planned water uses by communities, agriculture, recreation, fish, and wildlife which may be affected by the location of the proposed facility and a summary of those effects;
(3) A map drawn to scale locating any known surface or groundwater supplies within the siting area to be used as a water source or a direct water discharge site for the proposed facility and all offsite pipelines or channels required for water transmission;
(4) If aquifers are to be used as a source of potable water supply or process water, specifications of the aquifers to be used and definition of their characteristics, including the capacity of the aquifer to yield water, the estimated recharge rate, and the quality of groundwater;
(5) A description of designs for storage, reprocessing, and cooling prior to discharge of heated water entering natural drainage systems; and
(6) If deep well injection is to be used for effluent disposal, a description of the reservoir storage capacity, rate of injection, and confinement characteristics and potential negative effects on any aquifers and groundwater users which may be affected.

The following sections describe the existing hydrology within the Project Area, the potential effects of the proposed Project on hydrology, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

13.1 Groundwater Resources

The existing groundwater resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

13.1.1 Existing Groundwater Resources

The groundwater system underlying the parts of South Dakota that are east of the Missouri River, including the Project Area, is nearly exclusively based on glacial outwash aquifers. According to the SDGS, there are approximately 444 public water supply systems east of the Missouri River, and 392 of them utilize glacial outwash aquifers (Iles, 2008). This is consistent with the types of the soils in the area, many of which were formed from glacial till or glacial drift. Glacial drift and alluvium aquifers in South Dakota vary in depth from 0 to 400 feet, with a range of yield from 3 to 50 gallons per minute (Chadima, 1994). Unlike bedrock-type aquifers, glacial outwash aquifers are extremely difficult to predict at the subsurface; however, the quality of water from glacial outwash aquifers tends to exceed that of water derived from bedrock-type aquifers.

13.1.2 Groundwater Resources Impacts/Mitigation

The construction of wind farm facilities can require dewatering of excavated areas as a result of shallow groundwater, particularly for wind turbine foundations or collector line trenches. Construction dewatering may temporarily lower the water table in the immediate area and may temporarily lower nearby surface water elevations depending on the proximity and connectivity of groundwater and surface water and extent of the excavated area.

Groundwater dewatering is not anticipated to be a major concern within the Project Area, because wind turbines are most likely to be placed at higher elevation where the water table tends to be deeper. Should groundwater be encountered that must be dewatered, the necessary permits would be obtained and associated requirements implemented. In addition, the duration of dewatering would be limited to the extent possible. Dewatered groundwater would be properly handled to allow sediments to settle out and be removed before the water is discharged, to reduce soil erosion and sedimentation of surface waters.

13.2 Surface Water Resources

The existing surface water resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

13.2.1 Existing Surface Water Resources

This section describes the existing hydrology, floodplains, NPS Nationwide Rivers Inventory (NRI) resources, and impaired waters within the Project Area.

13.2.1.1 Hydrology

The majority of the Project Area is located within the Big Sioux watershed, part of the Missouri River Basin surface water drainage system. Drainage from the Project Area is to the southwest into the Big Sioux River via the Indian River, Soo Creek, Mahoney Creek, Mud Creek, and their tributaries (Figure 10). The northeastern portion of the Project Area is located within the Minnesota River watershed, and drainage is to the east into the Minnesota River via the South Fork Whetstone River and its tributaries.

Prairie potholes, depressions formed by previous glacier activity, are common in the Upper Midwest region. These potholes fill with rain and snowmelt and become depression wetlands (primarily freshwater marshes). Many prairie potholes are temporary and are not connected to surface waters, but permanently filled prairie potholes also exist (U.S. Environmental Protection Agency [EPA], 2016).

To more accurately characterize surface water resources, including wetlands, streams, and other surface waters, within the facility footprint, a wetland delineation was completed for the Project in September 2017. The results of the delineation and a discussion of Project impacts to wetlands and other waters of the U.S. is discussed in Section 14.2.

13.2.1.2 National Park Service Nationwide Rivers Inventory

The NRI is a "listing of more than 3,400 free-flowing river segments in the U.S. that are believed to possess one or more 'outstandingly remarkable' natural or cultural values judged to be of more than local or regional significance. Under a 1979 Presidential Directive, and related Council on Environmental Quality procedures, all Federal agencies must seek to avoid or mitigate actions that would adversely affect one or more NRI segments" (NPS, 2015b). There are no NRI-listed rivers within the Project Area. The nearest NRI-listed rivers are the South Fork of the Yellow Bank River, located approximately 12 miles southeast of the Project Area, and the North Fork of the Whetstone River, located approximately 12 miles north of the Project Area.

13.2.1.3 Impaired Waters

The CWA requires states to publish biannually a list of streams and lakes that are not meeting their designated uses because of excess pollutants. These streams and lakes are considered impaired waters (EPA, 2015). The list, known as the 303(d) list, is based on violations of water quality standards. States establish priority rankings for waters on the 303(d) list and develop the total maximum daily load (TMDL) of a pollutant that the water can receive and still safely meet water quality standards. The section of the Big Sioux River that extends through the Project Area is listed as impaired on South Dakota's 2016 303(d) list requiring TMDLs for exceedance of *Escherichia coli* (*E. coli*) and dissolved oxygen standards (SDDENR, 2016). This section of the Big Sioux is classified for the following beneficial uses: warmwater semipermanent fish life propagation; limited contact recreation; fish and wildlife propagation, recreation, and stock watering; and irrigation (Minerich, 2017). An unnamed tributary in Grant County that extends through the Project Area is also on the 303(d) list and classified for the following beneficial uses: warmwater marginal fish life propagation; limited contact recreation; fish and wildlife propagation, recreation, and stock watering; and irrigation (Minerich, 2017).

13.2.1.4 Floodplains

Within the Project Area, narrow floodplains exist along major streams, including Indian River, Soo Creek, and Mud Creek, as well as along several unnamed tributaries to these streams (Figure 10). According to the Federal Emergency Management Agency (FEMA)-mapped floodplain zones, all floodplains within the Project Area are mapped as Zone A, indicating no base flood elevations have been determined.

13.2.2 Surface Water Resources Impacts/Mitigation

Potential impacts to water resources from the construction and operation of wind projects include deterioration of surface water quality through sedimentation, impacts to drainage patterns, and increased runoff due to the creation of impervious surfaces. Project facilities have been designed to avoid impacts on surface water resources to the extent practicable. Therefore, the Project is not expected to cause significant changes in runoff patterns or volume of runoff, nor is it expected to have adverse impacts on existing hydrology.

In general, because wind turbines would be located at higher elevations within the Project Area to maximize wind exposure, impacts to streams and drainage ways are not anticipated from turbine sites. The underground collection system may temporarily impact surface drainage patterns during construction if the collection system is trenched through drainage ways; however, these impacts would be short-term, and existing contours and drainage patterns are expected to be restored within 24 hours of trenching. Where stream/drainage crossings cannot be avoided for construction of access roads, appropriately designed culverts or low water crossings would be placed to maintain the free flow of water. As such, the Project would not result in changes to existing drainage patterns in the Project Area.

The creation of impervious surfaces reduces the capacity of an area to absorb precipitation into the soil and tends to increase the volume and rate of storm water runoff. The Project would create up to 65 acres of impermeable surface through the construction of turbine pads, access roads, meteorological equipment, overhead collection structures, the O&M facility, and the collection substation (see Table 11-1). The wind turbine pads, access roads, and O&M facility and substation yards would be constructed of compacted gravel and would not be paved. However, this level of compaction may inhibit infiltration and may increase runoff in these areas. As discussed in Section 12.2.2.2, appropriate storm water management BMPs would be implemented during the construction and operation of the Project to control erosion and reduce potential for sediment runoff from exposed soils during precipitation events. These BMPs are anticipated to adequately mitigate for runoff due to the increase in impervious surface. After decommissioning of the Project is complete, no irreversible changes to surface water resources would remain beyond the operating life of the Project.

Due to the lack of NRI-listed rivers within the Project Area, construction and operation of the proposed facility poses no impact to these resources. Therefore, no mitigation is required for impacts to NRI-listed rivers.

13.2.2.1 Impacts to Impaired Waters and Mitigation

SDDENR indicated that because of the beneficial use classifications of the Big Sioux River and the unnamed tributary in Grant County (discussed in Section 13.2.1.3), special construction measures may be necessary to prevent exceedance of the 30-day average total suspended solids (TSS) standard of 90 milligrams per liter (mg/L) for the Big Sioux and 150 mg/L for the unnamed tributary (see letter from SDDENR dated July 26, 2017, in Appendix B). As discussed in Section 12.2.2.2, construction of the Project would require development and implementation of a SWPPP and BMPs in accordance with the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. Any special construction measures necessary to prevent exceedance of the TSS standards for the Big Sioux River and the unnamed tributary in Grant County would be identified in the SWPPP.

13.2.2.2 Impacts to Flood Storage Areas and Mitigation

In natural systems, floodplains serve several functions that include storing excess water during high-flow/high-runoff periods, moderating the release of water during high-flow/high-runoff periods, reducing flow velocity, and filtering out sediments and other pollutants. The placement of fill into floodplains reduces the effectiveness of these functions.

As noted previously, wind turbines would be located at higher elevations, and the current layout avoids placing the turbines and new access roads in floodplains. Based on the current layout, the underground collector system and some of the existing roads to be upgraded for the Project would cross floodplains associated with Indian River, Soo Creek, and several tributaries. The underground collection system may temporarily impact flood storage areas during construction if the collection system is trenched through these streams; however, these impacts would be short-term, and existing contours and drainage patterns are expected to be restored within 24 hours of trenching. Where floodplain crossings cannot be avoided for construction of access roads, appropriately designed culverts or low water crossings would be placed to maintain the free flow of water. Construction or fill within floodplains would be designed in accordance with Codington or Grant County floodplain development regulations.

13.3 Current and Planned Water Uses

The current and planned water uses within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

13.3.1 Current and Planned Water Uses within Project Area

The Grant-Roberts Water District supplies rural water to the Project Area and maintains a network of distribution lines within the Project Area. Private wells that supply water for domestic and irrigation purposes are also located throughout the Project Area. Perennial streams within the Project Area, including the Big Sioux River, Indian River, Soo Creek, Mahoney Creek, Mud Creek, and their tributaries (Figure 10) provide habitat for fish and wildlife and support recreational activities, such as fishing.

13.3.2 Effect on Current or Planned Water Use

The proposed Project facilities would not have impacts on either municipal or private water uses in the Project Area. Water storage, reprocessing, or cooling is not required for either the planned construction or operation of the facilities. The Project facilities would not require deep well injection. The Project operation would not require the appropriation of surface water or permanent dewatering. SDDENR's Drinking Water Program reviewed the Project and does not anticipate any adverse impacts to drinking waters of the State (see letter from SDDENR dated July 26, 2017, in Appendix B).

The Applicant would connect the O&M facility to the rural water system. Water usage at the O&M facility would be similar to household volume, less than 5 gallons per minute. The Applicant would coordinate with the Grant-Roberts Water District to locate and map its network of distribution lines within the Project Area and determine if a rural water supply connection is necessary for the Project. Existing water lines would be avoided by Project design and construction. If necessary, the Applicant would obtain required permits or crossing agreements from the Grant-Roberts Water District.

Alternatively, a water supply well would be required if rural water service is not available. The Applicant would work with the SDDENR to obtain the necessary water rights permit. The specific aquifer to be used and the characteristics of that aquifer would depend on the final location of the O&M facility. Water usage at the O&M facility would be negligible (similar to household volume as stated above). Therefore, regardless of the water supply well location and aquifer source, the Project would not affect aquifer recharge rates. The Project will comply with all applicable permit requirements for water rights and the protection of groundwater quality.

The construction of wind farm facilities can interrupt the availability of groundwater through construction dewatering. Construction dewatering may temporarily lower the water table such that nearby wells may lose some of their capacity. However, the Project is not anticipated to require major dewatering; therefore, interruption of groundwater availability caused by dewatering is unlikely. As a result, no negative impacts on groundwater resources are anticipated.

The Project would have no impact on surface water availability or use for communities, agriculture, recreation, fish, or wildlife. As discussed in Section 14.2.2, boring will be used for the installation of collector lines under two perennial surface water features (both sections of Indian River, thus avoiding impacts to these perennial streams, including water flow and availability.

14.0 EFFECT ON TERRESTRIAL ECOSYSTEMS (ARSD 20:10:22:16)

ARSD 20:10:22:16. Effect on terrestrial ecosystems. *The applicant shall provide information on the effect of the proposed facility on the terrestrial ecosystems, including existing information resulting from biological surveys conducted to identify and quantify the terrestrial fauna and flora potentially affected within the transmission site, wind energy site, or siting area; an analysis of the impact of construction and operation of the proposed facility on the terrestrial biotic environment, including breeding times and places and pathways of migration; important species; and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.*

The following sections describe the existing terrestrial ecosystems within the Project Area, potential effects of the proposed Project on these terrestrial systems, and mitigation and minimization measures planned to ameliorate potential impacts to terrestrial systems. Terrestrial ecosystem data were collected from literature searches, Federal and State agency reports, natural resource databases, and field surveys completed for the Project. Specific resources discussed in the following sections include vegetation, wetlands, and wildlife, including federally and state-listed species.

14.1 Vegetation (Flora)

The existing vegetation within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

14.1.1 Existing Vegetation

The majority of the Project Area is in agricultural use, and, therefore, vegetation is predominantly grassland for grazing (pasture) and cultivated crops. Cultivated crops are primarily a mix of soybean and corn, and additional crop areas are set aside for hay production. Grassland grazing areas are dominated by a mix of grasses, such as smooth brome (*Bromus inermis*), sideoats grama (*Bouteloua curtipendula*), big bluestem (*Andropogon gerardii*), and quackgrass (*Elymus repens*). Additional vegetation includes goldenrod (*Solidago spp*.), white sagebrush (*Artemisia ludoviciana*), thistles (*Cirsium spp*.), asters (*Symphyotrichum spp*.), and areas of sunflowers (*Helianthus spp.*).

Trees within the Project Area are found mainly around housing sites, windbreaks, and floodplains of streams. The most common tree species in the Project Area include eastern cottonwood (*Populus deltoides*), bur oak (*Quercus macrocarpa*), and green ash (*Fraxinus pennsylvanica*). Dense stands of Siberian peashrub (*Caragana arborescens*) are common in many of the windbreaks.

Wetlands, discussed further in Section 14.2, are found in low-lying depressions around crops and in cattle pastures. Vegetation in the wetlands is dominated by prairie cordgrass (*Spartina pectinata*) and cattail (*Typha spp*.).

14.1.1.1 Native Grassland

As recommended by the USWFS and SDGFP during agency coordination completed for the Project (Section 27.2), the Applicant completed an analysis to identify potential native grasslands within the Project Area. Areas of untilled grasslands were identified based on a review of the 2016 U.S. Department of Agriculture (USDA) National Agriculture Imagery Program imagery, verified by review of the 2016 USDA Cropland Data Layer, and then reviewed with the Quantifying Undisturbed (Native) Lands in Eastern South Dakota: 2013 (Bauman et al., 2013) digital data layer to further evaluate potential for past disturbances (see DASK/POSK Habitat Survey in Appendix C).

A total of 2,952 acres of untilled grasslands within the Project Area were identified based on the desktop analysis. These grassland areas are displayed on Figure 11. In subsequent field investigations completed in June 2016 and June 2017, most of these grassland areas were found to be dominated by cool-season invasive grasses such as bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*). Some grasslands (e.g., far northeastern half-section of Project Area, south half of T120N R51W Sec. 5) were found to have more healthy populations of native grass species (see DASK/POSK Habitat Survey in Appendix C).

14.1.1.2 Noxious Weeds

Noxious weeds are regulated by State (SDCL 38-22) and Federal (U.S. CFR 2006) rules and regulations designed to stop the spread of plants that are detrimental to the environment, crops, livestock, and/or public health. According to the South Dakota Department of Agriculture (SDDOA), 15 listed species of noxious weeds have the potential to occur and are regulated within Codington and/or Grant Counties (SDDOA, 2016a and 2016b) (Table 14-1).

Table 14-1: State and Local Noxious Weeds of South Dakota

Common Name	Scientific Name	Weed Status
Canada thistle	*Cirsium arvense*	State noxious weed
Hoary cress	*Cardaria draba*	State noxious weed
Leafy spurge	*Euphorbia esula*	State noxious weed
Perennial sow thistle	*Sonchus arvensis*	State noxious weed
Purple loosestrife	*Lythrum salicaria*	State noxious weed
Russian knapweed	*Centaurea repens*	State noxious weed
Salt cedar	*Tamarix aphylla, T. chinensis, T. gallica, T. parviflora, and T. ramosissima*	State noxious weed
Absinth wormwood	*Artemisia absinthium*	Local noxious weed – Codington/ Grant
Field bindweed	*Convolvulus arvensis*	Local noxious weed – Grant

Common Name	Scientific Name	Weed Status
Bull thistle	*Cirsium vulgare*	Local noxious weed – Codington
Musk thistle	*Carduus nutans*	Local noxious weed – Codington/Grant
Plumeless thistle	*Carduus acnthoides*	Local noxious weed – Codington/Grant
Poison hemlock	*Conium maculatum*	Local noxious weed – Codington
Spotted knapweed	*Centaurea maculosa*	Local noxious weed – Grant
Yellow toadflax	*Linaria vulgaris*	Local noxious weed – Codington

14.1.2 Vegetation Impacts/Mitigation

Construction activities of the proposed Project would result in approximately 647 acres of temporary disturbance and 65 acres of disturbance (see Table 11-1) to vegetation (predominantly cultivated crops and pasture) during the operational life of the Project. Direct impacts would occur due to construction of the wind turbine foundations, access roads, Project substation, meteorological equipment, and O&M facility during the life of the Project. These impacts would result in a loss of seasonal production of crops; however, these impacts would not be considered biologically significant, because these lands are frequently disturbed by tilling, planting, and harvesting activities associated with crop production. For further discussion of impacts to agricultural cropland, see Section 21.2.2.

The Project facilities have been sited to avoid native grasslands, to the extent practicable (see Figure 11). In areas where impacts cannot be avoided, temporary impacts would be minimized through construction BMPs (i.e., re-vegetation and erosion control devices).

Other indirect impacts could include the potential spread of noxious weed species resulting from construction equipment introducing seeds into new areas, or erosion or sedimentation due to clearing ground in the construction areas. The spread of weeds is generally managed via use of appropriate seed mixes in non-cultivated areas and SWPPP compliance to restore vegetation in disturbed areas. If listed noxious weed infestations are found in non-cultivated disturbed areas after construction activities are completed, each area will be evaluated and addressed separately, in coordination with landowner input.

The Project would not involve any major tree clearing activities. Access roads, crane paths, and underground collector lines were sited to avoid crossing shelterbelts to the extent practicable. In areas where access roads may need to cross shelterbelts due to engineering restrictions or the layout of leased lands, the Applicant would work with the landowner in order to develop an appropriate alignment that would be the least intrusive. As discussed in Chapter 24.0, the facility would be decommissioned after the end of the Project's operating life, and disturbed surfaces would be graded, reseeded, and restored to their preconstruction conditions to the extent possible. Therefore, after decommissioning for the Project is complete, no irreversible changes to vegetation would remain beyond the operating life of the Project.

14.2 Wetlands and Waterbodies

The wetlands and waterbodies identified within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures. While aquatic in nature, wetlands and waterbodies are important functional components of the terrestrial ecosystem and are thus discussed in this section.

14.2.1 Existing Wetlands and Waterbodies

Wetlands are defined in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987) as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." The Manual identifies three wetland criteria that must be met in order for a wetland to be present: dominance of hydrophytic vegetation, hydric soils, and sufficient hydrology. Some wetlands, as well as other waterbodies are considered waters of the U.S. under Section 404 of the CWA and are therefore regulated by the U.S. Army Corps of Engineers (USACE) with respect to discharge of fill material into the water features.

Based on a desktop review of USFWS National Wetland Inventory (NWI) maps, there are approximately 546 acres of wetlands or other waterbodies within the Project Area. These wetlands and waterbodies are displayed on Figure 10 and summarized in Table 14-2.

Table 14-2: NWI Wetlands and Waterbodies Mapped Within the Project Area

Wetland Type	Acres within Project Area
Freshwater emergent wetland	425
Freshwater ponds	53
Forested wetland	3
Scrub-Shrub wetland	1
River	18
Freshwater lake	46
Total:	**546**

Source: USFWS NWI data

To more accurately characterize wetlands and waters of the U.S. within the facility footprint, a wetland delineation was completed for the Project in September 2017, in accordance with USACE-approved methodology. All parcels containing proposed Project facilities (turbines, access roads, collector lines, potential substation locations, etc.) were surveyed, for a total of 125 parcels or approximately 17,600 acres.

A total of 122 wetlands were delineated during field surveys, for a total of 567 acres of wetland within the area surveyed. The majority (n=120) of wetlands were identified as emergent (Palustrine Emergent Wetlands [PEM]) with only two wetlands being identified as a mix of scrub-shrub vegetation (Palustrine Scrub/Shrub Wetlands [PSS]).

In addition to the delineated wetlands, a total of 80 other waterbodies were delineated during field surveys. These waterbodies consisted of 60 constructed (cattle) ponds, 10 stream reaches, and 10 impoundments. Most of these waterbodies (n=75) were identified as perennial, followed by 4 intermittent streams, and 1 ephemeral stream. The delineated wetlands and waterbodies are summarized in Table 14-3.

Table 14-3: Delineated Wetlands and Waterbodies

Wetland Type	Acres Delineated
Freshwater emergent wetland	566
Freshwater ponds	95
Scrub-Shrub wetland	1
River	11
Total:	673

Source: Cardno Waters of the U.S. Delineation Report, 2018

14.2.2 Wetland and Waterbody Impacts/Mitigation

Project infrastructure has been sited to avoid and minimize impacts to wetlands and waterbodies, to the extent practicable. Through Project design and avoidance measures, Dakota Range has minimized permanent wetland impacts to five areas, consisting of minor impacts associated with access road crossings of emergent wetlands. During construction, approximately 37 wetlands will incur short-term, small scale, temporary disturbance, but each will be restored to natural contours after construction is complete. These temporary impacts are associated with temporary disturbance from installation of access roads and collector lines. No permanent or temporary wetland impacts will result from turbine foundations, substations, permanent met towers, construction laydown or O&M areas.

Boring will be used for the installation of collector lines under two perennial surface water features (both sections of Indian River), thus avoiding impacts to these perennial streams. No other perennial streams are anticipated to be crossed by Project infrastructure. Any portion of a collector line crossing an ephemeral or intermittent ditch would be crossed via open-cut method or via boring, where appropriate. No permanent impacts are associated with the installation of the collector lines, as once lines are buried the disturbed area is restored to pre-construction conditions.

Based on the impact avoidance and minimization measures described above, impacts to wetlands and waterbodies are minor and would be authorized under the USACE Nationwide Permit (NWP) 12 for utility lines and associated facilities in waters of the U.S., with no pre-construction notification requirement to the USACE. These authorized, permanent impacts to five wetland areas would potentially remain beyond the operational lifetime of the facility. As discussed in Chapter 24.0, disturbed surfaces would be restored as nearly as possible to their preconstruction conditions during Project decommissioning. However, these wetland areas may not reestablish depending on the hydrologic conditions of these areas at the time of decommissioning.

14.3 Wildlife (Fauna)

In order to reduce the potential impacts of wind energy facilities on wildlife species and habitat, the USFWS has developed the Land-Based Wind Energy Guidelines (WEG; USFWS, 2012) and the Eagle Conservation Plan Guidance (ECPG; USFWS, 2013). These voluntary guidelines provide a structured, scientific approach for assessing wildlife risks at wind energy facilities, promote communication between project proponents and federal/state agencies, and provide a practical approach to address wildlife conservation concerns at all stages of land-based wind energy development. The SDGFP, in cooperation with the South Dakota Bat Working Group, has also developed siting guidelines for wind energy projects to address potential impacts to natural resources (SD Siting Guidelines; South Dakota Bat Working Group and SDGFP, Undated). These guidelines are generally consistent with the WEG, but also provide guidance for other non-wildlife resources (e.g., land use, noise, visual resources, soil erosion and water quality).

The Applicant followed the processes outlined in the WEG, ECPG, and SD Siting Guidelines for developing, constructing, and operating wind energy projects. The Applicant has engaged in ongoing coordination with the USFWS and SDGFP to seek input on wildlife resources potentially occurring within the Project Area and to seek guidance on the appropriate studies to evaluate risk and inform development of impact avoidance and minimization measures for the Project. Summaries of coordination meetings from August 12, 2015; March 28, 2017; and September 25, 2017 are included in Appendix B.

14.3.1 Existing Wildlife

The wildlife identified within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project's construction and operation and mitigation and minimization measures.

14.3.1.1 Initial Site Assessment

In accordance with Tiers 1 and 2 of the WEG, Stage 1 of the ECPG, and the SD Siting Guidelines, a review of readily available desktop information was completed to assess potential adverse effects to species of concern and their habitats. Data sources included USFWS Information for Planning and Conservation (IPaC) website; South Dakota Natural Heritage Database; U.S. Geological Services (USGS) Breeding Bird Survey; aerial imagery; and non-governmental organization websites (e.g., Audubon Society, American Wind Wildlife Institute Landscape Assessment Tool, e-Bird, and the Hawk Migration Association of North America). In addition, preliminary agency input was requested from USFWS and SDGFP regarding any instances of federally and state-listed animals and plants, significant natural communities, and other species of concern or significant habitats that occur in the area of interest.

14.3.1.2 Federally Listed Terrestrial Species

There are six federally listed species protected under the ESA that could potentially occur in the Project Area. One is an aquatic species, the Topeka shiner, which is discussed in Section 15.1.1. The other five listed species are terrestrial species and include the Poweshiek skipperling, whooping crane, Dakota skipper, northern long-eared bat, and red knot. Table 14-4 identifies the potential for each of the federally listed terrestrial species to occur in the Project Area.

Table 14-4: Federally Listed Terrestrial Species Potentially Occurring in Project Area

Species	Status	Potential to Occur
Dakota skipper	Threatened	Potential to occur within suitable habitat
Poweshiek skipperling	Endangered	Largely extirpated from region, unlikely to occur
Northern long-eared bat	Threatened	Summer habitat lacking, potential migration risk
Red knot	Threatened	Rarely observed in Midwest, unlikely to occur
Whooping crane	Endangered	Over 150 miles east of migration corridor, unlikely to occur

Source: USFWS IPaC, September 2017

Based on coordination with the USFWS and SDGFP, the only federally listed species with the potential to occur in the Project Area are the northern long-eared bat, Dakota skipper, and Poweshiek skipperling (Appendix B).

Northern Long-Eared Bat

Due to declines caused by white-nose syndrome and continued spread of white nose syndrome caused by a fungus (*Pseudogymnoascus destructans*), the northern long-eared bat was listed as threatened under the ESA on April 2, 2015. However, per Section 4(d) of the ESA, protections for the species are tailored to areas affected by white-nose syndrome and during the bat's most sensitive life stages.

Based on coordination with the USFWS and SDGFP, it was agreed that risk to northern long-eared bats is low, and it was also agreed that no species-specific surveys were warranted to ensure no significant adverse effect or risk noncompliance with federal ESA requirements. To minimize any potential adverse effect, the Project is not planned to involve any major tree clearing activities; however, if tree clearing is required, it would be avoided between June 1 and July 31 to avoid potential impacts during the maternal roost period.

Dakota Skipper and Poweshiek Skipperling

Because the Project Area has the potential to contain suitable Dakota skipper and Poweshiek skipperling habitat, desktop habitat assessments were completed for the Project Area in June 2016 and June 2017 to identify grasslands with potentially suitable Dakota skipper and Poweshiek skipperling habitat (i.e., areas of untilled grasslands; discussed in Section 14.1.1.1; Appendix C). Pedestrian field surveys were then completed to evaluate areas identified during the desktop review as potentially suitable habitat and to confirm areas of unsuitability.

A total of 2,952 acres of potentially untilled grassland within the Project Area were identified as warranting field evaluation. Field evaluations of these areas were completed between June 12-14, 2016 and June 16-19, 2017. One approximate 5-acre area of potential Dakota skipper habitat was identified within the northeast corner of the Project Area. This approximate 5 acres of potential Dakota habitat will be completely avoided through Project design, and therefore, it was determined that no further assessment was needed. No other suitable habitat for Dakota skipper or Poweshiek skipperling was identified within the Project Area.

14.3.1.3 State-Listed Terrestrial Species

State-listed terrestrial species identified as potentially occurring within Grant and Codington Counties are identified in Table 14-5. SDGFP agreed that these species are unlikely to occur wihthin the Project Area, therefore risk to these sepcies is considered low and species-specific surveys were not necessary.

Table 14-5: State-Listed Terrestrial Species in Grant and Codington Counties

Species	Status	Potential to Occur
Peregrine falcon	State-Endangered	Found in a wide variety of habitats, more common near water, especially along coastlines; unlikely to occur.
Osprey	State-Threatened	Found near aquatic areas, rare outside Black Hills; unlikely to occur.
Piping plover	State-Threatened	Barren sandbars in large river systems and on alkaline lakes shores; unlikely to occur
Northern river otter	State-Threatened	Riparian vegetation along wetland margins; unlikely to occur.

Source: https://gfp.sd.gov/wildlife/docs/ThreatenedCountyList.pdf (March 2017); doesn't include federally listed species

14.3.1.4 Studies Conducted to Date

The following wildlife studies have been completed for the Project in accordance with USFWS and SDGFP recommendations (see Appendix B).

14.3.1.4.1 Birds

Federal protection is provided for bald and golden eagles, as well as species of migratory birds, through the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA). Both laws are intended to prohibit 'take' and regulate impacts to eagles and other migratory birds from direct mortality, habitat degradation, and/or displacement of individual birds.

To determine the presence of bird species that occur within the Project Area, the Applicant completed various surveys in accordance with Tier 3 of the WEG, Stage 2 of the ECPG, and USFWS and SDGFP guidance. Surveys included raptor nest surveys, eagle/avian use surveys, and prairie grouse lek surveys. Additional avian surveys focused on the migration period (generally defined as spring [March 15 to May 1] and fall [September 1 to October 31]) or breeding period (generally defined as May 1 to August 31) were not recommended by USFWS or SDGFP and were, therefore, not completed, because the agencies agreed that wind projects in this region have overall low effects on avian migrants and breeding birds if turbines are sited to avoid sensitive habitats.

The reports detailing the methods and results of the avian surveys are included in Appendices D-H and summarized below.

Raptor and Eagle Nest Surveys

Aerial raptor nest surveys were completed in April 2016 (Appendix D) and April 2017 (Appendix E) to characterize the raptor nesting community and locate nests for all raptors within the Project Area and 1-mile buffer, and for eagles within 10 miles of the Project.

Aerial surveys were completed prior to leaf-out and during the breeding season when raptors would be actively tending nests, incubating eggs, or brood-rearing. Raptor nest surveys focused on locating stick nest structures in suitable raptor nesting substrate (trees, transmission lines, cliff faces, etc.) within each respective survey area.

Non-Eagle Raptor Nests – During the April 2016 and 2017 surveys, a total of 32 non-eagle raptor nests (15 occupied and 17 unoccupied) were located within the Project Area and 1-mile buffer. The occupied nests were primarily common species (11 red-tailed hawk, 3 great horned owl, and 1 unknown non-eagle raptor), and none of the unoccupied nests exhibited characteristics of eagle nests.

Eagle Nests – During the April 2016 survey, three occupied bald eagle (*Haliaeetus leucocephalus*) nests were recorded, all outside the Project Area approximately 2.3, 3.5, and 7.4 miles from the Project boundary. One unoccupied potential bald eagle nest was also recorded outside of the Project Area, approximately 8.7 miles from the Project boundary. During the April 2017 survey, five occupied bald eagle nests were recorded, all outside the Project Area, approximately 1.8, 3.5, 7.4, 9.0, and 10.7 miles from the Project boundary. Another bald eagle nest that was occupied and active in 2016 was unable to be located in 2017. The nearest occupied bald eagle nest to the Project Area was located approximately 1.8 miles west of the Project boundary. The nearest occupied eagle nest to a proposed turbine location is over 3.7 miles east from a proposed turbine.

Avian Use Surveys

Avian/eagle use point-count surveys were completed for the Project during winter and spring from December 2015 through May 2017 to evaluate species composition, relative abundance, and spatial characteristics of avian use in accordance with agency recommendations (Appendix F).

Because eagles have the potential to occur in the region, eagle surveys were completed using methodology consistent with the USFWS ECPG (USFWS, 2013). The surveys recorded data for small and large bird species, eagles, and species of concern (i.e., federally or state-threatened and endangered species [Endangered Species Act 1973], USFWS Birds of Conservation Concern [BCC; USFWS, 2008], and South Dakota Species of Greatest Conservation Need [SGCN; SDGFP, 2017a]).

Fixed-point avian use surveys were completed approximately once monthly during winter and spring from December 2015 to May 2017 at 40 survey points. The 40 survey plots are representative of areas proposed for development areas and encompass approximately 30 percent of the Project Area. Twenty small bird species, with 753 observations in 153 groups, were recorded during surveys. The most commonly observed small bird species were red-winged blackbird (*Agelaius phoeniceus*; 408 observations) and horned lark (*Eremophila alpestris*; 104 observations). Thirty large bird species, with 1,863 observations in 126 groups, were recorded during surveys. The most commonly recorded species were waterfowl, comprising 84 percent of the total number of large bird observations. Canada goose (*Branta canadensis*), greater white-fronted goose (*Anser albifrons*), and snow goose (*Chen caerulescens*) accounted for most of those observations. Six raptor species were identified during the large bird surveys, which accounted for 20 raptor observations or 1 percent of large bird observations. Red-tailed hawk (*Buteo jamaicensis*; 10 observations) was the most commonly observed raptor, followed by northern harrier (*Circus cyaneus*; four observations).

No federally listed species and one state-listed species (peregrine falcon [*Falco peregrinus*; 1 observation]) were observed during the study. No golden eagles (*Aquila chrysaetos*) were observed during surveys, and one bald eagle was observed in winter (December 3, 2015) and one in spring (March 3, 2017). Four BCC species and four SGCN species were documented in low numbers.

Prairie Grouse Lek Surveys

In 2016, aerial-based lek surveys were completed for sharp-tailed grouse and greater prairie-chicken within the Project Area and a 0.5-mile buffer (Appendix G). The Project boundary was modified after the 2016 surveys to include additional area; therefore, additional ground-based lek surveys were completed in 2017 within the unsurveyed portions of the Project Area and 0.5-mile buffer (Appendix H). In addition, previously documented leks from 2016 were revisited to evaluate 2017 status.

During the 2016 surveys, one potential sharp-tailed grouse lek was documented within the Project Area, and one confirmed greater prairie-chicken lek was documented within the 0.5-mile buffer. During the 2017 surveys, one confirmed and one potential sharp-tailed grouse lek were documented within the Project Area, and the leks documented in 2016 were not found and, therefore, were classified as historic. Results of the 2016 and 2017 surveys indicate that both sharp-tailed grouse and greater prairie chickens are present at low density in and within 0.5 mile of the Project. The nearest known lek is located approximately 0.4 mile from the nearest proposed turbine location

14.3.1.4.2 Bats

There are thirteen species of bats that inhabit South Dakota (SDGFP, 2017b), six of which have the potential to occur within the Project Area (Table 14-6). Of these species, the northern long-eared bat (*Mytois septentrionalis*) is the only state and federally listed bat with the potential to occur within the area.

Table 14-6: Bat Species Potentially Occurring in Project Area

Common Name	Scientific Name
Red bat	*Lasiurus borealis*
Hoary bat	*Lasiurus cinereus*
Silver-haired bat	*Lasionycteris noctivagans*
Northern long-eared bat	*Myotis septentrionalis*
Little brown myotis	*Myotis lucifugus*
Big brown bat	*Eptesicus fuscus*

Source: South Dakota Bat Working Group, 2004

Acoustic bat surveys were completed for the Summit Wind Farm (proposed wind farm adjacent to Dakota Range) from May 15 through October 11, 2015, during which time 1,567 bat passes over 238 detector nights were recorded. Bat activity was higher within areas of potential bat habitat (e.g., treed areas), which recorded 97 percent of the bat passes, when compared to activity in areas where turbines are likely to be placed (e.g., open field habitats). Bat pass rates were higher during the fall monitoring period compared to the summer monitoring period, with a peak during the last week of July through early August. The majority (53 percent) of the bat passes were classified as low-frequency bats (e.g., big brown bat, hoary bat, and silver-haired bat), and 47 percent of the bat passes were classified as high-frequency bats (e.g., red bat and *Myotis* species).

As documented in Appendix B, the Applicant met with USFWS and SDGFP on multiple occasions to discuss risk to bats and agree upon appropriate response measures. It was agreed that data collected from the adjacent Summit Wind Farm was sufficient to assess risk at the Project due to similarity in habitats (WEST, 2015) and no site-specific acoustic studies were warranted. The Project Area contains very few trees or areas of open water that would provide suitable habitat for bats; therefore, it was agreed that the period of risk to bats, including the listed northern long-eared bat, is primarily during fall migration.

14.3.2 Wildlife Impacts/Mitigation

Terrestrial wildlife species could be impacted at various spatial and temporal scales during the construction and operation of the Project. Direct disruption of habitat and potentially direct mortality could occur during the construction phase of the Project to some less mobile animals. Permanent wildlife habitat loss and functionality due to construction and operation of the Project would be minimal across the Project Area.

14.3.2.1 Federally Listed Species

The only federally listed species determined to have the potential to occur within the Project Area are the endangered Poweshiek skipperling, and the threatened Dakota skipper and northern long-eared bat. No suitable habitat for the Poweshiek skipperling was identified in the Project Area, and areas identified as potentially suitable Dakota skipper habitat have been avoided through Project design. Due to the lack of suitable habitat and avoidance of potential habitat, impacts to these species are not anticipated.

To minimize potential impacts to the northern long-eared bat, turbines and access roads have been sited to avoid wooded draws and shelterbelts (potential northern long-eared bat habitat) to the extent possible, and minimal tree removal is expected. If tree removal is necessary, removal will occur between August 1 and May 31 to minimize potential impacts to roosting northern long-eared bats, as well as other tree-roosting bats. In addition, risk of collision will be reduced by feathering the turbines to manufacturer’s cut in speed from sunset to sunrise during the bat active period (Apr 15-Oct 15) to avoid potential impacts to bats flying and/or migrating through the Project Area. Additional avoidance and minimization measures are identified in Section 14.3.2.5.

14.3.2.2 State-Listed Species

The only state-listed species documented to occur during site-specific studies completed for the Project was peregrine falcon (state-endangered). Only one individual was observed during 221 hours of systematic avian study, suggesting that use of the Project by this species and associated risk of impact is very low. The avoidance and minimization measures identified in Section 14.3.2.5 will be implemented for the protection of wildlife, including state-listed species. Given the low risk of impact to state-listed species, no additional species-specific mitigation measures are necessary.

14.3.2.3 Avian Species

Potential impacts to avian species from the construction and operation of the Project include indirect impacts, such as the removal, degradation, and fragmentation of habitat, and direct impacts, such as turbine blade strikes. Indirect impacts will be minimized by siting facilities within previously disturbed areas and avoiding untilled grassland habitats and forested areas to the extent practicable. Additionally, all areas of temporary disturbance will be reclaimed with vegetation consistent with the surrounding vegetation types.

Direct impacts to birds, including species of concern, from the operation of this Project are anticipated to be low based on pre-construction survey results. Four BCC species and four SGCN species were documented at very low numbers, indicating low risk of significant impacts to these species. The most commonly observed species during the avian use surveys represent common, widespread species. Raptor use documented for the Project Area was low compared to other wind project sites sited in similar habitat, and species documented consisted primarily of common raptors, suggesting risk of impacts are not likely to be significant at the local or regional population level (see data on bird use and fatality estimates in Appendix B and C of the Avian Use Survey Report [Appendix F]). To prevent potential bird strikes with electric lines, collector lines will be buried underground.

The majority of bird species observed during the surveys are widespread and abundant, and most are at low risk of collision with turbines or impacts due to the high amount of agricultural lands and localized habitat fragmentation. Analysis of the data collected during the avian surveys generally indicated that potential impacts to birds, including species of concern, diurnal raptors, grassland species and eagles are expected to be low as evidenced by data from regional wind projects operating in similar habitats (see data on bird use and fatality estimates in Appendix B and C of the Avian Use Survey Report [Appendix F]). Additional avoidance and minimization measures are identified in Section 14.3.2.5.

14.3.2.4 Bats

Potential impacts to bat species from the construction and operation of the Project include indirect impacts, such as removal, degradation, and fragmentation of roosting and foraging habitat, and direct impacts including turbine blade strikes. Turbines and access roads have been sited to avoid wooded draws and shelterbelts to the extent possible and minimal tree removal is expected. To minimize degradation of habitat, all areas of temporary disturbance will be reclaimed with vegetation consistent with the surrounding vegetation types. All publicly available curtailment studies to date show an inverse relationship between cut-in speeds and bat mortality. Feathering below the manufacturer's cut-in speed is expected to reduce overall bat mortality by a minimum of 35 percent (Good et al., 2012; Young et al., 2011; Baerwald et al., 2009). Therefore, risk of direct impact to bats will be reduced by feathering the turbines to manufacturer's cut in speed from sunset to sunrise during the bat active period (Apr 15-Oct 15). Additional avoidance and minimization measures are identified in Section 14.3.2.5.

14.3.2.5 Avoidance, Minimization and Mitigation Measures

Dakota Range is preparing a Bird and Bat Conservation Strategy (BBCS) in accordance with the USFWS WEG that will be implemented to minimize impacts to avian and bat species during construction and operation of the Project. The following impact minimization and avoidance measures, developed in coordination with the USFWS and SDGFP, will be implemented for the Project to ameliorate potential negative biological impacts as a result of construction and operation of the proposed facility:

- Minimize ground disturbance/clearing of native grasslands;
- Avoid potentially suitable Dakota skipper habitat;
- Avoid siting turbines in wetland/waterbodies;
- Avoid siting turbines within 0.3 mile of active or potential leks and follow construction timing recommendations within 2 miles;
- Feather blades to manufacturer’s cut-in speed from sunset to sunrise during the bat active period (April 15 – October 15);
- Avoid tree removal from June 1 through July 31 to minimize risk of impact to northern long-eared bat maternal roosts and other tree roosting habitat;
- Train staff to recognize whooping cranes and eagles, and if observed, evaluate risk and respond appropriately; and
- Monitor during operations in year 1 to assess low risk conclusions.

15.0 EFFECT ON AQUATIC ECOSYSTEMS (ARSD 20:10:22:17)

ARSD 20:10:22:17. Effect on aquatic ecosystems. *The applicant shall provide information of the effect of the proposed facility on aquatic ecosystems, and including existing information resulting from biological surveys conducted to identify and quantify the aquatic fauna and flora, potentially affected within the transmission site, wind energy site, or siting area, an analysis of the impact of the construction and operation of the proposed facility on the total aquatic biotic environment and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.*

The following sections describe the existing aquatic ecosystems within the Project Area, the potential impacts to aquatic ecosystems as a result of the Project, and mitigation and minimization measures planned to ameliorate potential impacts to aquatic systems.

15.1 Existing Aquatic Ecosystems

As described in Section 13.2.1.1, the majority of the Project Area is located within the Big Sioux watershed, part of the Missouri River Basin surface water drainage system, and the northeastern portion of the Project Area is located within the Minnesota River watershed. Perennial streams and intermittent drainages bisect the terrain. Named perennial streams within the Project Area include Indian River, Soo Creek, Mahoney Creek, and Mud Creek. As described in Section 14.2.1, a total of 122 wetlands were delineated during field surveys, for a total of 567 acres of wetlands within the area surveyed. In addition to the delineated wetlands, a total of 80 other waterbodies were delineated during field surveys. These waterbodies consisted of 60 cattle ponds, 10 stream reaches, and 10 impoundments.

15.1.1 Federally Listed Aquatic Species

There is one federally listed aquatic species, the endangered Topeka shiner, that could potentially occur in the Project Area. Based on coordination with the USFWS and SDGFP, the agencies concurred that habitat for the Topeka shiner is not expected to occur in the Project Area (Appendix B). The nearest suitable habitat to the Project Area is Willow Creek, which is more than 8 miles south of the Project Area.

15.1.2 State-Listed Aquatic Species

State-listed aquatic species identified as potentially occurring within Grant and Codington Counties are identified in Table 15-1. SDGFP agreed that these species are unlikely to occur wihthin the Project Area, therefore risk to these sepcies is considered low and species-specific surveys were not necessary.

Table 15-1: State-Listed Aquatic Species in Grant and Codington Counties

Species	Status	Potential to Occur
Blacknose shiner	State-Endangered	Project outside range; unlikely to occur.
Northern redbelly dace	State-Threatened	Unlikely to occur.

Source: https://gfp.sd.gov/wildlife/docs/ThreatenedCountyList.pdf (March 2017); doesn't include federally listed species

15.2 Aquatic Ecosystems Impacts/Mitigation

As described in Section 14.2.2, impacts to wetlands and other waterbodies would be minimal, because these features have been avoided during design of the Project to the extent possible, and those impacts that are required are managed per State and Federal requirements. The primary potential for impact to aquatic ecosystems would be from increased sedimentation or increased total suspended solids due to soil erosion during Project construction; however, this risk is managed via implementation of the SWPPP required prior to construction. USFWS and SDGFP have been consulted regarding the federally and state-listed aquatic species with potential to occur in or near the Project, and both agencies agree that the species are not anticipated to be affected by the Project.

16.0 LAND USE (ARSD 20:10:22:18)

ARSD 20:10:22:18. Land use. *The applicant shall provide the following information concerning present and anticipated use or condition of the land:*
(1) A map or maps drawn to scale of the plant, wind energy, or transmission site identifying existing land use according to the following classification system:
(a) Land used primarily for row and nonrow crops in rotation;
(b) Irrigated lands;
(c) Pasturelands and rangelands;
(d) Haylands;
(e) Undisturbed native grasslands;
(f) Existing and potential extractive nonrenewable resources;
(g) Other major industries;
(h) Rural residences and farmsteads, family farms, and ranches;
(i) Residential;
(j) Public, commercial, and institutional use;
(k) Municipal water supply and water sources for organized rural water systems; and
(l) Noise sensitive land uses;
(2) Identification of the number of persons and homes which will be displaced by the location of the proposed facility;
(3) An analysis of the compatibility of the proposed facility with present land use of the surrounding area, with special attention paid to the effects on rural life and the business of farming; and
(4) A general analysis of the effects of the proposed facility and associated facilities on land uses and the planned measures to ameliorate adverse impacts.

The following sections describe the existing land use, sound, and aesthetics within the Project Area, the potential land use impacts of the Project, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

16.1 Land Use

The existing land uses within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project's construction and operation on land use, and the proposed mitigation and minimization measures to ameliorate impacts.

16.1.1 Existing Land Use

Land use within the Project Area is predominantly agricultural, consisting of a mix of cropland, hayland, pastureland, and rangeland. Occupied farm sites and rural residences are located throughout the Project Area. Figure 12 is a land use map of the Project Area based on the classification system specified in ARSD 20:10:22:18(1). The following land use classifications occur within the Project Area:

- Land used primarily for row and non-row crops in rotation
- Irrigated lands
- Pasturelands and rangelands

- Haylands
- Undisturbed native grasslands
- Rural residences and farmsteads, family farms, and ranches
- Public, commercial, and institutional use
- Noise sensitive land uses

The following land use classifications were not identified within the Project Area:

- Existing and potential extractive nonrenewable resources
- Other major industries
- Residential
- Municipal water supply and water sources for organized rural water systems

In Codington County in 2012 (the latest available year for the USDA Census of Agriculture), approximately 69 percent of the farmland area was cropland, with corn for grain being the most common crop (USDA, 2012a). Soybeans for beans was the second most common cultivated crop in the county. Cultivated cropland in Codington County increased by 3 percent from 247,710 acres in 2007 to 255,903 acres in 2012 (USDA, 2012b). In Codington County in 2012, approximately 22 percent of the farmland area was pastureland (USDA, 2012a). Pastureland decreased 15 percent from 99,773 acres in 2007 to 84,359 acres in 2012 (USDA, 2012b).

In Grant County in 2012, approximately 68 percent of the farmland area was cropland, with corn for grain being the most common crop (USDA, 2012c). Soybeans for beans was the second most common cultivated crop in Grant County. Cultivated cropland in Grant County increased by 10 percent from 263,680 acres in 2007 to 290,676 acres in 2012 (USDA, 2012b). In Grant County in 2012, approximately 27 percent of the farmland area was pastureland (USDA, 2012c). Pastureland increased 36 percent from 91,869 acres in 2007 to 125,399 acres in 2012 (USDA, 2012b).

Specific acreages of different crops within the Project Area, which change from year to year, are not available.

16.1.2 Land Use Impacts/Mitigation

Construction of the Project will result in the conversion of land within the Project Area from existing agricultural land uses into a renewable energy resource during the life of the Project. Temporary impacts from the proposed Project will also result. Land use impacts associated with construction staging and laydown areas and underground collector lines will be temporary. Following construction, the areas will be returned to pre-construction land uses, which primarily consist of cultivated croplands and pastureland/grassland.

The proposed Project is compatible with the existing agricultural land uses in areas surrounding the Project facilities. Agricultural uses will continue within the Project Area during construction and operation. It is estimated that approximately 647 acres of agricultural land would be temporarily impacted by Project construction, and 65 acres of agricultural land would be impacted during the life of the Project (less than 0.2 percent of the total land within the Project Area; see Table 11-1). Areas disturbed due to construction that would not host Project facilities would be re-vegetated with vegetation types matching the surrounding agricultural landscape. Agricultural impacts are discussed further in Section 21.2.2. As discussed in Chapter 24.0, the facility would be decommissioned after the end of the Project's operating life. Facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. Disturbed surfaces would be graded, reseeded, and restored as nearly as possible to their preconstruction conditions. After decommissioning for the Project is complete, no irreversible changes to land use would remain beyond the operating life of the Project.

There are 73 occupied residences within the Project Area. Based on the proposed Project layout of turbines, access roads, collector lines, and associated facilities, there would be no displacement of residences or businesses due to construction of the Project facilities.

16.2 Public Lands and Conservation Easements

The existing public lands and conservation easements within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project's construction and operation, and potential avoidance, minimization, and mitigation measures.

16.2.1 Existing Public Lands and Conservation Easements

Figure 13 is a map showing publicly owned or managed lands and conservation easements within or adjacent to the Project Area.

USFWS Wetland and Grassland Easements – Based on data provided by the USFWS Habitat and Population Evaluation Team (HAPET) in January 2017, six wetland easement parcels, eight grassland easement parcels, and one combined wetland/grassland conservation easement parcel managed by the USFWS as part of the Waubay National Wildlife Refuge Complex are within the Project Area. USFWS wetland and grassland easements are part of the National Wildlife Refuge System and are managed for the protection of wildlife and waterfowl habitat. Three of the grassland easements in the Project Area are Dakota Tallgrass Prairie Wildlife Management Areas, which are managed to protect tallgrass prairie.

USFWS Waterfowl Production Areas – There are three Grant County Waterfowl Production Areas, which are managed by the USFWS Waubay Wetland Management District, located adjacent to, but not within, the Project Area. Waterfowl Production Areas are satellite areas of the National Wildlife Refuge System and are managed for the preservation of wetlands and grasslands critical to waterfowl and other wildlife.

SDGFP Game Production Areas – There is one Game Production Area (Mazzeppa) located adjacent to, but not within, the Project Area. Game Production Areas are state lands managed by the SDGFP for the production and maintenance of wildlife.

SDGFP Walk-In Areas – There are four parcels of privately owned lands within the Project Area that are leased for public hunting access by SDGFP (referred to as Walk-In Areas).

16.2.2 Impacts/Mitigation to Public Lands and Conservation Easements

The USFWS Waterfowl Production Areas and SDGFP Game Production Areas are located outside of the Project Area, and, therefore, no direct impacts to these public lands would occur from the Project. The Applicant coordinated with the USFWS regarding the exact boundaries of the USFWS Wetland and Conservation easements within the larger easement parcels shown on Figure 13. The actual easement is a subset of these parcels (i.e., actual wetland areas for wetland easements and the area defined in the lease amendments for the conservation easements). The Project has been designed such that no Project facilities (e.g., turbines, collector lines, access roads) would be placed on these USFWS Wetland, Conservation, or Grassland Easements, and thus, no direct impacts to these easement areas would occur.

Five turbines (and associated access roads and collector lines) would be placed on three of the privately owned Walk-In Areas. During Project construction, there could be temporary access disruptions to these Walk-In Areas for hunting during construction, although it is unlikely. During operation of the Project, impacts to these lands would result due to placement of turbines and access roads. South Dakota's Walk-In Areas allow public hunting on private lands. Lands enrolled in the program do not require permission for private individuals to hunt on the land, and landowners receive lease payments from SDGFP as compensation. The Applicant would coordinate with landowners regarding impacts and access to Walk-In Hunting Areas.

16.3 Sound

The existing sound levels within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project's construction and operation, and potential avoidance, minimization, and mitigation measures.

16.3.1 Existing Sound Levels and Regulatory Framework

The Project Area is located in rural Codington and Grant Counties. The Project Area contains cropland, grassland, and rural residences scattered throughout. Farming activities and vehicular traffic are assumed to be the largest contributor to sound, although ambient sound measurements have not been recorded for the Project Area at this time. A sound level modeling study was conducted for the Project in December 2017 (Appendix I). Following is information from the report on sound terminology and noise regulations applicable to the Project.

16.3.1.1 Sound Terminology

There are several ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. Relative to this characteristic, a change in sound levels of less than 3 dB is imperceptible to the human ear.

Another mathematical property of decibels is that if one source of noise is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.[8] It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone". The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as "dBA". Sound pressure levels for some common indoor and outdoor environments are shown in Figure 14.

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[8] *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983 (R2006), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

Because the sounds in the environment vary with time, many different sound metrics may be used to quantify them. There are two typical methods used for describing variable sounds. These are exceedance levels and equivalent levels, both of which are derived from a large number of moment-to-moment A-weighted sound pressure level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n, where "n" is a value (typically an integer between 1 and 99) in terms of percentage. Equivalent levels are designated L_{eq} and quantify a hypothetical steady sound that would have the same energy as the actual fluctuating sound observed. The two sound level metrics that are commonly reported in community noise monitoring are described below.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during a measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.
- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is commonly A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with time-averaged mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.

16.3.1.2 Noise Regulations

There are no Federal or State community noise regulations applicable to this Project. The portion of the Project within Codington County is subject to the following sound level requirements in Section 5.22.03(12) of Ordinance #65 Zoning Ordinance of Codington County, Noise subsection of General Provisions for Wind Energy Systems (WES):

> *Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects at the property line of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.*

The portion of the Project within Grant County is subject to the following sound level requirements in Section 1211.04(13) of the Zoning Ordinance for Grant County, Noise subsection of General Provisions for Energy Systems (WES):

Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects at the perimeter of the principal and accessory structures of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.

16.3.2 Sound Level Impacts/Mitigation

The sound level modeling study, conducted for the Project in December 2017, is included in Appendix I. Following is information from the report on the anticipated sound levels from construction and operation of the Project.

16.3.2.1 Construction Sound Levels

The majority of the construction activity related to the Project will occur around each of the wind turbine sites. Full construction activity will generally occur at one wind turbine site at a time, although there will be some overlap at adjacent sites for maximum efficiency. There are generally three phases of construction at a wind energy project – excavation, foundations, and turbine erection. Table 16-1 presents the equipment sound levels for the louder pieces of construction equipment expected to be used at this site along with their phase of construction.

Table 16-1: Sound Levels for Construction Noise Sources

Phase	Equipment	Sound Level at 50 feet (dBA)
Excavation	Grader	85
Excavation	Bulldozer	82
Excavation	Front-end loader	79
Excavation	Backhoe	78
Excavation	Dump truck	76
Excavation	Roller	80
Excavation	Excavator	81
Excavation	Rock drill	89
Foundation	Concrete mixer truck	79
Foundation	Concrete pump truck	81
Foundation	Concrete batch plant	83
Turbine erection	Large crane #1	81
Turbine erection	Large crane #2	81
Turbine erection	Component delivery truck	84
Turbine erection	Air compressor	78

Source: Sound Level Modeling Report, Appendix I

Construction of the Project is expected to take multiple months. Construction of a single wind turbine from excavation to foundation pouring to turbine erection is roughly a three-week process. However, work will not proceed in that order for each wind turbine to be erected. For example, all foundations will be poured before any turbine erection work begins. Sound impacts would be reduced by scheduling heavy construction work during daylight hours, to the extent possible. Excavation work is expected to occur from early morning to the evening. Concrete foundation work and turbine erection work could extend into the overnight hours depending on the weather and timing of a concrete pour which must be continuous. Excavation work will be daytime only. Construction sound would comply with applicable county and State requirements, regulations, and ordinances.

16.3.2.2 Operational Sound Levels

The sound level modeling analysis conservatively included the 72 proposed primary wind turbine locations, as well as the 25 proposed alternate turbine locations. The analysis used a technical report from Vestas[9] which documented the expected sound power levels associated with the Vestas V136-4.2 wind turbine. According to these technical documents, which included broadband and third octave-band A-weighted sound power levels for various wind speeds, the maximum sound power level for the V136-4.2 of 103.9 dBA occurs at hub height wind speeds of 9 m/s (and above). These sound power levels represent an “upper 95% confidence limit for the wind turbine performance” and do not include any additional uncertainty factor. Octave-band sound levels were calculated from the third octave-band levels representing the maximum sound power level for the sound modeling.

In addition to the wind turbines, there will be a collection substation associated with the Project. Two 167 megavolt-ampere (MVA) transformers are proposed for the substation. Octave-band sound power levels were estimated using the MVA rating provided for the transformer and techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers.

The noise impacts associated with the proposed wind turbines were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from

[9] Vestas Wind Systems A/S, V136-4.0 MW Third octave noise emission, 2017. Confidential documentation and information.

multiple sources as well as computation of diffraction. The inputs and significant parameters employed in the model are described in the Sound Level Modeling Report in Appendix I.

The highest wind turbine sound power level for each wind turbine type including uncertainty (105.9 dBA) was input into Cadna/A to model wind turbine generated sound pressure levels during conditions when worst-case sound power levels are expected. Sound pressure levels due to operation of all 97 wind turbines and the substation transformer were modeled at 189 sensitive receptors (i.e., occupied structures) in Codington and Grant Counties. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 25 meters apart to allow for the generation of sound level isolines.

Table B-1 in the Sound Level Modeling Report (see Appendix I) shows the predicted "Project-Only" broadband (dBA) sound levels for the 86 receptors in Codington County. These sound levels range from 17 to 43 dBA. The predicted "Project-Only" broadband sound levels at 267 accessory structures in Codington County ranged from 14 to 43 dBA. Table B-2 in the Sound Level Modeling Report (see Appendix I) shows the predicted "Project-Only" broadband (dBA) sound levels for the 103 receptors in Grant County. These sound levels range from 22 to 45 dBA. The predicted "Project-Only" broadband sound levels at 288 accessory structures in Grant County ranged from 23 to 47 dBA. In addition to these receptor points, sound level isolines generated from the modeling grid are presented in Figure 5-2 in the Sound Level Modeling Report (see Appendix I).

Codington County – The sound level limit in Codington County regulation for a WES is 50 dBA at a property line of an existing off-site occupied structure. The predicted worst-case sound levels from the Project are well below the 50-dBA limit at all modeled occupied structures in Codington County. The highest sound level at a receptor in Codington County is modeled to be 43 dBA. This is at an off-site occupied structure. Sound levels at the modeled accessory structures do not exceed 43 dBA. Sound level isolines in Figure 5-2 of the Sound Level Modeling Report show no location where Project-related noise exceeds 50 dBA at any off-site property line. Therefore, the Project meets the requirements with respect to sound in the county regulation.

Grant County – The sound level limit in the Grant County regulation for a WES is 50 dBA at the perimeter of an existing off-site principal (occupied) structure and accessory structure. The predicted worst-case sound levels from the Project are well below the 50-dBA limit at all modeled occupied structures in Grant County. The highest sound level at a receptor in Grant County is modeled to be 45 dBA. This is at a participating occupied structure. The highest modeled sound level at a non-participating receptor is 44 dBA. Additionally, the highest sound level modeled at an accessory structure in Grant County is 47 dBA. This is at a participating accessory structure, and the highest modeled sound level at a non-participating accessory structure is 44 dBA. Therefore, the Project meets the requirements with respect to sound in the county regulation.

Because the wind turbines have been sited to avoid exceeding county regulatory sound level limits, no further mitigation for sound is required.

16.4 Shadow Flicker

A shadow flicker modeling study was conducted for the Project in December 2017 (Appendix J). Following is information from the report on the modeling methodology and results.

With respect to wind turbines, shadow flicker can be defined as an intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer experiences repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine, otherwise there is no shadow flicker. A stationary wind turbine only generates a stationary shadow similar to any other structure.

Shadow flicker was modeled using a software package, WindPRO version 3.1.617. WindPRO is a software suite developed by EMD International A/S and is used for assessing potential environmental impacts from wind turbines. Using the Shadow module within WindPRO, worst-case shadow flicker in the area surrounding the wind turbines was calculated based on data inputs including: location of the wind turbines, location of discrete receptor points, wind turbine dimensions, flicker calculation limits, and terrain data. Based on these data, the model was able to incorporate the appropriate sun angle and maximum daily sunlight for this latitude into the calculations. The resulting worst-case calculations assume that the sun is always shining during daylight hours and that the wind turbine is always operating. The WindPRO Shadow module can be further refined by incorporating sunshine probabilities and wind turbine operational estimates by wind direction over the course of a year. The values produced by this further refinement, also known as the "expected" shadow flicker, are presented in the report.

The shadow flicker modeling analysis conservatively included the 72 proposed primary wind turbine locations, as well as the 25 proposed alternate turbine locations. The inputs and significant parameters employed in the model are described in the Shadow Flicker Modeling Report in Appendix J.

WindPRO was used to calculate shadow flicker at the 189 discrete modeling points in Codington and Grant Counties and generate shadow flicker isolines based on the grid calculations. Table B-1 in the Shadow Flicker Modeling Report (see Appendix J) presents the modeling results for these modeling receptor locations. Utilizing the conservative modeling parameters, the shadow flicker modeling results indicate that 20 of the 189 receptors may experience shadow flicker levels between 10 and 30 hours per year, with the annual maximum expected level of shadow flicker at a non-participating residence at 29 hours. While the modeling indicates that 11 participating residences could experience annual shadow flicker levels above 30 hours per year, since the modeling treated homes as “greenhouses” and assumed no vegetation or other existing structures, the “expected” levels are likely higher than actual levels will be. Dakota Range plans to discuss the results with participating landowners and, if concerns are raised, will conduct modeling using site-specific data to further refine results. Additionally, mitigation measures, such as vegetative screening or darkening shades, can be implemented to address shadow flicker concerns should they arise after the Project is operational.

As discussed in Section 10.2 (see Table 10-1), the Project has committed to limit shadow flicker to 30 hours per year or less at non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity, per industry guidelines. Even using the conservative modeling methodology described above, the Project is not projected to result in shadow flicker levels above 30 hours per year at any non-participating residence, business, or building owned and/or maintained by a governmental entity.

16.5 Electromagnetic Interference

There is the potential for communication systems to experience disturbances from electric feeder and communication lines associated with wind farms. Based on a desktop review, eight Federal Communications Commission (FCC)-regulated systems were identified within the Project Area. The turbines are sited so as to not create disturbances to communications system by ensuring that the rotors are outside of any communication beam paths. If, after construction, the Applicant receives information relative to communication systems interference potentially caused by operation of the wind turbines in areas where reception is presently good, the Applicant would resolve such problems on a case-by-case basis.

16.6 Visual Resources

The existing visual resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project’s construction and operation and mitigation and minimization measures.

16.6.1 Existing Visual Resources

Cropland, grassland, large open vistas, and gently rolling topography visually dominate the Project Area landscape. Vegetation in and near the Project Area is predominantly cropland and grassland/pasture. Existing structures in the Project Area consist of occupied residences dispersed throughout, as well as scattered farm buildings. Interstate 29, State Highway 20, and county and township roads extend through the Project Area.

Visual impacts to the landscape attributable to the Project would depend on the extent to which the existing landscape is already altered from its natural condition, the number of viewers (residents, travelers, visiting recreational users, etc.) within visual range of the area, and the degree of public or agency concern for the quality of the landscape. There are 73 occupied residences within the Project Area (Figure 12). Travelers through the Project Area would include local or regional traffic along Interstate 29 and State Highway 20. USFWS Waterfowl Production Areas, USFWS Wetland and Grassland Easements, SDGFP Game Production Areas, and SDGFP Walk-In Areas for public hunting and recreation are present within the Project Area.

16.6.2 Visual Impacts

Visual impacts can be defined as the human response to the creation of visual contrasts that result from the introduction of a new element into the viewed landscape. These visual contrasts interact with the viewer's perception, preferences, attitudes, sensitivity to visual change, and other factors that vary by individual viewer to cause the viewer to react negatively, positively, or neutrally to the changes in the viewed landscape.

Construction, operation, and decommissioning of the proposed Project would potentially introduce visual contrasts in the Project Area that may cause visual impacts. The types of visual contrasts of concern include the potential visibility of wind turbines, electric transmission structures and conductors, and associated facilities such as roads; marker lighting on wind turbines and transmission structures as well as security and other lighting; modifications to landforms and vegetation; vehicles associated with transport of workers and equipment for construction, operations and maintenance, and facility decommissioning; and the construction, operation, maintenance, and decommissioning activities themselves. A subset of potential visual impacts associated with wind turbine generator structures are blade movement, blade glinting[10], and shadow flicker (discussed in Section 16.4).

[10] Reflection of sunlight from moving wind turbine blades when viewed from certain angles under certain lighting conditions.

The primary visual impacts associated with the Project would result from the introduction of the numerous vertical lines of the wind turbines into the generally strongly horizontal landscape found in the Project Area. The visible structures would potentially produce visual contrasts by their design attributes (form, color, and line) and the reflectivity of their surfaces and potential glare. In addition, marker lighting would be visible at night.

For nearby viewers including the rural residences dispersed throughout the Project Area, the large sizes and strong geometric lines of both the individual turbines themselves and the array of turbines could dominate views, and the large sweep of the moving rotors would tend to command visual attention. Structural details, such as surface textures, could become apparent, and the O&M facility and other structures could be visible as well, as could reflections from the towers and moving rotor blades (blade glint). Measuring the aesthetic value of a specific landscape is difficult and may vary based on an individual's personal values, experiences, or preferences. The degree of visual contrast will vary based on the viewpoint distance and location in relation to the Project.

As discussed above, viewers within the Project Area include the occupied residences, travelers along Interstate 29 and State Highway 20, and hunters utilizing the public hunting areas. For these viewers, the magnitude of the visual impacts associated with the Project would depend on certain factors, including:

- Distance of the proposed wind energy facility from viewers;
- Duration of views (highway travelers vs. permanent residents);
- Weather and lighting conditions;
- The presence and arrangements of lights on the turbines and other structures; and
- Viewer attitudes toward renewable energy and wind power.

To minimize visual impacts of the Project, Dakota Range has incorporated setback requirements and commitments into the design of the Project. As identified in Table 10-1 (see Section 10.2), turbines would be set back at least 1,000 feet from off-site residences, businesses, churches, and government buildings and at least 500 feet from on-site or lessor's residences, per Codington and Grant County requirements. Turbines would also be set back at least 110 percent the height of the turbines from the centerline of public roads and from any surrounding property line. In accordance with FAA regulations, the towers would be painted off-white to reduce potential glare and minimize visual impact. At the end of the Project's operating life, the facility would be decommissioned (see Chapter 24.0), and all wind turbines, electrical cabling, electrical components, roads, and any other associated facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. As such, no visual impacts would remain beyond the operating life of the Project.

Scenic resources with sensitive viewsheds can include national parks, monuments, and recreation areas; national historic sites, parks, and landmarks; national memorials and battlefields; national wild and scenic rivers, national historic trails, national scenic highways, and national wildlife refuges; State- or locally designated scenic resources, such as State-designated scenic highways, State parks, and county parks; and other scenic resources that exist on Federal, State, and other non-Federal lands. No scenic resources with sensitive viewsheds are located within the Project Area or within viewing distance of the Project. Therefore, no impacts to scenic resources would result from construction or operation of the Project.

17.0 LOCAL LAND USE CONTROLS (ARSD 20:10:22:19)

ARSD 20:10:22:19. Local land use controls. *The applicant shall provide a general description of local land use controls and the manner in which the proposed facility will comply with the local land use zoning or building rules, regulations or ordinances. If the proposed facility violates local land use controls, the applicant shall provide the commission with a detailed explanation of the reasons why the proposed facility should preempt the local controls. The explanation shall include a detailed description of the restrictiveness of the local controls in view of existing technology, factors of cost, economics, needs of parties, or any additional information to aid the commission in determining whether a permit may supersede or preempt a local control pursuant to SDCL 49-41B-28.*

As noted previously, the Project is located in portions of Grant County and Codington County. Both counties have enacted zoning ordinances in which wind energy facilities are identified as conditional uses within the area zoned as the Agricultural District. As a result, proponents of wind energy facilities must obtain a conditional use permit prior to constructing a wind energy facility in the Agricultural District of either county.

The Project is located within the Agricultural District in both Grant County and Codington County. Dakota Range was unanimously granted a conditional use permit for the Project by Grant County on June 12, 2017, and by Codington County on June 19, 2017. Copies of each permit, as well as a letter of support from the Grant County Commission, are provided in Appendix K. Prior to construction, Dakota Range will submit a final Project layout to each county in connection with obtaining building permits. The final layout will comply with all applicable zoning ordinance requirements and permit conditions, including the setbacks, noise standard, and shadow flicker commitment set forth in Table 10-1 in Section 10.2. No organized townships with separate zoning jurisdiction are located within the Project boundary.

Dakota Range also plans to enter into road use and maintenance agreements with each county governing the use, improvement, repair, and restoration of roads within the applicable county. In addition, Dakota Range will obtain from each road authority any road crossing, approach, and/or utility permits required for the Project.

18.0 WATER QUALITY (ARSD 20:10:22:20)

ARSD 20:10:22:20. Water quality. *The applicant shall provide evidence that the proposed facility will comply with all water quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.*

Groundwater and surface water resources are discussed in Chapter 13.0. As discussed in Section 13.2.2, the excavation and exposure of soils during the construction of wind turbines, access roads, underground collector lines, and other Project facilities could cause sediment runoff during rain events. This sediment may increase TSS loading in receiving waters. However, erosion control BMPs would keep sediments onsite that might otherwise increase sediment loading in receiving waters.

As discussed in Section 12.2.2.2, construction of the Project would require coverage under the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. A condition of this permit is the development and implementation of a SWPPP. The SWPPP would be developed during civil engineering design of the Project and would prescribe BMPs to control erosion and sedimentation. The BMPs may include use of silt fence, wattles, erosion control blankets, temporary storm water sedimentation ponds, re-vegetation, or other features and methods designed to control storm water runoff and mitigate erosion and sedimentation. The BMPs would be implemented to reduce the potential for impacts to drainage ways and streams by sediment runoff. Because erosion and sediment control would be in place for construction of the Project, impacts to water quality are not expected to be significant.

SDDENR's Ground Water Quality Program reviewed the Project for potential impacts to groundwater quality and does not anticipate the Project will adversely impact groundwater quality (see letter from SDDENR dated July 26, 2017, in Appendix B). SDDENR indicated that there are records of petroleum and other chemical releases in the vicinity of the Project, as there are throughout the State. The records for these releases indicate that all cases are either closed or require no further action, and none are indicated as open/being monitored. As such, it is not anticipated that Project construction activities would encounter soil contamination from these releases. However, in the event that contamination is encountered during construction activities or caused by the construction work, Dakota Range would report the contamination to SDDENR in accordance with State and Federal regulations.

19.0 AIR QUALITY (ARSD 20:10:22:21)

ARSD 20:10:22:21. Air quality. *The applicant shall provide evidence that the proposed facility will comply with all air quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.*

The following sections discuss the existing air quality conditions within the Project Area and the potential air quality impacts from the Project.

19.1 Existing Air Quality

The entire State of South Dakota is in attainment for all NAAQS criteria pollutants (EPA, 2017a). The nearest ambient air quality monitoring site to the Project Area is located in Watertown, approximately 10 miles south of the Project Area (EPA, 2017b). The primary emission sources that exist within the Project Area include agricultural-related equipment and vehicles traveling along roads.

19.2 Air Quality Impacts/Mitigation

During construction of the Project, fugitive dust emissions would temporarily increase due to truck and equipment traffic in the Project Area. Additionally, there would be short-term emissions from diesel trucks and construction equipment. However, air quality effects caused by dust or vehicle emissions would be short-term, limited to the time of construction or decommissioning, and would not result in any NAAQS exceedances for criteria pollutants. Implementation of the Project components would not result in a violation to Federal, State, or local air quality standards and, therefore, would not result in significant impacts to air quality. SDDENR's Air Quality Program reviewed the Project and does not anticipate any adverse impacts to air quality of the State (see letter from SDDENR dated July 26, 2017, in Appendix B). Temporary minor sources of air pollution emissions from Project construction equipment, such as a concrete batch plant, would be permitted by the balance-of-plant contractor or concrete batch plant operator through the SDDENR. The operation of the Project would not produce air emissions that would impact the surrounding ambient air quality. Potential complaints regarding fugitive dust emissions would be addressed in an efficient manner (i.e., implementation of best management practices to suppress fugitive dust emissions during construction such as spraying the roads with water).

20.0 TIME SCHEDULE (ARSD 20:10:22:22)

ARSD 20:10:22:22. Time schedule. *The applicant shall provide estimated time schedules for accomplishment of major events in the commencement and duration of construction of the proposed facility.*

A variety of factors influence the timing of the Dakota Range Project schedule. Table 20-1 includes a best estimate at this time of the schedule. The construction of the Project could be delayed or accelerated depending on a number of factors, including permitting, financing, turbine supply, and the construction of the Big Stone South to Ellendale transmission line that the Project would interconnect to. After development of Dakota Range is complete and the necessary development permits have been obtained, ownership will transfer from Apex to Northern States Power Company. This transfer is scheduled to occur in late 2018; thus, Dakota Range needs to acquire an Energy Facility Permit for the Project prior to the scheduled closing date. Northern States Power Company, due to internal scheduling factors, will not begin construction until the second half of 2020. Dakota Range expects construction to be completed sometime between Q2 and Q4 2021. Closeout activities from construction may not end until Q1 2022.

Table 20-1: Preliminary Permitting and Construction Schedule

Milestone	Date
Land leasing	January 2015 to April 2017
Environmental studies	December 2015 to March 2018
County conditional use permits	May 2017 to June 2017
SDPUC Facility Permit	December 2017 to June 2018
Pre-construction engineering	August 2018 to February 2019
Finalize layout	February 2019
Construction	May 2020 to December 2021
Commercial operation date	December 2021

21.0 COMMUNITY IMPACT (ARSD (20:10:22:23)

ARSD 20:10:22:23. Community impact. *The applicant shall include an identification and analysis of the effects the construction, operation, and maintenance of the proposed facility will have on the anticipated affected area including the following:*

(1) A forecast of the impact on commercial and industrial sectors, housing, land values, labor market, health facilities, energy, sewage and water, solid waste management facilities, fire protection, law enforcement, recreational facilities, schools, transportation facilities, and other community and government facilities or services;

(2) A forecast of the immediate and long-range impact of property and other taxes of the affected taxing jurisdictions;

(3) A forecast of the impact on agricultural production and uses;

(4) A forecast of the impact on population, income, occupational distribution, and integration and cohesion of communities;

(5) A forecast of the impact on transportation facilities;

(6) A forecast of the impact on landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance. The information shall include the applicant's plans to coordinate with the local and state office of disaster services in the event of accidental release of contaminants from the proposed facility; and

(7) An indication of means of ameliorating negative social impact of the facility development.

The following sections describe the existing socioeconomic and community resources within the Project Area, the potential community impacts of the proposed Project, and measures to avoid, minimize, and/or mitigate potential impacts.

21.1 Socioeconomic and Community Resources

The existing socioeconomic resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

21.1.1 Existing Socioeconomic and Community Resources

The Project Area is located in northeastern South Dakota in Codington and Grant Counties. Codington and Grant Counties had estimated populations of 28,063 and 7,148, respectively, in 2016 (U.S. Census Bureau, 2016). Watertown, with an estimated 2016 population of 22,172, is the largest city in Codington County (U.S. Census Bureau, 2016). Watertown is located approximately 10 miles south of the Project Area. In Grant County, Milbank is the most populous community near the Project Area with an estimated 2016 population of 3,203. The populations of these communities, as well as other communities in Codington and Grant Counties and their distances from the Project Area, are shown in Table 21-1.

Table 21-1: Population Estimates of Communities and Distance from Project Area

Community	2016 Population Estimate	County	Distance and Direction from Project Area
Watertown	22,172	Codington	9.8 miles south

Community	2016 Population Estimate	County	Distance and Direction from Project Area
Florence	369	Codington	10.3 miles west
South Shore	226	Codington	3.1 miles east
Kranzburg	177	Codington	11.3 miles southeast
Wallace	84	Codington	17.5 miles west
Marvin	32	Grant	3.3 miles northeast
Twin Brooks	66	Grant	9.0 miles east
Milbank	3,203	Grant	15.5 miles east
Summit	288	Roberts	4.3 miles north

Source: U.S. Census Bureau, 2016

The population in Codington County is predominantly white (96.0 percent), while 3.6 percent of the population is American Indian and 0.4 percent is some other race. In Grant County, 97.9 percent of the population is white, while 1.9 percent is American Indian. The remaining 0.2 percent is some other race (U.S. Census Bureau, 2015). In the State of South Dakota as a whole, 87.5 percent of the population is white, 10.3 percent is American Indian, and 2.2 percent is some other race (U.S. Census Bureau, 2015).

The median household income in 2015 in Codington and Grant Counties was $48,912 and $51,272 respectively. In 2015, 10.3 and 8.1 percent of the population, respectively, were below the poverty level in Codington and Grant Counties. By comparison, the median household income for the State ($50, 957), was between the reported median income for the counties and the poverty level (14.1 percent) was higher than both counties.

In Codington County, the top industries in terms of employment in 2015 were: (1) manufacturing (comprising 20.2 percent of employment); (2) educational services, health care, and social services (16.4 percent); and (3) retail trade (12.2 percent). In Grant County, the top industries in terms of employment in 2015 were: (1) agriculture, forestry, fishing and hunting, and mining (comprising 18.1 percent of employment); (2) educational services, health care, and social services (16.3 percent); and (3) wholesale trade (8.7 percent). The unemployment rates in Codington and Grant Counties in April 2017 were 3.0 and 3.2 percent, respectively, and the South Dakota unemployment for that same month was 2.9 percent (South Dakota Department of Labor and Regulation [SDDLR], 2017).

21.1.2 Socioeconomic and Community Impacts/Mitigation

This section describes the potential impacts of the proposed Project on economics, population and housing, and property values.

21.1.2.1 Economic Impacts

The Project is expected to create both short-term and long-term positive impacts to the local economy. Impacts to social and economic resources from construction activities would be short-term. Local businesses, such as restaurants, grocery stores, hotels, and gas stations, would see increased business during this phase from construction-related workers. Local industrial businesses, including aggregate and cement suppliers, welding and industrial suppliers, hardware stores, automotive and heavy equipment repair, electrical contractors, and maintenance providers, would also likely benefit from construction of the Project.

During construction, a typical 300-MW wind project such as Dakota Range typically generates an immediate need for up to 300 temporary construction jobs over 9 months. Construction and operation of a typical 300-MW wind project results in the injection of millions of dollars into the local economy both immediately and throughout the life of the project. These investments will be seen throughout the community, including at hotels, restaurants, gas stations, auto repair companies, tire companies, grocery stores, and countless other local businesses. During operation, the Facility will employ approximately 10 full-time personnel as facility managers, site managers, and turbine technicians. A breakdown of the typical construction and operation jobs for a 300-MW wind energy project are shown in Table 21-2. It is expected the construction of the Project will take approximately 400,000 man-hours.

Table 21-2: Construction and Operation Jobs for 300-MW Wind Energy Project

Project Phase	Job Title	Affiliation	Number On-Site	Approximate Hourly Salary
Construction	Site Superintendent	Xcel	1	$75
Construction	Civil Superintendent	Xcel	1	$50
Construction	Electrical Superintendent	Xcel	1	$50
Construction	Site Administrator	Xcel	1	$30
Construction	Tower Climbers	Xcel Subcontractor	2	$90
Construction	Concrete Crews	General Contractor	18 (6 per crew)	$15
Construction	Re-Bars Crews	General Contractor	18 (6 per crew)	$22
Construction	Crane Crews	General Contractor	15 (5 per crew)	$30
Construction	Main Erection Crane	General Contractor	15 (5 per crew)	$30
Construction	Laborers	General Contractor	120	$15
Construction	Office Staff	General Contractor	6	$20

Project Phase	Job Title	Affiliation	Number On-Site	Approximate Hourly Salary
Construction	Electricians	Subcontractor	30	$30
Construction	Heavy Equipment Operators	Subcontractor	30	$20
Construction	Laborers	Subcontractor	40	$15
Operation	Facility Manager	Operator	1	$100,000/year
Operation	Deputy Facility Manager	Operator	1	$90,000/year
Operation	Wind Turbine Technicians	Operator	8	$25/hour
Operation	Lead Technician	Operator	1	$34/hour
Operation	Site Admin	Operator	1	$12/hour

Furthermore, the Facility represents an approximately $400 million investment in Grant and Codington Counties. Dakota Range will pay taxes on the Facility, which will significantly increase the revenue available for a variety of local needs. A breakdown of this tax information over 25 years is shown in Table 21-3.

Table 21-3: Projected Tax Revenue for the Dakota Range Project

	Annual Tax Revenue (Approximate)	Total Tax Revenue (Approximate)
Codington County	$80,000	$2,000,000
Leola Township	$6,000	$150,000
Germantown Township	$30,000	$700,000
Grant County	$280,000	$6,900,000
Lura Township	$25,000	$600,000
Mazeppa Township	$90,000	$2,300,000
Waverly School District	$225,000[a]	$5,600,000[a]
Summit School District	$280,000[a]	$7,000,000[a]
South Dakota	$420,000	$10,600,000

(a) After the fifth year of receiving the total annual tax revenue as well as South Dakota State-aid funds for the school districts, the amount of the wind energy tax revenue that is considered local effort funding will increase by 20 percent each year until year 10, after which all wind energy tax revenue will be considered local effort funding in the South Dakota School Funding Formula, which may decrease the State-aid funds the school districts receive. However, as shown in the table, 100 percent of the wind tax revenue allocated to the school districts will still be received by the school districts.

Over the expected 25-year life of the Project, the Project would generate over $92 million in direct economic benefits for local landowners, new local employees, local communities, and the State of South

Dakota. Some of these payments are outlined in Table 21-4. Further benefits that are not quantified below include local spending on operations and maintenance needs such as automotive repair, tires, gas,

Table 21-4: Direct Economic Benefit from the Dakota Range Project

Payment	Direct Beneficiary	Approximate Total
Lease Payments	Project Landowners	$39,000,000
Operations and Maintenance	~10 Employees	$17,000,000
Taxes	Townships, Counties, School Districts, and South Dakota	$36,000,000

21.1.2.2 Population and Housing

There is the potential for residents within 60 or more miles from the Project Area to take advantage of these employment opportunities during Project construction. During construction, non-local workers would relocate to the area, resulting in a temporary increase in population. These non-local construction workers would need temporary housing. Temporary housing for workers will likely include available facilities at several towns throughout the area, with larger towns, such as Watertown likely having more available facilities.

The proposed Project could increase demand on the local labor force and for local housing during construction; however, the construction period is only temporary. Overall, Dakota Range anticipates that the Project will be socioeconomically beneficial to the local population and will not impact long-term population trends. Therefore, no mitigation measures are anticipated to be required.

21.1.2.3 Property Value Impacts

Extensive statistical studies have demonstrated that large-scale wind energy facilities do not substantially injure the value of adjoining or abutting property. The Massachusetts Clean Energy Center published a report in January 2014 entitled *Relationship between Wind Turbines and Residential Property Values in Massachusetts*. This study analyzed more than 122,000 home sales near the current or future location of a wind farm in Massachusetts and found no net effect on prices attributed to the proximity of the dwelling to the wind energy project. Jennifer Hinman at Illinois State University completed a study based on 3,851 property transactions over a 9-year period near a 240-turbine wind energy facility in Illinois. This study, entitled *Wind Farm Proximity and Property Values: A Pooled Hedonic Regression Analysis of Property Values in Central Illinois* found a negative location effect on property values before the wind farm was approved, a concept known as anticipation stigma, but the study found that property values rebounded to levels higher in real terms than before the wind farm was approved (Hinman, 2010).

In 2009, the Ernest Orlando Lawrence Berkeley National Laboratory published a study entitled *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis* (see Appendix L). This study analyzed data from approximately 7,500 sales of single-family homes within 10 miles of 24 existing wind facilities in nine different states and found “no evidence… that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities.” The author of this study, Ben Hoen, completed a second study on this topic at the Ernest Orlando Lawrence Berkeley National Laboratory in 2013 entitled *A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States* (see Appendix L). This study is based on more than 50,000 home sales within 10 miles of 67 different wind facilities in 27 states, and found “no statistical evidence that home prices near wind turbines were affected in either the post-construction or post-announcement/pre-construction periods.”

The Lawrence Berkeley National Laboratory hedonic analyses studied wind farms in landscapes primarily similar to those of Grant and Codington Counties in terms of population, income, home value, and how much of the counties are considered rural. The 2009 and 2013 studies examined 36 unique counties in the United States. Codington County is 22 percent rural and Grant County is 55 percent rural, and 18 of the 36 counties included in the studies are in that range of rural percentage, with only 6 of the other counties having a lower rural percentage than 22 percent. See Table 21-5 for demographic data on the counties included in the Lawrence Berkeley National Laboratory 2009 and 2013 studies compared to Grant and Codington Counties. Based on these national studies of property value impacts of constructed wind farms in rural areas, it is expected that Dakota Range will not have an impact on property values near the Project.

Table 21-5: Demographic Data On Counties in Lawrence Berkeley National Laboratory Studies

County	State	Population	Population/ Square Mile	Median Age	Median Home Value	Median Income	Percentage Rural
Lawrence Berkeley National Laboratory, 2009 Study							
Buena Vista	IA	20,578	36	37	$99,744	$46,469	44
Lee	IL	34,735	48	42	$140,291	$51,682	53
Livingston	IL	37,903	36	40	$102,523	$55,287	41
Madison	NY	72,369	110	39	$135,300	$52,300	59
Oneida	NY	232,871	192	40	$113,600	$43,702	33
Custer	OK	29,500	30	31	$114,228	$45,179	30
Umatilla	OR	76,705	24	35	$138,600	$48,514	29

County	State	Population	Population/ Square Mile	Median Age	Median Home Value	Median Income	Percentage Rural
Somerset	PA	76,218	71	44	$103,900	$43,429	71
Wayne	PA	51,401	70	45	$179,354	$47,932	88
Howard	TX	36,651	41	38	$67,485	$47,906	20
Benton	WA	184,486	109	35	$176,500	$48,997	11
Walla Walla	WA	58,844	47	36	$186,784	$45,875	17
Door	WI	27,766	58	49	$187,484	$50,586	69
Kewaunee	WI	20,444	60	42	$145,344	$52,929	72
Average		**68,605**	**67**	**40**	**$135,081**	**$48,628**	**46**
Lawrence Berkeley National Laboratory, 2013 Study							
Carroll	IA	20,562	36	42	$107,911	$50,074	52
Floyd	IA	16,077	32	43	$92,087	$44,152	53
Franklin	IA	10,436	18	42	$89,330	$48,715	60
Sac	IA	10,035	17	46	$81,367	$48,451	100
DeKalb	IL	105,462	166	29	$160,600	$52,867	20
Livingston	IL	37,903	36	40	$102,523	$55,287	41
McLean	IL	172,418	146	32	$160,300	$61,846	16
Cottonwood	MN	11,633	18	44	$83,197	$45,949	62
Freeborn	MN	30,840	44	44	$99,683	$46,698	43
Jackson	MN	10,629	15	44	$93,644	$52,428	69
Martin	MN	20,220	29	45	$98,341	$51,865	54
Atlantic	NJ	275,209	491	39	$218,600	$52,127	13
Clinton	NY	81,632	79	39	$121,200	$43,892	64
Franklin	NY	51,262	31	39	$93,529	$45,580	63
Herkimer	NY	63,744	45	42	$89,098	$43,754	52
Lewis	NY	27,220	21	40	$103,257	$47,990	87
Madison	NY	72,369	110	39	$135,300	$52,300	59
Steuben	NY	98,394	71	41	$90,900	$47,046	60
Wyoming	NY	41,188	69	40	$96,515	$50,949	64
Paulding	OH	18,989	46	40	$89,619	$44,650	82
Wood	OH	129,590	210	35	$147,300	$51,680	30
Custer	OK	29,500	30	31	$114,229	$45,179	30
Grady	OK	53,854	49	38	$111,956	$50,677	64
Fayette	PA	134,086	170	43	$89,100	$38,903	48
Somerset	PA	76,218	71	44	$103,900	$43,429	71

County	State	Population	Population/ Square Mile	Median Age	Median Home Value	Median Income	Percentage Rural
Wayne	PA	51,401	70	45	$179,354	$47,932	88
Kittitas	WA	42,522	19	31	$234,150	$43,849	40
Average		**62,718**	**79**	**40**	**$118,037**	**$48,454**	**55**
South Dakota Counties Dakota Range is Located In							
Codington	SD	27,938	41	37	$140,909	$46,361	22
Grant	SD	7,241	11	45	$105,054	$48,354	55
Average		**17,590**	**26**	**41**	**$122,982**	**$47,358**	**39**

Furthermore, increased tax revenue will positively impact the Counties, Townships, and local school districts, providing improved services for the community which can positively impact property values in the long-term. Research has shown that an increase in school funding results in an increase in housing value. In a paper for the National Bureau of Economic Research (2002), the authors found that "a $1.00 increase in per pupil state aid increases aggregate housing values per pupil between $19 and $20." In this scenario, the increase in per pupil aid would come from wind energy property taxes, rather than state aid. Details on the projected tax funding provided to the local school districts due to the Dakota Range project can be seen in Table 21-3, with over $500,000 being paid annually to Summit and Waverly School Districts combined.

21.2 Commercial, Industrial, and Agricultural Sectors

No commercial or industrial sectors occur within the Project Area. The existing agricultural sector within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

21.2.1 Existing Agricultural Sector

The Project Area is predominantly agricultural, consisting of a mix of cropland, rangeland, and pastureland. In 2012, Codington County's 713 farms (totaling 369,235 acres of land) produced $172.4 million in agricultural products (USDA, 2012a). Thirty-seven percent was from livestock sales, and 63 percent was crop sales. Cattle and calves were the top livestock inventory item in the county, and corn (for grain) was the top crop in terms of acreage. Codington County ranked 23 out of the 66 South Dakota counties in total value of agricultural products sold (USDA, 2012a).

In 2012, Grant County's 618 farms (totaling 428,624 acres of land) produced nearly $240.8 million in agricultural products (USDA, 2012b). Forty-four percent was from livestock sales, and 56 percent was crop sales. Cattle and calves were the top livestock inventory item in the county, and corn (for grain) was the top crop in terms of acreage. Grant County ranked 12 out of the 66 South Dakota counties in total value of agricultural products sold (USDA, 2012b).

21.2.2 Agricultural Impacts/Mitigation

Minimal existing agricultural land would be taken out of crop and forage production by the proposed Project, primarily the area around wind turbine foundations, access roads, and electric collection and interconnection facilities. Landowners would be compensated by the Applicant for losses to crop production during construction. Agricultural activities can occur up to the edge of access roads and turbine pads. The buried underground collection system would not alter agricultural activities.

It is estimated that approximately 647 acres of agricultural land would be temporarily impacted by Project construction, and 65 acres of agricultural land would be impacted during the life of the Project (less than 0.2 percent of the total land within the Project Area, see Table 11-1). Areas disturbed due to construction and that would not host Project facilities would be re-vegetated with vegetation types matching the surrounding agricultural landscape.

21.3 Community Facilities and Services

The existing community facilities and services within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

21.3.1 Existing Community Facilities and Services

The majority of community facilities and services near the Project Area are located in the town of Watertown, which is approximately 10 miles south of the Project Area. Watertown contains a hospital, police, fire and ambulance services, schools, churches, and parks and recreational facilities. One church and an associated cemetery are located within the Project Area (Figure 13).

Electrical service in the Project Area is provided by Otter Tail Power Company, Whetstone Valley Electric Power Cooperative, and Codington-Clark Electric Cooperative. The Grant-Roberts Water District supplies rural water to the Project Area and maintains a network of distribution lines within the Project Area.

21.3.2 Community Facilities and Services Impacts/Mitigation

The additional workers moving into the region during construction of the proposed Project could temporarily add an additional demand on some of the existing community facilities and services. However, this demand would be temporary, and it is anticipated that the existing facilities would have sufficient capacity to meet this demand. Therefore, no mitigation measures are anticipated to be required. SDDENR's Drinking Water Program reviewed the Project and does not anticipate any adverse impacts to drinking waters of the State (see letter from SDDENR dated July 26, 2017, in Appendix B). SDDENR's Waste Management Program also reviewed the Project and does not anticipate any adverse impacts, because all waste material would be managed according to SDDENR's solid waste requirements (see same letter from SDDENR in Appendix B).

21.3.3 Emergency Response

The proposed wind farm is located within a rural portion of Codington and Grant Counties. During the Project construction period and during subsequent operation, it is expected that the Project would have no significant impact on the security and safety of the local communities and the surrounding area. Some additional risk for worker or public injury may exist during the construction phase, as it would for any large construction project. However, work plans and specifications would be prepared to address worker and community safety during Project construction. During Project construction, the Project's general contractor would identify and secure all active construction areas to prevent public access to potentially hazardous areas.

During Project construction, the Project contractor would work with local and county emergency management to develop procedures for response to emergencies, natural hazards, hazardous materials incidents, manmade problems, and potential incidents concerning Project construction. The contractor would provide site maps, haul routes, project schedules, contact numbers, training, and other requested project information to local and county emergency management.

During Project operations, the Project operator would coordinate with local and county emergency management to protect the public and the property related to the Project during natural, manmade or other incidents. The Project would register each turbine location and the O&M building with the rural identification/addressing (fire number) system and 911 systems.

21.4 Transportation

The existing transportation resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

21.4.1 Existing Transportation

This section describes the existing surface transportation and aviation within the Project Area.

21.4.1.1 Surface Transportation

Table 21-6 lists the major roads that intersect the Project Area. The primary access to the Project Area is via Interstate 29 which extends through the central portions of the Project Area (Figure 1). Secondary access to turbine locations would be via existing County and Township gravel roads. Paved County roads would be avoided wherever possible due to their light construction. Roads would be assessed for strength and condition prior to construction. County and Township gravel roads determined to be insufficient for construction use would be upgraded and strengthened prior to construction at the Project's expense. County and Township gravel roads would be maintained during construction at the Project's expense. Paved roads would be returned to preconstruction or better condition if damage occurs. The Project would enter into Road Use Agreements with each road authority, as required, to define use and restoration of roads utilized during construction of the Project.

Table 21-6: Project Area Roads

Road	Surface Type	Surface Width	Total Lanes
Interstate 29	Concrete	24 feet	4 (divided)
State Highway 20	Bituminous	24 feet	2
Secondary County roads	Gravel or crushed rock / Bituminous	22 to 28	2
Secondary Township roads	Gravel or crushed rock	16 to 20	2

Source: SDDOT, 2017

In 2016, Average Daily Traffic (ADT) volume was 6,600 trips along Interstate 29 through the Project Area, and 303 trips along State Highway 20 (SDDOT, 2016). ADT along the county roads through the Project Area were generally less than 200.

21.4.1.2 Aviation

There are no airports located within the Project Area. The closest airport is Watertown Regional Airport, which is a city owned public airport located in Watertown, South Dakota, approximately 10 miles southwest of the Project Area. The closest private airport to the Project Area is the Whipple Ranch airstrip, located 13 miles north of the Project Area in Wilmot, South Dakota. The nearest U.S. air military installation is Grand Forks Air Force Base, located approximately 185 miles north of the Project Area (U.S. Air Force, 2017). The nearest South Dakota National Guard Air National Guard installation is the 114th Fighter Wing, located approximately 100 miles south of the Project Area at Joe Foss Field Base, in Sioux Falls, South Dakota.

21.4.2 Transportation Impacts/Mitigation

This section addresses the potential impacts of the proposed Project on ground transportation and air traffic.

21.4.2.1 Ground Transportation

The Project Area contains Highways, one paved four-lane interstate highway, and several paved County roads as well as County and Township gravel roads. During construction, it is anticipated that several types of light, medium, and heavy-duty construction vehicles would travel to and from the site, as well as private vehicles used by the construction personnel. Construction hours are expected to be from 6:00 a.m. to 9:00 p.m. on weekdays, and possibly on weekends. Some activities may require extended construction hours, and nighttime construction may be necessary to meet the overall proposed Project schedule. The movement of equipment and materials to the site would cause a relatively short-term increase in traffic on local roadways during the construction period. Most equipment (e.g., heavy earthmoving equipment and cranes) would remain at the site for the duration of construction activities. Shipments of materials, such as gravel, concrete, and water would not be expected to substantially affect local primary and secondary road networks. That volume would occur during the peak construction time when most of the foundation and tower assembly is taking place. At the completion of each construction phase, this equipment would be removed from the site or reduced in number, and replaced with equipment for the next phase, as appropriate.

The Project would not result in any permanent impacts to the area's ground transportation resources. There would be improvements to most gravel roads and temporary impacts to local roads during the construction phase of the Project. The Applicant would work with each County and Township on Road Use Agreements so that all parties understand how the Project would proceed prior to construction starting. Within the Project Area, oversized and overweight loads would be strictly confined to roads designated in the Road Use Agreement. The Applicant would work with SDDOT, Codington and Grant Counties, and the local townships to obtain the appropriate access and use permits, and to reduce and mitigate the impacts to area transportation.

21.4.2.2 Air Traffic

The air traffic generated by the airports listed above would not be impacted by the proposed Project. The Applicant would follow FAA guidelines for marking towers and would implement the necessary safety lighting. Dakota Range applied for and received Determinations of No Hazard from the FAA for a preliminary layout in February 2016 and for the current layout in December 2017, and these included a condition for the turbines to be marked/lighted in accordance with FAA Advisory Circular 70/7460 L

Change 1, Obstruction Marking and Lighting, white paint/synchronized red lights. The Applicant expects Determinations of No Hazard to be issued for the finalized layout, and for the Determinations to include the same lighting/marking condition. Notification of construction and operation of the wind energy facility would be sent to the FAA, and the Project will comply with all applicable FAA requirements. The Applicant would also file Tall Structures Aeronautical Hazard Applications with the South Dakota Aeronautics Commission for a permit approving the proposed wind turbine and permanent meteorological tower locations.

Air traffic may be present near the Project Area for crop dusting of agricultural fields. Crop dusting is typically carried out during the day by highly maneuverable airplanes or helicopters. The installation of wind turbine towers in active croplands and installation of aboveground collector and transmission lines would create potential hazards for crop-dusting aircraft. However, aboveground collection and transmission lines are expected to be similar to existing distribution lines (located along the edges of fields and roadways), and the turbines and meteorological tower(s) themselves would be visible from a distance and lighted and marked according to FAA guidelines.

21.5 Cultural Resources

The following sections provide information on the cultural resources potentially affected by the construction, operation, and maintenance of Project facilities and how impacts to these resources will be avoided and/or minimized.

21.5.1 Existing Cultural Resources

This section describes the existing cultural resources within the Project Area.

21.5.1.1 Regulatory Framework

South Dakota state law (SDCL 1-19A-11[1]) requires that state agencies or political subdivisions of the state, or any instrumentality thereof (i.e. county, municipal, etc.) may not undertake any project which will encroach upon, damage or destroy any historic property included in the National or State Registers of historic places until the SHPO has been given notice and an opportunity to investigate and comment on the proposed project. Any permits required by the state, county, or municipalities, including an SDPUC Energy Facility Permit, will invoke this law.

Furthermore, ARSD 20:10:22:23 states that an application for a Facility Permit shall include a forecast of the impact on landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance. The Applicant has completed cultural resources investigations for the Project, as described in the following sections, in accordance with SDCL 1-19A-11(1) and ARSD 20:10:22:23, to enable forecasting of potential impacts and respond with appropriate field studies and impact avoidance or minimization measures.

21.5.1.2 Level I Records Search

A Level I Cultural Resources Records Search was completed for the Project in June 2017 in accordance with SHPO survey guidelines (Appendix M). The records search was completed to provide an inventory of previously recorded cultural resources within the Project Area and a 1-mile buffer. The records search was requested from the South Dakota Archaeological Research Center (SDARC) on June 16, 2017.

The records search indicated that 29 cultural resources surveys have been completed within or partly within the Project Area, and 10 more have been performed in the 1-mile buffer. One hundred and five archaeological sites have been previously recorded in or within 1 mile of the Project Area. Of these, 41 sites are located within the Project Area and 64 are within the 1-mile buffer. Forty of the 41 sites within the Project Area have been determined eligible for listing in the National Register of Historic Places (NRHP), and 1 site has been determined not eligible for listing. Twenty-six of the 64 sites located within the 1-mile buffer have been determined eligible for NRHP listing, 6 have been determined or recommended not eligible for listing, and 32 sites are unevaluated for NRHP listing. All of the eligible sites previously recorded within the Project Area and 1-mile buffer are Native American cairns, stone circles, or alignments, and may also be traditional cultural properties.

Ninety-two historic/architectural resources have been previously inventoried, including 43 within the Project Area and an additional 49 within the 1-mile buffer. These resources include 73 structures, 16 bridges, and 3 cemeteries. One structure, a farmstead, is listed in the NRHP and two other structures have been determined eligible for an NRHP listing.

21.5.1.3 Cultural Resources Monitoring and Management Plan

A CRMMP (Appendix N) was developed for the Project in coordination with the SHPO to avoid or minimize potential impacts to cultural resources during design and construction of Project facilities and to comply with the SDPUC Energy Facility Permit requirements. The CRMMP identifies the methodology for completing Level III intensive cultural resources surveys and historical/architectural surveys for the Project. The CRMMP also identifies the proposed management plan for archeological or architectural resources that are identified during the surveys and provides a plan for unanticipated discovery of sensitive cultural resources, should any be unearthed during construction.

21.5.1.4 Level III Intensive Survey

Level III intensive cultural resource surveys were completed for the Project footprint in December 2017 in accordance with the CRMMP. As discussed in the CRMMP, Level III surveys were proposed for areas of potential ground disturbance from Project construction activities within the Project footprint that are identified as High Probability Areas (HPAs). HPAs consist of areas most likely to contain intact archaeological sites in the region and are primarily found on uncultivated and undisturbed land areas and around water sources such as rivers, streams, and lakes. The survey results are pending; however, based on preliminary data, no cultural resources were identified that would require turbine location modifications.

Level III Intensive Survey Methodology

During the Level III intensive surveys, the historic and prehistoric HPAs within the Project footprint were visually inspected and shovel tested if the ground surface visibility was poor. If surface rock features such as cairns or tipi rings were identified, no shovel testing or other disturbance to the site area and features occurred. They were recorded and photographed and recommended for avoidance. Shovel testing or coring was used to delineate the vertical and horizontal limits of other types of sites investigated. Any cultural resources were photo-documented and recorded with GPS equipment with sub-meter accuracy. Archaeological sites were documented on archaeological site forms from the SDARC. Potentially sensitive tribal resources were reported to the SWO for review and recommendations.

21.5.1.5 Architectural Survey

A historical/architectural survey (Appendix O) was completed for the Project in accordance with the CRMMP in November 2017. As discussed in the CRMMP, the proposed architectural survey consisted of windshield reconnaissance within the Project footprint and 1-mile buffer (indirect or visual area of potential effects [APE]) to document all resources 45-years-of-age or older that have not been recorded in previous surveys or have been previously recorded but have undetermined NRHP-eligibility status. Following field documentation, additional research was conducted to understand prior ownership, land usage patterns, building distributions, configurations, materials, and ages. Each recorded structure was evaluated for its State and NRHP eligibility.

The results of the survey indicate a low concentration of NRHP-eligible architectural resources. No historic architectural resources were identified within the proposed Project footprint, or direct APE. Within the indirect or visual APE, there were three structures (two farmsteads and one barn) recommended eligible for listing on the NRHP. While the turbines will be visible from these properties, when viewed from the right-of-way, the turbines will be behind the viewer with the settings of the farms intact. Therefore, the survey concluded that there will be no adverse effect to historic properties in the Project's visual APE.

21.5.1.6 Tribal Coordination

As discussed in Section 27.2, the Applicant has engaged in ongoing voluntary coordination with the SWO to seek input on cultural resources in the Project Area and to seek input on the CRMMP and proposed cultural resources surveys for the Project. The Level III surveys are being completed in coordination with the SWO, allowing the SWO opportunities to review findings and participate in eligibility recommendations and avoidance plans for sensitive tribal resources.

21.5.2 Cultural Resource Impacts/Mitigation

The CRMMP outlines the proposed management plan for cultural and tribal resources that are identified during the Level III intensive surveys and provides a plan for unanticipated discovery of these resources, should any be unearthed during construction. Both SHPO and SWO have agreed that the measures outlined in the CRMMP are appropriate to avoid negatively impacting landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance.

For cultural resources identified during the surveys, the following steps, as identified in the CRMMP, will be taken:

- The cultural resource specialist will make a recommendation on the NRHP eligibility of the resource and request SHPO concurrence on the recommendation. There is no federal agency with jurisdiction over this Project, and, therefore, this recommendation will be made directly to SHPO.
- Sites identified as potentially eligible for NRHP listing will be addressed by micrositing facilities to avoid impacts. If complete avoidance cannot be achieved, Dakota Range Wind will work with SHPO to minimize impacts to the maximum extent practicable.
- In accordance with the Siting Guidelines for Wind Power Projects in South Dakota 8(c), and in accordance with informal consultation completed between the Project and tribes, disruption of sensitive resources that are identified as important to Native Americans will be avoided by marking them with orange snow fencing and ensuring facilities are set back in accordance with recommendations from the SWO, or as practicable and consistent with applicable State and Federal regulations.

22.0 EMPLOYMENT ESTIMATES (ARSD 20:10:22:24)

ARSD 20:10:22:24. Employment estimates. *The application shall contain the estimated number of jobs and a description of job classifications, together with the estimated annual employment expenditures of the applicants, the contractors, and the subcontractors during the construction phase of the proposed facility. In a separate tabulation, the application shall contain the same data with respect to the operating life of the proposed facility, to be made for the first ten years of commercial operation in one-year intervals. The application shall include plans of the applicant for utilization and training of the available labor force in South Dakota by categories of special skills required. There shall also be an assessment of the adequacy of local manpower to meet temporary and permanent labor requirements during construction and operation of the proposed facility and the estimated percentage that will remain within the county and the township in which the facility is located after construction is completed.*

As discussed in Section 21.1.2.1, the Project is expected to employ approximately 300 temporary workers over 9 months to support Project construction. It is likely that general skilled labor is available in either Codington and Grant Counties or the State to serve the basic infrastructure and site development needs of the Project. Specialized labor will be required for certain components of Project construction. It is likely that this labor will be imported from other areas of the State or from other states, as the relatively short duration of construction makes special training of local or regional labor impracticable.

23.0 FUTURE ADDITIONS AND MODIFICATIONS (ARSD 20:10:22:25)

ARSD 20:10:22:25. Future additions and modifications. *The applicant shall describe any plans for future modification or expansion of the proposed facility or construction of additional facilities which the applicant may wish to be approved in the permit.*

With the exception of the final micrositing flexibility requested in Section 9.1, the Applicant does not have any current plans for future additions to or modifications of the Project. Apex does hold interconnection queue positions for an additional 400 MW of capacity at the same POI through MISO and is exploring the potential for future projects depending on available transmission capacity.

24.0 DECOMMISSIONING OF WIND ENERGY FACILITIES (ARSD 20:10:22:33.01)

ARSD 20:10:22:33.01. Decommissioning of wind energy facilities -- Funding for removal of facilities. *The applicant shall provide a plan regarding the action to be taken upon the decommissioning and removal of the wind energy facilities. Estimates of monetary costs and the site condition after decommissioning shall be included in the plan. The commission may require a bond, guarantee, insurance, or other requirement to provide funding for the decommissioning and removal of a wind energy facility. The commission shall consider the size of the facility, the location of the facility, and the financial condition of the applicant when determining whether to require some type of funding. The same criteria shall be used to determine the amount of any required funding.*

The Applicant has entered into long-term lease and easement agreements for placement of the wind turbines and associated Project infrastructure with private landowners within the Project Area. The Applicant anticipates that the life of the Project would be approximately 25 years but reserves the right to extend the life of the Project as well as explore alternatives regarding Project decommissioning. One such option may be to retrofit the turbines and power system with upgrades based on new technology, which may allow the wind farm to produce efficiently and successfully for many more years.

The Project will be decommissioned in accordance with applicable State and County regulations. Current decommissioning requirements in Grant and Codington Counties require that all towers, turbine generators, transformers, overhead collector and feeder lines, foundations, buildings, and ancillary equipment be dismantled and removed to a depth of 4 feet. To the extent possible, the site shall be restored and reclaimed to its pre-project topography and topsoil quality. All access roads shall be removed unless written approval is given by the landowner requesting roads be retained.

The Decommissioning Plan for the Project is included in Appendix P.

The estimated net decommissioning costs for the Project are summarized in Chapter 6 of the Decommissioning Plan in Appendix P. The net decommissioning cost (in 2017 U.S. dollars) is estimated to be $2,906,000, assuming no resale of Project components. The net decommissioning cost is estimated to be a positive return of $1,883,500, assuming resale of some of the Project's major components. The second scenario, assuming partial resale, is considered to be the more likely option. The estimates are based on the decommissioning approach outlined in the Decommissioning Plan.

25.0 RELIABILITY AND SAFETY (ARSD 20:10:22:33.02(8))

The following sections discuss the reliability and safety of the wind farm facility.

25.1 Reliability

Reliability (Availability) is defined as the ability of the turbine to generate electricity when sufficient wind is available. Vestas has over 59,000 wind turbines (85 GW) currently installed globally. In the Vaisala Wind Energy Due Diligence Report completed for the Project and discussed in Section 7.1, Vaisala “observed that turbine availability at newly constructed wind farms achieve 96.0% or higher availability when averaged over an entire calendar year.” To further provide for reliability and to protect the Project financially, availability guarantees are included in turbine supply agreements with the turbine manufacturer. Availability guarantees require the turbine manufacturer maintain the turbine at 96 percent availability or higher. If the turbine manufacturer fails to maintain the required level of availability, then the turbine manufacturer is required to pay a project liquidated damages for the lost revenue from lost energy production. Typically, the turbine manufacturer maintains the turbine for the first 2 years, then the turbines are maintained under O&M service contracts with terms of 5 or 10 years.

To further improve reliable operation of the region’s power grid, wind energy projects are required to provide short-term forecasts of wind speed and energy that would be produced. Accurately anticipating weather conditions allows wind energy project owners and operators to maximize facility output and efficiency. Transmission system operators need to know how much energy wind facilities can deliver and when to dispatch generators on the system to match load to generation. Typically, wind projects provide a next-day, next-hour, and next-15 minutes forecast, updated every 15 minutes to the off-taker, balancing authority, and/or regional TO. These predictions of energy generation through in-depth, site-specific weather forecasting are used to integrate wind energy into the region’s power grid and to schedule turbine and transmission maintenance windows, improving overall reliability. As wind forecasting has improved, the reliability of wind energy generation forecasts provided to the transmission operators has also improved.

25.2 Safety

The Project Area is located in an area of low population density; therefore, construction and operation of the Project would have minimal impacts on the security and safety of the local population. The following safety measures would be taken to reduce the chance of property damage, as well as personal injury, at the site:

- The towers would be placed at distances away from existing roadways and residences per the applicable setback requirements described in Section 10.2;
- Security measures would be implemented during the construction and operation of the Project, including temporary (safety) and permanent fencing, warning signs, and locks on equipment and wind power facilities;
- Turbines would sit on solid steel enclosed tubular towers; access to each tower would be only through a solid steel door that would be locked and accessed only by authorized personnel;
- Tower exteriors would be designed to be unclimbable;
- A professional engineer would certify that the foundation and tower design of the turbines is within accepted professional standards, given local soil and climate conditions.
- Prior to construction, the Project contractor would request utility locates through the One-Call program to avoid impacting existing underground infrastructure.
- Prior to construction, the Project contractor would work with local and county emergency management to develop procedures for response to emergencies, natural hazards, hazardous materials incidents, manmade problems, and potential incidents concerning Project construction. The contractor would provide site maps, haul routes, project schedules, contact numbers, training, and other requested project information to local and county emergency management.
- During Project operations, the Project operator would coordinate with local and county emergency management to develop an emergency management plan to be implemented in the event of an emergency at the Project site. The Project would register each turbine location and the O&M building with the rural identification/addressing (fire number) system and 911 systems.
- Following construction, the Project will register Project underground facilities with the One-Call program.

26.0 INFORMATION CONCERNING WIND ENERGY FACILITIES (ARSD 20:10:22:33.02)

ARSD 20:10:22:33.02. Information concerning wind energy facilities. *If a wind energy facility is proposed, the applicant shall provide the following information:*
(1) Configuration of the wind turbines, including the distance measured from ground level to the blade extended at its highest point, distance between the wind turbines, type of material, and color;
(2) The number of wind turbines, including the number of anticipated additions of wind turbines in each of the next five years;
(3) Any warning lighting requirements for the wind turbines;
(4) Setback distances from off-site buildings, right-of-ways of public roads, and property lines;
(5) Anticipated noise levels during construction and operation;
(6) Anticipated electromagnetic interference during operation of the facilities;
(7) The proposed wind energy site and major alternatives as depicted on overhead photographs and land use culture maps;
(8) Reliability and safety;
(9) Right-of-way or condemnation requirements;
(10) Necessary clearing activities;
(11) Configuration of towers and poles for any electric interconnection facilities, including material, overall height, and width;
(12) Conductor configuration and size, length of span between structures, and number of circuits per pole or tower for any electric interconnection facilities; and
(13) If any electric interconnection facilities are placed underground, the depth of burial, distance between access points, conductor configuration and size, and number of circuits.

The following information requirements concerning wind energy facilities have been discussed in previous sections of this Application, as indicated below.

- Configuration of wind turbine – Section 9.2
- Number of wind turbines – Section 9.1
- Warning lighting requirements for wind turbines – Section 21.4.2.2
- Setback distances – Section 10.2
- Sound levels during construction and operation – Section 16.3.2
- Electromagnetic interference – Section 16.5
- Site and major alternatives – Chapter 10.0
- Reliability and safety – Chapter 25.0
- Right-of-way or condemnation requirements – Chapter 9.0 and Section 10.3
- Clearing activities – Sections 9.10 and 14.1.2
- Configuration of interconnection towers and poles – Section 9.6
- Conductor and structure configurations – Section 9.6
- Underground electric interconnection facilities – Section 9.4

Please refer to Chapter 4.0 Completeness Checklist (ARSD 20:10:22:33.02, Information concerning wind energy facilities) for additional requirement details.

27.0 ADDITIONAL INFORMATION IN APPLICATION (ARSD 20:10:22:36)

The following sections discuss permits and approvals, agency coordination, public and agency comments, and burden of proof.

27.1 Permits and Approvals

The Project must comply with Federal, State, and local laws requiring permits or approvals. Table 27-1 lists the permits and approvals that are applicable to the Project.

Table 27-1: List of Applicable Permits or Approvals

Agency	Permit/Approval	Description	Status
USFWS	Compliance with Section 10 of the ESA	Private non-federal entities undertaking projects may not result in the take of an endangered or threatened species, unless an incidental take permit is issued by the USFWS.	Wildlife studies and coordination with USFWS determined low risk to threatened and endangered species warranting permitting under the ESA. No incidental take permit warranted. BBCS to be prepared and implemented for the Project.
USFWS	Compliance with the BGEPA	Projects may not result in the take of bald or golden eagles, unless an eagle take permit is issued by the USFWS.	Wildlife studies and coordination with USFWS determined low risk to eagles. No permit warranted. BBCS to be prepared and implemented for the Project.
FAA	Form 7460-1, Notice of Proposed Construction or Alteration	Required if construction or alteration is within 6 miles of public aviation facility and for structures higher than 200 feet	Received Determinations of No Hazard from FAA for a preliminary layout in February 2016 and for current layout in December 2017. Notices of Proposed Construction for the final layout will be filed after final design is complete.
USACE	Section 404 permit	Authorization under the Clean Water Act for impacts to wetlands and waters of the U.S.	Impacts will comply with USACE NWP 12 requirements.

Agency	Permit/Approval	Description	Status
South Dakota SHPO	Coordination	Coordination regarding potential effects on archaeological and historical resources	A CRMMP was developed in coordination with SHPO; cultural resources surveys completed in December 2017 in accordance with CRMMP. Avoidance and mitigation measures will be implemented per the CRMMP to protect archaeological and historic resources.
Native American tribes	Coordination	Coordination regarding potential effects on Native American cultural resources	Cultural resources surveys are being completed in coordination with the SWO, allowing the SWO opportunities to review finds and participate in eligibility recommendations and avoidance plans for sensitive tribal resources.
SDPUC	Energy Facility Site Permit	Application required for wind facilities with nameplate capacity greater than 100 megawatts	Submitted January 2018
SDGFP	Coordination	Coordination regarding effects on state-listed threatened or endangered species	Wildlife studies and coordination with SDGFP complete. Site determined low risk to state-listed species. Avoidance and minimization measures will be implemented to address potential impacts. BBCS to be prepared and implemented for the Project
SDDENR	Section 401 Water Quality Certification	Complete an application under the Clean Water Act, only if Individual Permit is required for Section 404	Project-specific certification is not anticipated due to NWP 12 compliance.
	General Permit for Storm Water Discharges Associated with Construction Activities	Storm water permit required for construction activities	SWPPP will be prepared and Notice of Intent will be submitted after final design is complete.

Agency	Permit/Approval	Description	Status
	Temporary Water Use Permit	Temporary permits for the use of public water for construction, testing, or drilling purposes; issuance of a temporary permit is not a grant of water right	If necessary, will be obtained prior to construction.
	General Permit for Temporary Discharges	Temporary permit for the use of public water for construction dewatering	If necessary, will be obtained prior to construction.
	Water Rights Permit for Nonirrigation Use	Needed if water will be appropriated for O&M facility	If necessary, will be obtained prior to construction.
SDDOT, Aeronautics Commission	Aeronautical Hazard Permit	Permit lighting plan determined with FAA coordination	Will be completed after final design is complete.
SDCL 49-32-3.1	Notice to telecommunications companies	Telecommunication companies review the preliminary electrical layout and may suggest revisions to reduce impact to their systems	Will be completed after final design is complete.
SDDOT	Highway Access Permit	Permit required for any access roads abutting State roads	If necessary, will be obtained after final design is complete.
	Utility Permit	Permit required for any utility crossing or use within State road right-of-way	If necessary, will be obtained after final design is complete.
	Oversize & Overweight Permit	Permit required for heavy equipment transport over State roads during construction	Will be obtained prior to transport of overweight/oversized loads.
Codington County	Conditional Use Permit	Permit required for construction of the Project	Obtained June 19, 2017.
	Individual Building Permits	Permit required for construction of each turbine and building	Will be obtained prior to construction.
	County Road Permits	County Road Permits are required for right-of-way occupancy, utility crossings, road approaches, and overweight loads	Will be obtained prior to activity requiring permit.
	County Road Use Agreement	Road use agreement may be required	Will be obtained in Q3 2018.
Grant County	Conditional Use Permit	Permit required for construction of the Project	Obtained June 12, 2017.

Agency	Permit/Approval	Description	Status
	Individual Building Permits	Permit required for construction of each turbine and building	Will be obtained prior to construction.
	County Road Permits	County Road Permits are required for right-of-way occupancy, utility crossings, road approaches, and overweight loads	Will be obtained prior to activity for which permit is required.
	County Road Use Agreement	Road use agreement may be required	Will be obtained in Q3 2018.

27.2 Agency Coordination

Throughout Project planning and development, the Applicant has coordinated with various Federal, State, Tribal, and local agencies to identify potential concerns regarding the proposed Project. Copies of agency correspondence and meeting summaries are included in Appendix B. Following is a summary of the primary agency meetings completed to date:

USFWS and SDGFP

- **August 12, 2015 Coordination Meeting at SDGFP Office in Pierre**: The Applicant met with the USFWS and SDGFP to discuss the proposed Project. The purpose of the meeting was to introduce the agencies to Dakota Range, present results of the Tier 1 and 2/Stage 1 reviews, agree on Tier 3/Stage 2 studies to be completed to assess risk, and discuss potential impact avoidance and minimization measures for the Project.
- **March 28, 2017 Coordination Meeting at SDGFP Office in Pierre**: The Applicant met with the USFWS and SDGFP to continue coordination on the Project in accordance with the WEG, ECPG, and SD Guidelines. The purpose of the meeting was to review the current Project boundary, discuss the results of wildlife studies completed to date, and agree on next steps.
- **September 25, 2017 Coordination Meeting at SDGFP Office in Pierre**: The Applicant met with the USFWS and SDGFP to continue coordination on the Project in accordance with the WEG, ECPG, and SD Guidelines. The purpose of the meeting was to discuss the results of wildlife studies completed to date, agree on avoidance and minimization measures, and discuss the SDPUC Energy Facility Permit application requirements.
- USFWS and SDGFP coordination and recommendations regarding federally listed species, state-listed species, eagles/avian species, and bats are discussed in Sections 14.3.1 and 15.1.

SHPO

- **June 13, 2017 Coordination Meeting at SHPO Office in Pierre**: The Applicant met with the SHPO to discuss the Project. The purpose of the meeting was to introduce SHPO to Dakota Range, discuss the Level I cultural resources records search, and discuss recommendations for Level III cultural resources surveys.
- **August 29, 2017 Coordination Meeting at SHPO Office in Pierre**: The Applicant met with the SHPO to continue coordination on the Project. The purpose of the meeting was to review Dakota Range's proposed CRMMP and solicit SHPO's recommendations and comments on the CRMMP.
- SHPO coordination and recommendations regarding cultural resource surveys and the CRMMP are discussed in Sections 21.5.1.3 and 21.5.2.

SWO

- **October 10, 2017 Coordination Meeting at SWO Office in Agency Village, SD**: The Applicant met with the SWO to continue coordination on the Project. The purpose of the meeting was to review Dakota Range's proposed CRMMP and solicit SWO's recommendations on tribal monitoring and cultural resources surveys for the Project.
- Tribal coordination is discussed in Section 21.5.1.6.

SDDENR

- **July 2017 Correspondence with SDDENR**: A letter was sent to SDDENR on July 7, 2017, requesting input regarding environmental resources in the Project area that should be considered in the SDPUC application. SDDENR provided comments on the Project in a letter dated July 26, 2017.
- SDDENR comments regarding impaired waters, drinking waters, groundwater quality, air quality, and waste management are discussed in Sections 13.2.2.1, 13.3.2, 18.0, 19.2, and 21.3.2, respectively.

Codington County

- **March 1, 2017 Pre-Application Meeting at Codington County Zoning Office in Watertown, SD**: The Applicant met with the Codington County Zoning Office to discuss county zoning and land use permitting requirements for the Project.
- **May 16, 2017 Punished Woman's Lake Association Meeting in South Shore, SD**: The applicant met with the Punished Woman's Lake Association to inform the community about the Project and address concerns related to potential viewshed impacts at Punished Woman's Lake.

- **June 19, 2017 Codington County Planning Commission Public Hearing in Watertown, SD**: The Codington County Planning Commission unanimously approved Dakota Range's application for a Conditional Use Permit for the Project during their June 19, 2017 meeting.
- Codington County permitting is discussed in Chapter 17.0.

Grant County

- **February 28, 2017 Pre-Application Meeting at County Planning and Zoning Office in Milbank, SD**: The Applicant met with the Grant County Planning and Zoning Office to discuss county zoning and land use permitting requirements for the Project.
- **June 12, 2017 Grant County Planning and Zoning Board Public Hearing in Milbank, SD**: The Grant County Planning and Zoning Board unanimously approved Dakota Range's application for a Conditional Use Permit for the Project during their June 12, 2017 meeting.
- Grant County permitting is discussed in Chapter 17.0.

Dakota Range will continue coordinating with these agencies throughout Project development.

28.0 TESTIMONY AND EXHIBITS (ARSD 20:10:22:39)

The Applicant is submitting testimony and exhibits in support of this Application. The individuals identified in Table 28-1 are providing testimony in support of the Application. Dakota Range reserves the right to provide supplemental and/or rebuttal testimony, as needed, to further support this Application.

Table 28-1: List of Individuals Providing Testimony

Individual	Title	Company	Subject Matter
Mark Mauersberger	Senior Development Manager	Apex Clean Energy Holdings, LLC	Project development
David Phillips	Vice President of Environmental	Apex Clean Energy Holdings, LLC	Wildlife; vegetation; cultural resources
Robert O'Neal	Certified Consulting Meteorologist	Epsilon Associates, Inc.	Sound; shadow flicker

28.1 Applicant Verification

Mr. Mark Goodwin, the President and Chief Executive Officer and authorized representative of the Applicant, is authorized to sign this Application on behalf of the Project Owner/Applicant, Dakota Range.

He further states that he does not have personal knowledge of all the facts recited in the Application and Exhibits and Attachments attached hereto, but the information has been gathered from employees and agents of the Owner/Applicant, and the information is verified by him as being true and correct on behalf of the Owner/Applicant.

Dated this 24th day of January 2018.

M Goodwin

Mr. Mark Goodwin
President and Chief Executive Officer
Apex Clean Energy Holdings, LLC
On Behalf of Dakota Range I, LLC and Dakota Range II, LLC

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APPENDIX A – FIGURES

APPENDIX B – AGENCY COORDINATION

APPENDIX C – DASK/POSK HABITAT SURVEY

APPENDIX D – 2016 RAPTOR NEST SURVEY

APPENDIX E – 2017 RAPTOR NEST SURVEY

APPENDIX F – AVIAN USE SURVEY

APPENDIX G – 2016 GROUSE LEK SURVEY

APPENDIX H – 2017 GROUSE LEK SURVEY

APPENDIX I – SOUND LEVEL MODELING REPORT

APPENDIX J – SHADOW FLICKER MODELING REPORT

APPENDIX K – COUNTY CONDITIONAL USE PERMITS

APPENDIX L – PROPERTY VALUE EFFECTS STUDIES

APPENDIX M – LEVEL I CULTURAL RESOURCES REPORT (NOT FOR PUBLIC DISCLOSURE)

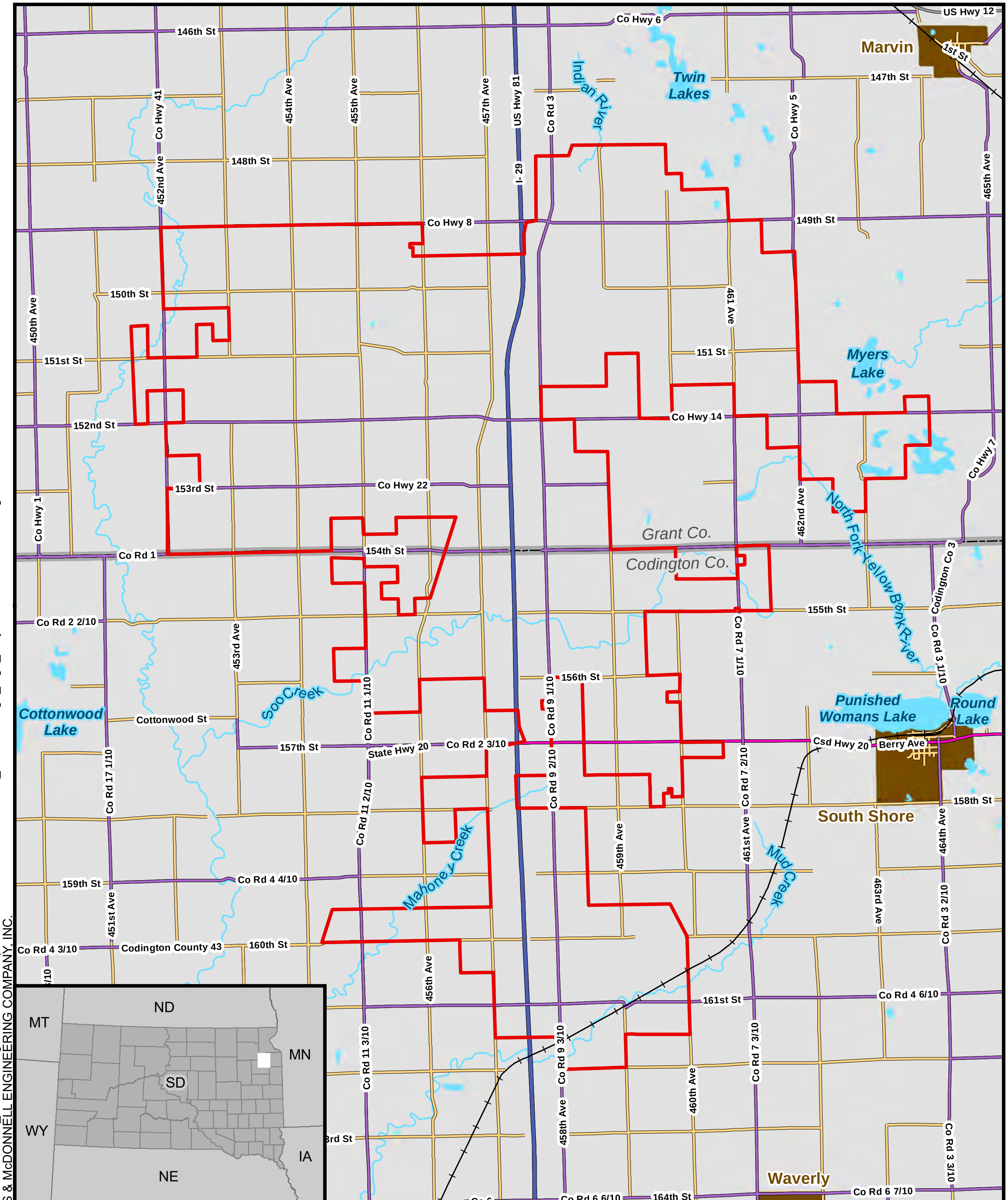
APPENDIX N – CULTURAL RESOURCES MONITORING AND MANAGEMENT PLAN

APPENDIX O – ARCHITECTURAL SURVEY REPORT (NOT FOR PUBLIC DISCLOSURE)

APPENDIX P – DECOMMISSIONING PLAN

CREATE AMAZING.

Burns & McDonnell Denver Regional Office
9785 Maroon Circle, Suite 400
Centennial, CO 80112
O 303-721-9292
F 303-721-0563
www.burnsmcd.com



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Project Area	County Boundary
County Highway	Town
Interstate	River
Major Road	Lake
State Highway	Railroad
US Highway	

NORTH

2 1 0 2

Scale in Miles

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Figure 1
Project Area
Dakota Range Wind Energy Facility
SDPUC Application

Source: Esri, Census TIGER Data, and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018

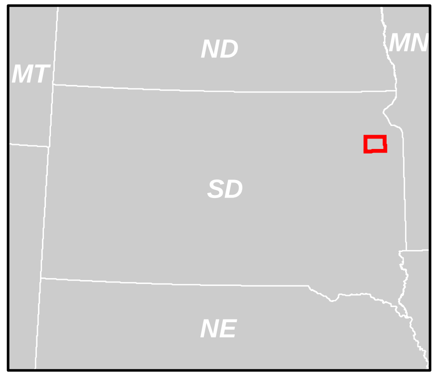


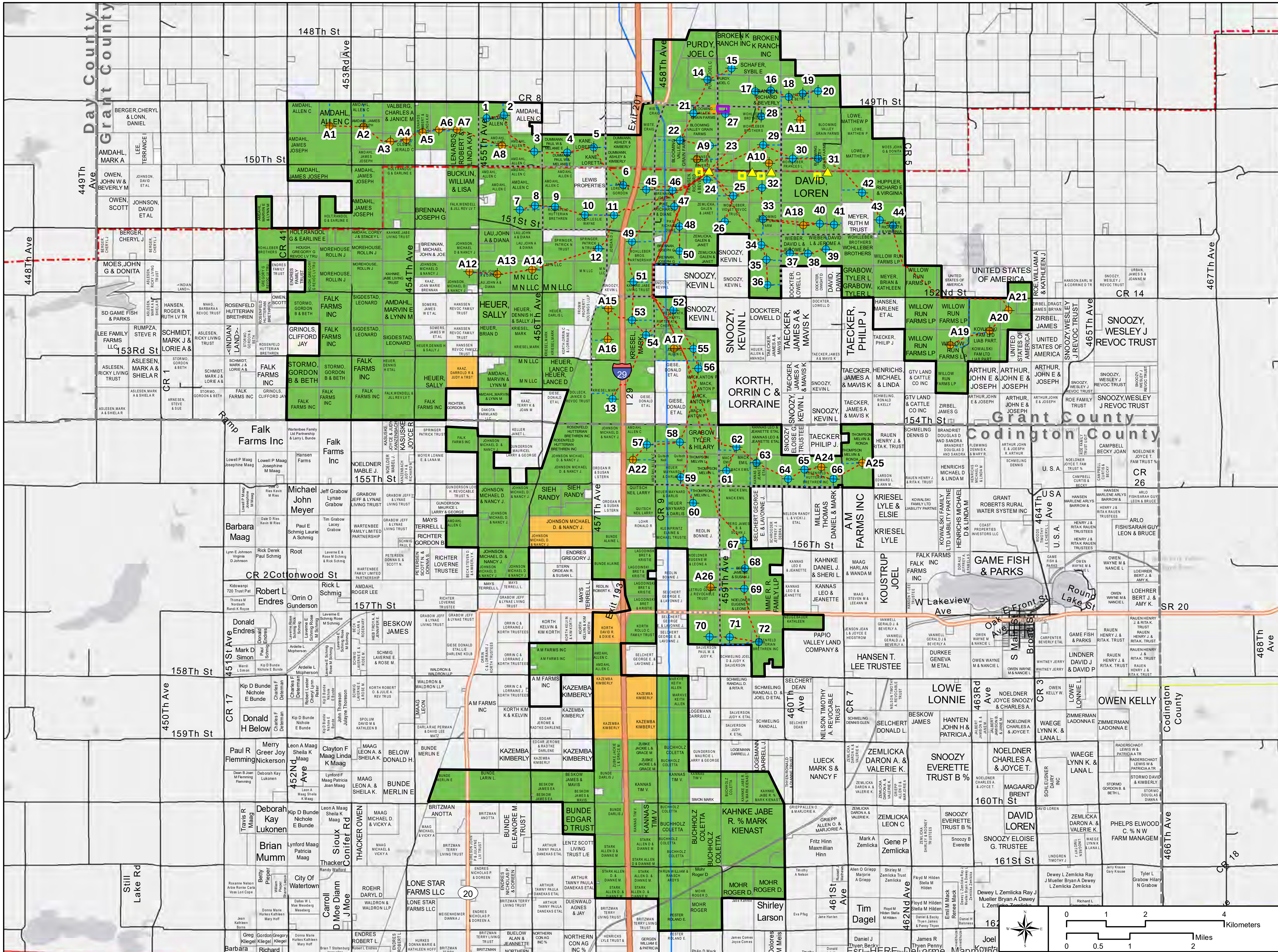
Figure 2
Dakota Range
Project Map

- Project Boundary
- County Boundary
- Parcel Boundary
- Primary Turbine
- Spare Turbine
- Private Access Road
- Public Road
- Underground Collection
- Potential Laydown
- Potential O&M
- Potential Substations
- Potential Point of Interconnect

Lease Status
- Lease, Signed
- Collection Easement, Signed

Existing Transmission
- 34kV5 - 69kV
- 240kV - 345kV
- 100kV - 138kV

Proposed Transmission
- 240kV - 345kV



Date: 1/5/2018 Author: MR

Coordinate System: NAD 1983 StatePlane South Dakota North FIPS 4001 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US

APEX CLEAN ENERGY

Figure 3: Typical Wind Turbine Diagram

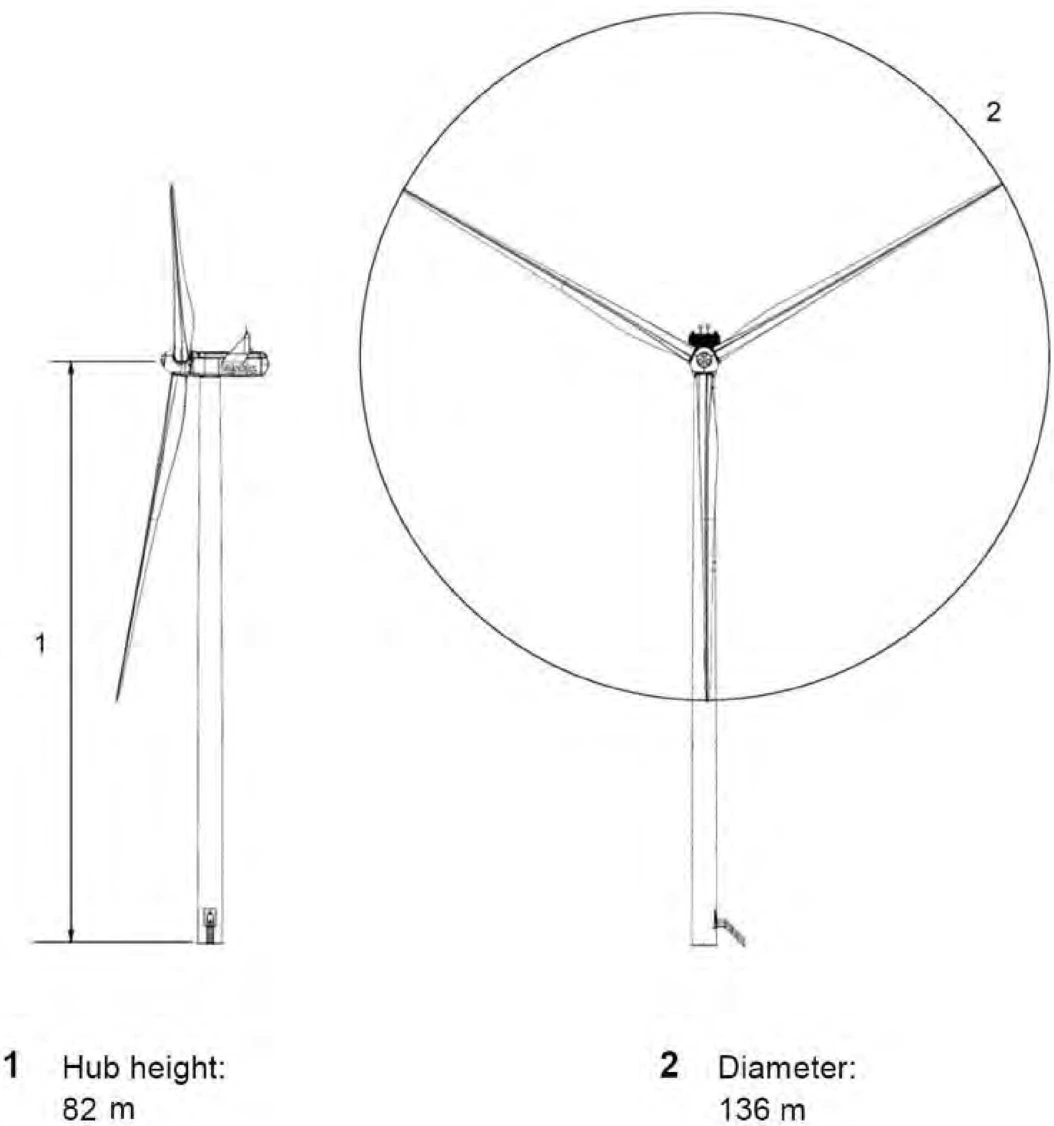
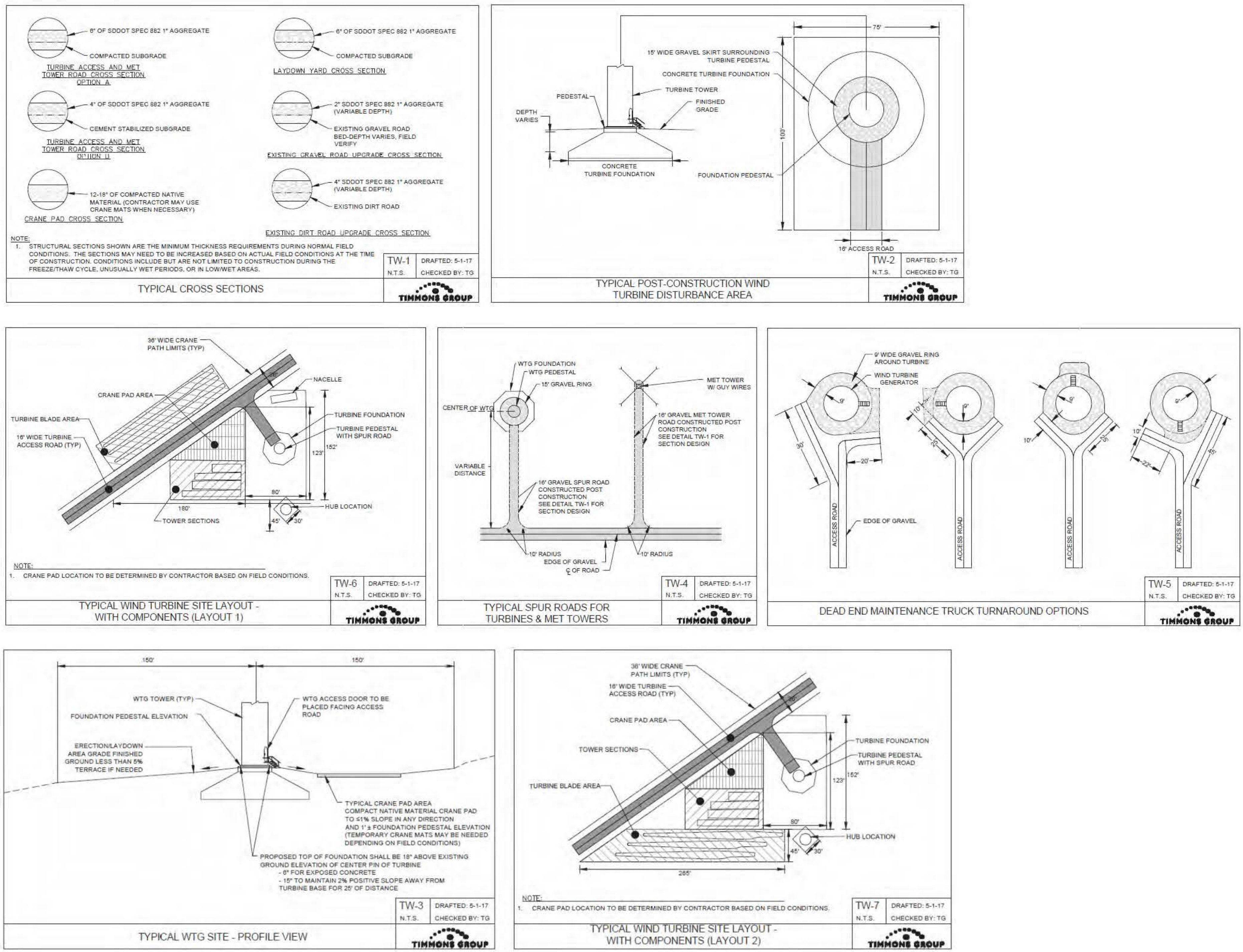


Figure 4: Typical Turbine Construction Site Layout



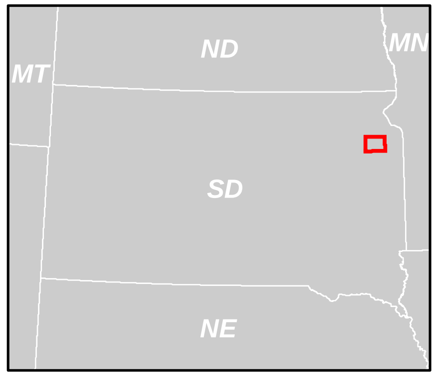
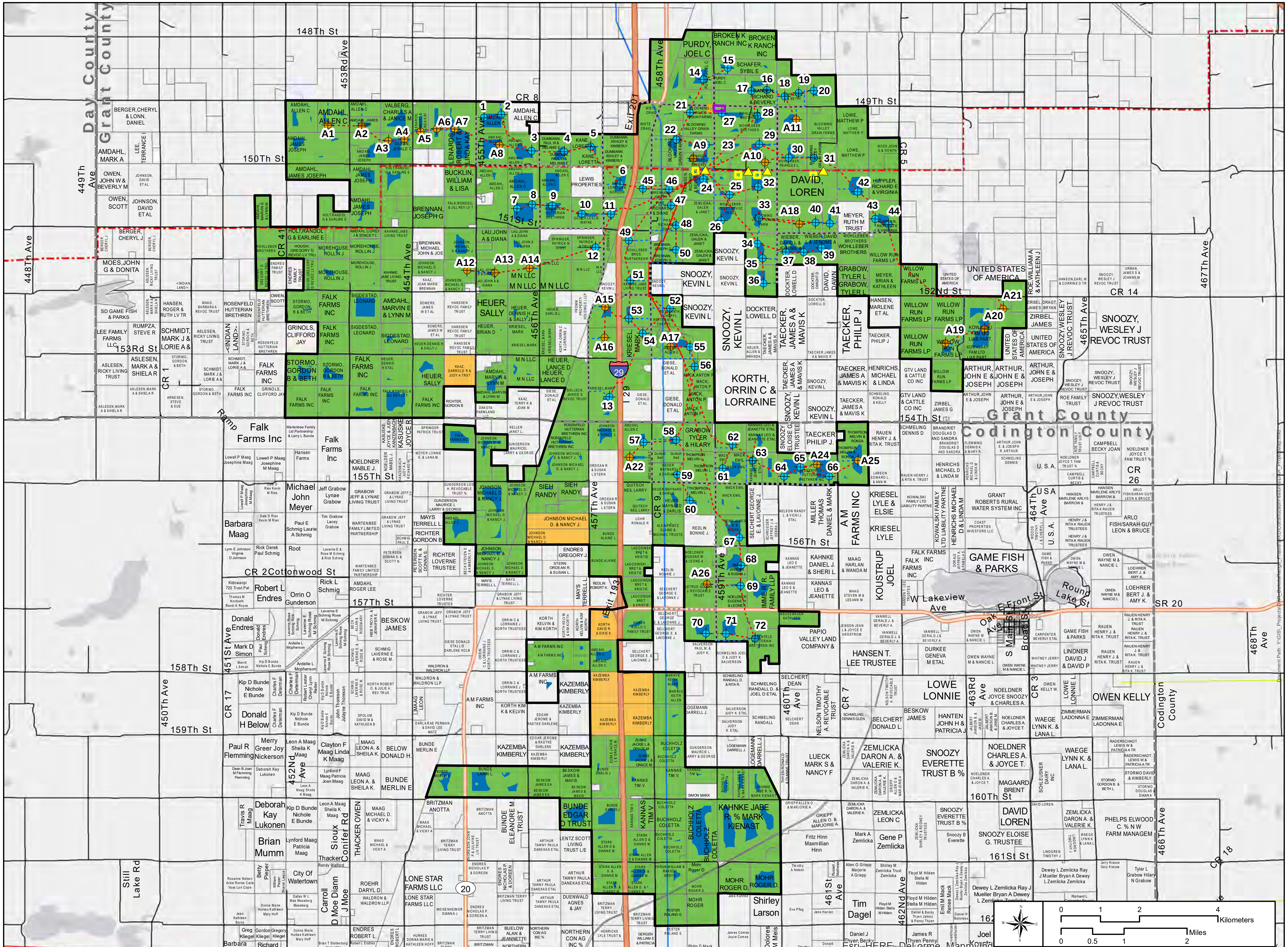


Figure 5
Dakota Range
Constraints Map



- Project Boundary
- County Boundary
- Parcel Boundary
- Buildable Area
- Primary Turbine
- Spare Turbine
- Private Access Road
- Public Road
- Underground Collection
- Potential Laydown
- Potential O&M
- Potential Substations
- Potential Point of Interconnect

Lease Status

- Lease, Signed
- Collection Easement, Signed

Existing Transmission

- 34kV5 - 69kV
- 240kV - 345kV
- 100kV - 138kV

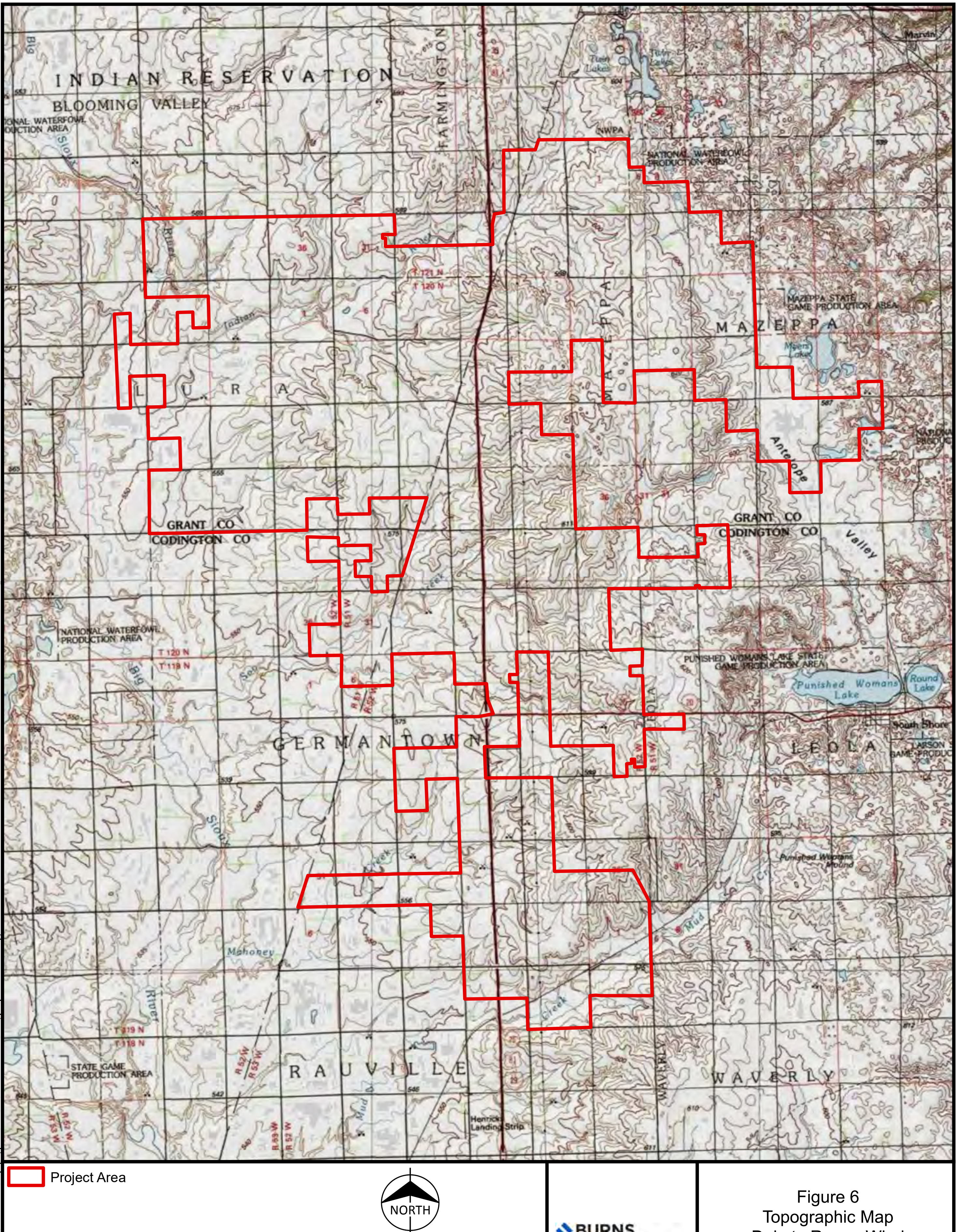
Proposed Transmission

- 240kV - 345kV

Date: 1/5/2018 Author: MR

Coordinate System: NAD 1983 StatePlane South Dakota North FIPS 4001 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US

APEX CLEAN ENERGY



Project Area

NORTH

2 1 0 2

Scale in Miles

BURNS McDONNELL

Figure 6
Topographic Map
Dakota Range Wind
Energy Facility
SDPUC Application

Source: Esri, and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018

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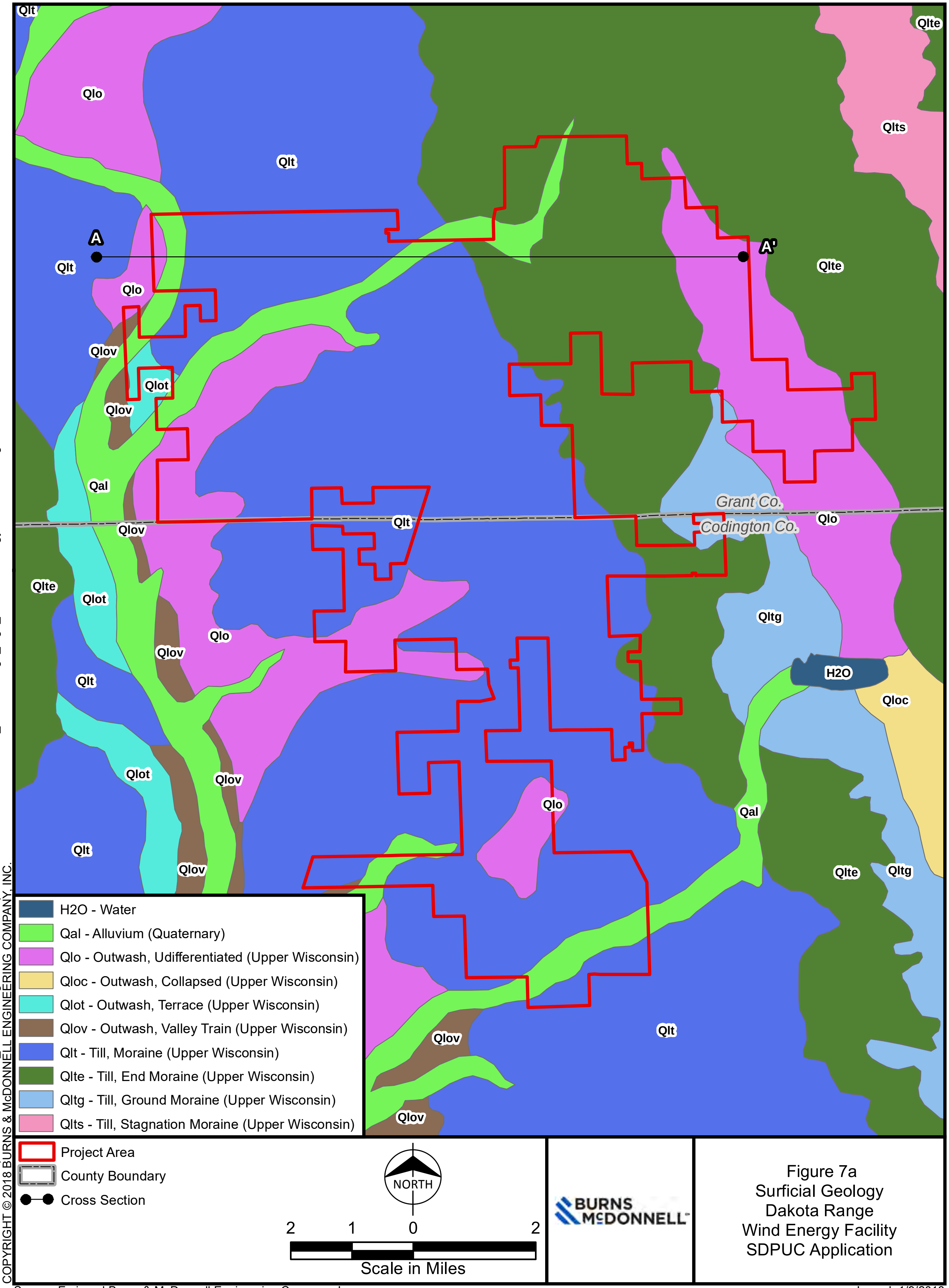

Figure 7a
Surficial Geology
Dakota Range
Wind Energy Facility
SDPUC Application

Source: Esri, and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018

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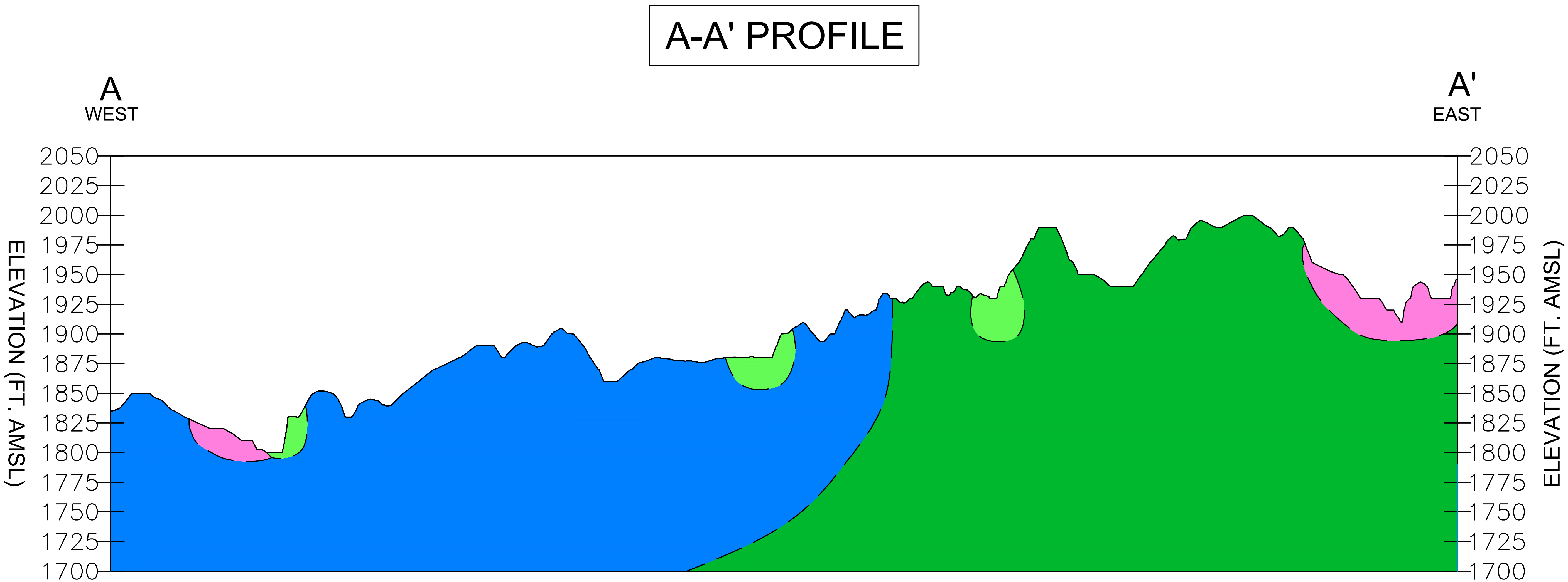

LEGEND

QAL - ALLUVIUM (QUATERNARY)

QLO - OUTWASH, UNDIFFERENTIATED (UPPER WISCONSIN)

QLT - TILL, MORAINE (UPPER WISCONSIN)

QLTE - TILL, END MORAINE (UPPER WISCONSIN)

— — INFERRED CORRELATION

NOTES:

1. CORRELATION OF UNITS IS AN INTERPRETATION AND NOT NECESSARILY A DELINEATION OF ACTUAL EXTENT AND THICKNESS OF INDIVIDUAL UNITS.

0 4500' 9000'
HORIZONTAL SCALE IN FEET

0 90' 180'
VERTICAL SCALE IN FEET

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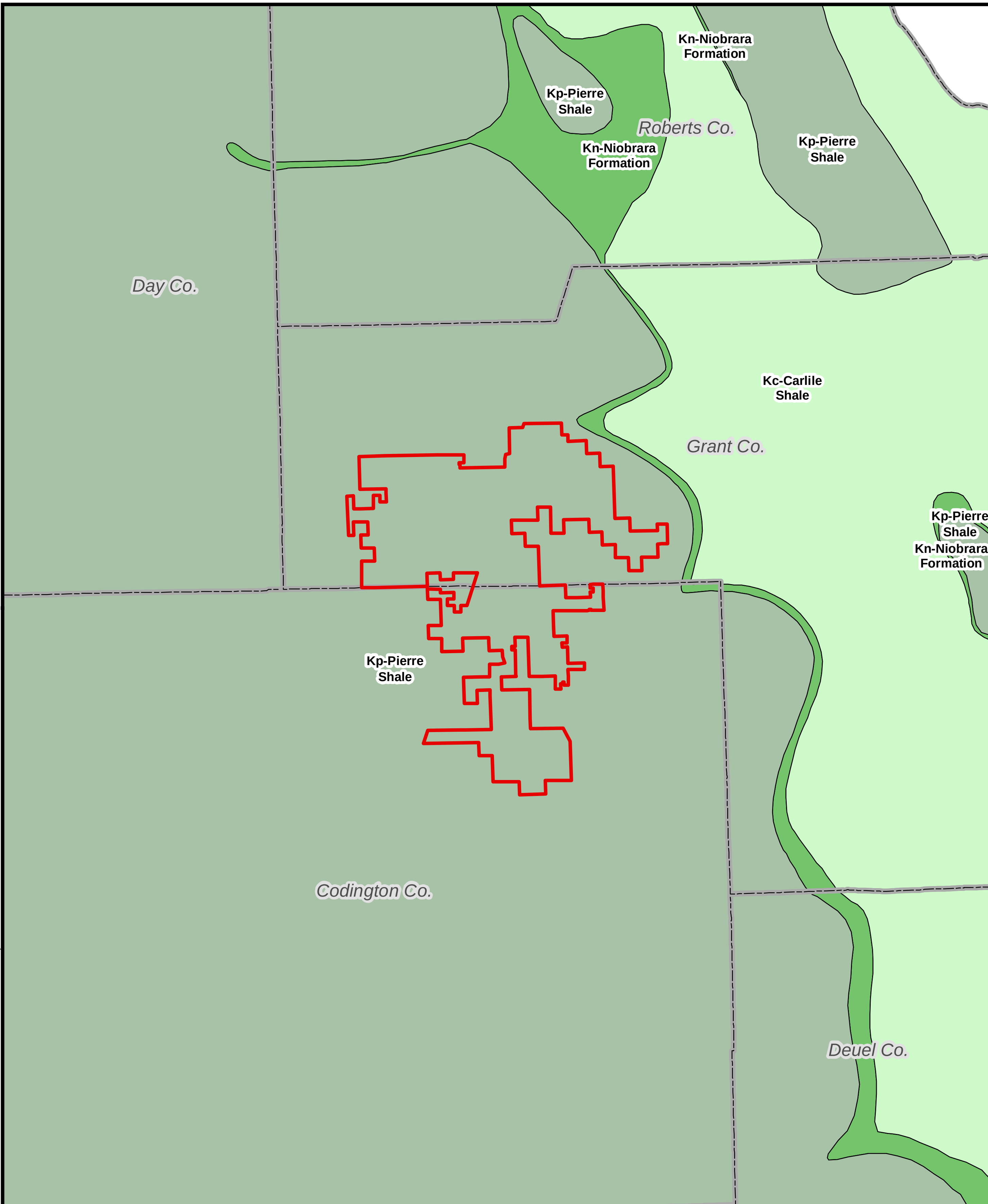
FIGURE 7B

GEOLOGIC CROSS SECTION A-A'

SOUTH DAKOTA
WIND ENERGY FACILITY
SDPUC APPLICATION



Project Area
County Boundary

Formation

Kp-Pierre Shale
Kn-Niobrara Formation
Kc-Carlile Shale

NORTH

5 2.5 0 5

Scale in Miles

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Figure 8
Bedrock Geology
Dakota Range
Wind Energy Facility
SDPUC Application

Source: Esri, South Dakota DENR, and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018

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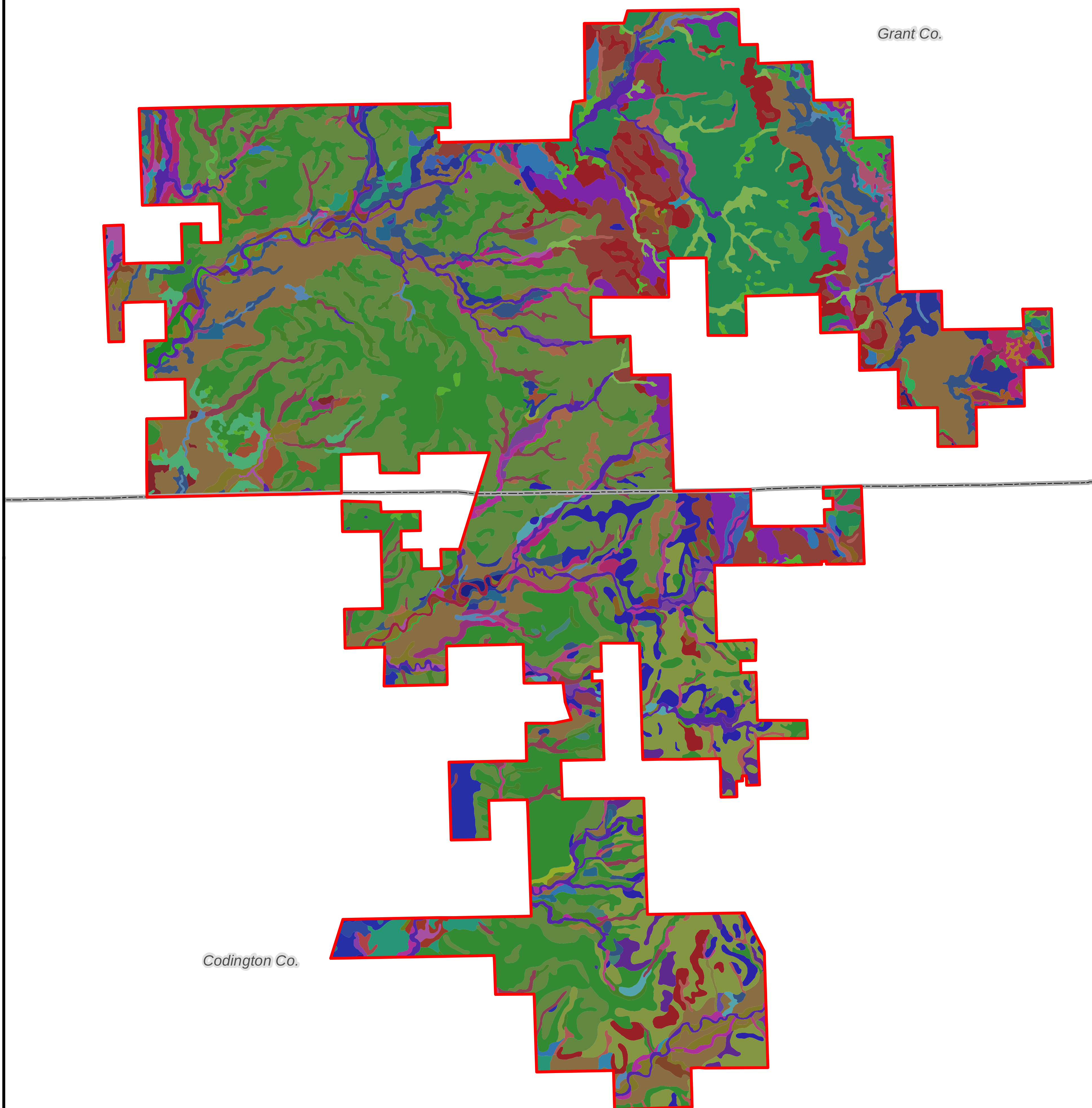

MUSYM, MUName

- J124A - Cubden-Tonka silty clay loams, coteau, 0 to 2 percent slopes
- J143A - Kranzburg-Brookings silty clay loams, 0 to 2 percent slopes
- J143B - Kranzburg-Brookings silty clay loams, 1 to 6 percent slopes
- J145A - Kranzburg-Cresbard complex, 0 to 2 percent slopes
- J192A - Waubay-Badger silty clay loams, 0 to 2 percent slopes
- M-W - Miscellaneous water
- Pb - Southam silty clay loam, 0 to 1 percent slopes
- Ta - Tonka silty clay loam, 0 to 1 percent slopes
- W - Water
- Z101A - Tonka silty clay loam, 0 to 1 percent slopes
- Z102A - Badger-Tonka silty clay loams, coteau, 0 to 1 percent slopes
- Z107A - Parnell silty clay loam, coteau, 0 to 1 percent slopes
- Z110A - Vallers loam, coteau, 0 to 1 percent slopes
- Z112A - Vallers-Hamerly loams, coteau, 0 to 2 percent slopes
- Z113A - Vallers-Parnell complex, coteau, 0 to 2 percent slopes
- Z114A - Hamerly-Tonka complex, coteau, 0 to 2 percent slopes
- Z115A - Hamerly-Badger complex, coteau, 0 to 2 percent slopes
- Z116A - McKranz-Hidewood, frequently flooded, silty clay loams, 0 to 2 percent slopes
- Z117A - McKranz-Badger silty clay loams, 0 to 2 percent slopes
- Z125B - Kings Lake-Buse-Waubay complex, 1 to 6 percent slopes
- Z139 - Udorthents, loamy, coteau (cut and fill land)
- Z140F - Buse-Langhei complex, coteau, 15 to 40 percent slopes
- Z141A - Barnes-Svea loams, coteau, 0 to 2 percent slopes
- Z141B - Barnes-Svea loams, coteau, 1 to 6 percent slopes
- Z142B - Barnes-Buse-Svea loams, coteau, 1 to 6 percent slopes
- Z142C - Barnes-Buse-Svea loams, coteau, 2 to 9 percent slopes
- Z143C - Barnes-Buse loams, coteau, 6 to 9 percent slopes
- Z144E - Buse-Barnes loams, coteau, 9 to 20 percent slopes
- Z145D - Buse-Barnes loams, coteau, 2 to 15 percent slopes, very stony
- Z145F - Buse-Barnes loams, coteau, 9 to 40 percent slopes, very stony
- Z146F - Buse-Lamoure, channeled, frequently flooded, complex, 0 to 40 percent slopes
- Z150A - Rauville silty clay loam, coteau, 0 to 1 percent slopes, frequently flooded
- Z152A - Lamoure silty clay loam, coteau, 0 to 1 percent slopes, occasionally flooded
- Z153A - Lamoure-Rauville silty clay loams, channeled, 0 to 2 percent slopes, frequently flooded
- Z157A - Fairdale loam, channeled, 0 to 2 percent slopes, frequently flooded
- Z158A - Marysland loam, 0 to 1 percent slopes, occasionally flooded
- Z159A - Divide loam, 0 to 2 percent slopes, occasionally flooded
- Z160A - Moritz, occasionally flooded-Lamoure, frequently flooded, complex, 0 to 2 percent slopes
- Z161A - Spottswood loam, 0 to 2 percent slopes, occasionally flooded
- Z162A - La Prairie loam, coteau, 0 to 2 percent slopes, occasionally flooded
- Z165B - Darnen loam, coteau, 2 to 6 percent slopes
- Z166A - Fordtown loam, 0 to 2 percent slopes, rarely flooded
- Z167A - Renwash loam, 0 to 2 percent slopes, rarely flooded
- Z168A - Allivar sandy loam, 0 to 2 percent slopes, rarely flooded
- Z170A - Fordville loam, coteau, 0 to 2 percent slopes
- Z171A - Renshaw-Fordville loams, coteau, 0 to 2 percent slopes
- Z171B - Renshaw-Fordville loams, coteau, 2 to 6 percent slopes
- Z172B - Renshaw loam, coteau, 2 to 6 percent slopes
- Z173B - Renshaw-Sioux complex, 2 to 6 percent slopes
- Z173C - Renshaw-Sioux complex, 6 to 9 percent slopes
- Z174D - Sioux-Renshaw complex, coteau, 9 to 15 percent slopes
- Z174F - Sioux-Renshaw complex, coteau, 15 to 40 percent slopes
- Z177 - Udorthents, coteau (gravel pits)
- Z178A - Rentill loam, coteau, 0 to 2 percent slopes
- Z179F - Sioux-Renshaw complex, 15 to 40 percent slopes, very stony
- Z180A - Goldsmith silty clay loam, coteau, 0 to 2 percent slopes
- Z182A - Estelline silt loam, coteau, 0 to 2 percent slopes
- Z182B - Estelline silt loam, coteau, 2 to 6 percent slopes
- Z183B - Estelline-Sioux complex, coteau, 2 to 6 percent slopes
- Z185A - Egeland-Embden complex, coteau, 0 to 2 percent slopes
- Z185B - Egeland-Embden complex, coteau, 2 to 6 percent slopes
- Z186B - Maddock-Egeland sandy loams, coteau, 2 to 6 percent slopes
- Z186C - Maddock-Egeland sandy loams, coteau, 6 to 9 percent slopes
- Z187A - Swenoda fine sandy loam, coteau, 0 to 2 percent slopes
- Z188B - Lanona-Swenoda fine sandy loams, coteau, 2 to 6 percent slopes
- Z190A - Brookings silty clay loam, 0 to 2 percent slopes
- Z192A - Vienna-Brookings complex, coteau, 0 to 2 percent slopes
- Z192B - Vienna-Brookings complex, coteau, 1 to 6 percent slopes
- Z193C - Vienna-Buse complex, coteau, 6 to 9 percent slopes
- Z194A - Barnes clay loam, coteau, 0 to 2 percent slopes
- Z194B - Barnes clay loam, coteau, 2 to 6 percent slopes
- Z198A - Vienna-Forestville loams, coteau, 0 to 2 percent slopes
- Z199B - Vienna-Barnes-Forestville loams, 1 to 6 percent slopes
- Z201A - Minnewaukan loamy sand, occasionally ponded, 0 to 3 percent slopes
- Z217A - McKranz silty clay loam, 0 to 2 percent slopes
- Z250A - Rauville mucky silty clay loam, ponded, 0 to 1 percent slopes, frequently flooded
- Z252A - Hidewood silty clay loam, 0 to 2 percent slopes, frequently flooded
- Z259A - Mahoney silt loam, 0 to 2 percent slopes
- Z282B - Estelline-Kampeska silt loams, 2 to 6 percent slopes

Project Area

NORTH

1.4 0.7 0 1.4

Scale in Miles

BURNS McDONNELL

Figure 9
Soil Types
Dakota Range
Wind Energy Facility
SDPUC Application

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Source: Esri, SSURGO Soils Database (SD029 V.20 09/26/2016, SD051 V.18 09/27/2016), and Burns & McDonnell Engineering Company, Inc.

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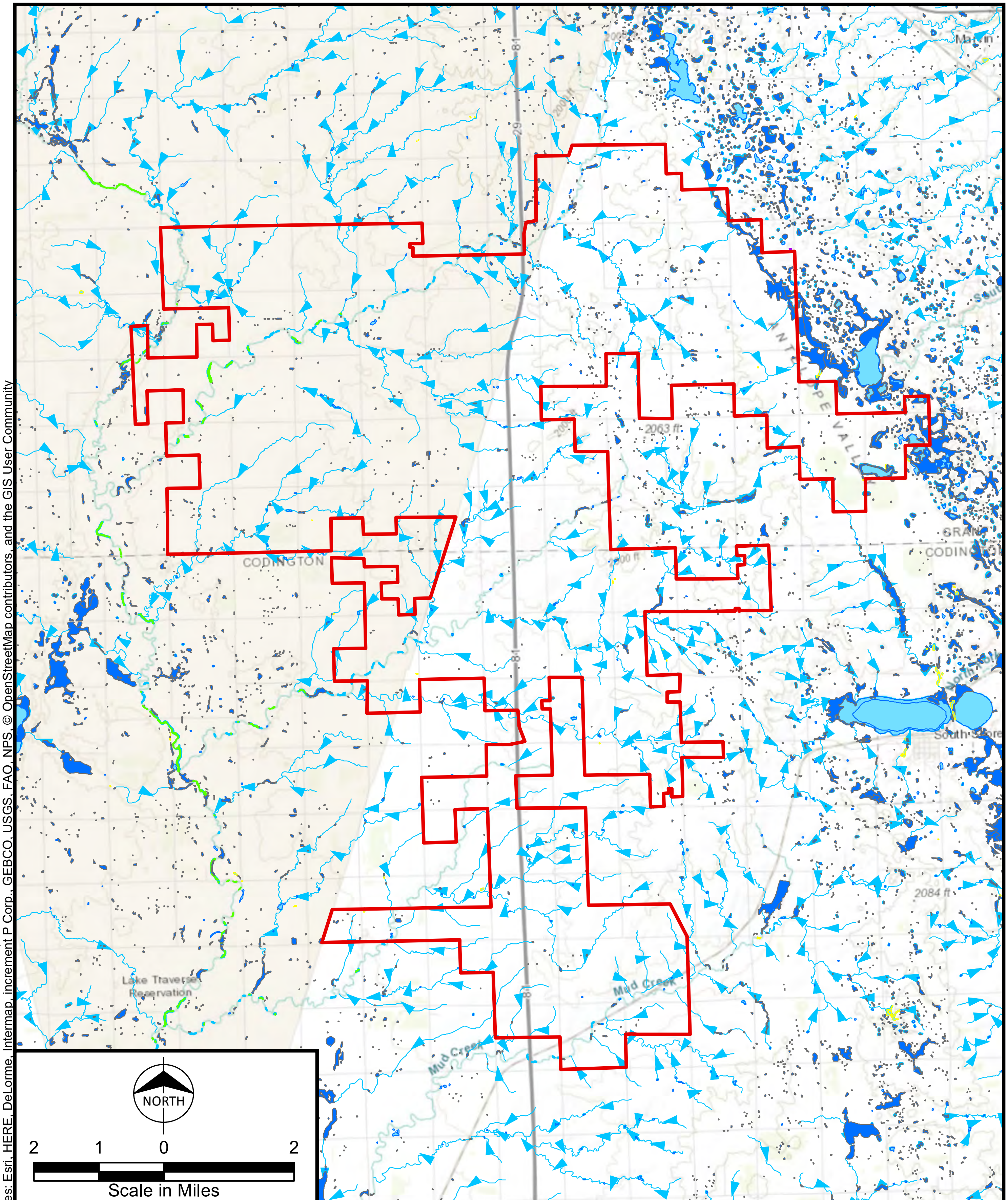

- Project
- Named NHD Flowline with Flow Direction
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond/Lake
- Other Wetland (Palustrine Unconsolidated Shore)
- Riverine
- NHD Waterbody/Area

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Figure 10
Water Resources
Dakota Range
Wind Energy Facility
SDPUC Application

Source: Esri, USFWS-National Wetland Inventory (NWI), USGS-National Hydrography Dataset, and Burns & McDonnell Engineering Company, Inc.

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Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, © OpenStreetMap contributors, and the GIS User Community

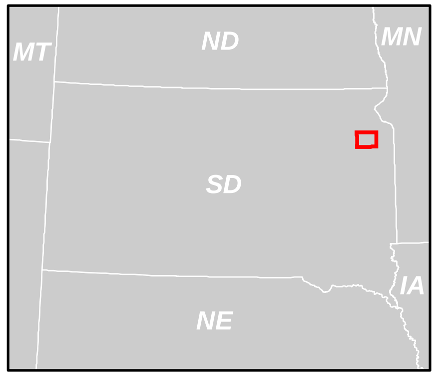


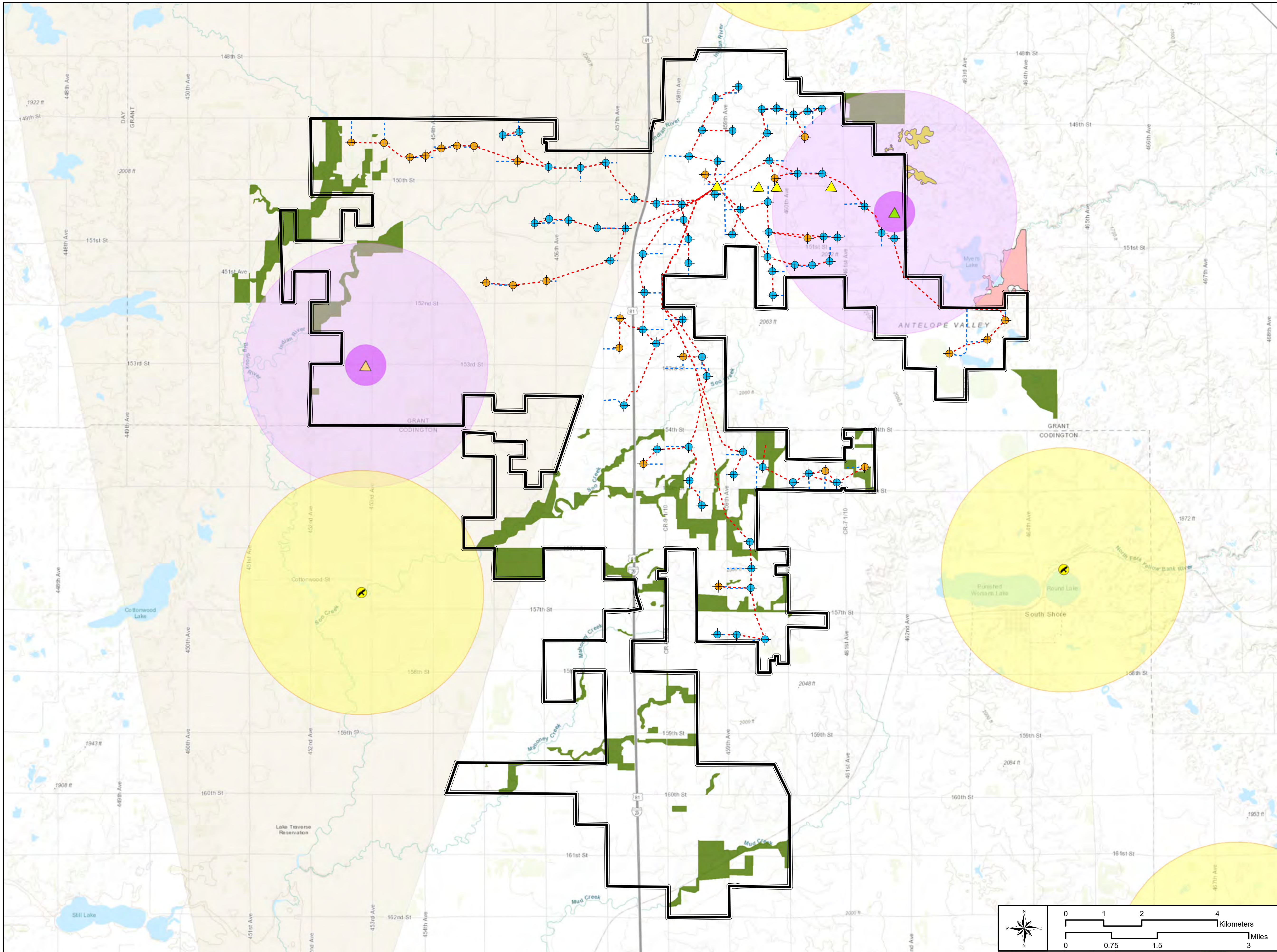
Figure 11
Dakota Range
Environmental Constraints

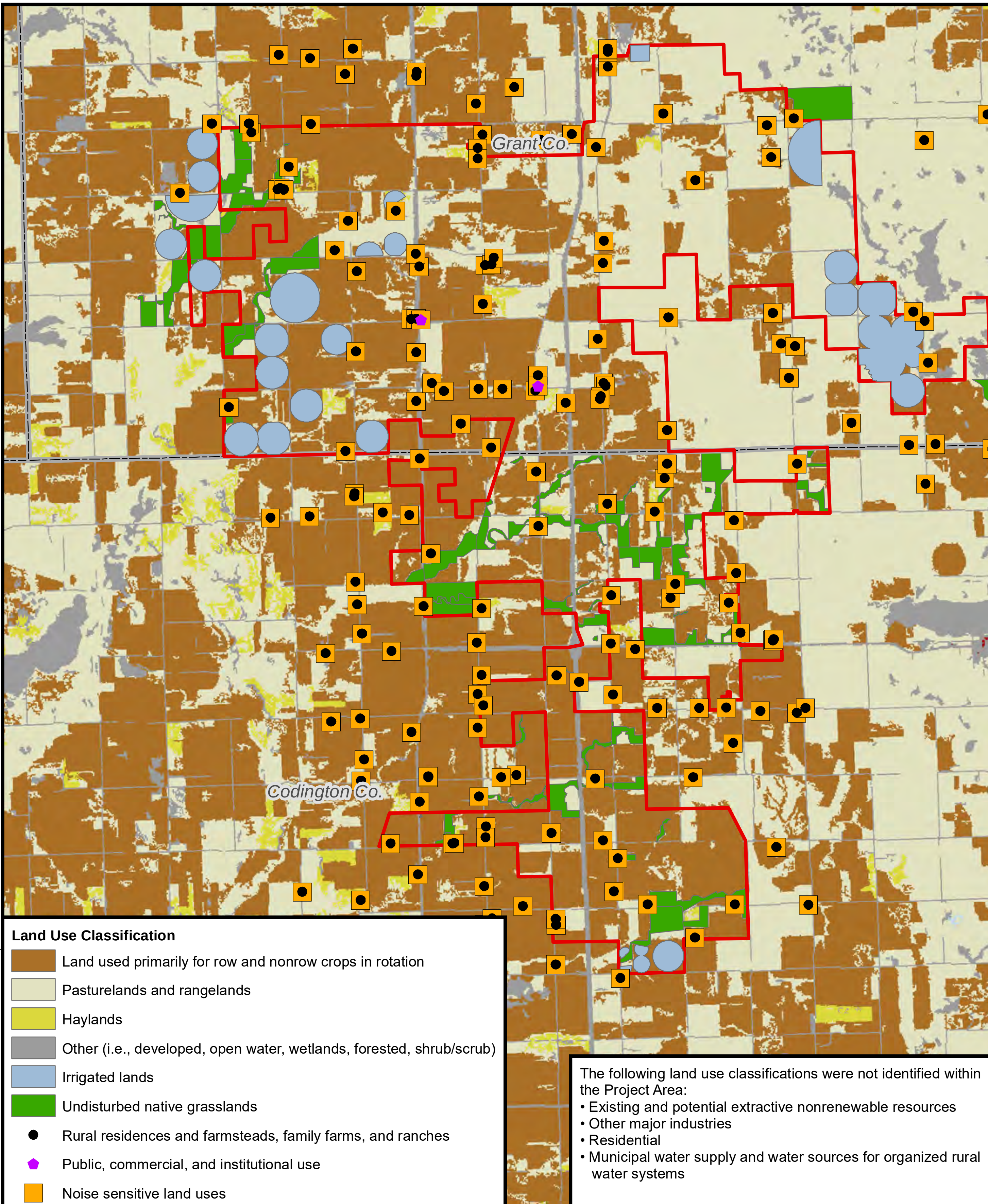
- Project Boundary
- Proposed POI
- Primary Turbine
- Spare Turbine
- Private Access Road
- Underground Collection
- BAEA, Occupied and Active
- 2-mi BAEA Nest Buffer
- STG, Confirmed 2017 Lek
- STG, Potential 2017 Lek
- Lek Avoidance Buffer (1/3-mi)
- Lek Construction Timing Buffer (2-mi)
- USFWS Critical Habitat
- Potentially Suitable DASK Habitat
- Untilled Grassland

Date: 1/5/2018 Author: MR

Coordinate System: NAD 1983 2011 StatePlane South Dakota North FIPS 4001 Ft US
Projection: Lambert Conformal Conic
Datum: NAD 1983 2011
Units: Foot US

APEX CLEAN ENERGY





The following land use classifications were not identified within the Project Area:

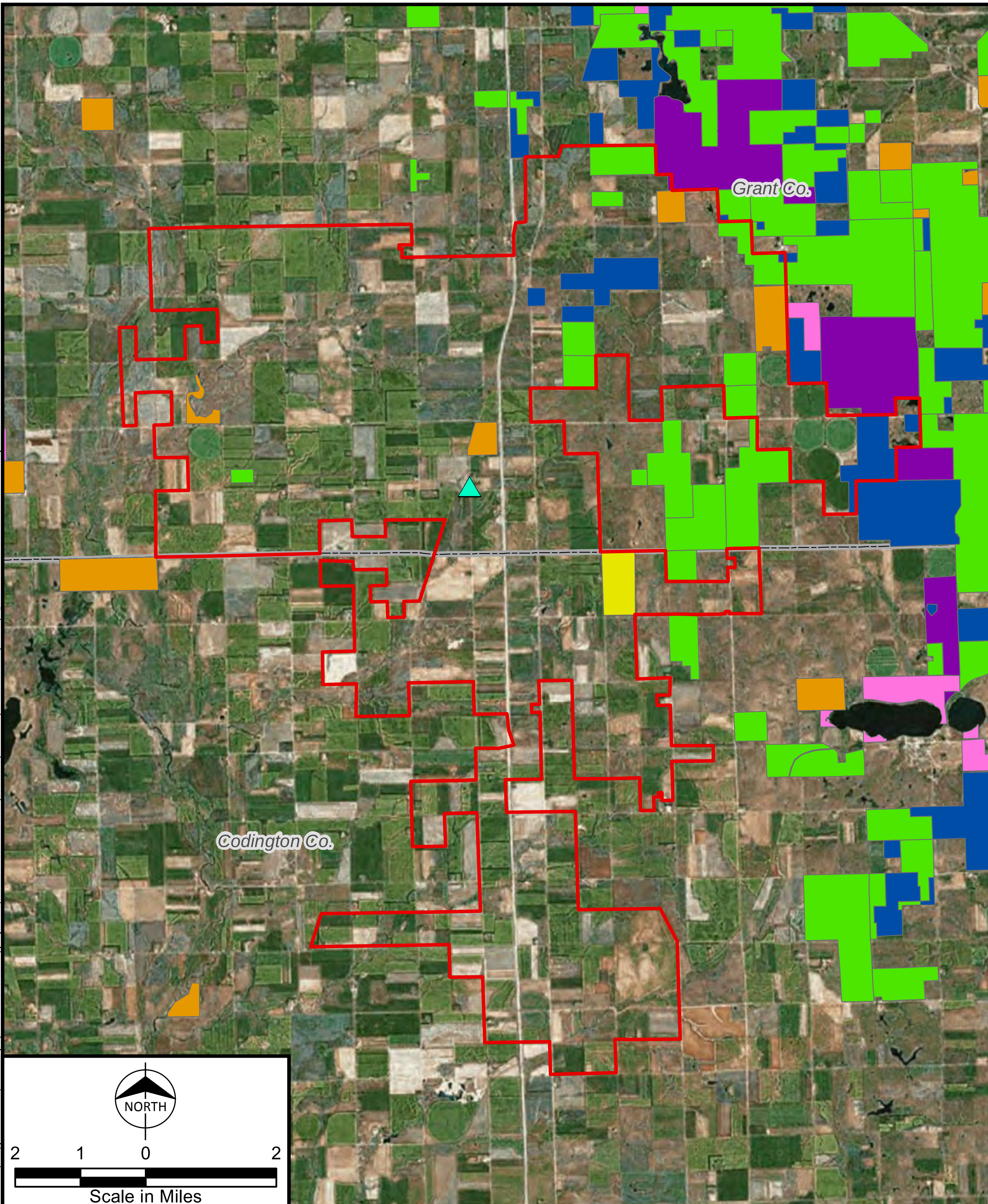
- Existing and potential extractive nonrenewable resources
- Other major industries
- Residential
- Municipal water supply and water sources for organized rural water systems

BURNS & McDONNELL

Figure 12
Land Use
Dakota Range
Wind Energy Facility
SDPUC Application

Source: Esri, National Land Cover Database (2011), and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018



Project Area
County Boundary
SDGFP Game Production Areas
SDGFP Walk-In-Areas
Church and Cemetery

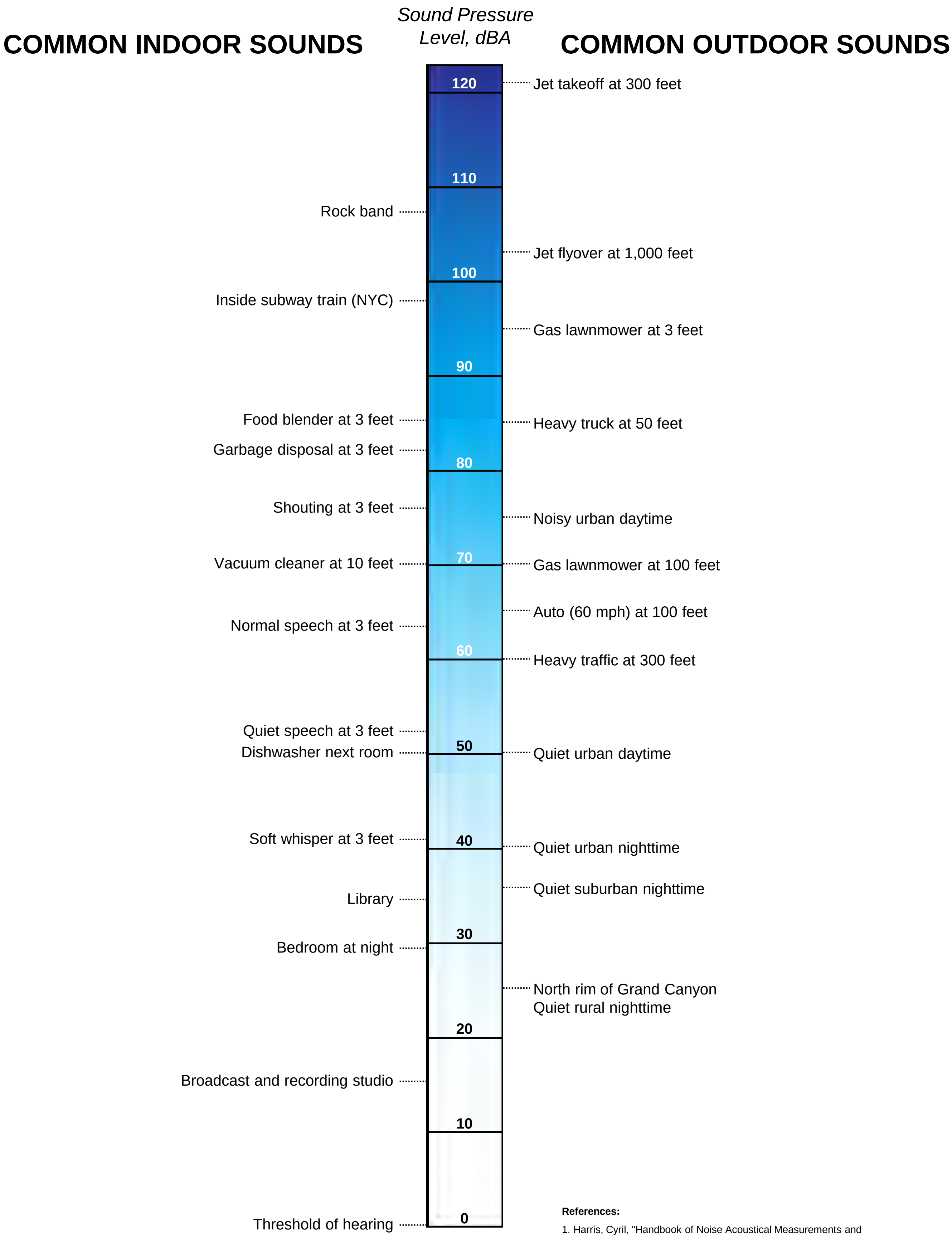
Public Lands and Facilities
USFWS Wetland Easements
USFWS Grassland Easements
USFWS Conservation Easements
Waterfowl Production Areas

BURNS McDONNELL

Figure 13
Public Lands and Facilities
Dakota Range
Wind Energy Facility
SDPUC Application

Source: Esri, USFWS HAPET, SDGFP, Apex, and Burns & McDonnell Engineering Company, Inc.

Issued: 1/9/2018



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Epsilon ASSOCIATES INC.

Figure 14

Common Sound Levels in the Environment

USFWS and SDGFP

August 12, 2015 Meeting Summary and Correspondence

Dave Phillips

From:	Dave Phillips
Sent:	Tuesday, September 8, 2015 12:56 PM
To:	'Gates, Natalie'
Cc:	Kempema, Silka; Clayton Derby (cderby@west-inc.com); Chad Little; Jennie Geiger
Subject:	RE: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

Agreed Natalie, thanks for getting back to me on that. For efficiency sake it is best to have 1 thorough count per month (given costs of mobilization), so we will go with the 1hr counts per the ECPG, 1X/month with solid spatial coverage of the site. That approach is consistent with and effectively addresses the ECPG.

Thanks, Dave

DAVE PHILLIPS
office: 434-282-2104 (x3051)| cell: 434-906-9127
dave.phillips@apexcleanenergy.com
APEX CLEAN ENERGY

From: Gates, Natalie [mailto:natalie_gates@fws.gov]
Sent: Tuesday, September 8, 2015 12:51 PM
To: Dave Phillips <dave.phillips@apexcleanenergy.com>
Cc: Kempema, Silka <Silka.Kempema@state.sd.us>; Clayton Derby (cderby@west-inc.com) <cderby@west-inc.com>; Chad Little <chad.little@apexcleanenergy.com>; Jennie Geiger <jennie.geiger@apexcleanenergy.com>
Subject: Re: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

Dave, we did talk about lowering the time spent at each location looking for eagles at our meeting and what you were proposing seemed reasonable. But I decided to look into it a bit more before going against our agency's national guidelines and saying that lower level of effort is adequate. Didn't want to make an off-the-cuff decision without a bit more info. The items below from our guidelines caught my eye:

"Many raptor biologists have suggested that the likelihood of detecting an eagle during a 20- to 40-minute point count survey is extremely low in all but locales of greatest eagle activity and datasets generated by pre-construction point count surveys of this duration typically are replete with counts of zero eagles, resulting in unwieldy confidence intervals and much uncertainty. Moreover, time spent traveling to and accessing points for 20-minute surveys may exceed time spent conducting the observations. .....Another advantage of longer counts is that they reduce biases created if some eagles avoid conspicuous observers as they approach their points and begin surveys, although some observers may become fatigued and overlook eagles during longer counts."

Since we don't think this is an eagle hot spot, eagle sightings likely will be relatively low, and the guidelines indicate that such areas are where the longer timeframe is particularly appropriate. I recognize an hour is a long time to be out there, particularly in winter. Perhaps there's a compromise possible....shortening the point count length but visiting twice/month? That would offer additional hours on the ground...although that doesn't address the issue of eagles that might avoid conspicuous observers at first.

-Natalie

Natalie Gates
U.S. Fish and Wildlife Service
Ecological Services South Dakota Field Office
420 South Garfield Avenue, Suite 400
Pierre, South Dakota 57501
Phone: 605-224-8693, Ext. 227
Fax: 605-224-9974
http://www.fws.gov/southdakotafieldoffice/

On Tue, Sep 1, 2015 at 11:49 AM, Dave Phillips <dave.phillips@apexcleanenergy.com> wrote:

Thank you for your comments Natalie and Silka. Based on your comments, I've made a few changes to the attached meeting summary. Below is what I suggest we do going forward:

1) Avian/eagle use: I thought we agreed that an appropriate survey plan included 20 min avian point counts covering 30% of the project area, 1x/mo, during the potential eagle risk period (i.e., winter), to assess whether or not there might be areas of concern to avoid with turbine siting, or if there might be an issue warranting further study or permitting. I didn't think we were talking about ECPG level studies, although what we've proposed certainly provides strong spatial and temporal coverage and assesses the area well with regard to an eagle/winter avian risk assessment. Natalie, in response to your suggestion, we will bump this up to 1hr point counts to be consistent with the ECPG and get that done this winter. If I am misinterpreting this recommendation, and you'd prefer that we scale back in this area to the 20-min assessment, please let me know.

2) Leks: I think it is reasonable to do lek surveys to identify previously undocumented leks in or near the project, so we will go ahead and plan to do that this spring. However, Silka, can you please clarify for me the regulatory protection afforded to leks in South Dakota so we can plan accordingly?

3) Grasslands: we can't avoid all grasslands and build a project like this. What is great about wind is that the habitat impacts are small and the majority of the grasslands remain intact. Clayton and I have been wrestling with how best to approach this issue, given that the majority of the grasslands aren't protected but your recommendations to avoid and/or mitigate are so strong. I think what we need to do given this juncture is design our project and then have qualified biologists assess the areas for potential suitability for the listed butterflies. Then, if the habitat is such that it may support butterfly species, we will either avoid or survey for presence/probable absence. This will result in the conservation benefit of avoiding high quality grasslands, retaining intact habitats for grassland obligate birds. And, we can continue to discuss options for potential mitigation.

I've made a few changes to the meeting summary based on the comments. We will circle back when the surveys are complete and review findings at that time.

Thanks again, Dave

DAVE PHILLIPS

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dave.phillips@apexcleanenergy.com

From: Gates, Natalie [mailto:natalie_gates@fws.gov]
Sent: Monday, August 24, 2015 12:55 PM
To: Dave Phillips <dave.phillips@apexcleanenergy.com>
Cc: Kempema, Silka <Silka.Kempema@state.sd.us>; Clayton Derby (cderby@west-inc.com) <cderby@west-inc.com>; Chad Little <chad.little@apexcleanenergy.com>
Subject: Re: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

I do have a few comments - attached.

Thank you,

-Natalie

Natalie Gates

U.S. Fish and Wildlife Service

Ecological Services South Dakota Field Office

420 South Garfield Avenue, Suite 400

Pierre, South Dakota 57501

Phone: 605-224-8693, Ext. 227

Fax: 605-224-9974

http://www.fws.gov/southdakotafieldoffice/

On Tue, Aug 18, 2015 at 4:43 PM, Dave Phillips <dave.phillips@apexcleanenergy.com> wrote:

Thanks Silka.

Natalie, any comments before I revise based on Silka's comments?

Dave

DAVE PHILLIPS

office: 434-282-2104 (x3051)| cell: 434-906-9127

dave.phillips@apexcleanenergy.com

From: Kempema, Silka [mailto:Silka.Kempema@state.sd.us]
Sent: Tuesday, August 18, 2015 4:24 PM
To: Dave Phillips <dave.phillips@apexcleanenergy.com>; Gates, Natalie <natalie_gates@fws.gov>
Cc: Clayton Derby (cderby@west-inc.com) <cderby@west-inc.com>; Chad Little <chad.little@apexcleanenergy.com>
Subject: RE: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

Hi all,

I reviewed the minutes from our meeting. Thanks for putting them together, Dave.

A few thoughts that were not included and some comments. I strongly encourage having alternate sites to help with micrositing of turbines. Information on grouse was not accurate as there are known leks in the project area. Other unknown leks are likely to go undetected if other survey efforts are not conducted in April (page 14 of power point). Under the "General Avian" section, I'd avoid stating that collision risk for birds is low, year-round for all birds. Maybe rephrase this or cite the information on which the statement is being made. In the same section, my recommendation is to avoid all grasslands. If forced to choose, I agree with avoiding high quality areas first, but my recommendation is to avoid all grasslands. I know this will likely not happen. In the "Operational Monitoring" section, given the extreme potential annual variation in bat activity we've seen in SD at other sites that have been monitored spring through fall, I recommend 2 years of post-construction monitoring especially since pre-construction monitoring for other bat species will not be conducted.

A bit of follow-up information:

Location of SD public lands: http://gfp.sd.gov/images/WebMaps/Viewer/WILMA/

Species monitored by Natural Heritage Program: http://gfp.sd.gov/wildlife/threatened-endangered/rare-animal.aspx . To make a data request: https://www.state.sd.us/eforms/secure/eforms/E1157V1-HeritageDataRequest.pdf. You may already be aware of this based on your power point.

Please be aware of SD's Species of Greatest Conservation Need. This is a species list generated as part of our state Wildlife Action Plan. Species and the criteria used to select them can be found at http://gfp.sd.gov/images/WebMaps/Viewer/WAP/Website/PlanSections/WAPCh2_SGCN.pdf. All of the state and federal listed TE species are on the list and some of the species monitored by the Heritage program.

I'll send Clayton the prairie grouse and waterbird colony data. Prairie grouse data are from 2010 and 2011, a MS study out of South Dakota State University (http://pubstorage.sdstate.edu/wfs/thesis/Orth-Mandy-R-2012-MS.pdf). Colonial waterbird data are from 2005-2007. A bit of information on the study can be found at http://rmbo.org/v3/OurWork/Science_/BirdPopulationMonitoring/SpecializedPrograms/SDColonialWaterbirds.aspx.

Information on the second SD Breeding Bird Atlas (http://www.rmbo.org/SDBBA2/).

Our agency wrote a comment letter on the Summit Wind EA. It was not well done. I've attached our comment letter. I know that WEST did survey work and it really seemed (if I'm remembering correctly) as if the results of those surveys were not included. I don't believe WEST wrote the EA.

Brian Rounds, South Dakota Public Utilities Commission (brian.rounds@state.sd.us; 605-773-3201).

Silka

From: Dave Phillips [mailto:dave.phillips@apexcleanenergy.com]
Sent: Friday, August 14, 2015 6:22 AM
To: Gates, Natalie; Kempema, Silka
Cc: Clayton Derby (cderby@west-inc.com); Chad Little
Subject: RE: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

Hello all, please see revised notes (attached), in which I've added discussion of the listed butterflies that I had inadvertently left out of the draft sent last night. If you could please direct us to the appropriate protocols for assessing habitat suitability for these species, and for assessing presence/absence within suitable habitat, it would be much appreciated so we can plan accordingly.

Thanks, Dave

DAVE PHILLIPS

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dave.phillips@apexcleanenergy.com

APEX CLEAN ENERGY

From: Dave Phillips
Sent: Thursday, August 13, 2015 9:02 PM
To: 'Gates, Natalie' <natalie_gates@fws.gov>; 'Kempema, Silka' <Silka.Kempema@state.sd.us>
Cc: Clayton Derby (cderby@west-inc.com) <cderby@west-inc.com>; Chad Little <chad.little@apexcleanenergy.com>
Subject: Apex-Dakota Range follow-up - Business Confidential/Not for Public Distribution

Hello Silka and Natalie, attached is a summary of our discussion and a copy of the PPT presented in our meeting yesterday.

If you have comments on the meeting summary, or find that edits are needed, please let me know and I will revise accordingly before finalizing. Otherwise, if you could confirm that they accurately reflect our discussion and your recommendations at this time, that would be much appreciated.

Thank you very much for you input on the project.

Sincerely, Dave

DAVE PHILLIPS

Environmental and Wildlife Permitting Director

Apex Clean Energy, Inc.

246 E. High Street, Charlottesville, VA 22902

office: 434-282-2104 (x3051)| cell: 434-906-9127 | fax: 434-220-3712

Dave.Phillips@apexcleanenergy.com | www.apexcleanenergy.com

APEX CLEAN ENERGY

DAKOTA RANGE WIND PROJECT - MEETING SUMMARY

Meeting Attendees: Natalie Gates, UWFWS
Silka Kempema, SDGFP
Dave Phillips, Apex
Chad Little, Apex
Clayton Derby, WEST

Notes Prepared by: Apex

Date: September 1, 2015

On August 12, 2015, Apex Clean Energy (Apex) met with the U.S. Fish and Wildlife Service (USFWS) and South Dakota Game Fish and Parks (SDGFP) to discuss the proposed Dakota Range Wind Project (Project) in Codington and Grant Counties, South Dakota. The purpose of the meeting was to introduce the agencies to Apex, discuss the project and Tier 1 and 2 reviews, agree on Tier 3 studies to be completed to assess risk, and discuss potential impact avoidance and minimization measures for the project. The meeting was held at the SDGFP Office in Pierre, South Dakota. The following is a summary of the topics discussed and notes based on subsequent email discussion of survey plans.

Apex presented an overview of the company, project status, risk assessment completed to date and Apex's proposed studies using the attached Power Point (PPT) presentation. Some points of clarification to the PPT were noted by USFWS and SDGFP regarding the proposed avian use study plan, the need to assess grouse leks, and the importance of minimizing impacts so as not to cause indirect effects on grassland obligate birds; however, it was agreed that the material presented in the PPT was accurate and adequately addressed the Tier 1 and Tier 2 review processes as recommended in the USFWS Wind Energy Guidelines.

Eagles: Apex and USFWS agreed that the project site presented low risk to eagles, but that studies were warranted to assess eagle nests within 10 miles of the project, and to evaluate potential for eagle risk during winter. The group agreed that 20-minute point counts during December, January and February could be used to assess whether or not there might be areas of concern to avoid with turbines, or to determine if there was an issue warranting further study or potential permitting, but that it may be prudent to apply the 60-minute point count approach to winter assessment as suggested in the Eagle Conservation Plan guidance (ECGP). Therefore, it was agreed that 60-minute point counts, using 800-m radius plots covering approximately 30% of the project, studied once each month during December, January and February provide adequate spatial and temporal coverage to assess winter use. Also, if nests are found in close proximity to the project during nest surveys, similar studies of eagle use near nests during spring/early summer may be appropriate to determine how nesting eagles and their young might use the project area. No summer, spring, or fall eagle point count surveys were recommended and at this time, none are planned.

General Avian: Winter raptors (e.g., short eared owl, rough-legged hawk, etc.) and passerines (e.g., snow buntings) were identified as of potential concern, and it was agreed that the winter eagle use surveys would effectively evaluate the potential use by these species by recording all birds observed during point counts. Although collision risk is likely to be low year-round for all birds, the loss of grassland habitat associated with installation of turbines and roads was identified as a primary concern of USFWS and SDGFP. Avoidance of higher quality grassland habitats and potential mitigation of habitat impacts through acquisition of conservation easements or other methods of generating conservation lands was recommended for Apex to consider; however, it is recognized that this is not required by regulation. Given that existing information on nearby wind projects is substantial (i.e., Summit Wind), it was agreed that breeding bird or migration period surveys would not contribute information beyond what we already know about these habitat types in this region, and that bird use and operational fatality would be within acceptable limits as presented in Attachment 2.

<u>Grouse Leks</u>: It was agreed during the meeting that lek surveys were not warranted; however, subsequent communication from SDGFP indicated this resource issue warrants baseline survey. Apex will complete lek surveys in Spring 2015.

<u>Bats</u>: USFWS and SDGFP agreed that general acoustic monitoring was limited in utility given Apex's intent to avoid treed and wetland habitats with turbine siting and to feather turbines up to manufacturer's cut in speed. But, both agencies agreed that it was important to assess potential summer presence of northern long-eared bat using USFWS protocols, and inform siting and operational protocols if presence was confirmed.

<u>Listed Species</u>: Potential exists for the Dakota skipper to occur in suitable habitats within the project area, and although highly unlikely, the Poweshiek skipperling could also occur; therefore surveys to habitat potential is warranted in areas planned for disturbance. USFWS and SDGFP recommend avoiding identified suitable habitat, or that presence-absence surveys be completed in suitable habitat to determine if avoidance is required to avoid permitting under Section 10 of the Endangered Species Act. Apex will follow appropriate survey protocols for the species using qualified surveyors (e.g., Dennis Skadsen).

With the exception of northern long-eared bat and these butterflies, no other species-specific protocols were recommended for federal or state-listed species due to the low risk nature of the project site.

<u>Operational Monitoring</u>:
It was discussed that an operational monitoring program to assess low risk conclusions is appropriate for this project site. One, possibly two, years of monitoring during the fall bat migration period, and possibly during the winter avian risk period may be appropriate; however, results of the studies described above are expected to inform the level of operational monitoring warranted for the site.

II. Action Items:

During the discussions, several action items surfaced:

- Apex will meet with Connie Mueller from USFWS @ Waubay NWR, SD, to identify and define key grassland habitats within the proposed project area.
- Apex will assess the potential for listed butterflies and the quality of grassland habitat present within the project site and work to design the project in response to these findings.
- Apex will complete the studies discussed and planned for the project to assess bird and bat risk.
- Apex will meet with USFWS and SDGFP to discuss survey results and agree on next steps in late summer/fall 2016.

USFWS and SDGFP

March 28, 2017 Meeting Summary and Correspondence

Jennie Geiger

From:	Jennie Geiger
Sent:	Thursday, April 6, 2017 4:44 PM
To:	Natalie Gates (natalie_gates@fws.gov); Mueller, Connie (connie_mueller@fws.gov); Silka Kempema (silka.kempema@state.sd.us); Murphy, Leslie
Cc:	Dave Phillips (dave.phillips@apexcleanenergy.com); Nate Pedder (nate.pedder@apexcleanenergy.com); Mark Mauersberger (mark.mauersberger@apexcleanenergy.com)
Subject:	BUSINESS CONFIDENTIAL: Dakota Range Meeting Follow Up
Attachments:	DKR_USFWS_SDGFP Agency Meeting Summary_2017-04-06.pdf; Final Summit Winds Bat Acoustic Report_23March2015.pdf

Hi Natalie/Silka/Connie/Leslie –

Thank you for meeting last week to discuss the Dakota Range I Wind Project. I have attached meeting notes outlining the topics discussed, as well as the Powerpoint presentation (PPT) presented. Note that I have revised slide 16 to accurately reflect the original habitat assessment area for the DASK/POSK, as well as added a slide presenting information on the acoustic bat surveys conducted at the adjacent Summit Wind Farm in similar habitats (I have also attached the report from Summit Wind to this email). This study shows that bat risk is generally low and the BMPs discussed are appropriate to avoid and minimize impacts to bats at the Dakota Range I Wind Project.

Also, Apex completely understands that maintaining intact grassland habitat is a regional priority for both agencies. In response to your feedback we've committed to avoid all grasslands (and wetlands) currently protected as USFWS easements and will avoid siting facilities in higher quality grassland habitats as practicable.

Thank you again for your time and helpful input. I look forward to connecting again soon once studies are complete.

Regards,
Jennie

JENNIE GEIGER
Environmental Permitting Manager

Apex Clean Energy, Inc.
310 4th St. NE, Suite 200, Charlottesville, VA 22902
office: 434-260-6982 | cell: 720-320-9450 | fax: 434-220-3712
jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

DAKOTA RANGE I WIND PROJECT - MEETING SUMMARY

Meeting Attendees: Natalie Gates, USFWS
Silka Kempema, SDGFP
Leslie Murphy, SDGFP
Jennie Geiger, Apex
Connie Mueller, USFWS (by phone)
Dave Phillips, Apex (by phone)
Nate Pedder, Apex (by phone)

Notes Prepared by: Apex

Date: April 6, 2017

On March 28, 2017, Apex Clean Energy (Apex) met with the U.S. Fish and Wildlife Service (USFWS), and South Dakota Game, Fish and Parks (SDGFP) to continue coordination on the Dakota Range I Wind Project (Project) in accordance with the USFWS 2012 Guidelines for Land-based Wind Energy Projects and 2013 Eagle Conservation Plan Guidance (ECPG). The purpose of the meeting was to review the current project boundary, discuss the results of wildlife studies completed to date, and agree on next steps necessary for the project to proceed to construction and operations. The meeting was held at the SDGFP Office in Pierre, South Dakota. The attached Powerpoint (PPT) presentation was provided and the following is a summary of the topics discussed.

There was general agreement that the material presented in the PPT presentation was accurate and that the studies being completed and proposed are appropriate for risk assessment. It was also agreed that the overall impacts and risk associated with the revised boundary was improved as a result of the focus on disturbed agricultural landscape and reduced density of intact grasslands in the new boundary. Both USFWS and SDGFP voiced appreciation of the steps Apex had taken to avoid higher risk areas (e.g., USFWS easements, leks, eagle nests) with Project facilities.

Avian Studies: Apex presented results from avian use, raptor nest, and grouse lek surveys conducted to date. USFWS requested that additional eagle nest surveys be conducted to improve determination of the number and location of occupied bald eagle nests in accordance with ECPG guidance. A 10 mi bald eagle nest survey area buffer and 1 mi non-eagle raptor nest survey area buffer around the project area for spring 2017 nest surveys was determined acceptable. USFWS also recommended that additional survey points be incorporated to evaluate potential eagle use in the northwest portion of the revised boundary. The survey approach of 5 min small bird surveys followed by 60-minute ECPG- level surveys consisting of 20-minute raptor/large bird and 40-minute eagle only surveys was deemed acceptable and consistent with the WEG and ECPG.

Bats: It was agreed that risk to federal/state-listed bats is limited to the federally threatened northern long-eared bat, and that the period of risk is most likely during migration only due to the limited amount of summer habitat onsite. Both agencies agreed that the proposed best management practices (1,000 ft turbine setback from potentially suitable NLEB habitat, feathering to manufacturer's cut in speed from sunset to sunrise during the bat active period [Apr 15-October 15 and operational monitoring during this period to evaluate effectiveness) are appropriate to minimize and respond to potential impact to other bat species.

SDGFP requested bat acoustic surveys be conducted in July and August to assess bat activity patterns during fall migration; however, it was discussed that data from the acoustic surveys conducted at the adjacent Summit Wind Farm may provide sufficient information to assess risk at this project due to the similarity in habitats. Since the meeting, Apex provided the Summit Wind Farm Acoustic Bat Report to both agencies and added slide 11 to the attached PPT summarizing the study protocol and results. The Summit Wind study provided indicates low passage rates of bats overall, especially at ground units in open habitats compared to wooded habitats and supports the appropriateness of implementing the aforementioned BMPs without preconstruction acoustic studies. Given the 4d rule exemption for northern long-eared bats, no further studies or permitting are needed to ensure ESA compliance.

Federally Listed Species: USFWS and SDGFP confirmed that the only federally listed species with the potential to occur within the revised Project boundary are the northern long-eared bat (discussed above) and the Dakota skipper and Poweshiek skipperling. As discussed, Apex will complete additional habitat assessments for the butterfly species within the unsurveyed portions of the current boundary (see slide 15 of the PPT), and either avoid areas identified as potentially suitable for the species or conduct presence/absence surveys to ensure no impact to either species.

Other Wildlife: USFWS and SDGFP confirmed that no additional species-specific surveys are warranted for state protected species or other wildlife.

<u>Action Items</u>:

- Apex to provide shapefiles of the revised boundary to SDGFP and USFWS.
- Apex to complete additional studies and reconvene with USFWS and SDGFP once complete.

USFWS and SDGFP

September 25, 2017 Meeting Summary and Correspondence

Jennie Geiger

From: Gates, Natalie <natalie_gates@fws.gov>
Sent: Monday, October 02, 2017 9:48 AM
To: Jennie Geiger
Subject: Re: Dakota Range I Follow Up

Yep, got it. Thank you.

Natalie Gates, U.S. Fish and Wildlife Service
Ecological Services South Dakota Field Office
420 South Garfield Avenue, Suite 400
Pierre, South Dakota 57501
Phone: 605-224-8693, Ext. 227; Fax: 605-224-9974
http://www.fws.gov/southdakotafieldoffice/

On Mon, Oct 2, 2017 at 9:18 AM, Jennie Geiger <jennie.geiger@apexcleanenergy.com> wrote:

Good morning Natalie/Silka/Leslie/Connie –

I sent out the 9/25/17 meeting notes, shps of the project area, and the 2015-2017 Avian/Eagle Use Summary on Friday afternoon. Can you confirm that you received them as the file size was quite large?

Thanks,
Jennie

JENNIE GEIGER

Environmental Permitting Manager

Apex Clean Energy, Inc.

310 4th St NE, Suite 200, Charlottesville, VA 22902

office: 434-260-6982 | cell: 720-320-9450 | fax: 434-220-3712

jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

APEX CLEAN ENERGY

From:	Kempema, Silka
To:	Jennie Geiger; Natalie_Gates@fws.gov; Murphy, Leslie; Mueller, Connie (connie_mueller@fws.gov)
Subject:	RE: Dakota Range I Follow Up
Date:	Monday, October 02, 2017 8:39:30 AM
Attachments:	image001.png

Yes, I received them.

Thanks, Jennie.

Silka

From: Jennie Geiger [mailto:jennie.geiger@apexcleanenergy.com]
Sent: Monday, October 02, 2017 9:18 AM
To: Natalie_Gates@fws.gov; Kempema, Silka; Murphy, Leslie; Mueller, Connie (connie_mueller@fws.gov)
Subject: [EXT] Dakota Range I Follow Up

Good morning Natalie/Silka/Leslie/Connie –

I sent out the 9/25/17 meeting notes, shps of the project area, and the 2015-2017 Avian/Eagle Use Summary on Friday afternoon. Can you confirm that you received them as the file size was quite large?

Thanks,
Jennie

JENNIE GEIGER
Environmental Permitting Manager

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jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

APEX CLEAN ENERGY

From: Mueller, Connie
To: Jennie Geiger
Cc: Natalie Gates (natalie_gates@fws.gov); Silka Kempema (silka.kempema@state.sd.us); Murphy, Leslie
Subject: Re: Dakota Range I Follow Up
Date: Monday, October 02, 2017 8:21:03 AM

Yes, they arrived in my inbox.

Thanks.

Connie Mueller, Project Leader
Waubay NWR Complex
44401 134 A Street
Waubay, SD 57273
605-947-4521 ext 110 office

National Wildlife Refuges - Where Wildlife Comes First

On Mon, Oct 2, 2017 at 9:18 AM, Jennie Geiger <jennie.geiger@apexcleanenergy.com> wrote:

> Good morning Natalie/Silka/Leslie/Connie -
>
> I sent out the 9/25/17 meeting notes, shps of the project area, and the 2015-2017 Avian/Eagle Use Summary on Friday afternoon. Can you confirm that you received them as the file size was quite large?
>
> Thanks,
> Jennie
>
> JENNIE GEIGER
> Environmental Permitting Manager
>
> Apex Clean Energy, Inc.
> 310 4th St NE, Suite 200, Charlottesville, VA 22902
> office: 434-260-6982 | cell: 720-320-9450 | fax: 434-220-3712
> jennie.geiger@apexcleanenergy.com<mailto:jennie.geiger@apexcleanenergy.com> |
> www.apexcleanenergy.com<http://www.apexcleanenergy.com/>
>
> [cid:image001.png@01CE6DB9.0BF695D0]

From:	Jennie Geiger
To:	Natalie Gates (natalie_gates@fws.gov); Silka Kempema (silka.kempema@state.sd.us); Mueller, Connie (connie_mueller@fws.gov); Murphy, Leslie
Cc:	Dave Phillips (dave.phillips@apexcleanenergy.com)
Subject:	BUSINESS CONFIDENTIAL: Follow Up on Dakota Range I Apex_Agency Meeting
Date:	Friday, September 29, 2017 1:25:29 PM
Attachments:	image001.png DKR_Agency Meeting Summary and PPT_2017-09-26.pdf DKR_2015-17 Avian-Eagle Use Summary_2017-09-28.pdf DKR_bdy_20170919.zip

Hi Natalie/Silka/Connie/Leslie –

Thank you for meeting earlier this week to discuss the Dakota Range I Wind Project. I have attached meeting notes outlining the topics discussed, as well as the Powerpoint presentation (PPT) presented. Note that we have revised the table on slide 8 to accurately reflect the results of the 2016 and 2017 lek surveys, as well as adjusted the colors of the USFWS easements on slide 13 to eliminate confusion.

As discussed, I have also attached shps for the current Project boundary, as well as the 2015-17 Avian/Eagle Use Summary for your records and review.

Thank you again for your time and helpful input.
Jennie

JENNIE GEIGER
Environmental Permitting Manager

Apex Clean Energy, Inc.
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jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

APEX CLEAN ENERGY

DAKOTA RANGE I WIND PROJECT - MEETING SUMMARY

Meeting Attendees: Natalie Gates, USFWS
Silka Kempema, SDGFP
Leslie Murphy, SDGFP
Jennie Geiger, Apex
Clayton Derby, WEST
Connie Mueller, USFWS (by phone)
Dave Phillips, Apex (by phone)

Notes Prepared by: Apex

Date: September 29, 2017

On September 25, 2017, Apex Clean Energy (Apex) met with the U.S. Fish and Wildlife Service (USFWS), and South Dakota Game, Fish and Parks (SDGFP) to continue coordination on the Dakota Range I Wind Project (Project) in accordance with the USFWS 2012 Guidelines for Land-based Wind Energy Projects and 2013 Eagle Conservation Plan Guidance (ECPG). The purpose of the meeting was to discuss the results of wildlife studies completed to date, agree on avoidance and minimization measures, and agree on any necessary steps to complete in advance of submittal of a South Dakota Public Utilities Commission Wind Energy Conversion Facility Siting Permit application in November 2017.

The meeting was held at the SDGFP Office in Pierre, South Dakota. The attached Powerpoint (PPT) presentation was provided and the following is a summary of the topics discussed. Copies of all finalized reports discussed within the PPT were provided to USFWS and SDGFP on September 22, 2017.

Federally Listed Species: It was agreed that given the findings of studies completed to date and the resulting low risk to federally listed species, no further studies are recommended for federally listed species and risk is such that no permits are required. Details for the federally listed species with potential to occur are as follows:

- Dakota skipper/Poweshiek skipperling: It was agreed that because the Project is designed to avoid suitable habitat, no further surveys are needed to confirm no impact.
- Northern long-eared bat: It was agreed that feathering to mfr cut in speed from Apr 15-Oct 15 and avoiding tree removal during June and July would minimize risk of impact to northern long-eared bat and other bat species.
- Red knot: It was agreed that this species is unlikely to occur or be affected by the Project.
- Whooping crane: It was agreed that this species is unlikely to occur, but that training staff to recognize the species if present and respond with a specified response plan are reasonable precautions.
- Topeka shiner: It was agreed that the species will be unaffected by Project activities.

Birds: Apex presented results from the avian/eagle use, raptor nest, and grouse lek surveys conducted in 2017, as well as risk assessment slides combining data from all surveys conducted to date. There was agreement that the surveys conducted to date were sufficient to adequately assess risk within the Project area during the seasons evaluated; however, USFWS noted that the low levels of documented activity by birds of conservation concern were likely a function of the seasons evaluated and that more may occur during breeding season.

USFWS believes that grassland mitigation through easement or fee acquisition is appropriate to offset displacement impacts to grassland birds; however, very limited studies are available to understand this potential affect. Apex clarified that current research shows that displacement appears to occur for some species and not others, but that such effects would not be considered “take” as per MBTA standards and that mitigation in this manner would not provide liability protection under the MBTA. Apex has addressed this recommendation by avoiding and minimizing impacts on grasslands to the maximum extent practicable (see slide 14) to substantially reduce potential displacement impacts that may be caused by construction or operation of the Project. Both agencies agreed that the avoidance/minimization measures outlined on slides 9 (prairie grouse), 11 (eagles), 14 (grasslands) and 15 (general) were appropriate to reduce potential impacts to species of concern.

Apex indicated that updates to the raptor nest and grouse lek survey reports would be completed once the layout is finalized, and that agreed upon avoidance/minimization measures would be applied where appropriate. It was also agreed that the low level of eagle use documented during eagle studies completed for the 2 winters and 1 spring season, coupled with the comparable data collected year-round at the adjacent Summit Wind Farm site, indicated a low risk site for eagles with no permit warranted.

Other: Apex presented a slide identifying USFWS easements within the Project boundary and illustrating how facilities have been designed to avoid the easements (slide 13). USFWS confirmed that this was appropriate to avoid a federal nexus; however, recommended Apex request an updated easement map to ensure that the most current data is incorporated into final siting considerations.

Both USFWS and SDGFP voiced appreciation of the steps Apex had taken to focus facilities on disturbed agricultural lands and avoid higher risk areas (e.g., USFWS easements, leks, nests, untilled grasslands).

<u>Action Items</u>:

- Apex to provide shapefiles of the current boundary to SDGFP and USFWS (sent with these meeting notes).
- USFWS to provide updated information on easements located within Project boundary based on above shps.
- Apex to provide a copy of the avian/eagle use survey report that combines data from all surveys conducted to date once final (sent with these meeting notes).

SHPO

June 13, 2017 Meeting Summary and Correspondence

Jennie Geiger

From: Jennie Geiger
Sent: Wednesday, July 5, 2017 2:33 PM
To: 'Olson, Paige'
Cc: Dave Phillips; Nelson, Kate; Carlson Dietmeier, Jenna
Subject: RE: BUSINESS CONFIDENTIAL: Dakota Range Meeting Summary

Hi Paige –

Thank you for confirming that you were able to open the shapefiles. One correction, however, is that the project is located in Grant and Codington Counties. If that is not what the boundary I sent is illustrating please let me know and I will resend.

Thanks – hope you had a nice holiday weekend ☺
Jennie

JENNIE GEIGER
office: 434-260-6982 | cell: 720-320-9450
jennie.geiger@apexcleanenergy.com
APEX CLEAN ENERGY

From: Olson, Paige [mailto:Paige.Olson@state.sd.us]
Sent: Wednesday, July 5, 2017 10:37 AM
To: Jennie Geiger <jennie.geiger@apexcleanenergy.com>
Cc: Dave Phillips <dave.phillips@apexcleanenergy.com>; Nelson, Kate <Kate.Nelson@state.sd.us>; Carlson Dietmeier, Jenna <Jenna.CarlsonDietmeier@state.sd.us>
Subject: RE: BUSINESS CONFIDENTIAL: Dakota Range Meeting Summary

Hi Jennie,

I just want to verify that I've opened all of appropriate files you sent on June 22nd. I downloaded the information into ArcMap and see the boundaries of the wind project in Day and Codington Counties. Is this correct? Did I miss anything?

Thanks,
Paige

Paige Olson
Review and Compliance Coordinator
South Dakota State Historical Society
900 Governors Drive
Pierre, SD 57501
(605) 773-6004

From: Jennie Geiger [mailto:jennie.geiger@apexcleanenergy.com]
Sent: Thursday, June 29, 2017 1:48 PM
To: Olson, Paige

Cc: Dave Phillips
Subject: RE: [EXT] BUSINESS CONFIDENTIAL: Dakota Range Meeting Summary

Hi Paige –

I just wanted to follow up with you and make sure you were able to open the shapefiles I sent last Friday? If a PDF map would be more useful, please let me know and I will send that along.

Also, I wanted to let you know that we are working with Burns and McDonnell and other cultural firms to address your concerns about archaeological surveys, as well as to assess the architectural review information available through the SHPO CRGRID. We will circle back with you very shortly to revisit the topic once we have our plan together and some ideas on next steps.

Thank you again for your thoughtful input. Please let me know if you would like to further discuss anything regarding the project at this time.

Jennie

JENNIE GEIGER
office: 434-260-6982 | cell: 720-320-9450
jennie.geiger@apexcleanenergy.com
APEX CLEAN ENERGY

From: Olson, Paige [mailto:Paige.Olson@state.sd.us]
Sent: Friday, June 23, 2017 4:34 PM
To: Jennie Geiger <jennie.geiger@apexcleanenergy.com>
Subject: RE: BUSINESS CONFIDENTIAL: Dakota Range Meeting Summary

Hi Jennie,

We received your e-mail and attachments. I'm having some trouble opening the attachments, but will ask our computer guru on Monday.

Thank you!
Paige

Paige Olson
Review and Compliance Coordinator
South Dakota State Historical Society
900 Governors Drive
Pierre, SD 57501
(605) 773-6004

From: Jennie Geiger [mailto:jennie.geiger@apexcleanenergy.com]
Sent: Thursday, June 22, 2017 1:15 PM
To: Olson, Paige; Nelson, Kate; Carlson Dietmeier, Jenna
Cc: Dave Phillips; Mark Mauersberger; Nate Pedder; Bell, Jennifer
Subject: [EXT] BUSINESS CONFIDENTIAL: Dakota Range Meeting Summary

Hello Paige/Kate/Jenna –

Thank you for meeting with us last week to discuss the Dakota Range Wind Project. Attached is the summary of our June 13, 2017 meeting, including the Powerpoint presentation discussed, for your review and consideration. Given the size of the email attachment, it would be much appreciated if you could confirm receipt of this email.

Thanks,
Jennie

JENNIE GEIGER
Environmental Permitting Manager

Apex Clean Energy, Inc.
310 4th St. NE, Suite 200, Charlottesville, VA 22902
office: 434-260-6982 | cell: 720-320-9450 | fax: 434-220-3712
jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

DAKOTA RANGE WIND PROJECT - MEETING SUMMARY

Meeting Attendees: Paige Olsen, SHPO
Kate Nelson, SHPO
Jenna Carlson Dietmeier, SHPO
Jennifer Bell, Burns & McDonnell
Mollie Smith, Fredrikson & Byron
Mark Mauersberger, Apex
Nate Pedder, Apex
Dave Phillips, Apex (by phone)
Jennie Geiger, Apex (by phone)

Notes Prepared by: Apex

Date: June 22, 2017

On June 13, 2017, Apex Clean Energy (Apex) met with staff of the South Dakota State Historical Society to discuss the Dakota Range Wind Project (Project). The purpose of the meeting was to introduce the project, coordinate with SDSHS per the Public Utilities Commission (PUC) Guidelines for Wind Power Projects, and agree on next steps to ensure regulatory compliance. The meeting was held at the SDSHS Office in Pierre, South Dakota. The attached Powerpoint (PPT) presentation was provided and the following is a summary of the topics discussed.

Apex presented information on Project status, clarifying that the Project will be located entirely upon private lands and thus there is no federal nexus that would trigger National Historic Preservation Act Section 106 requirements. It was agreed that regulatory compliance would be achieved by meeting state and local cultural resource protection laws as required by the PUC to issue a Wind Energy Conversion Facility Siting Permit.

Apex presented information on its consultation and coordination with stakeholders to date, as well as the results of the Level I Cultural Resources Records Search completed by Westwood, Inc. in November 2016. Because there is no federal nexus for the Project, Level III field investigations are not required to ensure regulatory compliance; however, SHPO recommended Level III surveys be completed in non-cultivated areas where ground disturbance is planned to minimize risk of impacts.

The SHPO concurred that the impact minimization and avoidance measures presented on slides 10-11 are appropriate to ensure regulatory compliance. Apex indicated that a Cultural Resources Management Plan would be prepared for the Project, which would include information on staff training and how potential unanticipated discoveries would be handled if found.

The SHPO mentioned that they do not have regulatory authority or expertise regarding fossil resources and offered to provide an agency contact to confirm Westwood's conclusion that the Project lacks fossil resource potential due to glaciation. The SHPO offered to provide a list of potential stakeholders, as well as a sample Monitoring and Mitigation Plan for Apex's consideration. It was agreed that avoidance of direct impact to protected cultural resources would be the goal during Project design, construction and operations; therefore, no mitigation, data recovery, mapping or analyses is expected.

Action Items:

- Apex to provide shapefiles of the project boundary to SHPO (provided with transmittal of this email).
- SHPO to provide the following to Apex:
  - Contact information of agency with fossil expertise
  - List of potential stakeholders that should be informed of the Project
  - Example monitoring and mitigation plan from previous non-federal nexus

SHPO

Correspondence Regarding August 29, 2017 Meeting and CRMMP

Jennie Geiger

From: Jennie Geiger
Sent: Friday, September 1, 2017 2:42 PM
To: 'Carlson Dietmeier, Jenna'; Dave Phillips; Nelson, Kate
Subject: RE: Dakota Range Wind - CRMMP
Attachments: DKR_ Cultural Resources Monitoring and Management Plan_2017-09-01_Final.pdf

Thanks Jenna. The requested changes have been made and the final document is attached.

JENNIE GEIGER
office: 434-260-6982 | cell: 720-320-9450
jennie.geiger@apexcleanenergy.com
APEX CLEAN ENERGY

From: Carlson Dietmeier, Jenna [mailto:Jenna.CarlsonDietmeier@state.sd.us]
Sent: Friday, September 1, 2017 1:41 PM
To: Dave Phillips <dave.phillips@apexcleanenergy.com>; Nelson, Kate <Kate.Nelson@state.sd.us>
Cc: Jennie Geiger <jennie.geiger@apexcleanenergy.com>
Subject: RE: Dakota Range Wind - CRMMP

Hi, Dave,

Kate and I have read over the CRMMP one last time and have two remaining comments.

1) In the unanticipated discoveries plan, when referring to the actions to be taken if human remains are discovered, I would clean up the language to more accurately reflect SDCL 34-27-25. This law states, "Any person who encounters or discovers human skeletal remains or what he believes may be human skeletal remains in or on the ground shall immediately cease any activity which may disturb those remains and shall report the presence and location of such human skeletal remains to an appropriate law enforcement officer." The plan's use of the phrasing of "If the site appears to be a crime scene warranting immediate action…" makes me a bit uncomfortable.
2) In the next portion of the unanticipated discoveries plan where it discusses cultural resources that are not human remains, SHPO would like to be notified of the discovery as well.

Thank you for taking our comments into consideration. If you have any further questions, please let us know. Otherwise, enjoy the upcoming long weekend!

Jenna

From: Dave Phillips [mailto:dave.phillips@apexcleanenergy.com]
Sent: Friday, September 01, 2017 1:31 PM
To: Nelson, Kate; Carlson Dietmeier, Jenna
Cc: Jennie Geiger
Subject: [EXT] Dakota Range Wind - CRMMP

Hello Kate and Jenna,

Thank you very much for your time and helpful input on the CRMMP for the Dakota Range Wind Project. Attached is a redline with the changes we discussed in today's call, as well as a clean version as a final PDF. If you could confirm this revised version addresses all of your recommendations effectively, as it relates to minimizing potential risks to sensitive cultural resources on the site, we will consider it final and include it in our PUC permit application planned for submittal this fall.

Sincerely, Dave

DAVE PHILLIPS
Director, Environmental and Wildlife Permitting

Apex Clean Energy, Inc.
246 E. High Street, Charlottesville, VA 22902
W: 434-906-9127
Dave.Phillips@apexcleanenergy.com | www.apexcleanenergy.com

Jennie Geiger

From: Olson, Paige <Paige.Olson@state.sd.us>
Sent: Tuesday, November 07, 2017 9:30 AM
To: Jennie Geiger
Subject: SDCL Chapter 34-27-26
Attachments: 120_20171105_012810_001.pdf

Hi Jennie,

Good to talk with you this morning. I've attached a copy of SDCL Chapter 34-27-26, which speaks to funerary objects.

Thanks,
Paige

Paige Olson
Review and Compliance Coordinator
South Dakota State Historical Society
900 Governors Drive
Pierre, SD 57501
(605) 773-6004

Historical Society;

(4) "Tribal group," a federally recognized Indian tribe.

Source: SL 1990, ch 6, § 1; SL 1991, ch 281, § 1.

34-27-22. Buying, selling, or bartering human skeletal remains or funerary objects as felony. No person may knowingly buy, sell, or barter for profit human skeletal remains or associated funerary objects, previously buried within this state. A violation of this section is a Class 6 felony.

Source: SL 1990, ch 6, § 2.

34-27-23. Repealed by SL 1991, ch 281, § 2.

34-27-24. Commercial display of human skeletal remains or funerary objects as felony. No person may knowingly display funerary objects or human skeletal remains previously buried in South Dakota for profit or to aid and abet a commercial enterprise. A violation of this section is a Class 6 felony.

Source: SL 1990, ch 6, § 4.

34-27-25. Reporting discovery of human skeletal remains--Failure to report as misdemeanor. Any person who encounters or discovers human skeletal remains or what he believes may be human skeletal remains in or on the ground shall immediately cease any activity which may disturb those remains and shall report the presence and location of such human skeletal remains to an appropriate law enforcement officer. Willful failure to report the presence or discovery of human skeletal remains or what may be human skeletal remains within forty-eight hours to an appropriate law enforcement officer in the county in which the remains are found is a Class 2 misdemeanor.

Source: SL 1990, ch 6, § 5.

34-27-26. Disturbing human skeletal remains or funerary objects as felony. No person unless authorized by the state archaeologist may knowingly disturb or knowingly permit disturbance of human skeletal remains or funerary objects except a law enforcement officer or coroner or other official designated by law in performance of official duties. A violation of this section is a Class 6 felony.

Source: SL 1990, ch 6, § 6.

34-27-27. Repealed by SL 1991, ch 281, § 3.

34-27-28. Notification to landowner and coroner--Notification to state archaeologist and tribal officials--Time limits. If a law enforcement officer has reason to believe that the skeletal remains, reported pursuant to § 34-27-25, may be human, he shall promptly notify the landowner and the coroner. If the remains reported under § 34-27-25 are not associated with or suspected of association with any crime, the state archaeologist shall be notified within fifteen days. The state archaeologist shall thereupon follow the procedure set out in § 34-27-31, except that the skeletal remains shall be turned

Jennie Geiger

From: Olson, Paige <Paige.Olson@state.sd.us>
Sent: Monday, November 06, 2017 2:49 PM
To: Jennie Geiger; Carlson Dietmeier, Jenna; Nelson, Kate
Cc: Dave Phillips; Ryan Henning
Subject: RE: Follow Up on Dakota Range I Wind Project - Business Confidential

Thank you. I'll review the information and get back to you.

From: Jennie Geiger [mailto:jennie.geiger@apexcleanenergy.com]
Sent: Friday, November 03, 2017 1:30 PM
To: Olson, Paige; Carlson Dietmeier, Jenna; Nelson, Kate
Cc: Dave Phillips; Ryan Henning
Subject: RE: [EXT] Follow Up on Dakota Range I Wind Project - Business Confidential

Hi Paige –

Yes, the CRMMP was finalized in September in coordination with Jenna and Kate. I have attached the final document for your records – apologies for the initial oversight in copying you in the final correspondence.

Thanks,
Jennie

JENNIE GEIGER
office: 434-260-6982 | cell: 720-320-9450
jennie.geiger@apexcleanenergy.com

From: Olson, Paige [mailto:Paige.Olson@state.sd.us]
Sent: Friday, November 03, 2017 12:08 PM
To: Jennie Geiger <jennie.geiger@apexcleanenergy.com>; Carlson Dietmeier, Jenna <Jenna.CarlsonDietmeier@state.sd.us>; Nelson, Kate <Kate.Nelson@state.sd.us>
Cc: Dave Phillips <dave.phillips@apexcleanenergy.com>; Ryan Henning <ryan.henning@apexcleanenergy.com>
Subject: RE: Follow Up on Dakota Range I Wind Project - Business Confidential

Hi Jennie,

Was the CRMMP finalized? If so, is it possible to get a copy?

Thank you,
Paige

Paige Olson
Review and Compliance Coordinator
South Dakota State Historical Society
900 Governors Drive
Pierre, SD 57501
(605) 773-6004

Jennie Geiger

From: Carlson Dietmeier, Jenna <Jenna.CarlsonDietmeier@state.sd.us>
Sent: Friday, November 03, 2017 11:17 AM
To: Jennie Geiger
Subject: RE: Follow Up on Dakota Range I Wind Project - Business Confidential

Thanks, Jennie,

I received your email and the PDF of the Level III survey areas.

Have a good weekend,
Jenna

From: Jennie Geiger [mailto:jennie.geiger@apexcleanenergy.com]
Sent: Friday, November 03, 2017 11:23 AM
To: Olson, Paige; Carlson Dietmeier, Jenna; Nelson, Kate
Cc: Dave Phillips; Ryan Henning
Subject: [EXT] Follow Up on Dakota Range I Wind Project - Business Confidential

Hi Paige/Jenna/Kate –

I wanted to give you an update on our Dakota Range I Wind Project in anticipation of upcoming field surveys and our PUC submittal next month.

The project footprint has been revised slightly to improve the efficiency of collection routes between turbines and the interconnection point. Therefore, Burns and McDonnell reviewed the new areas of planned disturbance and identified additional high probability areas for Level III Surveys. A revised map for incorporation into our CRMMP is attached.

QSI plans to begin Level III surveys Tuesday, November 7, weather permitting, in coordination with monitors from the Sisseton Wahpeton Oyate (SWO). The SWO will also review the lower probability areas, and we will work with them to avoid sensitive tribal resources based on their review and input. We hope to complete the surveys in advance of our PUC submittal; but weather, pace, and site density may make that impractical, requiring completion of surveys in spring, or at least after our PUC submittal in late November or early December.

As outlined in the CRMMP, Apex commits to design facilities to avoid all eligible, potentially eligible, and unevaluated cultural resources identified within the project area and we are working closely with the SWO to accommodate their concerns as well.

A Level III report will be provided to you as soon as possible, but we wanted to make sure you were comfortable commenting on our PUC application without the survey results in hand if the timing requires that, realizing that we intend to adhere to the CRMMP, avoid sensitive sites, and utilize the Unanticipated Discoveries Plan during construction. Please let us know if this is in line with your expectations so we can ensure that we are on the same page prior to the submittal of our PUC application.

If you would like to discuss this further, please let me know and I'll arrange a call or meeting asap.

Also, if you could please confirm receipt of this email given the size of the attachments I would appreciate it.

Thanks,
Jennie

JENNIE GEIGER
Environmental Permitting Manager

Apex Clean Energy, Inc.
310 4th St NE, Suite 200, Charlottesville, VA 22902
office: 434-260-6982 | cell: 720-320-9450 | fax: 434-220-3712
jennie.geiger@apexcleanenergy.com | www.apexcleanenergy.com

SWO

October 10, 2017 Meeting Summary and Correspondence

From:	Dave Phillips
To:	dianned@swo-nsn.gov; James Whitted (jamesw@swo.nsn.gov)
Cc:	Jennie Geiger; jmswhitted@yahoo.com; Gerry Bermel; Lance Rom
Subject:	Apex - Dakota Range Wind I - meeting follow up
Date:	Wednesday, October 18, 2017 9:48:52 AM
Attachments:	image002.png

Hi Dianne and Jim, I wanted to follow up with you on our meeting last week discussing Dakota Range Wind project. I really enjoyed meeting you and seeing your facility in Indian Village.

The following is a summary of the important issues discussed for the Dakota Range (300MW project) that is under contract with Xcel. Please review and provide suggestions or input if I've misrepresented or overlooked anything important to you.

For the purposes of a clear communication record, this email is limited to this project only, and I will send a separate email on other topics/projects discussed in our meeting. The main intent with this email is to memorialize the key commitments made for this project and summarize the points of our discussion for the Project's record.

1. SWO agreed to provide one Tribal Monitor to join QSI in field surveys beginning in ~2weeks if staff are available. In ~30 days SWO may be able to provide 2 more surveyors and they may be able to work until weathered out. Snow cover = no surveys.
    a. TCP surveys will be done in coordination with SWO on the entire facilities layout, including ag and low probability areas, and sensitive tribal resources will be avoided per SWO input. If there are situations that are problematic for avoidance, we will work together in good faith to resolve the siting issue.
    b. SWO will contract directly with QSI, not Apex, for the planned field survey work.
2. SWO expects tribal cultural surveys of the entire layout, including ag lands. In many cases they can survey the ag lands quickly using a drone.
    a. The single monitor avlble in ~2 weeks won't have access to the drone, so these areas may not get done this fall, but they will be completed spring and findings addressed via micrositing of facilities.
    b. If weather cooperates and staff availability allows, the surveys may continue into winter and possibly even be completed, but that is weather and staff dependent. Apex understands the need to be flexible.
3. SWO requested that a final cultural report to be a "joint report" with QSI and SWO, and that it include listing recommendations for all tribal resources SWO deems significant. This is inconsistent with state regulatory requirements and typical listing criteria, but is the tribes recommendation.
    a. Given we'd like to submit the PUC permit late fall, we may need a work around on this reporting request for the purpose of the PUC permit application. I think we can have QSI prep a traditional Level III archeological report on the High Probability Areas consistent with the CRMMP, that could be amended in spring with tribal input.
    b. Or we could do 2 stand-alone reports, one covering what gets completed this fall and one that covers what gets completed in spring.
    c. Regardless of the reporting situation and eligibility determinations, it doesn't change Apex's commitment to avoid impacts to sensitive TCPs identified by the SWO.

4. SWO has requested a written agreement, modeled after what they've set up with NextEra. Apex has asked for a draft to review and will do so once provided by the SWO.
5. SWO has no concerns on visual impacts on Dakota Range.

Thank you both for your time and helpful input on this project to date, as well as your willingness to work with us on trying to staff field surveys this fall. I realize you are meeting with Gerry and Lance next week to discuss field surveys and contracting and look forward to hearing how that goes.

I look forward to any feedback you may have on this meeting summary. If you'd like to meet in person to discuss further, please let me know and we can get another meeting on the calendar; otherwise, it sounds like based on planned coordination between Lance, Gerry and you two on the field surveys, things are moving forward.

Sincerely, Dave

DAVE PHILLIPS
Director, Environmental and Wildlife Permitting

Apex Clean Energy, Inc.
246 E. High Street, Charlottesville, VA 22902
W: 434-906-9127
Dave.Phillips@apexcleanenergy.com | www.apexcleanenergy.com

SWO

September 2, 2017 Correspondence Regarding CRMMP

Jennie Geiger

From: Mark Mauersberger
Sent: Saturday, September 2, 2017 6:22 AM
To: dianned@swo-nsn.gov; jmswhitted@yahoo.com
Cc: David Lau
Subject: Dakota Range SHPO Plan
Attachments: RE: Dakota Range Wind - CRMMP; DKR_ Cultural Resources Monitoring and Management Plan_ 2017-09-01_Final.pdf

Hello Dianne and Jim,

Please find the attached Cultural Resource Monitoring and Management Plan ("CRMMP") which was assembled by APEX.

This plan has been developed in close coordination with SHPO and incorporates your recommendations to "mark and avoid" important sites.

The Unanticipated Discovery Plan, included as Attachment 2 of the CRMMP, sets the stage for further coordination (in the event additional sites are found). The plan specifies "low risk to sensitive" cultural resources.

We will submit this CRMMP, with our PUC permit application this fall, and wanted to make certain you have had the opportunity to review the document.

Please contact me, if you have questions or need additional information.

We look forward to working with you on the project.

Regards,
Mark

Mark Mauersberger
Senior Development Manager

Apex Clean Energy, Inc.
8665 Hudson Blvd N, STE 110 Lake Elmo MN, 55402
cell: 612-834-2680 | fax: 434-220-3712
mark.mauersberger@apexcleanenergy.com | www.apexcleanenergy.com

SDDENR

July 2017 Correspondence

July 7, 2017

Mr. Kent Woodmansey
Natural Resources Engineering Director
South Dakota Department of Environment & Natural Resources
523 E. Capitol Ave.
Pierre, SD 57501

Re: Dakota Range Wind Energy Facility
Codington and Grant Counties, South Dakota

Dear Mr. Woodmansey:

Apex Clean Energy Holdings, LLC (Apex) is proposing to construct the Dakota Range Wind Energy Facility in Codington and Grant Counties, South Dakota. The project would be situated on approximately 40,000 acres (Figure 1) and would have a total capacity of up to 300 megawatts (MW). Project components would include:

- Up to 93 wind turbine generators
- Access roads to each turbine
- Underground 34.5-kilovolt (kV) electrical collector lines connecting the turbines to the collector substation
- Underground fiber-optic cable for turbine communications co-located with the collector lines
- A 34.5 to 345-kV collector substation
- A 345-kV interconnection transmission line connecting the collector substation and the interconnection switching station
- A 345-kV interconnection switching station connecting to the Big Stone South to Ellendale 345-kV line
- An operations and maintenance (O&M) facility
- Up to 5 permanent meteorological (met) towers

Apex will be applying to the South Dakota Public Utilities Commission (SDPUC) for a Facility Permit to construct the proposed project. At this time, Apex is requesting input from your agency regarding environmental resources in the project area that should be considered in the SDPUC application. Please send your comments to me at:

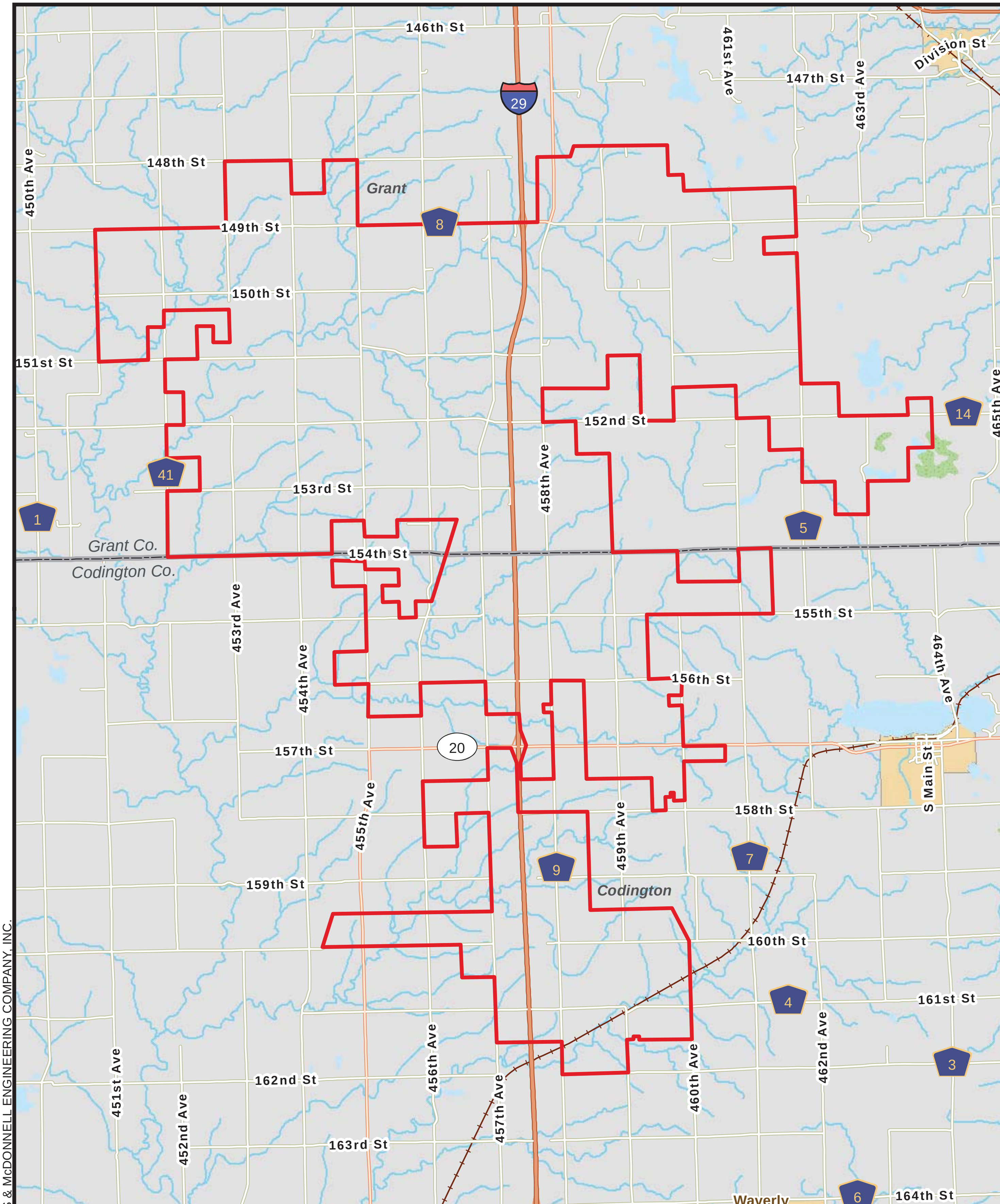
jbell@burnsmcd.com
-or-
Jennifer Bell
Burns & McDonnell
9785 Maroon Circle, Suite 400
Centennial, CO 80112

If you have any questions regarding the project or need additional information, please contact me at (303) 474-2229. Thank you for your time and assistance in providing this information.

Sincerely,

Jennifer Bell
Senior Environmental Scientist

Attachment
cc: Nate Pedder, Apex Clean Energy, Inc.



Project Boundary

County Boundary

NORTH

2 1 0 2

Scale in Miles

BURNS McDONNELL

Figure 1
Project Area
Dakota Range
Wind Energy Facility

Source: Esri, and Burns & McDonnell Engineering Company, Inc.

Issued: 6/5/2017

Path: Z:\Clients\ENS\ApexCleanEnr\99035_DakotaRangeI\Studies\Geospatial\DataFiles\ArcDocs\99035_DakotaRangeI_Fig1_ProjectArea.mxd kdboatright 6/5/2017

DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182

denr.sd.gov

July 26, 2017

Jennifer Bell
Burns & McDonnell
9785 Maroon Circle, Suite 400
Centennial, CO 80112

Dear Ms. Bell:

The South Dakota Department of Environment and Natural Resources (DENR) reviewed the request from Apex Clean Energy Holdings, LLC to construct the proposed Dakota Range Wind Energy Facility in Codington and Grant Counties. Based on the general information provided, the DENR has the following comments:

1. The department does not anticipate any adverse impacts to drinking waters of the state. The Drinking Water Program has no objections to this project.

2. The department does not anticipate any adverse impacts to the air quality of the state. The Air Quality Program has no objections to this project.

3. At a minimum and regardless of project size, appropriate erosion and sediment control measures must be installed to control the discharge of pollutants from the construction site. Any construction activity that disturbs an area of one or more acres of land must have authorization under the General Permit for Storm Water Discharges Associated with Construction Activities. Contact the Department of Environment and Natural Resources for additional information or guidance at 1-800-SDSTORM (800-737-8676) or http://denr.sd.gov/des/sw/StormWaterandConstruction.aspx.

4. A Surface Water Discharge (SWD) permit may be required if any construction dewatering should occur. Please contact this office for more information.

5. Impacts to rivers, tributaries, and wetlands should be avoided or minimized if possible. Surface waters are considered waters of the state and are protected under the South Dakota Surface Water Quality Standards.

   Within the proposed project area, the Big Sioux River is classified by the South Dakota Surface Water Quality Standards and Uses Assigned to Streams for the following beneficial uses:

   (5) Warmwater semipermanent fish life propagation waters;

(8) Limited contact recreation waters;
(9) Fish and wildlife propagation, recreation, and stock watering waters; and
(10) Irrigation waters.

An unnamed tributary (Grant County) has the following beneficial uses:
(6) Warmwater marginal fish life propagation waters;
(8) Limited contact recreation waters;
(9) Fish and wildlife propagation, recreation, and stock watering waters; and
(10) Irrigation waters.

Because of these beneficial uses, special construction measures may have to be taken to ensure that the 30-day average total suspended solids standards of 90 and 150 mg/L respectively are not violated.

The discharge of pollutants from any source, including indiscriminate use of fill material, may not cause destruction or impairment except where authorized under Section 404 of the Federal Water Pollution Control Act. Please contact the U.S. Army Corps of Engineers concerning this permit.

6. The Waste Management Program does not anticipate any adverse impacts. All waste material must be managed according to our solid waste requirements. Please contact the Waste Management Program if you have any questions on asbestos or solid waste disposal requirements at (605) 773-3153.

7. DENR's Ground Water Quality Program reviewed the above-referenced project for potential impacts to ground water quality and based on the information submitted does not anticipate the project will adversely impact ground water quality.

   There have been numerous petroleum and other chemical releases throughout the state. Of the releases reported to DENR, we have identified several releases in the vicinity of your projects. A list of releases in or near your project areas is enclosed in Table 1. However locational information provided to us regarding releases is sometimes inaccurate or incomplete. If you would like to do more research, additional information on reported releases in South Dakota is available at the following website: http://arcgis.sd.gov/server/denr/spillsviewer/.

   In the event that contamination is encountered during construction activities or caused by the construction work, Apex Clean Energy Holdings, LLC, or its designated representative, must report the contamination to DENR at 605-773-3296. Any contaminated soil encountered or caused by the construction activities should be temporarily stockpiled and sampled to determine disposal requirements.

If you have any questions concerning these comments, please contact me at (605) 773-3351.

Sincerely,

Shannon Minerich
Environmental Scientist
Surface Water Quality Program

cc: Mark Mayer, Drinking Water Program
Rick Boddicker, Air Quality Program
Vonni Kallemeyn, Waste Management Program
Ryan Fitzpatrick, Ground Water Quality Program

Table 1: Release Cases Near the Project Area(s) as of 07/25/2017

DENR ID	Site Name	City	County	Street	Material	Status	Latitude	Longitude
2008.076	Westcon Fertilizer Spill	Marvin	Grant	454th Ave. & 148th St	Dry Fertilizer	C	45.239014	-97.123489
2001328.00	Clean ATP - Zellner Property	Summit	Grant	45346 149th St		C	45.225040	-97.135515
2002.047	Lime Dumping	Milbank	Grant	I-29 Exit 201	Lime	C	45.224136	-97.051298
92.293	Southway Transport Limited Transport Event	Twin Brooks	Grant	I-29 MM 200	Diesel	C	45.218803	-97.051560
82.022	Regan Spraying - Aircraft Accident	Marvin	Grant	20 mi N & 1.25 mi W of Watertown	Parathion	C	45.201700	-97.036273
2004.085	Agrichem Disposal - Kowalski Property	South Shore	Grant	.25 miles N of 15282 463rd Ave	Unknown	C	45.170760	-96.944803
97.265	Transport Event	Marvin	Grant	Old Hwy 81, 2 miles S of Hwy 8	Diesel	C	45.192716	-97.102276
2002.295	ATP - Former Al's Service	Summit	Grant	455 Ave & 152nd St	Petroleum	NFA	45.181016	-97.102609
2002.294	ATP - Wallace Redlin Property	Summit	Grant	45496 152nd St	Petroleum	NFA	45.181172	-97.104015
95.161	Waste oil on roadway	Marvin	Grant	Old Hwy 81: 2 m N of County Line	Waste Oil	C	45.180881	-97.102781
93.308	Transport Event	Marvin	Grant	21 N & 1 E of Watertown	Diesel	C	45.180975	-97.072890
97.003	Transport Event Along I-29	Summit	Grant	I-29 MM 197	Diesel	C	45.165419	-97.056473
2002012.00	Clean ATP - Zubke Farm	Waverly	Codington	45785 159th Street		C	45.078308	-97.051717
99.125	Farm Tank - Roger Mohr	Waverly	Codington	16146 459th Avenue	Diesel	NFA	45.043053	-97.020934
2001.934	ATP - Richter Farm	Ortley	Grant	14785 453rd Avenue	Petroleum	C	45.240542	-97.145483
98.272	Truck Accident	South Shore	Codington	I-29 South Shore Exit	Diesel	C	45.107874	-97.056382

DENR ID = DENR Case Number

Status: C = Closed, NFA = No Further Action, O/M = Open/Monitoring, I=Inactive

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TECHNICAL MEMORANDUM

Date: August 29, 2017

To: Jennie Geiger, Apex Clean Energy Management, LLC

From: Western EcoSystems Technology, Inc.

Subject: Dakota Range I Wind Project – Dakota Skipper/Poweshiek Skipperling Habitat Survey Memo

INTRODUCTION

Dakota Range I, LLC, an affiliate of Apex Clean Energy Management, LLC (Apex), is developing the Dakota Range I Wind Project (Project), in Codington and Grant Counties, South Dakota (Figure 1). At Apex's request, Western EcoSystems Technology, Inc. (WEST) conducted a Dakota skipper (DASK; federally threatened) and Poweshiek skipperling (POSK; federally endangered) habitat survey to identify areas warranting avoidance during development and construction of the Project. This report includes results of surveys completed in 2016 and 2017 in the area currently proposed for development.

PROJECT AREA

The Project is approximately 47,483 acres (19,216 hectares) and is located in the Northern Glaciated Plains Level III Ecoregion (U.S. Environmental Protection Agency [USEPA] 2016) with about 92% of the Project in the Big Sioux Basin Level IV Ecoregion and the remainder in the Prairie Coteau. The predominant land cover/use types within the Project include approximately 54% cultivated crops and 38% herbaceous (grassland; Figure 2). The remaining land cover/use types account for less than 5% (U.S. Geological Survey [USGS] National Land Cover Database [NLCD] 2011, Homer et al. 2015). The most common cultivated cropland in 2016 was corn (*Zea mays*) and soybeans (*Glycine max*; U.S. Department of Agriculture [USDA] National Agricultural Statistics Service [NASS] 2016). Ownership within the Project area is largely private (USGS Protected Areas Database of the United States [PADUS] 2012); however, there are five US Fish and Wildlife Service (USFWS) Dakota Tallgrass Prairie Wildlife Management Areas totaling about 798 acres (323 hectares) within the Project area.

According to the National Wetlands Inventory (NWI; USFWS NWI 2007), about 600 acres (243 hectares) of the Project area is comprised of wetlands, of which about 79% are classified as freshwater emergent wetlands. The next most common wetland type is freshwater pond (10% of wetlands; Figure 2).

Several rivers and streams are within the Project area: the Big Sioux River flows southwest through the northwestern portion of the Project, Soo Creek flows southwest through the central area of the Project, Mahoney Creek flows southwest through the south-central portion of the Project, and Mud Creek flows southwest through the southern portion of the Project (Figure 2).

METHODS

Desktop Review: The Project area was evaluated by a WEST GIS Specialist using desktop analysis of available aerial photography and the *Quantifying Undisturbed (Native) Lands in Eastern South Dakota: 2013* (2013 Undisturbed Lands, Bauman et al. 2013) digital data layer to identify grasslands with potentially suitable DASK and POSK habitat (i.e., areas of untilled grassland). Potentially suitable habitat was defined as areas of grassland, based on a review of the 2016 USDA National Agriculture Imagery Program imagery, verified by review of the 2016 USDA Cropland Data Layer, and then reviewed with the 2013 Undisturbed Lands (Bauman et al. 2013) layer to further evaluate potential for past disturbances.

Field Review: Pedestrian field surveys were then conducted by a qualified WEST biologist to evaluate areas identified during the desktop review as potentially suitable habitat and to confirm areas of unsuitability. To ensure a thorough habitat evaluation of each potentially suitable area, the WEST biologist conducted a walking/meandering survey throughout each grassland area. All grasslands containing characteristics of suitable habitat for each species (see below), if found, were delineated using a sub-meter Trimble GPS unit.

Suitable Habitat Definitions

Dakota Skipper

According to the USFWS *Guidance for Interagency Cooperation under Section 7(a)(2) of the Endangered Species Act for the Dakota Skipper, Dakota Skipper Critical Habitat, and Poweshiek Skipperling Critical Habitat* (USFWS 2016), DASK habitat can be categorized into two general types, Type A and Type B.

Type A habitat typically occurs in wet-mesic portions of grasslands in North Dakota, but may occur in South Dakota. The indicator plant species within Type A habitat are prairie lily (*Lilium philadelphicum*), bluebell bellflower (*Campanula rotundifolia*), and mountain death camas/smooth camas (*Zigadenus elegans*) along with the host plants of native grasses such as little bluestem (*Schizachyrium scoparium*).

Type B habitat, which is more prevalent in South Dakota, includes native grass host plant species such as prairie dropseed (*Sporobolus heterolepis*), little bluestem, and sideoats grama (*Bouteloua curtipendula*) along with a high diversity and abundance of native flowering plants for nectar. The native forbs typical of Type B habitats include purple coneflower (*Echinacea purpurea*), purple prairie clover (*Dalea purpurea*), white prairie clover (*D. candida*), yellow sundrops (*Calylophus serrulatus*), prairie groundsel (*Packera plattensis*), groundplum milkvetch (*Astragalus crassicarpus*), eastern pasqueflower (*Pulsatilla patens*), old man's whiskers (prairie smoke, *Geum triflorum*), western silver aster (*Symphyotrichum sericeum*), dotted blazing star (*Liatris punctata*), tall blazing star (*L. aspera*), meadow zizia/heartleaf golden alexanders (*Zizia aptera*), blanket flower (*Gaillardia sp*.), prairie sagewort (*Artemisia frigida*), and leadplant (*Amorpha canescens*). Of these, purple coneflower is often one of the main forb species.

Poweshiek Skipperling

POSK habitat types are similar to the Type A DASK habitat in that they constitute a high diversity of native grasses and forbs in a more wet-mesic setting (USFWS 2016). Typical flowering plants include purple coneflower, black-eyed susan (*Rudbeckia hirta*), and palespike lobelia (*Lobelia spicata*). Native grass species that are indicators of potential POSK habitat include little bluestem, prairie dropseed, and slender spike rush (*Eleocharis elliptica*). There are no known current populations of POSK in South Dakota.

For field investigations of each habitat type, low densities of scattered individuals of characteristic plants were not deemed to be potential habitat

RESULTS

A total of 8,042.7 acres (4,760.6 acres in 2016 and 3,282.1 acres in 2017) of potentially untilled grassland were identified as warranting field evaluation (Figure 3). Field evaluations of these areas were completed between June 12-June 14, 2016 and June 16-June 19, 2017.

Most grasslands were found to be dominated by cool-season invasive grasses such as bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis).* Some grasslands (e.g., far northeastern half-section of Project area, south half of T120N R51W Sec. 5) were found to have more healthy populations of native grass species, but completely or nearly completely lacked the necessary native forbs for either DASK or POSK.

One 4.6 acre (1.9 hectares) area of potential Type B DASK habitat was identified within the northeast corner of the current Project boundary (Figure 3). Dakota Range I, LLC has determined that the 4.6 acres of potential DASK habitat will be completely avoided through Project design and no further assessment is needed. No other suitable habitat for DASK or POSK was identified within the Project.

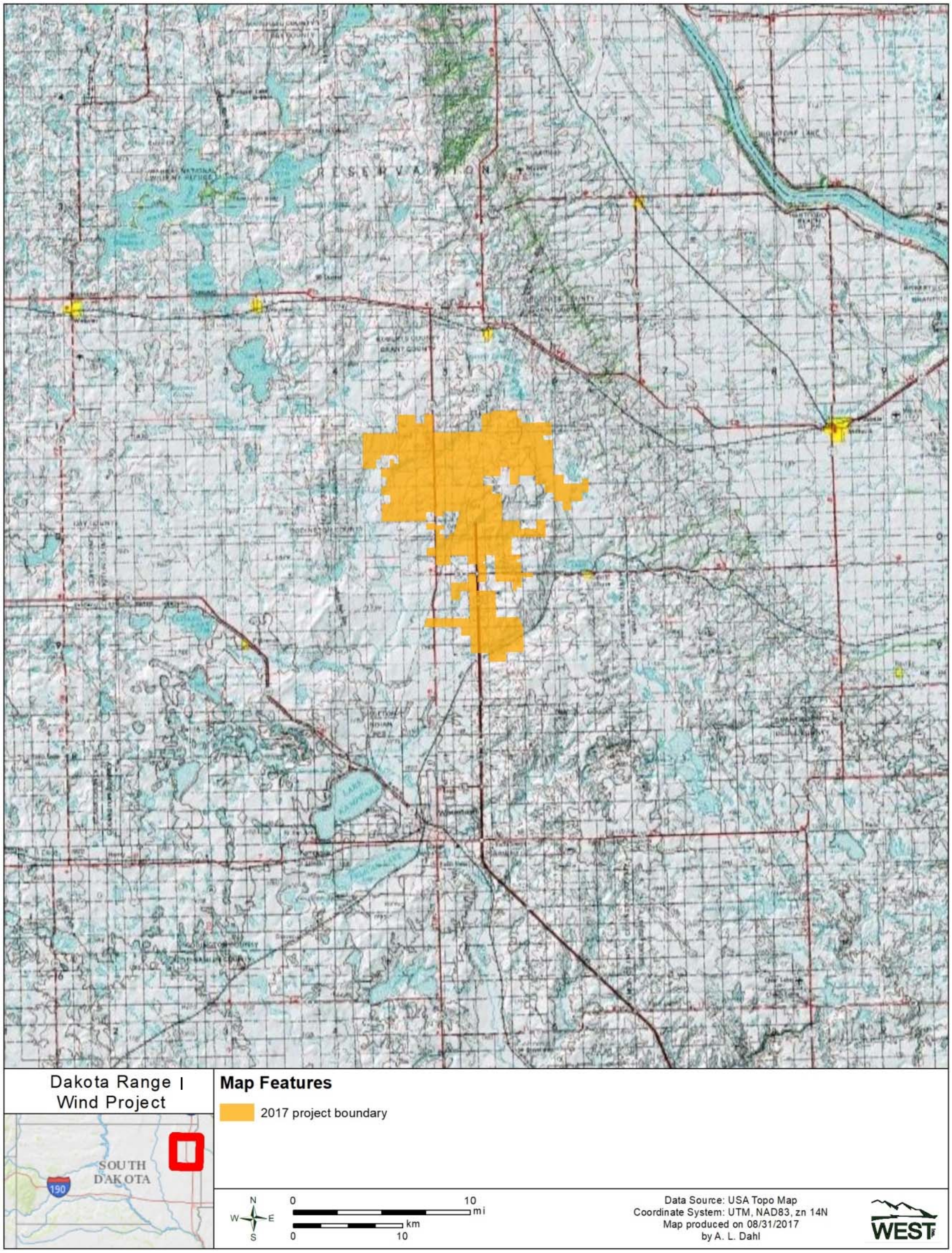

Figure 1. Location of the Dakota Range I Wind Project area in in Grant and Codington Counties, South Dakota.

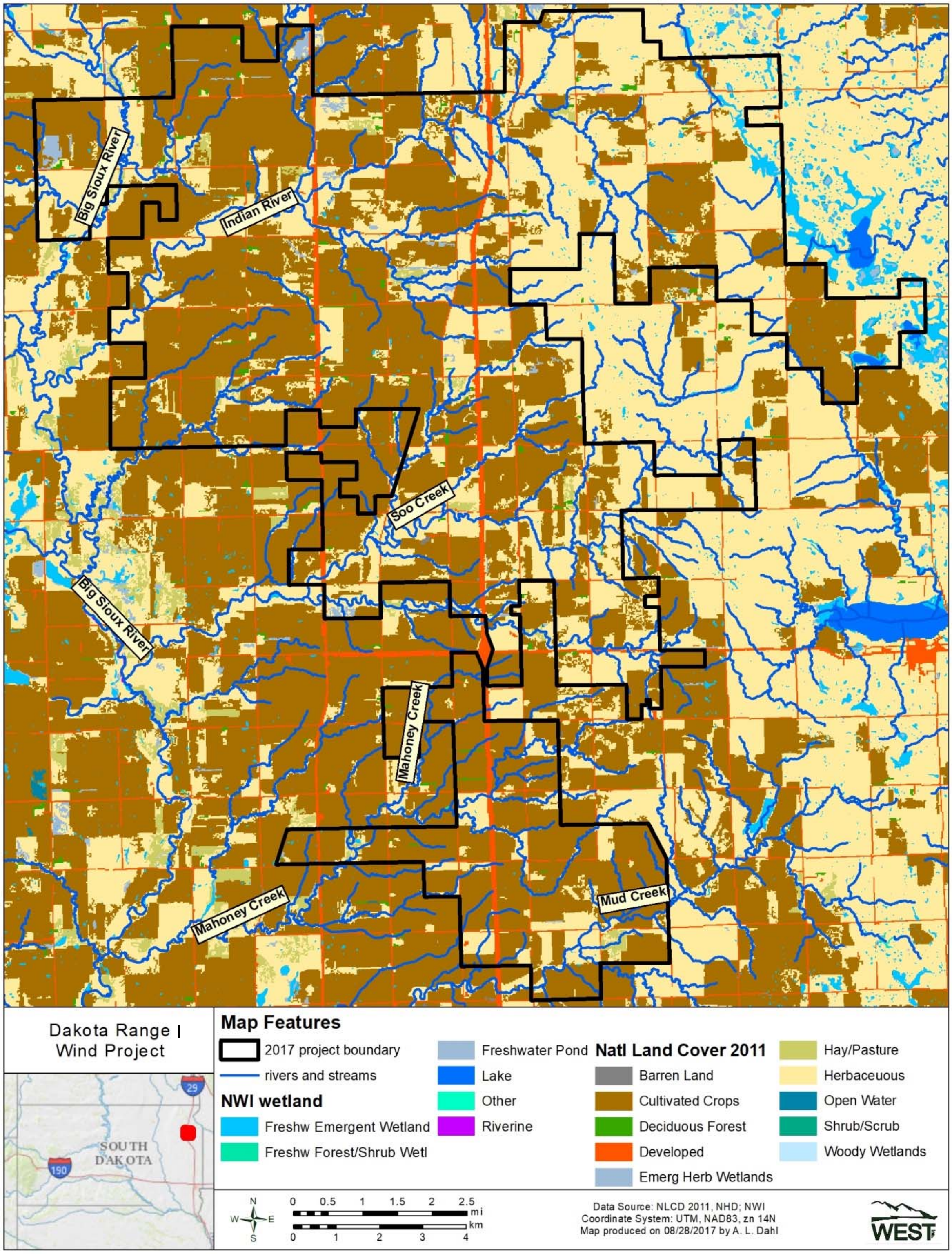

Figure 2. Land cover/use, wetlands, rivers, and streams in the Dakota Range I Wind Project area.

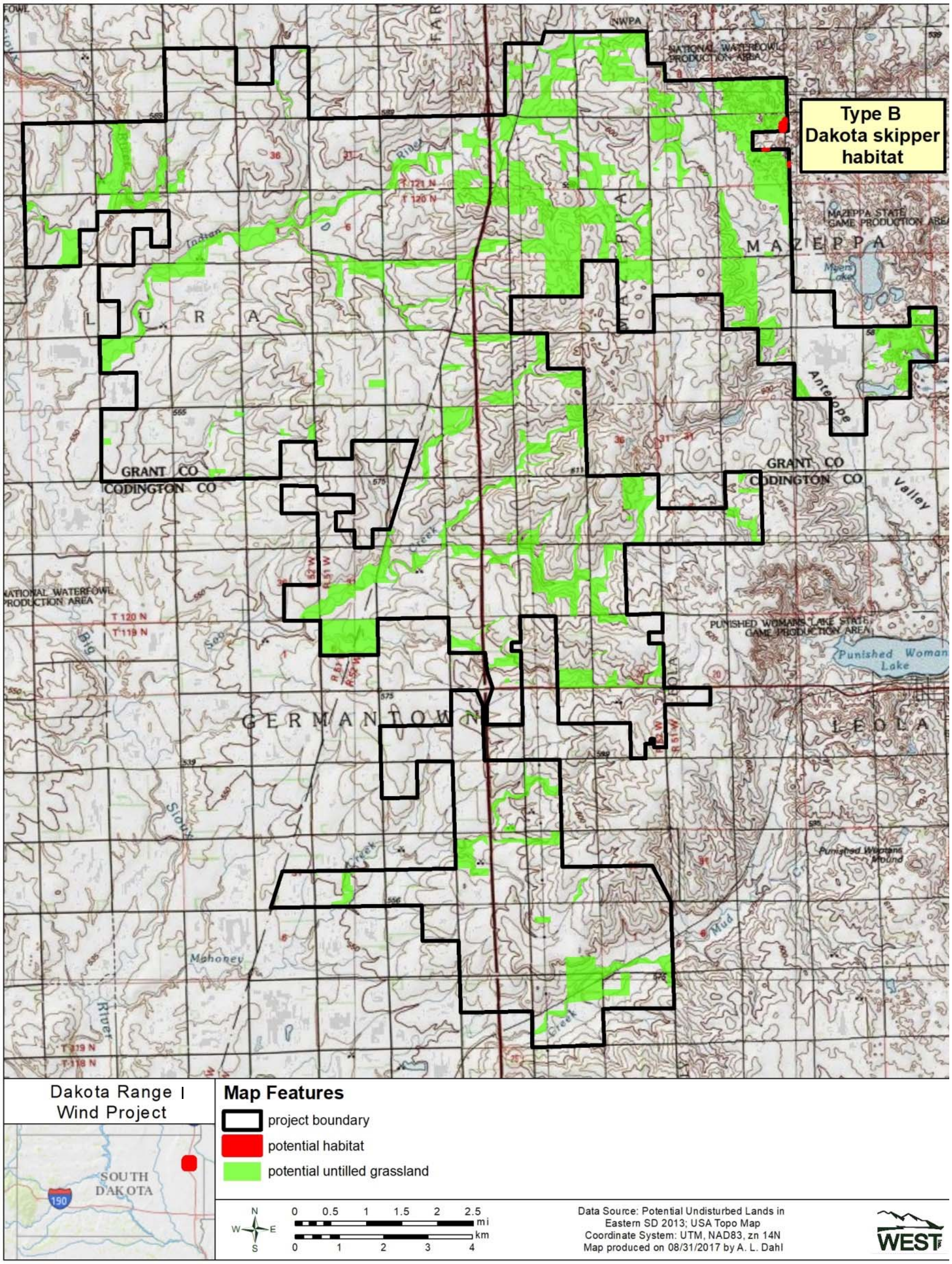

Figure 3. Potential untilled grassland areas evaluated for Dakota skipper and Poweshiek skipperling habitat and identified potential habitat within the Dakota Range I Wind Project area (2016-17).

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WEST Inc.
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May 20, 2016

Amanda Miller
Apex Clean Energy, Inc.,
244 East High Street
Charlottesville, VA 22902

RE: Dakota Range Raptor Nest Survey

Dear Ms. Miller,

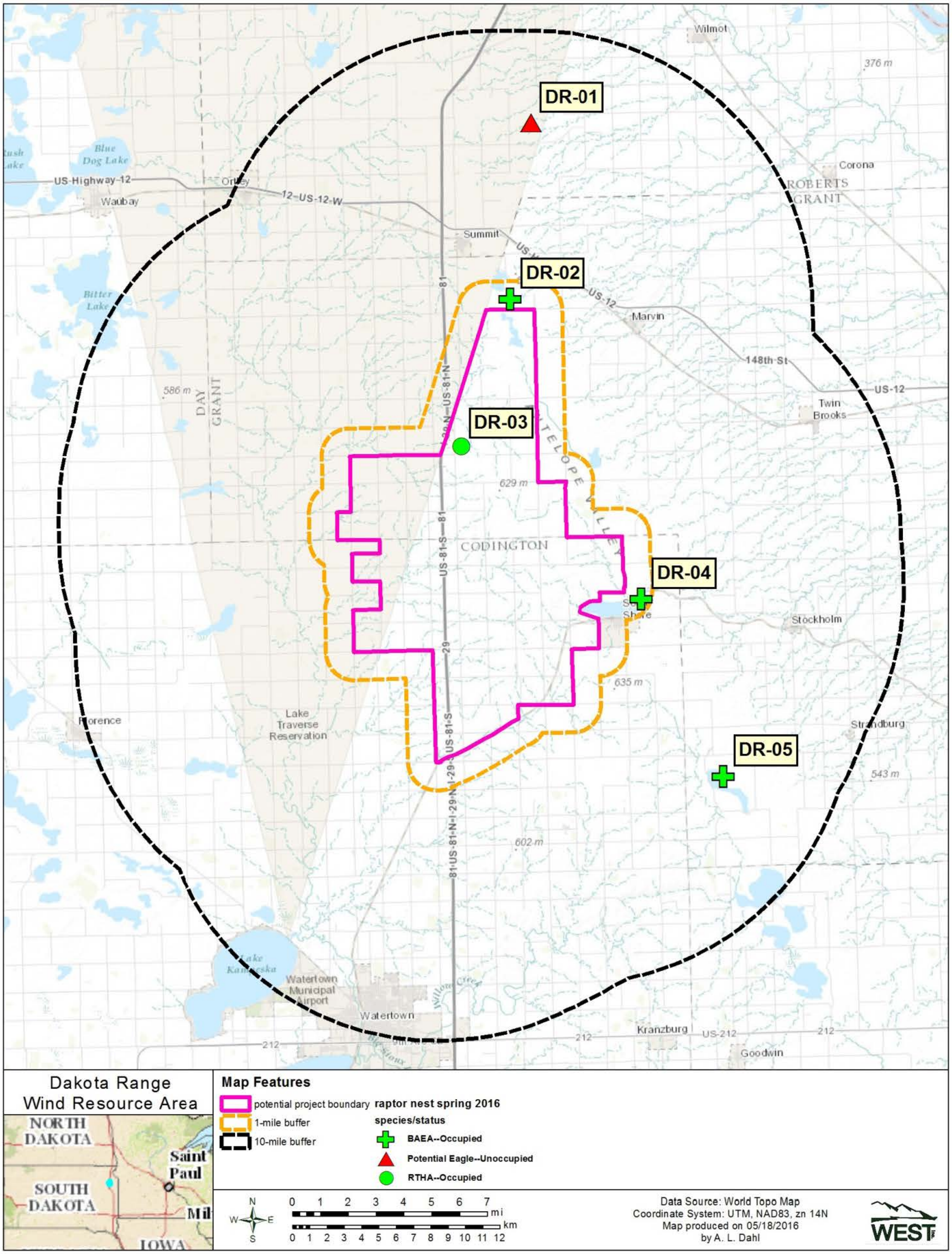
Western EcoSystems Technology, Inc. (WEST) completed the aerial nest survey for Dakota Range Wind Project (Project) on April 2, 2016.

Methods: Surveys were conducted by one qualified biologist flying low level surveys with a helicopter, in accordance with U.S. Fish and Wildlife Service and South Dakota Game, Fish and Parks Department recommendations. All potential nesting structures within the Project area and 1-mile buffer were surveyed for nesting raptor nests (e.g., eagles, buteos, owls). Only eagle nests or potential eagle nests based on size were recorded within a 1-10 mile buffer from the Project.

Results: A total of three occupied raptor nests were recorded within the Project and 1-mile buffer: one red-tailed hawk and two bald eagle nests. One occupied bald eagle nest and one unoccupied potential bald eagle nest were also identified within the 10-mile buffer (see attached map).

Sincerely,

Clayton Derby
Senior Manager



DR-01
DR-02
DR-03
DR-04
DR-05
Wilmot
Corona
ROBERTS
GRANT
Blue Dog Lake
US-Highway-12
Ortley
Waubay
Summit
Bitter Lake
Marvin
148th St
US-12
Twin Brooks
586 m
629 m
635 m
543 m
602 m
376 m
DAY
GRANT
CODINGTON
Stockholm
Florence
Lake Traverse Reservation
Strandburg
Lake Kampeska
Watertown Municipal Airport
Watertown
Kranzburg
US-212
Goodwin
Dakota Range Wind Resource Area
NORTH DAKOTA
SOUTH DAKOTA
Saint Paul
IOWA
Map Features
potential project boundary
1-mile buffer
10-mile buffer
raptor nest spring 2016
species/status
BAEA--Occupied
Potential Eagle--Unoccupied
RTHA--Occupied
0 1 2 3 4 5 6 7 mi
0 1 2 3 4 5 6 7 8 9 10 11 12 km
Data Source: World Topo Map
Coordinate System: UTM, NAD83, zn 14N
Map produced on 05/18/2016
by A. L. Dahl
WEST

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TECHNICAL MEMORANDUM

Date: June 20, 2017

To: Jennie Geiger, Apex Clean Energy Management, LLC

From: Western EcoSystems Technology, Inc.

Subject: Dakota Range Wind Project – Raptor Nest Survey Memo

INTRODUCTION

Apex Clean Energy Management, LLC. (Apex) is developing of the Dakota Range Wind Project (Project), in Coddington and Grant Counties, South Dakota. At Apex's request, Western EcoSystems Technology, Inc. (WEST) conducted an aerial raptor nest survey to record bald eagle (*Haliaeetus leucocephalus*) nests in or within 10 miles and other raptor nests in or within 1 mile of the Project. The purpose of the raptor nest survey report is to characterize the raptor nesting community in the Project vicinity for use in risk analysis and siting of facilities. The aerial survey was conducted in accordance with the guidance provided in the U.S. Fish and Wildlife Service (USFWS) *Eagle Conservation Plan Guidance: Module 1 – Land-based Wind Energy, Version 2* (ECPG; USFWS 2013), the USFWS *Interim Golden Eagle Inventory and Monitoring Protocols; and Other Recommendations* (Pagel et al. 2010), and by South Dakota Game, Fish and Parks Department.

PROJECT AREA

The Project, at the time of the raptor nest survey, was about 46,450 acres (18,798 hectares). The Project is located in the Northern Glaciated Plains Level III Ecoregion (U.S. Environmental Protection Agency [USEPA] 2016) with about 92% of the Project in the Big Sioux Basin Level IV Ecoregion and the remainder in the Prairie Coteau. The predominant land cover/use types within the Project include approximately 56% cultivated crops and 37% herbaceous (grassland; Figure 1). The remaining land cover/use types account for less than 5%, respectively (U.S. Geological Survey [USGS] National Land Cover Database [NLCD] 2011, Homer et al. 2015). The most common cultivated cropland in 2016 was corn (*Zea mays*) and soybeans (*Glycine max*; U.S. Department of Agriculture [USDA] National Agricultural Statistics Service [NASS] 2016). Ownership within the Project area is largely private (USGS Protected Areas Database of the United States [PADUS] 2012); however there are five Dakota Tallgrass Prairie Wildlife Management Areas totaling about 860 acres (348 hectares) within the Project.

According to the National Wetlands Inventory (NWI; USFWS NWI 2007), about 624 acres (253 hectares) of the Project area is composed of wetlands, of which about 78% of those wetlands are classified as freshwater emergent wetlands. The next most common wetland type was freshwater pond (10% of wetlands). The Big Sioux River flows through the northwestern portion of the Project. Mahoney Creek flows through the southern portion before joining the Big Sioux River. Mud Creek is within the Project, farther south than Mahoney Creek. Soo Creek flows through the central area of the Project before joining the Big Sioux River.

METHODS

One aerial survey was conducted from an R44 helicopter between April 11-14, 2017, a period before leaf-out when raptors would be actively tending to a nest or incubating eggs. An experienced raptor ecologist and a helicopter pilot skilled in wildlife surveys conducted the survey. Raptors are defined here as kites, accipiters, buteos, harriers, eagles, falcons, and owls (Buehler 2000). Raptor nest surveys focused on locating stick nest structures in suitable raptor nesting substrate (trees, transmission lines, cliff faces, etc.) within and around the proposed Project (Figure 2). The survey within the Project boundary and 1-mile (mi; 1.6 kilometer [km]) buffer documented all potential raptor nests, including bald eagles, while the surveys out to the 10-mi (16.1 km) buffer focused only on identifying potential bald eagle nests.

In general, all potential bald eagle and raptor nest habitat was surveyed by flying meandering transects between 0.25 and 1.0 mi (0.8 and 1.6 km) apart, flying at speeds of approximately 46 miles per hour (mph; 74 km per hour). Surveys were typically conducted between 07:00 hours and 18:00 hours. The helicopter was positioned to allow thorough visual inspection of the habitat, and in particular, to provide a view of the tops of the tallest dominant trees where bald eagles generally prefer to nest (Buehler 2000). The locations of all potential raptor nests were recorded using a hand-held Global Positioning System. To determine the status of a nest, the biologist evaluated behavior of adults on or near the nest, and presence of eggs, young, whitewash, or fresh building materials. Attempts were made to identify the species of raptor associated with each active nest. Raptor species, nest type, nest status, nest condition, and nest substrate were recorded at each nest location to the extent possible. Efforts were made to minimize disturbance to breeding raptors and nestlings; the greatest possible distance at which the species could be identified was maintained, with distances varying depending upon nest location and wind conditions.

Terminology

Included below are descriptions of terms used during the documentation of nests (see Results section), in accordance with the USFWS Eagle Conservation Plan Guidance (ECPG; USFWS 2013).

Nest ID - WEST assigned a unique nest identification number for each nest documented.

Species - A species was assigned to each nest when possible, otherwise, it was classified as an unknown raptor nest. Nests documented as unknown raptor species are defined as any stick nest that did not have an occupant associated with it at the time of the survey. Unknown raptor nests, including old nests or nests that could become suitable for raptors, are documented in order to populate a nest database to ensure that future surveys include all potentially suitable nest sites.

Nest Condition - Nest condition was categorized as either “good” or in “disrepair”. Although the determination of nest condition can be subjective and may vary between observers, it gives a general sense of when a nest or nest site may have last been used. Nests in disrepair were sloughing or sagging heavily, and they would require some level of effort to rebuild in order to be suitable for successful nesting. Nests in good condition are those that appear to have been well maintained, have a well-defined bowl shape, are not sagging or sloughing, and appear to be suitable for nesting.

Substrate - The substrate in which a nest was observed was recorded to provide observers a visual reference. Substrates can range from human-made structures (such as power lines, nest platforms, etc.) to biological and physical structures (conifer and deciduous tree species or cliff faces).

Nest Status - WEST categorizes basic nest use consistent with definitions from the ECPG. Nests were classified as occupied if any of the following were observed at the nest structure: (1) an adult in an incubating position, (2) eggs, (3) nestlings or fledglings, (4) occurrence of a pair of adults (or, sometimes, sub-adults), (5) a newly constructed or refurbished stick nest in the area where territorial behavior of a raptor had been observed early in the breeding season, or (6) a recently repaired nest with fresh sticks (clean breaks) or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. Occupied nests were further classified as active if there was an adult on the nest in incubating position, an egg or eggs had been laid or nestlings were observed, or inactive if no eggs or chicks were present. A nest that does not meet the above criteria for “occupied” was classified as “unoccupied”.

RESULTS

Five occupied bald eagle nests were observed in 2017 (Table 1; Figure 2). Another bald eagle nest, occupied and active in 2016, was unoccupied this year. None of the nests were located within the Project or 1-mile buffer, with the nearest occupied bald eagle nest located 1.8 miles to the west of the Project area.

Fifteen occupied and 17 unoccupied non-eagle raptor nests were located within the Project and 1-mile buffer (Table 1). The occupied nests were primarily common species (11 red-tailed hawk, three great horned owl, and one unknown non-eagle raptor).

Table 1. Summary details of raptor nests observed during aerial surveys at the Dakota Range Wind Project in April 2017. The projection for the Eastings and Northings is UTM, NAD83, zone 14N, units meters.

Nest ID	Date	Species	Nest Status	Nest Condition	Nest Substrate	Easting	Northing	Comments
DR-02	4/14/2017	Bald Eagle-	Unoccupied and Inactive	Good	Tree	656683	5015346	historic nest, empty nest at present
DR-04	4/11/2017	Bald Eagle	Occupied and Active	Good	Tree	664183	4998089	incubating
DR-05	4/12/2017	Bald Eagle	Occupied and Active	Good	Tree	668982	4987799	incubating
DR-06	4/14/2017	Bald Eagle	Occupied and Active	Good	Tree	657338	5026118	adult eagle incubating, recently repaired nest with fresh sticks
DR-07	4/12/2017	Bald Eagle	Occupied and Active	Good	Tree	627065	5012621	two adults, 1 sitting on nest & 1 in nearby tree, recently repaired nest w/fresh sticks
DR-08	4/12/2017	Bald Eagle	Occupied and Active	Good	Tree	645705	4997072	incubating
DR-09	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	657228	5011325	
DR-10	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	650370	5010853	incubating
DR-11	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	647920	5010051	
DR-12	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	649315	5008179	
DR-13	4/11/2017	Great Horned Owl	Occupied and Active	Good	Tree	652161	5007756	brooding
DR-14	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	660063	5005748	incubating
DR-15	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	662673	5005132	
DR-16	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	642188	5005440	
DR-17	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Disrepair	Tree	640664	5004526	
DR-18	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	646958	5004800	incubating
DR-19	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	648079	5004596	
DR-20	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	653328	5004388	
DR-21	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	656794	5004083	incubating
DR-22	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	658226	5004311	

Table 1. Summary details of raptor nests observed during aerial surveys at the Dakota Range Wind Project in April 2017. The projection for the Eastings and Northings is UTM, NAD83, zone 14N, units meters.

Nest ID	Date	Species	Nest Status	Nest Condition	Nest Substrate	Easting	Northing	Comments
DR-23	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Disrepair	Tree	646617	5003232	2 nests at this point
DR-24	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Disrepair	Tree	644743	4999907	
DR-25	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	659675	5000201	incubating
DR-26	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	651360	4999427	
DR-27	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	652970	4998674	
DR-28	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Disrepair	Tree	656956	4998512	
DR-29	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	658719	4998526	incubating
DR-30	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	650203	4996885	incubating
DR-31	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	655736	4997111	
DR-32	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	654779	4996743	
DR-33	4/11/2017	Great Horned Owl	Occupied and Active	Good	Tree	657473	4995369	brooding
DR-34	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	656486	4993632	incubating
DR-35	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Disrepair	Tree	656753	4993641	
DR-36	4/11/2017	Great Horned Owl	Occupied and Active	Good	Tree	648722	4991537	brooding
DR-37	4/11/2017	Unknown Raptor	Occupied and Inactive	Disrepair	Tree	651712	4990376	
DR-38	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	653503	4988308	
DR-39	4/11/2017	Unknown Raptor	Unoccupied and Inactive	Good	Tree	656428	4988601	
DR-40	4/11/2017	Red-tailed Hawk	Occupied and Active	Good	Tree	654616	4987289	incubating

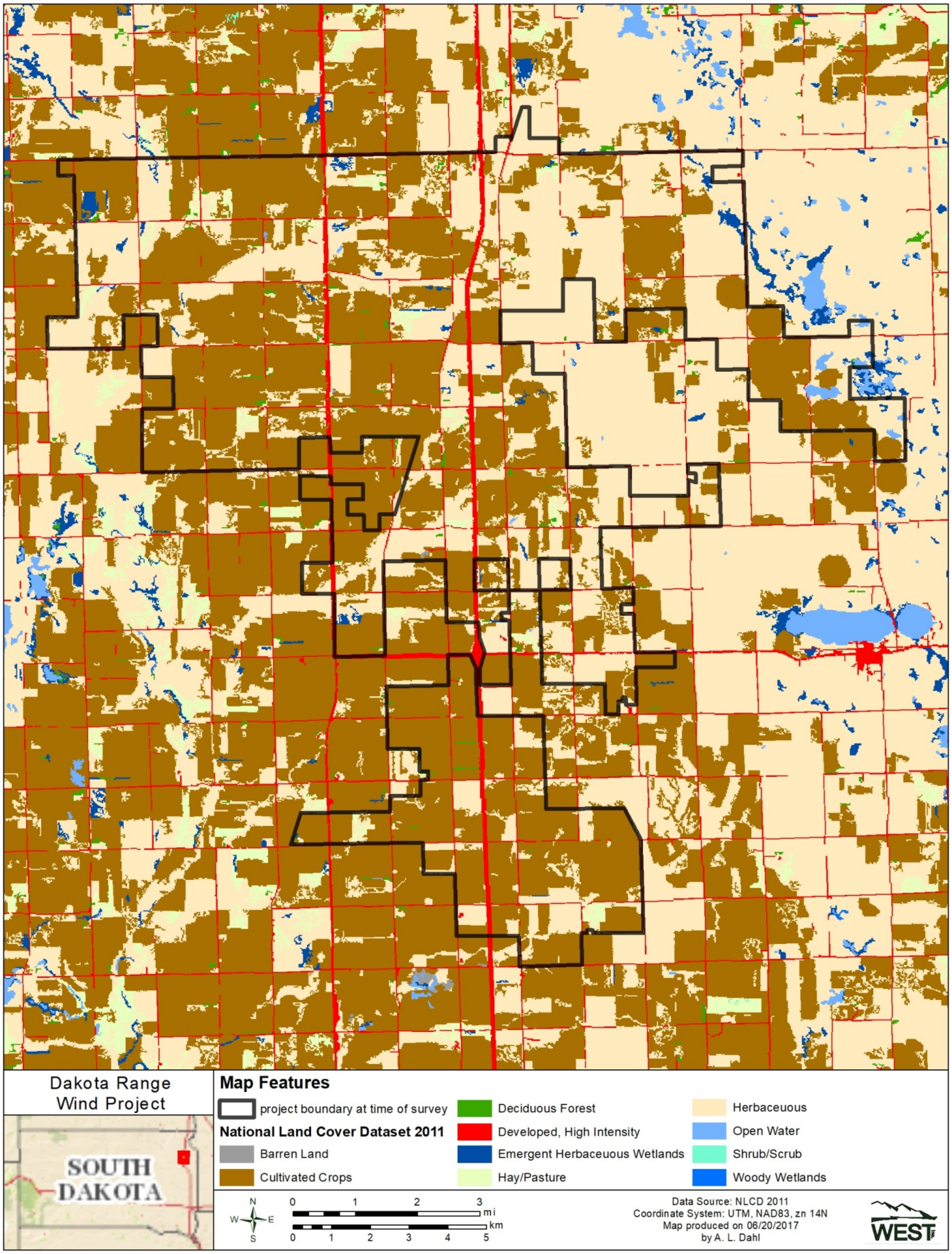

Figure 1. Land cover and use at the Dakota Range Wind Project.

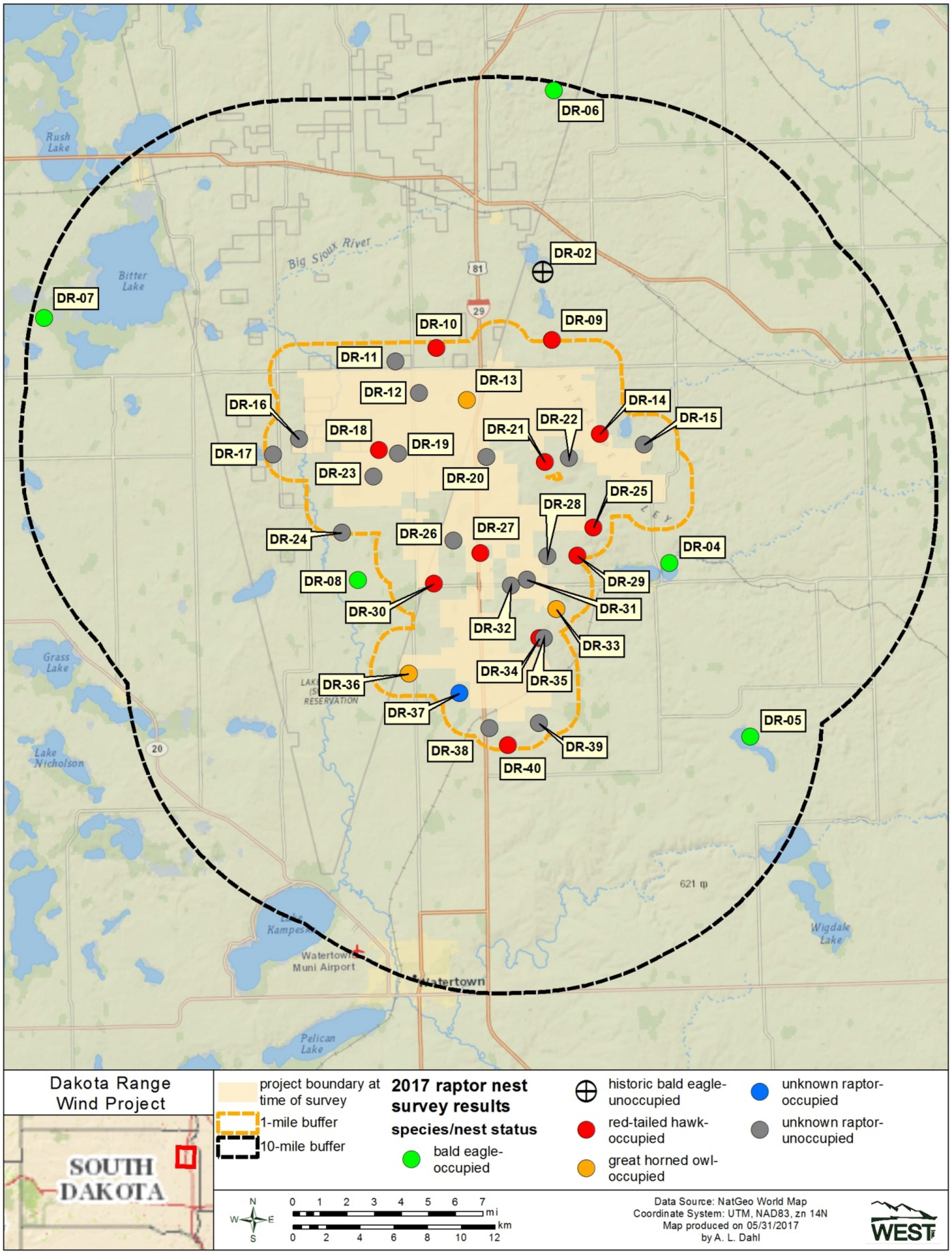

Figure 2. Raptor nests observed during aerial surveys at the Dakota Range Wind Project in April 2017.

CONCLUSIONS

Red-tailed hawks, great horned owls, and bald eagles are common raptor species that breed throughout South Dakota. Lack of bald eagle nests within the Project or within two miles of the Project minimizes potential impacts to the species.

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TECHNICAL MEMORANDUM

Date: September 28, 2017

To: Jennie Geiger, Apex Clean Energy Management, LLC

From: Western EcoSystems Technology, Inc.

Subject: Dakota Range I Wind Project – Avian/Eagle Use Summary

INTRODUCTION

Dakota Range I Wind, LLC, an affiliate of Apex Clean Energy Management, LLC (Apex), is developing the Dakota Range I Wind Project (Project), in Codington and Grant counties, South Dakota (Figure 1). General avian use point-count surveys were initiated in December 2015 to evaluate species composition (including small bird species), relative abundance, and seasonal variation for large bird species. Eagle use was evaluated at the same locations using methodology recommended in the US Fish and Wildlife Service (USFWS) *Eagle Conservation Plan Guidance* (ECPG; USFWS 2013). Study periods and methods were developed in coordination with USFWS and South Dakota Game Fish and Parks. In this technical memorandum, Western EcoSystems Technology, Inc. (WEST) summarizes data recorded for small and large bird species, eagles, and species of concern (i.e., federally or state-threatened and endangered species [Endangered Species Act 1973], USFWS Birds of Conservation Concern [BCC; USFWS 2008], and South Dakota Species of Greatest Conservation Need [SGCN; South Dakota Wildlife Action Plan 2017]) recorded during surveys.

Project Area

The Project, about 50,125 acres (20,285 hectares), is located in the Northern Glaciated Plains Level III Ecoregion (US Environmental Protection Agency 2016) with most of the Project in the Big Sioux Basin Level IV Ecoregion and the remainder in the Prairie Coteau. The predominant land cover/use types within the Project are cultivated crops and herbaceous (grassland; US Geological Survey [USGS] National Land Cover Database 2011, Homer et al. 2015; Figure 2). The most common cultivated cropland in 2016 was corn (*Zea mays*) and soybeans (*Glycine max*; US Department of Agriculture National Agricultural Statistics Service 2016).

According to the National Wetlands Inventory (NWI; USFWS NWI 2007), most of the wetlands within the Project are classified as freshwater emergent wetlands. The next most common wetland type is freshwater pond. Several rivers and streams are within the Project: the Big Sioux River flows southwest through the northwestern portion of the Project, Soo Creek flows southwest through the central area of the Project, Mahoney Creek flows southwest through the south-central portion of the Project, and Mud Creek flows southwest through the southern portion of the Project (Figure 3).

METHODS

Fixed-point avian use surveys were conducted approximately once monthly during winter and spring from between December 3, 2015 – May 30, 2017 at 40 survey points using methods described by Reynolds et al. (1980).

Each survey point was located to maximize visibility for the observer and to enable evaluation of representative habitats within and near the Project. Sampling intensity was designed to document use and behavior of birds during the study period. Surveys were carried out during daylight hours, and survey periods varied to cover approximately all daylight hours during a season. To the extent practical, survey effort was roughly consistent across survey points.

Surveys were conducted for 65 minutes (min), with small birds recorded within 100 meters (m; 328 feet [ft]) for the first five min, large birds (including raptors and eagles) recorded out to 800 m (2,625 ft) for the next 20 min, and eagles and sensitive species only recorded for the remaining 40 mins, resulting in 60-min eagle surveys. Sensitive species, if observed, were recorded at any time during the 65-min survey. The 60-min survey methodology for eagles is consistent with the methods recommended in the USFWS ECPG (USFWS 2013). The survey plots used in this evaluation were representative of potential development areas and encompassed approximately 30% of the area under consideration for development (Figure 3).

The following information was recorded during each survey: date, start and end time, and weather information (i.e., temperature, wind speed, wind direction, precipitation, and cloud cover). Additionally, the following data were recorded for each bird observation: species observed (or best possible identification), number of individuals observed, distance from survey point when first observed, closest distance of bird to observer, flight height above ground, flight direction, and activity of bird. Approximate flight height, flight direction, and distance from plot center were recorded when the bird or birds were first observed; the approximate lowest and highest flight heights were recorded at any time during the bird or birds observation.

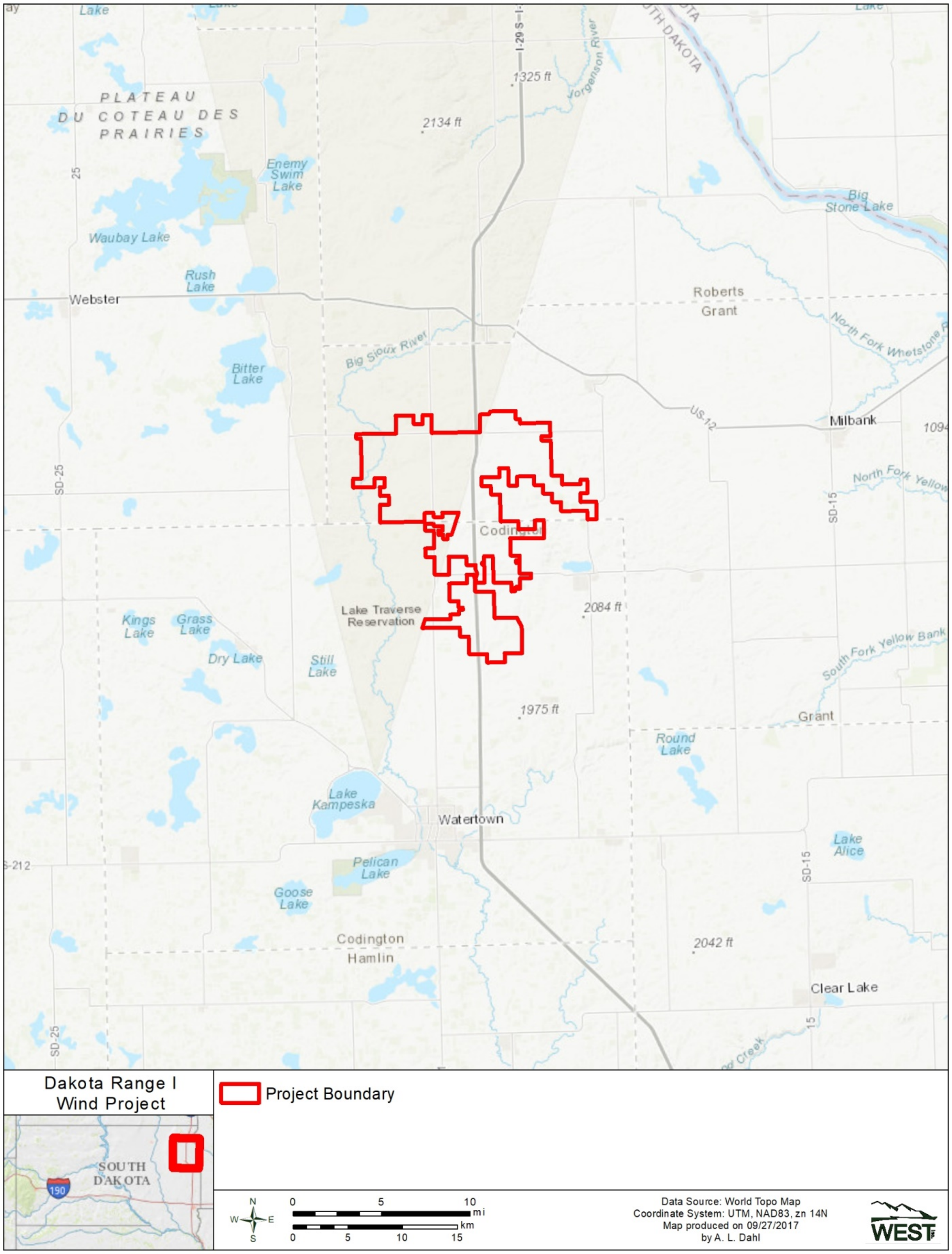

Figure 1. Dakota Range I Wind Project location in Codington and Grant counties, South Dakota.

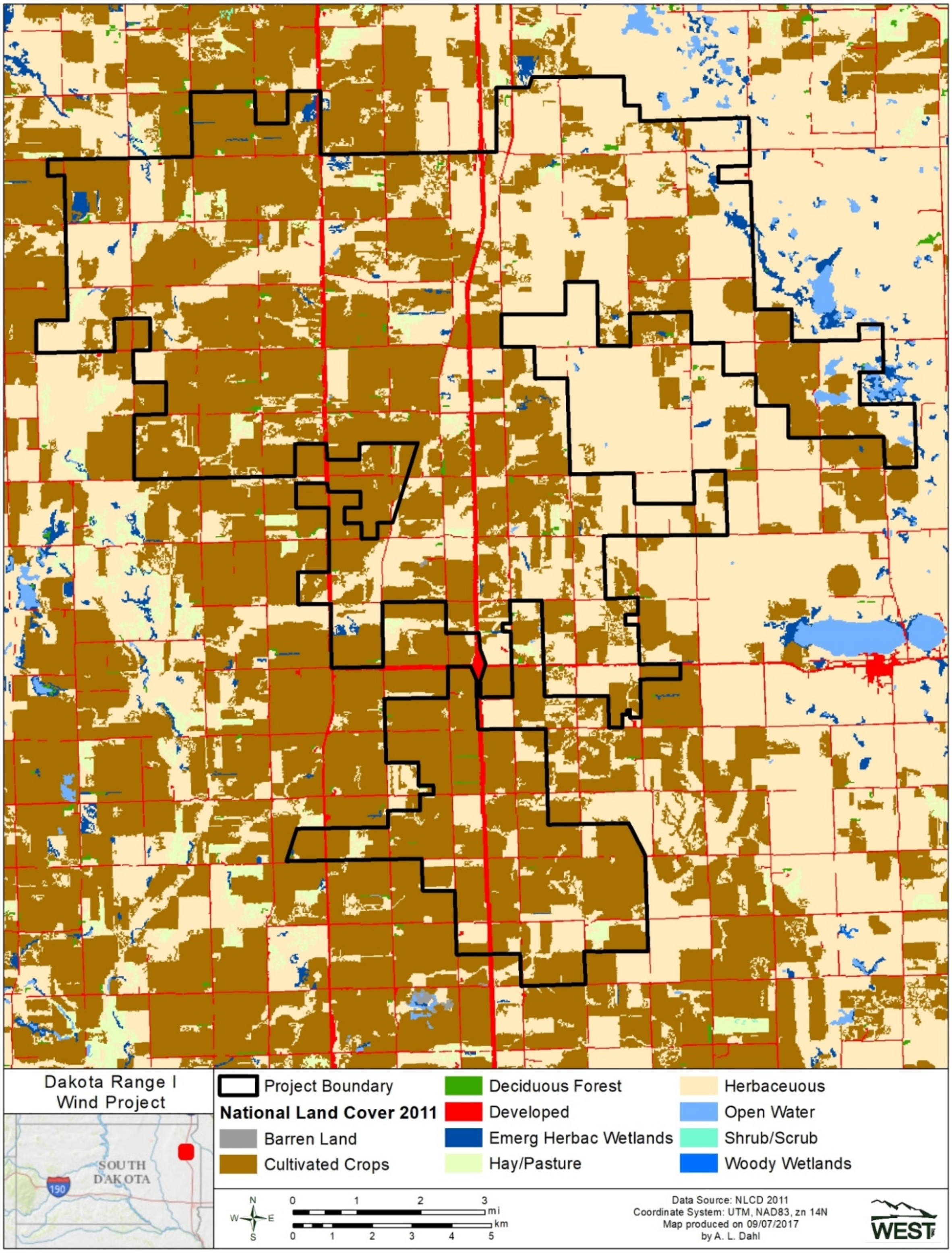

Figure 2. Land cover/use types in and near the Dakota Range I Wind Project in Codington and Grant counties, South Dakota (US Geological Survey National Land Cover Database 2011, Homer et al. 2015).

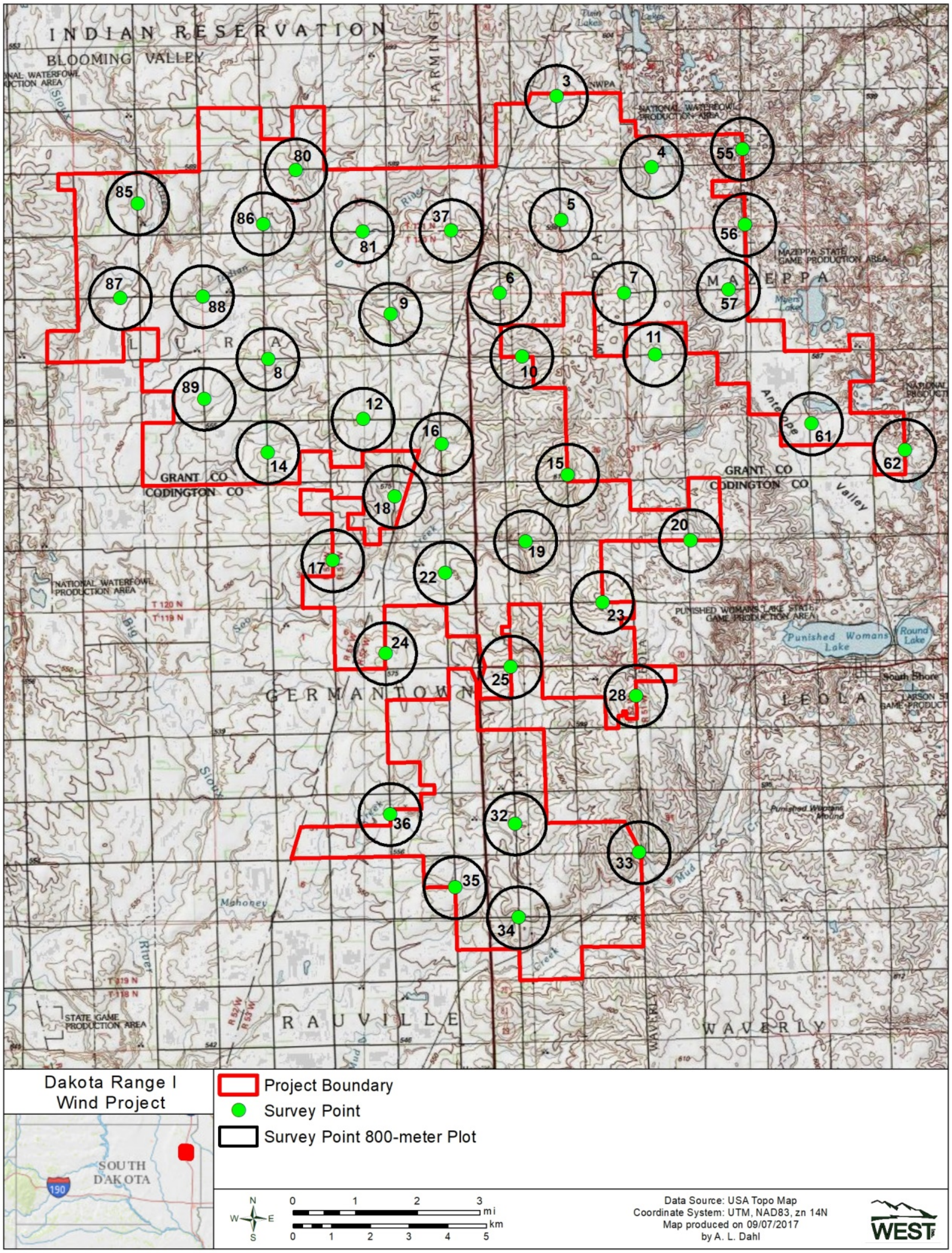

Figure 3. Survey point locations at the Dakota Range I Wind Project in Codington and Grant counties, South Dakota.

Data Analysis

For small birds, a list of species with number of individuals and groups observed during the 5-min survey was compiled.

For large birds, standardized fixed-point bird use estimates were generated based on large birds detected within the 800-m radius plot. Mean bird use was calculated as the number of birds per plot per 20-min survey. These standardized estimates of mean bird use can be used to compare differences between bird types, seasons, survey points, and other studies where similar methods were used. Mean use by season was calculated by summing the total number of birds seen within each plot during a visit, then averaging across plots within each visit, followed by averaging across visits within the season. Frequency of occurrence was calculated as the percent of surveys in which a particular bird type or species was observed. We generated a summary table for large birds, tallying the number of individuals and groups observed by species and season.

A separate summary of eagle minutes (i.e., observations of flying eagles that were recorded within 800-m of the observer and at or below 200 m (656 ft) above ground level), was calculated in accordance with the ECPG (USFWS 2013).

RESULTS

Surveys were conducted in winter and spring from December 3, 2015 – May 30, 2017, resulting in 221 hours of 60-min survey effort (108 hours in winter and 113 hours in spring). Each survey point was surveyed approximately six times, with approximately three surveys during the first winter (25 points from December 3, 2015 – February 25, 2016; 85 survey hours) or second winter (10 points from January 2, 2017 – February 24, 2017; 23 survey hours), followed by approximately three surveys during spring (40 points from March 2, 2017 – May 30, 2017; 113 survey hours).

Small Birds

Twenty small bird species, with 753 observations in 153 groups, were recorded during 5-min surveys (Appendix A). The most commonly observed small bird species were red-winged blackbird (*Agelaius phoeniceus*; 408 observations) and horned lark (*Eremophila alpestris*; 104 observations). No federal or state-listed, BCC, or SGCN small bird species were observed.

Large Birds

Thirty large birds species, with 1,863 observations in 126 groups, were recorded during the 20-min large bird survey (Appendix A). The most commonly recorded species were waterfowl, comprising 84% of the total number of large bird observations (Appendix B). Canada goose (*Branta canadensis*), greater white-fronted goose (*Anser albifrons*), and snow goose (*Chen caerulescens*) accounted for most of those observations. Large bird mean use was somewhat higher in spring (9.17 birds/800-m plot/20-min survey) than in winter (8.59 birds/800-m plot/20-min survey; Appendix B).

Six diurnal raptor species were identified during the large bird surveys, which accounted for 20 raptor observations (1% of large bird observations; Appendix A). Red-tailed hawk (*Buteo jamaicensis*; 10 observations) was the most commonly observed diurnal raptor, followed by northern harrier (*Circus cyaneus*; four observations). Diurnal raptor use was higher in spring (0.13 birds/800-m plot/20-min survey) than in winter (0.03 birds/800-m plot/20-min survey; Appendix B).

Eagles

One bald eagle (*Haliaeetus leucocephalus*) was observed in winter and one in spring during the 60-min eagle use count surveys. Three eagle minutes were recorded at Point 7 on December 3, 2015, and four were recorded at Point 36 on March 3, 2017 (Table 1). Bald eagle use was 0.006 eagles/800-m plot/60-min survey in winter, and 0.010 eagles/800-m plot /60-min survey in spring (Table 1). Eagle flight paths are shown in Figure 4. No golden eagles (*Aquila chrysaetos*) were observed during surveys.

Table 1. Number of bald eagle observations and minutes where eagles flew below 200 meters (m) above ground level within 800 m of the observer (eagle minutes [min]), survey effort (hours), and eagle use (eagles/800-m plot /60-min survey) observed during large bird surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

Season	Number of Eagle Observations	Eagle Minutes	Survey Effort (hours)	Eagle Use (eagles/plot/60 min)
Winter	1	3	108	0.006
Spring	1	4	113	0.010

Sensitive Species

No federally threatened or endangered species were observed during the study (Endangered Species Act 1973). One state endangered species, peregrine falcon (*Falco peregrinus*; n=1), was documented during surveys (South Dakota Wildlife Action Plan 2017). Four BCC species were documented: (American bittern [*Botaurus lentiginosus*; n=2], bald eagle [n=2], marbled godwit [*Limosa fedoa*; n=6], and peregrine falcon), and four SGCN species were documented (American white pelican [*Pelecanus erythrorhynchos*; n=21], bald eagle, marbled godwit, and peregrine falcon; Table 2).

Table 2. Sensitive species observed during surveys at Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

Species	Number of Observations	BCC	BGEPA	State	SGCN
American bittern	2	X			
American white pelican	21				X
bald eagle	2	X	X		X
marbled godwit	6	X			X
peregrine falcon	1	X		Endangered	X

BCC-Birds of Conservation Concern (US Fish and Wildlife Service 2008)
BGEPA-Bald and Golden Eagle Protection Act (1940)
SGCN-Species of Greatest Conservation Need (South Dakota Wildlife Action Plan 2017)

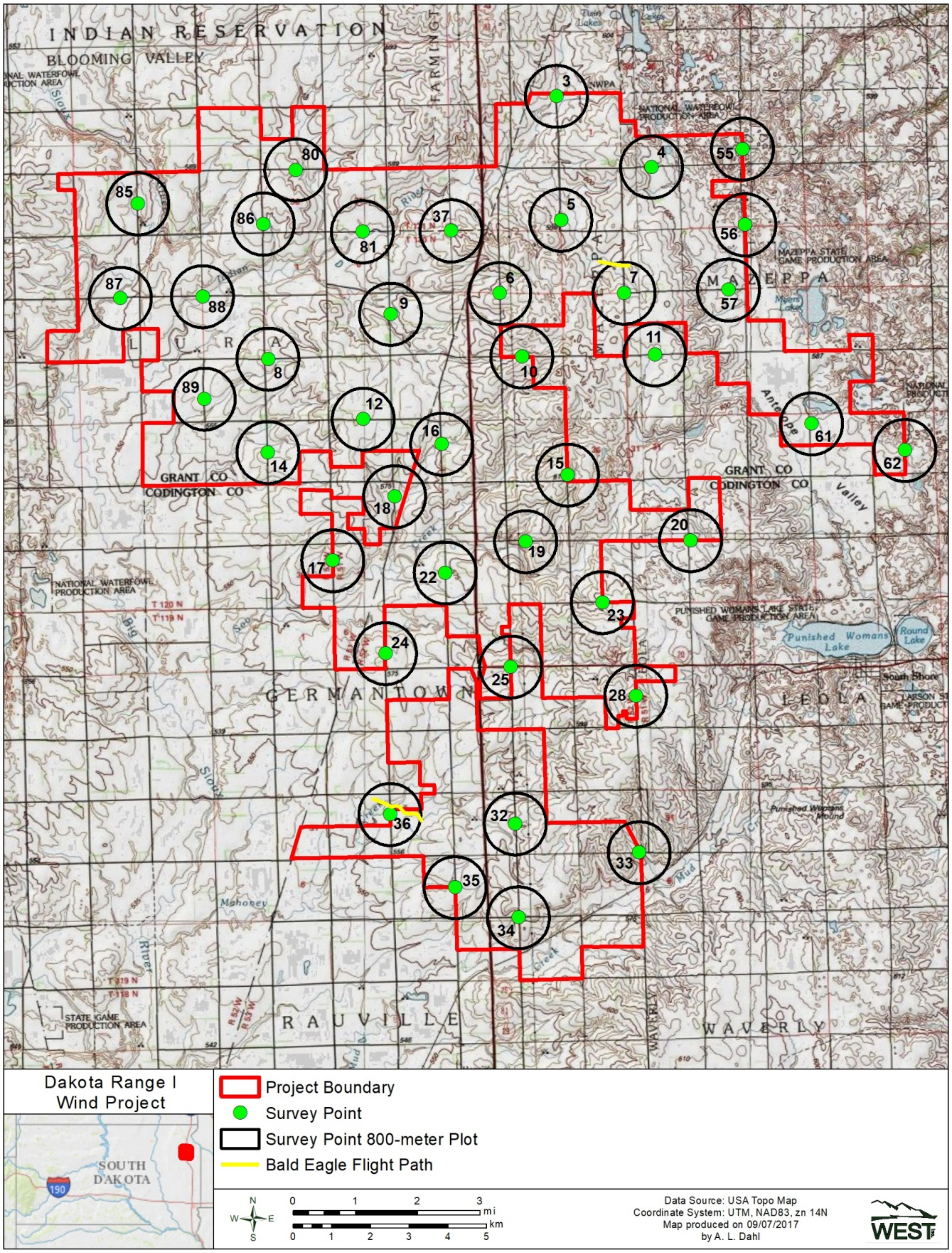

Figure 4. Bald eagle flight paths recorded during surveys at Dakota Range I Wind Project in Codington and Grant counties, South Dakota from December 3, 2015 – May 30, 2017.

DISCUSSION

In general, the bird species observed during the fixed-point bird use surveys at the Project were common species typical of agricultural and grassland environments in this area of South Dakota (Drilling et al. 2016, South Dakota Birds, Birding, and Nature 2017) during winter and spring. No federally threatened or endangered species and one state endangered species (peregrine falcon) were observed during the study. Five BCC and SGCN species were documented in low numbers (American bittern, American white pelican, bald eagle, marbled godwit, peregrine falcon). Direct impacts to avian species are expected to be low as evidenced by data from projects operating in similar habitats (Appendix C).

Diurnal raptors most often observed were relatively common, widespread species and potential impacts from the Project are unlikely to cause significant adverse impacts to local or regional populations. Two bald eagles were observed over 221 hours of surveys. The results of this study combined with other publicly available information within the area (i.e., adjacent Summit Wind project to the north with 231 hrs of study across a full year with no bald eagle and only one golden eagle observation [Derby and Dahl 2014]), suggest that risk to bald eagles is likely to be very low.

Waterfowl use at the Project was mostly comprised of snow geese, white-fronted geese, and Canada geese. In an analysis of 116 studies of bird mortality at over 70 facilities, waterfowl made up 2.7% of 4,975 fatalities (Erickson et al. 2014) suggesting waterfowl are not especially vulnerable to turbine collisions. The presence of similar habitat surrounding the Project suggests any displacement of these species is unlikely to negatively impact their populations.

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Appendix A. Summary of Individual and Group Observations of Small and Large Bird Type and Species by Season, Observed During Bird Surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017

Appendix A1. Summary of individual (# obs) and group (# grps) observations of small bird species and type, by season, observed within 100 meters of the observer, during small bird surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

		Winter		Spring		Total	
Type/Species	**Scientific Name**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**
Blackbird/Orioles		**0**	**0**	**80**	**468**	**80**	**468**
Baltimore oriole	*Icterus galbula*	0	0	1	1	1	1
bobolink	*Dolichonyx oryzivorus*	0	0	3	3	3	3
brown-headed cowbird	*Molothrus ater*	0	0	11	16	11	16
red-winged blackbird	*Agelaius phoeniceus*	0	0	26	408	26	408
western meadowlark	*Sturnella neglecta*	0	0	38	39	38	39
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	0	0	1	1	1	1
Corvids		**1**	**1**	**4**	**4**	**5**	**5**
blue jay	*Cyanocitta cristata*	1	1	4	4	5	5
Finches/Crossbills		**0**	**0**	**1**	**2**	**1**	**2**
American goldfinch	*Spinus tristis*	0	0	1	2	1	2
Flycatchers		**0**	**0**	**4**	**4**	**4**	**4**
eastern kingbird	*Tyrannus tyrannus*	0	0	4	4	4	4
Grassland/Sparrows		**4**	**54**	**25**	**156**	**29**	**210**
clay-colored sparrow	*Spizella pallida*	0	0	1	1	1	1
horned lark	*Eremophila alpestris*	4	54	15	50	19	104
Lapland longspur	*Calcarius lapponicus*	0	0	2	16	2	16
Savannah sparrow	*Passerculus sandwichensis*	0	0	6	9	6	9
snow bunting	*Plectrophenax nivalis*	0	0	1	80	1	80
Shorebirds		**0**	**0**	**11**	**14**	**11**	**14**
Wilson's snipe	*Gallinago delicata*	0	0	11	14	11	14
Swallows		**0**	**0**	**9**	**24**	**9**	**24**
barn swallow	*Hirundo rustica*	0	0	7	22	7	22
tree swallow	*Tachycineta bicolor*	0	0	2	2	2	2
Thrushes		**0**	**0**	**12**	**24**	**12**	**24**
American robin	*Turdus migratorius*	0	0	12	24	12	24
Warblers		**0**	**0**	**1**	**1**	**1**	**1**
yellow-rumped warbler	*Setophaga coronata*	0	0	1	1	1	1
Woodpeckers		**0**	**0**	**1**	**1**	**1**	**1**
unidentified woodpecker		0	0	1	1	1	1
Overall Small Birds		**5**	**55**	**148**	**698**	**153**	**753**

Appendix A2. Summary of individual (# obs) and group (# grps) observations of large bird species and type, by season, observed within 800 meters of the observer, during 20-minute large bird surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

Type/Species	Scientific Name	Winter # grps	Winter # obs	Spring # grps	Spring # obs	Total # grps	Total # obs
Waterbirds		**0**	**0**	**2**	**22**	**2**	**22**
American white pelican	*Pelecanus erythrorhynchos*	0	0	1	21	1	21
great blue heron	*Ardea herodias*	0	0	1	1	1	1
Waterfowl		**7**	**641**	**56**	**917**	**63**	**1,558**
blue-winged teal	*Anas discors*	0	0	9	57	9	57
Canada goose	*Branta canadensis*	3	236	17	95	20	331
gadwall	*Anas strepera*	0	0	3	8	3	8
greater white-fronted goose	*Anser albifrons*	2	260	2	130	4	390
lesser scaup	*Aythya affinis*	0	0	1	6	1	6
mallard	*Anas platyrhynchos*	1	75	15	44	16	119
northern pintail	*Anas acuta*	0	0	2	4	2	4
northern shoveler	*Anas clypeata*	0	0	1	1	1	1
ring-necked duck	*Aythya collaris*	0	0	1	2	1	2
ruddy duck	*Oxyura jamaicensis*	0	0	1	15	1	15
snow goose	*Chen caerulescens*	1	70	4	555	5	625
Shorebirds		**0**	**0**	**1**	**6**	**1**	**6**
marbled godwit	*Limosa fedoa*	0	0	1	6	1	6
Gulls/Terns		**0**	**0**	**7**	**9**	**7**	**9**
ring-billed gull	*Larus delawarensis*	0	0	7	9	7	9
Rails/Coots		**0**	**0**	**1**	**1**	**1**	**1**
American coot	*Fulica americana*	0	0	1	1	1	1
Diurnal Raptors		**5**	**5**	**15**	**15**	**20**	**20**
Buteos		*4*	*4*	*10*	*10*	*14*	*14*
broad-winged hawk	*Buteo platypterus*	0	0	1	1	1	1
red-tailed hawk	*Buteo jamaicensis*	1	1	9	9	10	10
rough-legged hawk	*Buteo lagopus*	3	3	0	0	3	3
Northern Harrier		*1*	*1*	*3*	*3*	*4*	*4*
northern harrier	*Circus cyaneus*	1	1	3	3	4	4
Eagles		*0*	*0*	*1*	*1*	*1*	*1*
bald eagle	*Haliaeetus leucocephalus*	0	0	1	1	1	1

Appendix A2. Summary of individual (# obs) and group (# grps) observations of large bird species and type, by season, observed within 800 meters of the observer, during 20-minute large bird surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

		Winter		Spring		Total	
Type/Species	**Scientific Name**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**
Falcons		*0*	*0*	*1*	*1*	*1*	*1*
peregrine falcon	*Falco peregrinus*	0	0	1	1	1	1
Owls		**1**	**1**	**1**	**1**	**2**	**2**
great horned owl	*Bubo virginianus*	0	0	1	1	1	1
snowy owl	*Bubo scandiacus*	1	1	0	0	1	1
Vultures		**0**	**0**	**1**	**1**	**1**	**1**
turkey vulture	*Cathartes aura*	0	0	1	1	1	1
Upland Game Birds		**9**	**102**	**5**	**6**	**14**	**108**
ring-necked pheasant	*Phasianus colchicus*	3	5	0	0	3	5
sharp-tailed grouse	*Tympanuchus phasianellus*	1	2	1	2	2	4
wild turkey	*Meleagris gallopavo*	5	95	4	4	9	99
Doves/Pigeons		**7**	**57**	**0**	**0**	**7**	**57**
rock pigeon	*Columba livia*	7	57	0	0	7	57
Large Corvids		**7**	**72**	**2**	**8**	**9**	**80**
American crow	*Corvus brachyrhynchos*	7	72	2	8	9	80
Overall Large Birds		36	878	90	985	126	1,863

Appendix B. Mean Bird Use, Percent of Total Use, and Frequency of Occurrence for Each Large Bird Type and Species by Season During Surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017

Appendix B. Mean bird use (number of birds/800-meter plot/20-minute survey), percent of total use (%), and frequency of occurrence (%) for each large bird type and species, by season, during surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

	Mean Use		% of Use		% Frequency	
Type/Species	**Winter**	**Spring**	**Winter**	**Spring**	**Winter**	**Spring**
Waterbirds	**0**	**0.19**	**0**	**2.1**	**0**	**1.7**
American white pelican	0	0.18	0	2	0	0.9
great blue heron	0	<0.01	0	<0.1	0	0.9
Waterfowl	**7.18**	**8.57**	**83.6**	**93.5**	**3.9**	**23.8**
blue-winged teal	0	0.49	0	5.3	0	6
Canada goose	2	0.86	23.3	9.3	3.3	9.6
gadwall	0	0.07	0	0.7	0	2.6
greater white-fronted goose	3.71	1.24	43.2	13.5	1.4	1
lesser scaup	0	0.05	0	0.6	0	0.9
mallard	1.07	0.4	12.5	4.3	1.4	11.3
northern pintail	0	0.03	0	0.4	0	1.7
northern shoveler	0	<0.01	0	<0.1	0	0.9
ring-necked duck	0	0.02	0	0.2	0	0.9
ruddy duck	0	0.13	0	1.4	0	0.9
snow goose	0.4	5.29	4.7	57.6	0.6	1.9
Shorebirds	**0**	**0.05**	**0**	**0.6**	**0**	**0.9**
marbled godwit	0	0.05	0	0.6	0	0.9
Gulls/Terns	**0**	**0.08**	**0**	**0.8**	**0**	**4.3**
ring-billed gull	0	0.08	0	0.8	0	4.3
Rails/Coots	**0**	**<0.01**	**0**	**<0.1**	**0**	**0.9**
American coot	0	<0.01	0	<0.1	0	0.9
Diurnal Raptors	**0.03**	**0.13**	**0.3**	**1.4**	**2.9**	**12.1**
Buteos	*0.02*	*0.09*	*0.3*	*0.9*	*2.3*	*8.5*
broad-winged hawk	0	<0.01	0	<0.1	0	0.9
red-tailed hawk	<0.01	0.08	<0.1	0.8	0.6	7.7
rough-legged hawk	0.02	0	0.2	0	1.7	0
Northern Harrier	*<0.01*	*0.03*	*<0.1*	*0.3*	*0.6*	*2.6*
northern harrier	<0.01	0.03	<0.1	0.3	0.6	2.6
Eagles	*0*	*<0.01*	*0*	*0.1*	*0*	*1*
bald eagle	0	<0.01	0	0.1	0	1

Appendix B. Mean bird use (number of birds/800-meter plot/20-minute survey), percent of total use (%), and frequency of occurrence (%) for each large bird type and species, by season, during surveys at the Dakota Range I Wind Project from December 3, 2015 – May 30, 2017.

	Mean Use		% of Use		% Frequency	
Type/Species	**Winter**	**Spring**	**Winter**	**Spring**	**Winter**	**Spring**
Falcons	*0*	*<0.01*	*0*	*<0.1*	*0*	*0.9*
peregrine falcon	0	<0.01	0	<0.1	0	0.9
Owls	*<0.01*	*<0.01*	*<0.1*	*0.1*	*0.6*	*1*
great horned owl	0	<0.01	0	0.1	0	1
snowy owl	<0.01	0	<0.1	0	0.6	0
Vultures	*0*	*<0.01*	*0*	*<0.1*	*0*	*0.9*
turkey vulture	0	<0.01	0	<0.1	0	0.9
Upland Game Birds	*0.62*	*0.05*	*7.3*	*0.6*	*6.4*	*4.3*
ring-necked pheasant	0.05	0	0.6	0	2.9	0
sharp-tailed grouse	0.01	0.02	0.1	0.2	0.6	0.9
wild turkey	0.56	0.03	6.5	0.4	2.9	3.4
Doves/Pigeons	*0.33*	*0*	*3.8*	*0*	*4*	*0*
rock pigeon	0.33	0	3.8	0	4	0
Large Corvids	*0.42*	*0.08*	*4.9*	*0.8*	*4.8*	*1.9*
American crow	0.42	0.08	4.9	0.8	4.8	1.9
Overall Large Birds	8.59	9.17	100	100		

Appendix C. Raptor and All Bird Fatality Estimates for Wind Facilities in the Midwest

Appendix C. Raptor and all bird fatality estimates (number of fatalties per megawatt [MW] per year) and dominant land cover/use for wind facilities in the Midwest.

Facility/Project Name	All Bird Fatalities/ MW/Year	Raptors Fatalities/ MW/Year	Dominanat Land Cover/Use	Reference
Barton I & II, IA (2010-2011)	5.50	0	agriculture	Derby et al. 2011a
Big Blue, MN (2013)	0.60	0	agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	0.37	0	agriculture	Fagen Engineering 2015
Blue Sky Green Field, WI (2008; 2009)	7.17	0	agriculture	Gruver et al. 2009
Buffalo Ridge I, SD (2009-2010)	5.06	0.20	agriculture/grassland	Derby et al. 2010a
Buffalo Ridge II, SD (2011-2012)	1.99	0	agriculture, grassland	Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1996)	4.14	0	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1997)	2.51	0	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1998)	3.14	0	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1999)	1.43	0.47	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.47	0	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	3.57	0	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 1999)	5.93	0	agriculture	Johnson et al. 2000
Cedar Ridge, WI (2009)	6.55	0.18	agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	3.72	0.13	agriculture	BHE Environmental 2011
Elm Creek II, MN (2011-2012)	3.64	0	agriculture, grassland	Derby et al. 2012b
Elm Creek, MN (2009-2010)	1.55	0	agriculture	Derby et al. 2010b
Fowler I, IN (2009)	2.83	0	agriculture	Johnson et al. 2010
Grand Ridge I, IL (2009-2010)	0.48	0	agriculture	Derby et al. 2010f
Heritage Garden I, MI (2012-2014)	1.30	NA	agriculture	Kerlinger et al. 2014
Kewaunee County, WI (1999-2001)	1.95	0	agriculture	Howe et al. 2002
Moraine II, MN (2009)	5.59	0.37	agriculture/grassland	Derby et al. 2010c
NPPD Ainsworth, NE (2006)	1.63	0.06	agriculture/grassland	Derby et al. 2007
Pioneer Prairie II, IA (2011-2012)	0.27	0	agriculture, grassland	Chodachek et al. 2012
Prairie Winds ND1 (Minot), ND (2010)	1.48	0.05	agriculture	Derby et al. 2011c
Prairie Winds ND1 (Minot), ND (2011)	1.56	0.05	agriculture, grassland	Derby et al. 2012c
Prairie Winds SD1, SD (2011-2012)	1.41	0	grassland	Derby et al. 2012d
Prairie Winds SD1, SD (2012-2013)	2.01	0.03	grassland	Derby et al. 2013
Prairie Winds SD1, SD (2013-2014)	1.66	0.17	grassland	Derby et al. 2014
Rail Splitter, IL (2012-2013)	0.84	0	agriculture	Good et al 2013a
Rugby, ND (2010-2011)	3.82	0.06	agriculture	Derby et al. 2011b
Summerview, Alb (2005-2006)	1.06	0.11	agriculture	Brown and Hamilton 2006
Top Crop I & II (2012-2013)	1.35	NA	agriculture	Good et al 2013b
Top of Iowa, IA (2003)	0.42	0	agriculture	Jain 2005
Top of Iowa, IA (2004)	0.81	0.17	agriculture	Jain 2005
Wessington Springs, SD (2009)	8.25	0.06	grassland	Derby et al. 2010e
Wessington Springs, SD (2010)	0.89	0.07	grassland	Derby et al. 2011d
Winnebago, IA (2009-2010)	3.88	0.27	agriculture/grassland	Derby et al. 2010d

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June 6, 2016

Amanda Miller
Apex Clean Energy, Inc.,
244 East High Street
Charlottesville, VA 22902

RE: Dakota Range Lek Survey

Dear Ms. Miller,

Western EcoSystems Technology, Inc. (WEST) completed the aerial lek survey for sharp-tailed grouse and greater prairie-chickens as part of the Dakota Range Wind Project (Project) development.

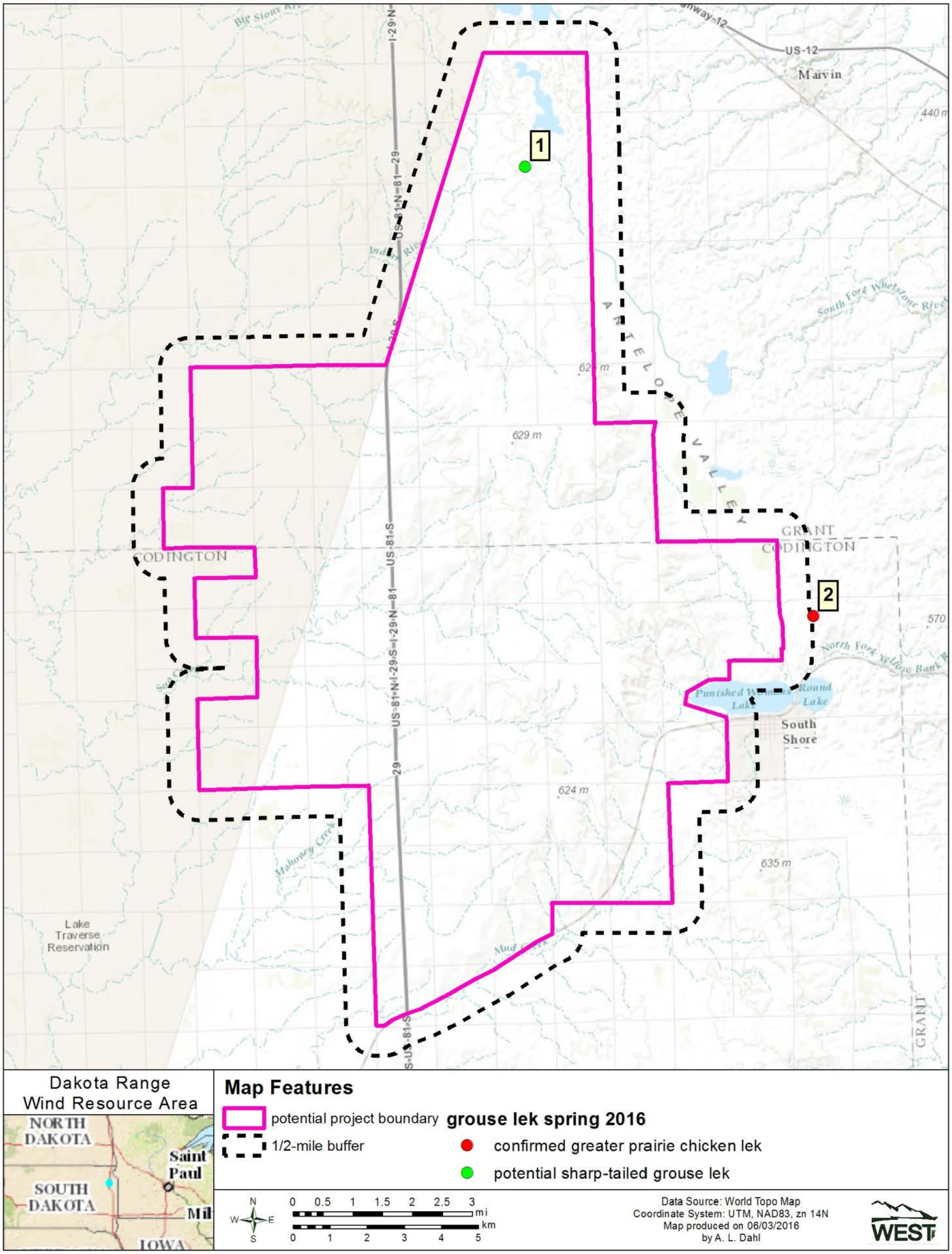
Methods: Surveys were completed by two biologists plus one pilot flying in a small (e.g., Cessna 172) fixed-wing aircraft, in accordance with U.S. Fish and Wildlife Service and South Dakota Game, Fish and Parks Department recommendations. Surveys were initiated in early April but due to weather the actual survey start was delayed until mid-April and resulted in only two of three survey rounds being completed by early May 2016. Surveys were completed between April 12 and May 5, 2016 and conducted by flying parallel north-south transects spaced 400-m apart through the entire Project and 0.5-mile buffer around the Project. Flight height was approximately 75-150 feet above ground level. Surveys were conducted when winds were below 20 mph and rain was not persistent. A potential lek was defined as a location where 3 or more birds are observed; however, leks were confirmed by repeated observations of strutting males.

Results:
A group of approximately 24 sharp-tailed grouse (STG) was observed flushing at Location 1 during the first survey; however, no birds were observed in this area during the second survey; therefore, this location was designated as a potential lek, which may be present in the vicinity.

Six male greater prairie-chicken (GPC) were observed displaying at Location 2 during both surveys, indicating this is a GPC lek location.

Sincerely,

Clayton Derby
Senior Manager



Dakota Range
Wind Resource Area
NORTH DAKOTA
SOUTH DAKOTA
Saint Paul
IOWA
Map Features
potential project boundary
1/2-mile buffer
grouse lek spring 2016
confirmed greater prairie chicken lek
potential sharp-tailed grouse lek
1
2
Marvin
US-12
I-29-N
US-81-N-81-29
US-81-S
US-81-N-I-29-S-I-29-N-81
29
ANTELOPE VALLEY
South Fork Whetstone River
GRANT
CODINGTON
North Fork Yellow Bank River
Punished Womans Lake
Round Lake
South Shore
Mahoney Creek
Mud Creek
Lake Traverse Reservation
629 m
624 m
635 m
0 0.5 1 1.5 2 2.5 3 mi
0 1 2 3 4 5 km
Data Source: World Topo Map
Coordinate System: UTM, NAD83, zn 14N
Map produced on 06/03/2016
by A. L. Dahl
WEST

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TECHNICAL MEMORANDUM

Date: June 28, 2017

To: Jennie Geiger, Apex Clean Energy Management, LLC

From: Western EcoSystems Technology, Inc.

Subject: Dakota Range I Wind Project – Prairie Grouse Lek Survey Memo

Introduction

In 2016, Western EcoSystems Technology, Inc. completed an aerial-based survey for sharp-tailed grouse and greater prairie-chicken leks for the Dakota Range I Wind Project (Project). The Project boundary was modified since the 2016 surveys to include additional area; therefore, the unsurveyed portion of the Project was evaluated in 2017 using a ground-based methodology. In addition, previously documented leks from 2016 were revisited to evaluate 2017 status (Figure 1).

Methods

Surveys were completed three times between April 8 and May 9, 2017, in the areas shown in Figure 1, and two times in a small portion of this area because it was added in late April. The 2017 survey area included the unsurveyed portions of the Project and a 0.5-mile buffer. Public roads were driven by a biologist from 30 minutes prior to sunrise until approximately two hours after sunrise. The biologist stopped for a minimum of five minutes approximately every half-mile (more often in hilly terrain, less in flat) to listen and look for displaying birds. If a lek was located, the observer would then map the location (to the best of their ability from the road) and record the number of males, females, and birds of unknown sex attending the lek. When possible, surveys were completed on relatively calm mornings with little to no rain. Leks documented in 2016 that were outside the 2017 survey area were also visited to evaluate 2017 status.

Leks were classified as “potential” when three or more birds were observed in one location during the morning surveys. Leks were classified as “confirmed” if the biologists observed males engaged in lek attendance behavior (e.g., dancing, calling) more than one time. Leks were classified as “historic” if they were known leks that could not be found during the surveys.

Results

One confirmed (Lek 3) and one potential (Lek 4) sharp-tailed grouse lek was documented within the 2017 survey area. Lek 4 was a potential sharp-tailed grouse lek with a maximum of seven birds (3 male, 4 unknown sex) observed during the first survey; however, no males were exhibiting courtship behavior. Two previously documented leks (Leks 1 and 2) were not located in 2017 and classified as historic. Survey results are shown in Table 1 and Figure 2.

Lek 3 was the only confirmed lek with a maximum of 15 sharp-tailed grouse observed during the second and third survey.

Summary

Results of the 2016 and 2017 surveys indicate that both sharp-tailed grouse and greater prairie chickens are present at low density in and within 0.5 mile of the Project.

Table 1. 2017 Lek survey results (M=number of males, F=number of females, Unk=number of unknown birds, and Total=total number of birds) for the Dakota Range Wind Project.

			SURVEY 1 (4/8/17 to 4/21/17)				Survey 2 (4/22/17 to 5/4/17				Survey 3 (5/5/17 to 5/9/17)			
Lek ID	**Lek Status**	**Species**	**M**	**F**	**Unk**	**Total**	**M**	**F**	**Unk**	**Total**	**M**	**F**	**Unk**	**Total**
1	Historic	Sharp-tailed grouse	0	0	0	0	0	0	0	0	0	0	0	0
2	Historic	Greater prairie-chicken	0	0	0	0	0	0	0	0	0	0	0	0
3	Confirmed	Sharp-tailed grouse	-	-	-	-	9	2	4	15	6	unknown	2	8
4	Potential	Sharp-tailed grouse	3	0	4	7	0	0	0	0	0	0	1	1

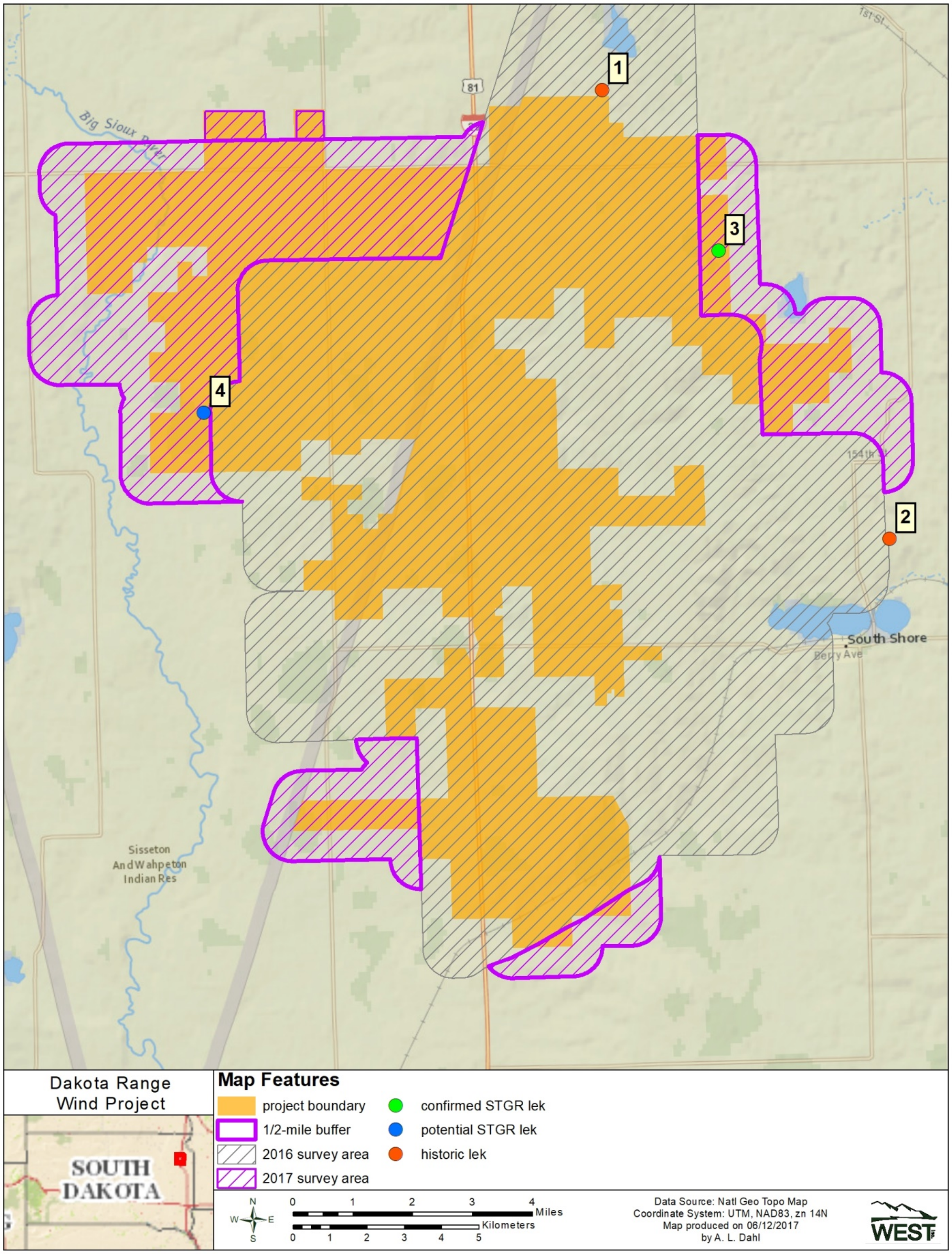

Figure 1. Location of grouse lek survey areas and lek locations for unsurveyed portions of the Dakota Range Wind Project. Surveys occurred from April 8 to May 9, 2017.

SOUND LEVEL MODELING REPORT

Dakota Range Wind Project
Codington & Grant Counties, South Dakota

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January 23, 2018

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1.0 EXECUTIVE SUMMARY

The Dakota Range Wind Project (the Project) is a proposed wind power electric generation facility expected to consist of 72 wind turbines in Codington and Grant Counties, South Dakota. The Project is being developed by Apex Clean Energy, Inc. (Apex). Epsilon Associates, Inc. (Epsilon) has been retained by Apex to conduct a sound level modeling study for the Project. This report presents results of the study.

A sound level modeling analysis was conducted for 72 proposed wind turbines and 25 alternates. All wind turbines for this Project are proposed to be Vestas V136-4.2 serrated trailing edge blade units. The purpose of this assessment is to predict worst-case community sound levels in Codington and Grant Counties when the wind turbines are operational and to compare the modeling results to applicable limits. Sound levels from wind energy systems (WES) are limited to 50 dBA at off-site residences' property lines in Codington County and 50 dBA at off-site residences and accessory structures in Grant County.

Using the Project specific data provided by Apex, the sound levels modeled at existing off-site residences, businesses, churches, and buildings owned and/or maintained by a governmental entity ("sensitive receptors") in Codington County ranged from 17 to 43 dBA and sound levels modeled at sensitive receptors in Grant County ranged from 22 to 45 dBA. Supplementary modeling was performed at accessory structures with results that ranged from 14 to 43 dBA in Codington County and from 23 to 47 dBA in Grant County. All sound levels are well below the respective county limits of 50 dBA. Sound level isoline results show no location where Project-related noise exceeds 50 dBA at any off-site property line within Codington County. Therefore, the Project meets the requirements with respect to sound in the regulations.

2.0 INTRODUCTION

The Dakota Range Wind Project to be located in Codington and Grant Counties, South Dakota will consist of 72 Vestas wind turbines and an electrical substation. A total of 25 alternate wind turbine locations are also proposed for the Project. The wind turbines will be Vestas V136-4.2 serrated trailing edge blade units. The V136-4.2 wind turbines have a hub height of 82 meters and a rotor diameter of 136 meters. Figure 2-1 shows the locations of the 72 proposed and 25 alternate wind turbines over aerial imagery in Codington and Grant Counties.

A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.[1] A few points are repeated herein. Wind turbine noise can originate from two different sources; mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine noise. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical noise. Aerodynamic noise has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction. Aerodynamic noise, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then typically remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

This report presents the findings of a sound level modeling analysis for the Project. The wind turbines were modeled with the Cadna/A software package using sound data from Vestas technical documents. The results of this analysis are found within this report.

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[1] Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Wind Turbine Acoustic Noise, June 2002, amended January 2006.

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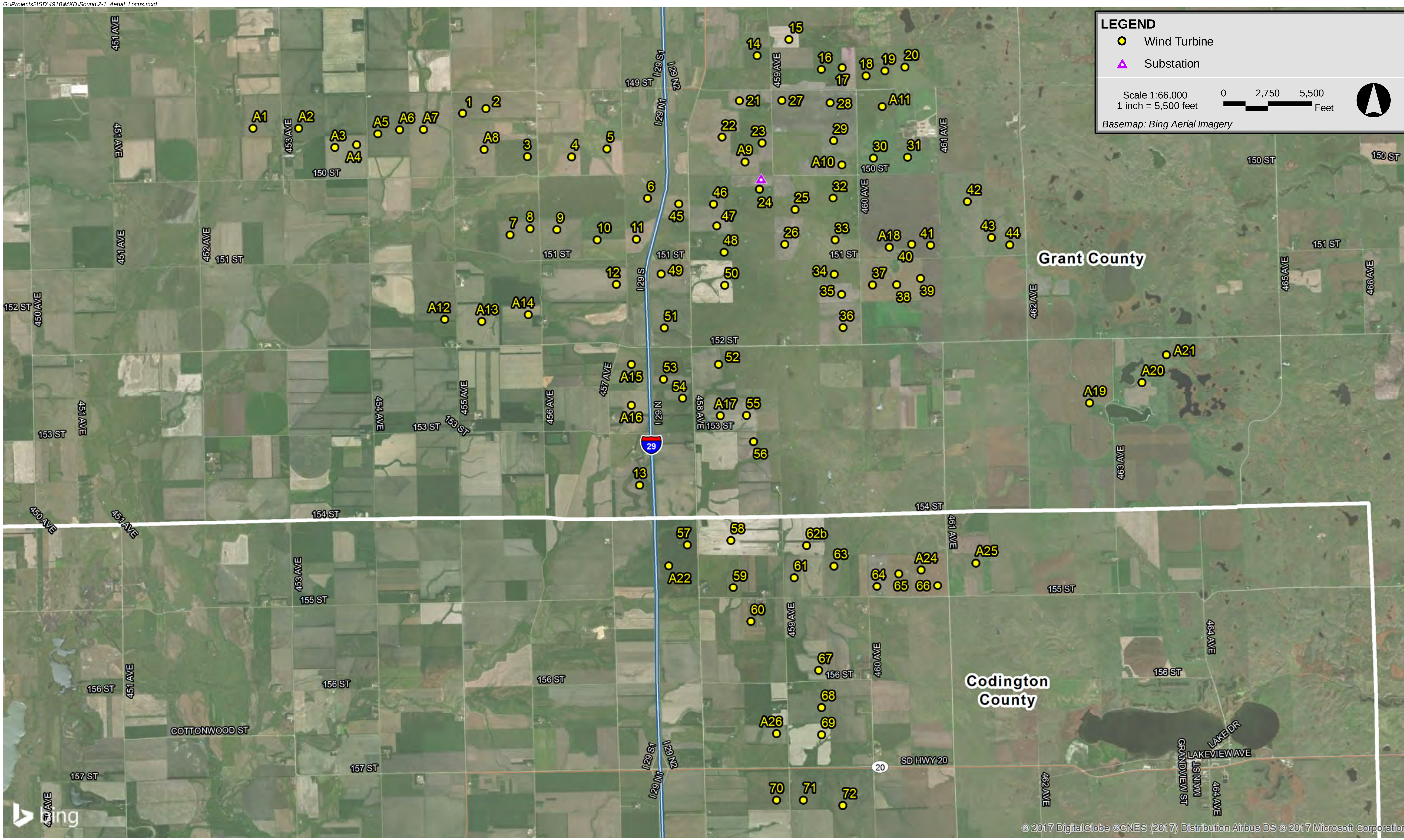


Dakota Range Wind Grant County/Codington County, South Dakota

Epsilon Associates Inc.

Figure 2-1
Aerial Locus

3.0 SOUND TERMINOLOGY

There are several ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level measurement terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. Relative to this characteristic, a change in sound levels of less than 3 dB is imperceptible to the human ear.

Another mathematical property of decibels is that if one source of noise is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.[2] It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone". The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as "dBA". Sound pressure levels for some common indoor and outdoor environments are shown in Figure 3-1.

Because the sounds in the environment vary with time, many different sound metrics may be used to quantify them. There are two typical methods used for describing variable sounds. These are exceedance levels and equivalent levels, both of which are derived from a large number of moment-to-moment A-weighted sound pressure level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n, where "n" is a value (typically an integer between 1 and 99) in terms of percentage. Equivalent

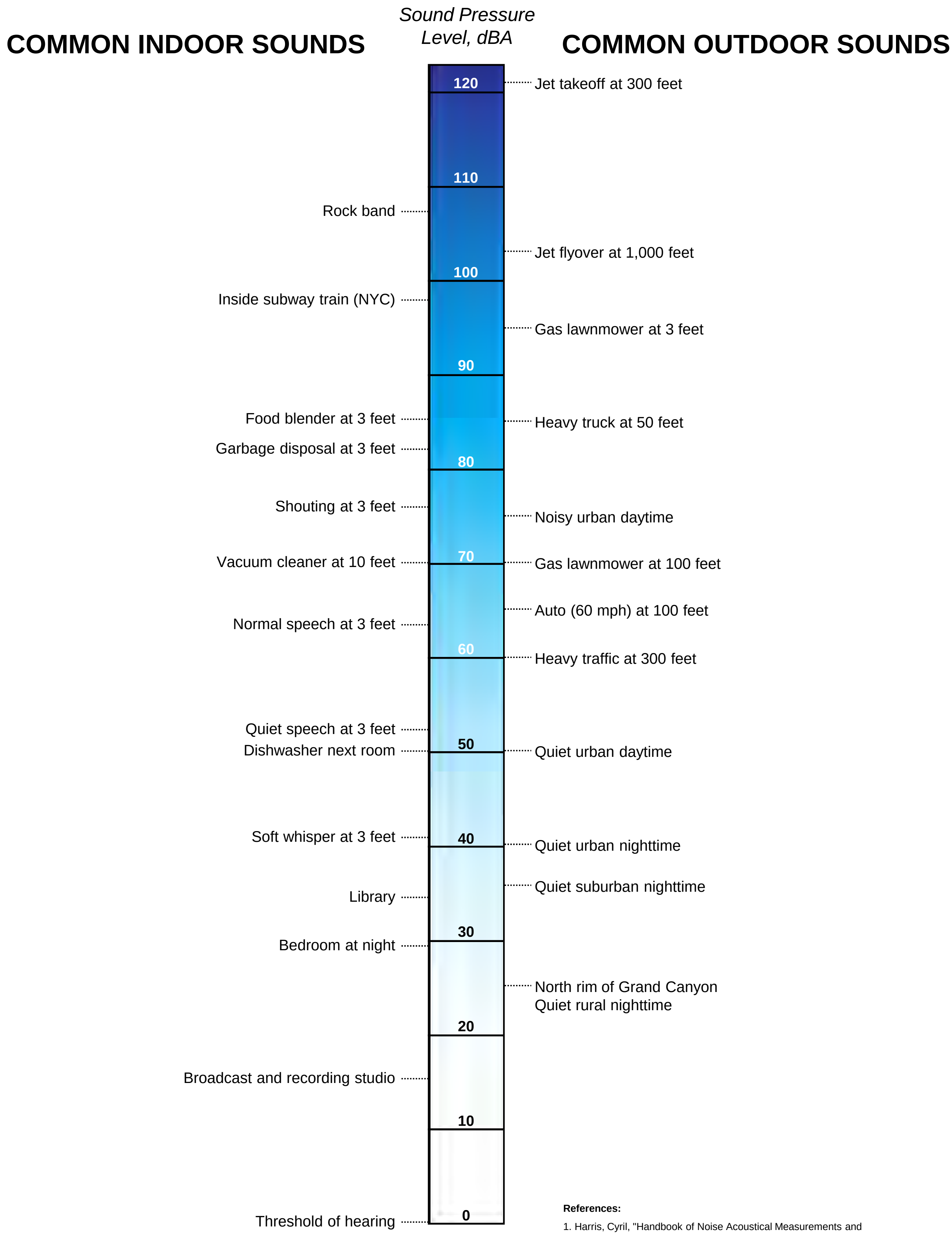
---

[2] *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983 (R2006), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

levels are designated L_{eq} and quantify a hypothetical steady sound that would have the same energy as the actual fluctuating sound observed. The two sound level metrics that are commonly reported in community noise monitoring and are utilized in this report are described below.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during a measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent noise sources.

- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is commonly A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with time-averaged mean square sound pressure values, the L_{eq} is mostly determined by occasional loud noises.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Figure 3-1

Common Sound Levels in the Environment

4.0 NOISE REGULATIONS

4.1 Federal Regulations

There are no federal community noise regulations applicable to this Project.

4.2 South Dakota State Regulations

There are no current state community noise regulations applicable to this Project. The South Dakota Public Utilities Commission (SDPUC) 2009 model ordinance for siting wind energy systems is no longer in effect.[3]

4.3 Local Regulations

4.3.1 Codington County

The section of the proposed Dakota Range Wind Project within Codington County, SD is subject to the following sound level requirements in Section 5.22.03(12) of Ordinance #65 Zoning Ordinance of Codington County, Noise subsection of General Provisions for Wind Energy Systems (WES):

> *Noise level shall not exceed 50 dBA, average A-weighted Sound pressure*[4] *including constructive interference effects at the property line of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.*

Therefore, the above listed sensitive receptors were evaluated in this analysis against the 50 dBA limit. Sound level isolines overlaying aerial imagery are also presented in this report to show sound levels at property lines.

4.3.2 Grant County

The section of the proposed Dakota Range Wind Project within Grant County, SD is subject to the following sound level requirements in Section 1211.04(13) of the Zoning Ordinance for Grant County, Noise subsection of General Provisions for Energy Systems (WES):

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3 NC Clean Energy Technology Center. http://programs.dsireusa.org/system/program/detail/3943. Accessed December 2017.

4 Epsilon assumes the ordinance intends to read "sound pressure level" reported in dBA, whereas "sound pressure" is reported in units of Pascals.

Noise level shall not exceed 50 dBA, average A-weighted Sound pressure[5] *including constructive interference effects at the perimeter of the principal and accessory structures of existing off-site residences, businesses, and buildings owned and/or maintained by a governmental entity.*

Therefore, the above listed sensitive receptors were evaluated in this analysis against the 50 dBA limit.

---

5 Epsilon assumes the ordinance intends to read "sound pressure level" reported in dBA, whereas "sound pressure" is reported in units of Pascals.

5.0 FUTURE CONDITIONS

5.1 Equipment and Operating Conditions

The sound level analysis includes 97 wind turbines, of which 25 are considered alternate locations but were conservatively included as active wind turbines. Global coordinates for the 97 wind turbines are provided in Appendix A. All wind turbines are Vestas V136-4.2 serrated trailing edge blade units. The V136-4.2 wind turbines have a hub height of 82 meters and a rotor diameter of 136 meters. A technical report from Vestas[6] was provided by Apex which documented the expected sound power levels associated with the Vestas V136-4.2 wind turbine. According to this technical document, which included broadband and one-third octave-band A-weighted sound power levels for various wind speeds, the maximum sound power level for the V136-4.2 of 103.9 dBA occurs at hub height wind speeds of 9 m/s (and above). These sound power levels represent an "upper 95% confidence limit for the wind turbine performance" and do not include any additional uncertainty factor. Octave-band sound levels were calculated from the third octave-band levels representing the maximum sound power level for the sound modeling.

In addition to the wind turbines, there will be a collector substation associated with the Project. The substation is proposed to be located north of wind turbine #24 as shown in Figure 5-1. Two 167 megavolt-ampere (MVA) transformers are proposed for the substation. Epsilon has estimated octave-band sound power levels using the MVA rating provided by Apex and techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers. Table 5-1 below summarizes the sound power level data used in the modeling.

Table 5-1 Modeled Substation Transformer Sound Power Levels

		Sound Power Levels per Octave-Band Center Frequency [Hz]								
Maximum Rating	Broadband dBA	31.5 dB	63 dB	125 dB	250 dB	500 dB	1k dB	2k dB	4k dB	8k dB
167 MVA	102	98	104	106	101	101	95	90	85	78

5.2 Modeling Scenarios

The noise impacts associated with the proposed wind turbines were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits

6 Vestas Wind Systems A/S, V136-4.0 MW Third octave noise emission, 2017. Confidential documentation and information.

of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

Inputs and significant parameters employed in the model are described below:

- *Project Layout:* A project layout dated December 18, 2017 was provided by Apex. The 72 proposed wind turbines and 25 alternates were input into the model. The substation transformer location was provided by Apex on December 7, 2017. The proposed wind turbines and substation are shown in Figure 5-1.

- *Modeling Locations:* A modeling receptor dataset with participation status information dated November 17, 2017 was provided by Apex. The dataset included receptors at a significant distance from wind turbines (greater than 5 miles from the wind turbines) and these receptors were excluded from the analysis. The remaining 189 receptors from this dataset (86 in Codington County, 103 in Grant County) were input into the Cadna/A model. These sensitive receptors were modeled as discrete points at a height of 1.5 meters above ground level (AGL) to mimic the ears of a typical standing person. These locations are shown in Figure 5-1. In addition, a dataset containing parcel boundaries and lease status dated November 10, 2017 was provided by Apex. Parcels identified as "agreement signed" were included as participating and are identified on Figure 5-1.

  A supplementary receptor dataset was provided by Apex on January 19, 2018 which contained accessory structures within the vicinity of the Project. The dataset was modified to exclude receptors greater than 5 miles from the wind turbines, for consistency. The remaining 555 accessory structures (267 in Codington County, 288 in Grant County) were input into Cadna/A as discrete points at a height of 1.5 meters above ground level. Modeling of these accessory structures was performed separately and the structures are not included in the modeling locations figure.

- *Terrain Elevation:* Elevation contours for the modeling domain were directly imported into Cadna/A which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey.

- *Source Sound Levels:* Octave-band sound power levels for the Vestas V136-4.2 wind turbines calculated from the provided third octave-band levels in technical report were input to the model. These sound levels represent "worst-case" operational sound level emissions. The substation transformer sound power levels as presented in Table 5-1 were input to the model.

- *Uncertainty factor:* No uncertainty factor was provided by the wind turbine manufacturer; however, based on experience with other wind turbine manufacturers, an uncertainty factor of 2.0 dBA was assumed and added to the sound power level for each modeled wind turbine.

- *Ground Attenuation:* Spectral ground absorption was calculated using a G-factor of 0.5 which corresponds to "mixed ground" consisting of both hard and porous ground cover.

The highest wind turbine sound power level for each wind turbine type including uncertainty (105.9 dBA) was input into Cadna/A to model wind turbine generated sound pressure levels during conditions when worst-case sound power levels are expected. Sound pressure levels due to operation of all 97 wind turbines and the substation transformer were modeled at 189 sensitive receptors and 555 accessory structures in Codington and Grant Counties. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 25 meters apart to allow for the generation of sound level isolines.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the Cadna/A model to ensure conservative results (i.e., higher sound levels), and are described below:

- All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts.

- As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.

- Meteorological conditions assumed in the model (temperature = 10°C & relative humidity = 70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.

- No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

5.3 Sound Level Results

Table B-1 in Appendix B shows the predicted "Project-Only" broadband (dBA) sound levels under conditions specified in the previous section for the 86 sensitive receptors in Codington County. These sound levels range from 17 to 43 dBA. The predicted "Project-

Only" broadband sound levels[7] at the 267 accessory structures in Codington County ranged from 14 to 43 dBA.

Table B-2 in Appendix B shows the predicted "Project-Only" broadband (dBA) sound levels for the 103 sensitive receptors in Grant County. These sound levels range from 22 to 45 dBA. The predicted "Project-Only" broadband sound levels[8] at the 288 accessory structures in Grant County ranged from 23 to 47 dBA.

In addition to the 189 receptor points, sound level isolines generated from the modeling grid are presented in Figure 5-2. Accessory structures are not included on the figure.

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[7] Accessory structure results are excluded from Appendix B.

[8] Accessory structure results are excluded from Appendix B.

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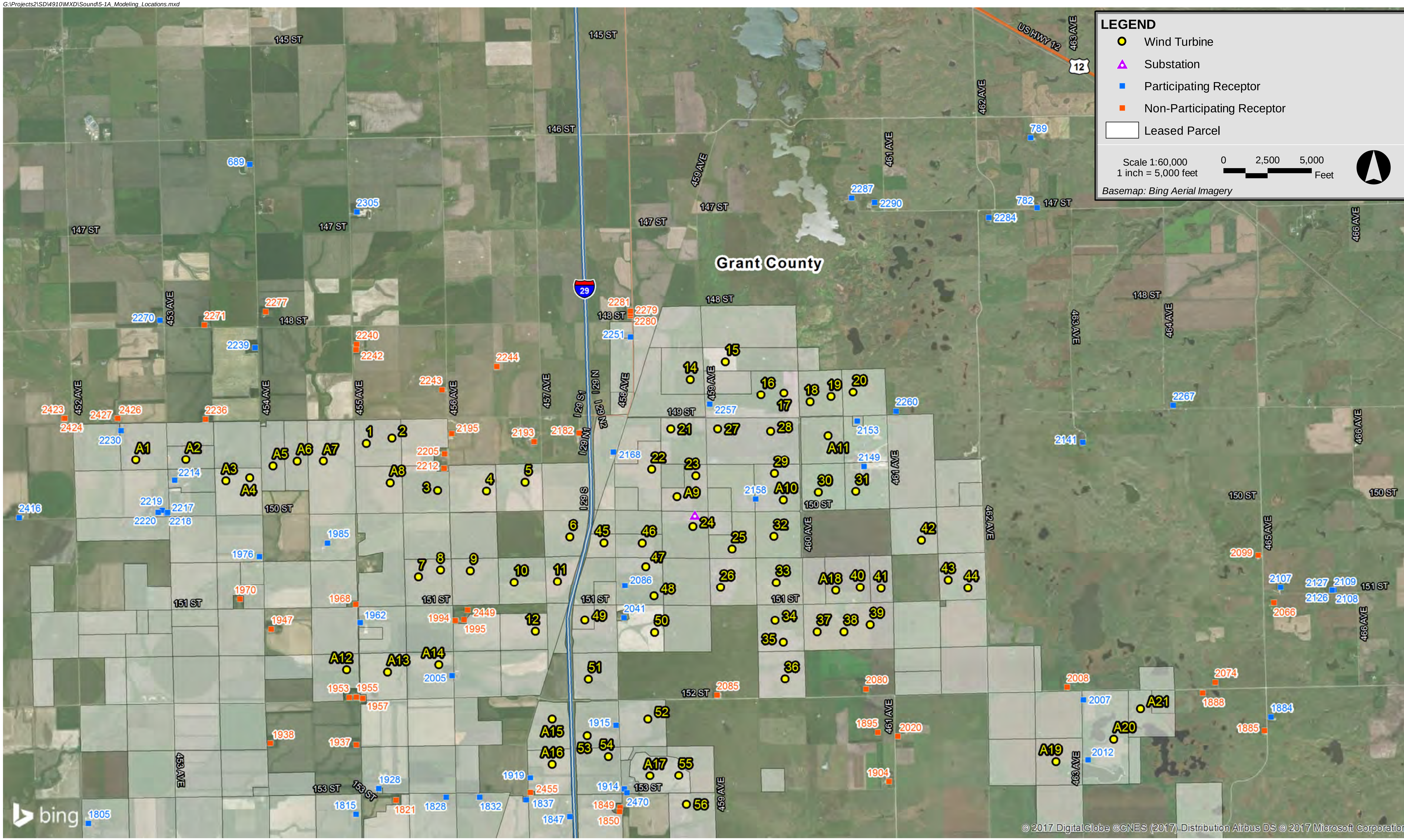

Dakota Range Wind   Grant County/Codington County, South Dakota

Figure 5-1A

Sound Level Modeling Locations

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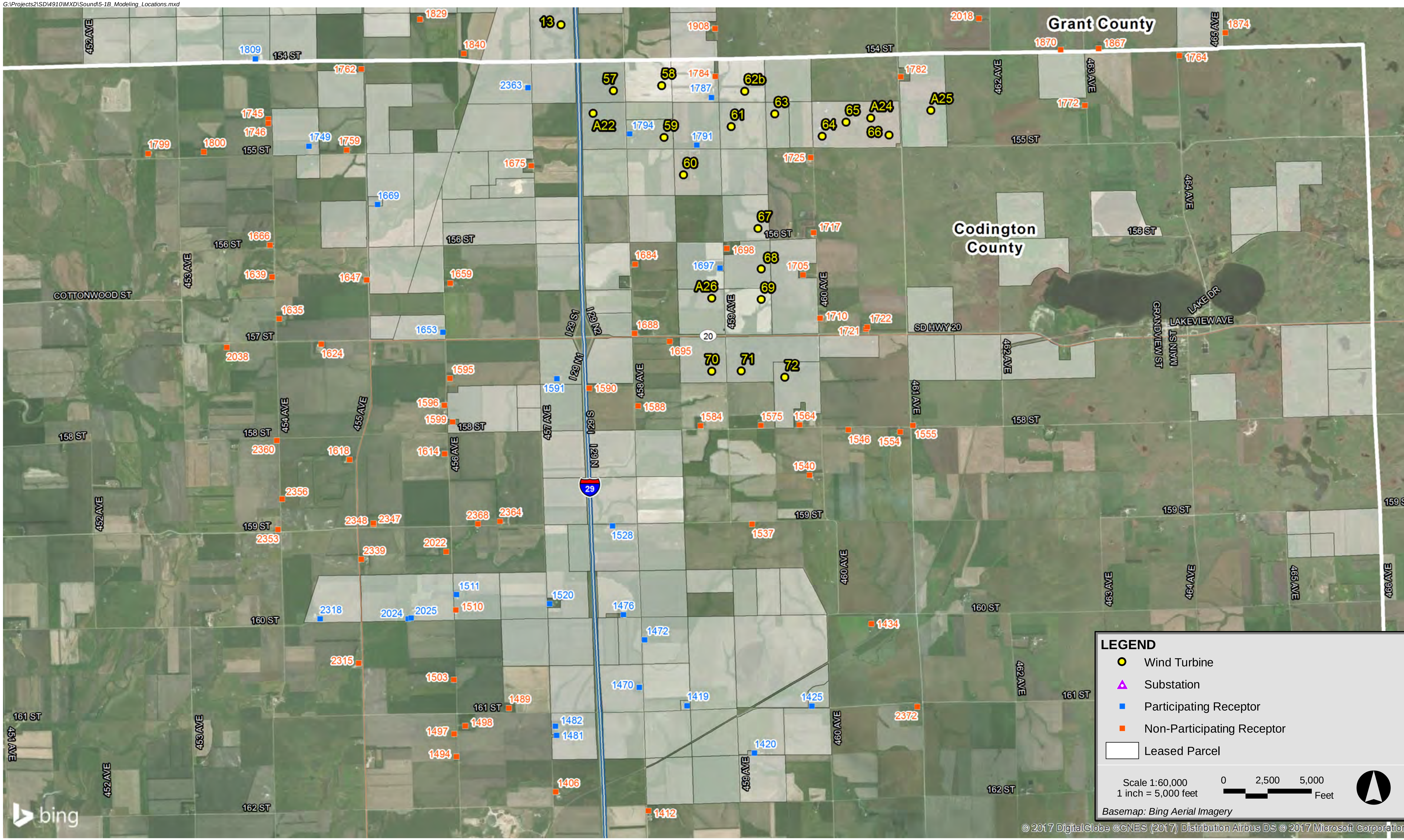

Dakota Range Wind **Grant County/Codington County, South Dakota**

Epsilon
ASSOCIATES INC.

Figure 5-1B

Sound Level Modeling Locations

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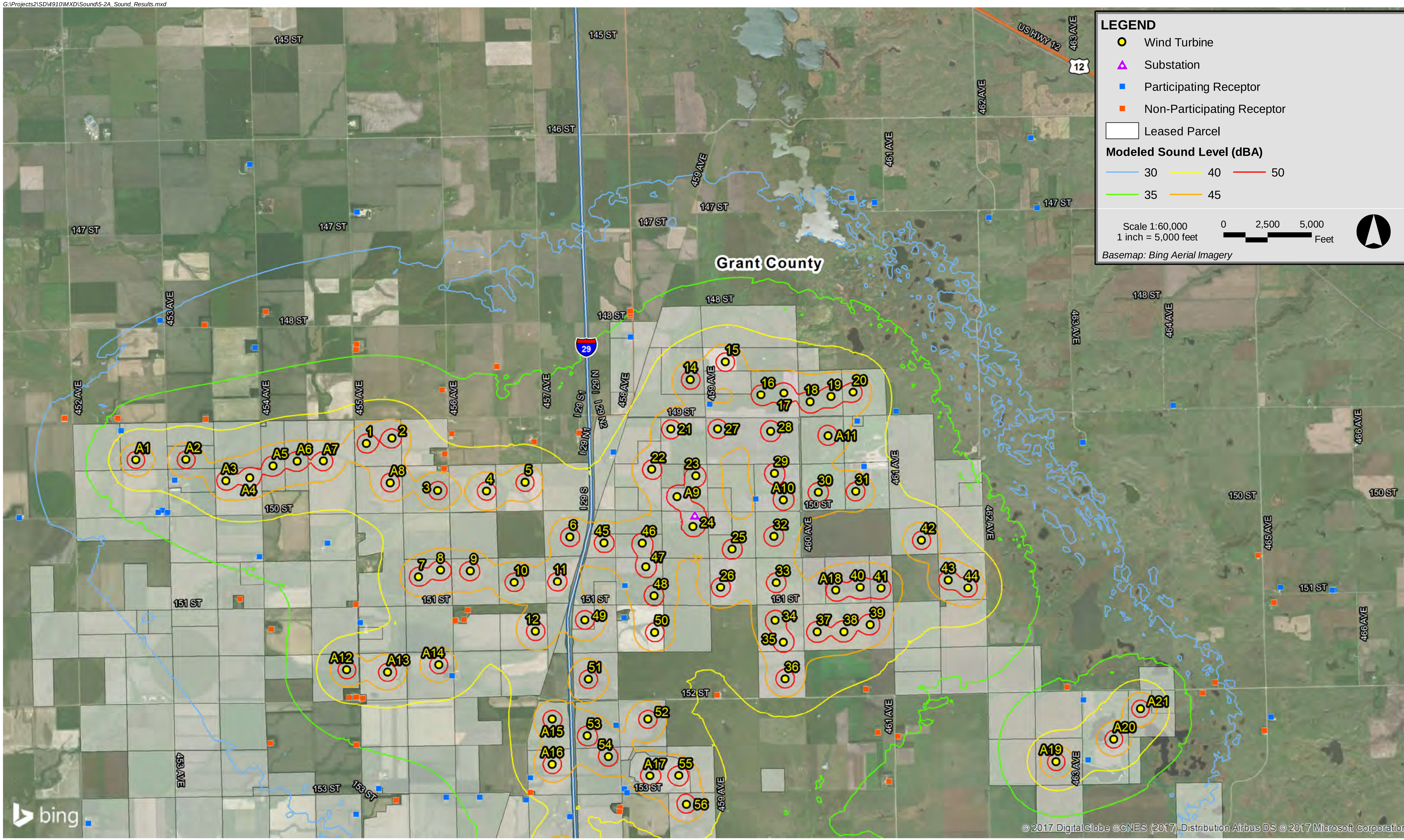

Dakota Range Wind   Grant County/Codington County, South Dakota

Epsilon ASSOCIATES INC.

Figure 5-2A

Sound Level Modeling Results

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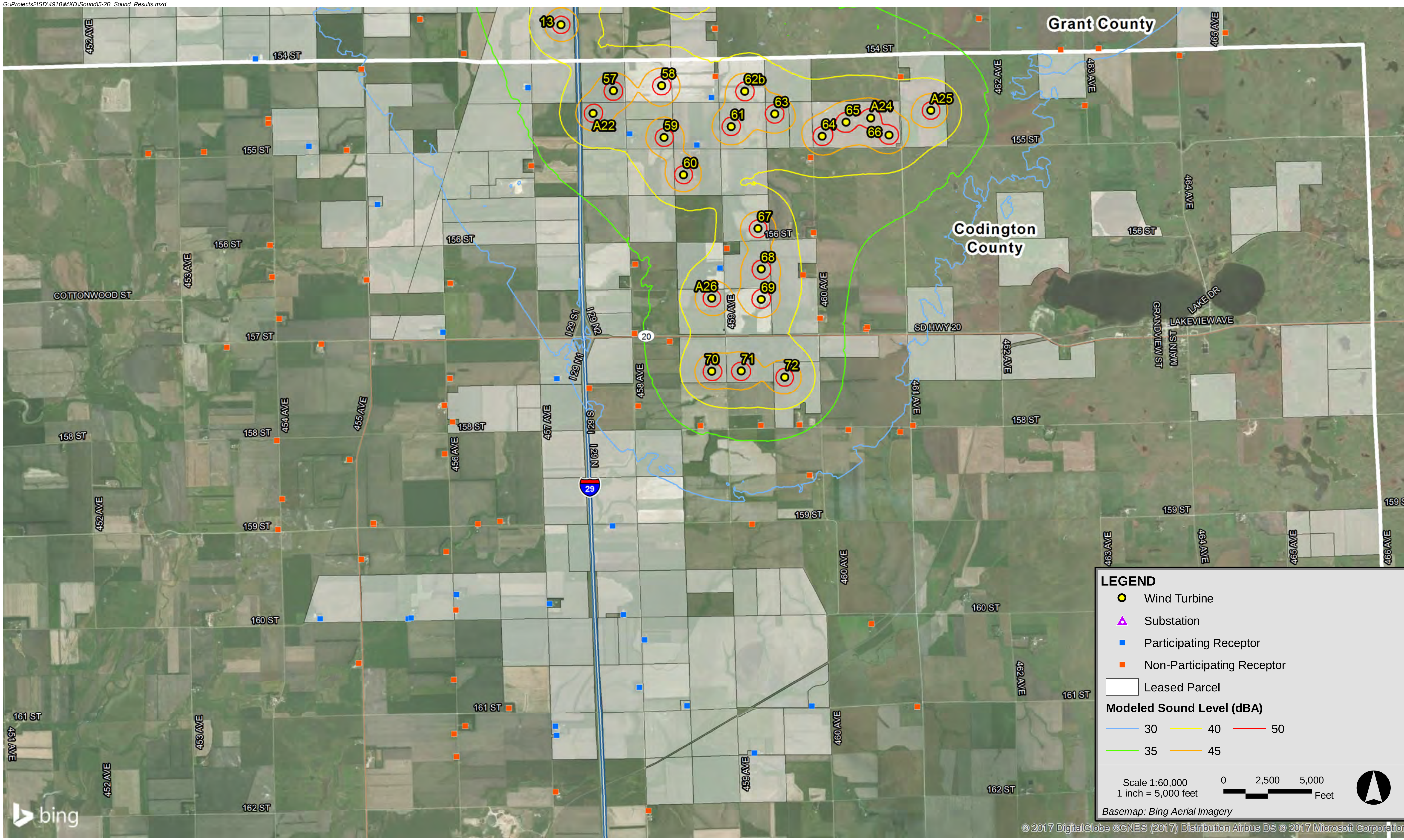

Dakota Range Wind **Grant County/Codington County, South Dakota**

Epsilon ASSOCIATES INC.

Figure 5-2B

Sound Level Modeling Results

6.0 CONSTRUCTION NOISE

The majority of the construction activity related to the Dakota Range Wind Project will occur around each of the wind turbine sites. By its very nature, construction activity moves around the site. Full construction activity will generally occur at one wind turbine site at a time, although there will be some overlap at adjacent sites for maximum efficiency. There are generally three phases of construction at a wind energy project – excavation, foundations, and turbine erection. Table 6-1 presents the equipment sound levels for the louder pieces of construction equipment expected to be used at this site along with their phase of construction. Reference sound source information in Table 6-1 was obtained from either Epsilon field measurements or the FHWA's Roadway Construction Noise Model database.

Construction of the Project is expected to take multiple months. Construction of a single wind turbine from excavation to foundation pouring to turbine erection is roughly a three week process. However, work will not proceed in that order for each wind turbine to be erected. For example, all foundations will typically be poured before any turbine erection work begins. Excavation work is expected to occur from early morning to the evening. Concrete foundation work and turbine erection work could extend into the overnight hours depending on the weather and timing of a concrete pour which must be continuous. Excavation work will typically be daytime only.

Table 6-1 Sound Levels for Construction Noise Sources

Phase	Equipment	Sound Level at 50 feet (dBA)
Excavation	Grader	85
Excavation	Bulldozer	82
Excavation	Front-end loader	79
Excavation	Backhoe	78
Excavation	Dump truck	76
Excavation	Roller	80
Excavation	Excavator	81
Excavation	Rock drill	89
Foundation	Concrete mixer truck	79
Foundation	Concrete pump truck	81
Foundation	Concrete batch plant	83
Turbine erection	Large crane #1	81
Turbine erection	Large crane #2	81
Turbine erection	Component delivery truck	84
Turbine erection	Air compressor	78

7.0 EVALUATION OF SOUND LEVELS

7.1 Modeled Sound Levels

All modeled sound levels, as output from Cadna/A and presented in Appendix B, are A-weighted equivalent sound levels (L_{eq}, dBA). These levels may be used in evaluating measured sound pressure levels over typical averaging durations, (i.e., 10 minutes or 1 hour).

7.2 Codington County Evaluation

The Project is subject to the requirements contained in the Zoning Ordinance of Codington County, South Dakota for WES. The sound level limit in this regulation for a WES is 50 dBA at a property line of an existing off-site occupied structure. The predicted worst-case sound levels from the Dakota Range Wind Project are well below the 50 dBA limit at all modeled occupied structures in Codington County. A review of Table B-1 in Appendix B shows the highest sound level to be 43 dBA at receptor #1725. This is at a non-participating occupied structure. Sound levels at the modeled accessory structures do not exceed 43 dBA. Sound level isolines in Figure 5-2 show no location where Project-related noise exceeds 50 dBA at any off-site property line. Therefore, the Project meets the requirements with respect to sound in the county regulation.

7.3 Grant County Evaluation

The Project is subject to the requirements contained in the Zoning Ordinance for Grant County, South Dakota for WES. The sound level limit in this regulation for a WES is 50 dBA at the perimeter of an existing off-site principal (occupied) and accessory structure. The predicted worst-case sound levels from the Dakota Range Wind Project are well below the 50 dBA limit at all modeled occupied structures in Grant County. A review of Table B-2 in Appendix B shows the highest sound level to be 45 dBA at receptor #2158. This is at a participating occupied structure. The highest modeled sound level at a non-participating receptor (#2212) is 44 dBA. Additionally, the highest sound level modeled at an accessory structure in Grant County is 47 dBA. This is at a participating accessory structure and the highest modeled sound level at a non-participating accessory structure is 44 dBA. Therefore, the Project meets the requirements with respect to sound in the county regulation.

8.0 CONCLUSIONS

A comprehensive sound level analysis was conducted for the proposed Dakota Range Wind Project within Codington and Grant Counties. A total of 72 wind turbines are proposed for this Project. Sound levels resulting from the operation of these 72 wind turbines and 25 alternates were calculated at 189 sensitive receptor points (i.e., existing off-site residences, businesses, churches, and buildings owned and/or maintained by a governmental entity), and isolines were generated from a grid encompassing the area surrounding the wind turbines using the proposed layout. The sound levels modeled at sensitive receptors[9] in Codington County ranged from 17 to 43 dBA and sound levels modeled at sensitive receptors[10] in Grant County ranged from 22 to 45 dBA. All sound levels are well below the respective county limits of 50 dBA. Sound level isoline results show no location where Project-related noise exceeds 50 dBA at any off-site property line within Codington County. Therefore, the Project meets the requirements with respect to sound in the regulations.

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[9] Excludes accessory structures for which sound levels ranged from 14 to 43 dBA in Codington County.

[10] Excludes accessory structures for which sound levels ranged from 23 to 47 dBA in Grant County.

Appendix A
Wind Turbine Coordinates

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
1	649150.68	5009210.55
2	649592.64	5009301.39
3	650382.14	5008394.08
4	651221.24	5008388.66
5	651887.81	5008536.33
6	652659.21	5007595.70
7	650048.07	5006906.21
8	650429.11	5007023.84
9	650941.68	5007007.69
10	651702.10	5006813.09
11	652445.44	5006824.28
12	652067.96	5005967.41
13	652508.47	5002155.46
14	654738.65	5010309.74
15	655342.56	5010617.87
16	655959.75	5010046.16
17	656353.73	5010078.42
18	656807.12	5009925.65
19	657165.19	5010016.56
20	657545.03	5010093.22
21	654403.27	5009456.11
22	654073.85	5008759.99
23	654834.57	5008649.35
24	654782.01	5007771.84
25	655461.81	5007386.09
26	655262.58	5006726.86
27	655209.73	5009458.69
28	656123.54	5009415.49
29	656190.63	5008691.29
30	656948.30	5008364.53
31	657593.24	5008379.77
32	656181.41	5007604.26
33	656220.17	5006808.38
34	656202.73	5006154.17
35	656341.29	5005779.24
36	656373.09	5005145.37
37	656928.93	5005957.45
38	657387.82	5005959.70
39	657839.76	5006079.27
40	657670.73	5006726.57
41	658031.93	5006708.57
42	658728.18	5007539.26
43	659189.32	5006853.26
44	659530.88	5006717.26
45	653250.85	5007492.28
46	653912.36	5007486.35
47	653971.67	5007079.89

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
48	654112.53	5006577.23
49	652919.63	5006162.99
50	654125.10	5005948.82
51	652979.75	5005140.46
52	654007.77	5004448.60
53	652959.73	5004165.46
54	653326.71	5003802.14
55	654539.43	5003479.34
56	654671.50	5002980.82
57	653412.66	5001019.09
58	654243.67	5001103.58
59	654285.80	5000211.18
60	654621.54	4999566.28
61	655443.20	5000399.81
62b	655678.86	5001007.79
63	656197.91	5000617.81
64	657012.96	5000231.13
65	657424.44	5000476.02
66	658166.89	5000251.64
67	655906.42	4998639.32
68	655964.72	4997936.95
69	655962.56	4997416.19
70	655110.53	4996175.39
71	655618.94	4996179.18
72	656367.12	4996073.95
A1	645172.45	5008926.68
A2	646038.25	5008927.64
A3	646726.68	5008563.81
A4	647137.99	5008616.63
A5	647539.89	5008820.59
A6	647956.98	5008901.81
A7	648409.37	5008903.36
A8	649560.48	5008528.49
A9	654509.77	5008288.83
A10	656345.65	5008235.30
A11	657114.06	5009343.43
A12	648810.69	5005302.13
A13	649516.40	5005259.92
A14	650398.22	5005389.99
A15	652354.92	5004448.62
A16	652353.57	5003672.36
A17	654041.01	5003475.27
A18	657249.87	5006672.81
A19	661049.92	5003716.42
A20	662041.92	5004103.34
A21	662506.37	5004630.35
A22	653061.13	5000624.85

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
A24	657850.58	5000545.83
A25	658890.90	5000677.60
A26	655109.25	4997437.35

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Appendix B

Predicted Wind Energy System Sound Levels at Sensitive Receptors

Table B-1: Modeled Sound Pressure Levels at Sensitive Receptors in Codington County

Receptor ID	Coordinates UTM NAD83 Zone 14N		County	Participation Status	Source Only Broadband Sound Level (dBA)	Regulation Evaluation	
	X (m)	Y (m)				Limit (dBA)	Exceed Limit?
1406	652415.58	4988918.69	Codington	Non-Participating	19	50	No
1412	654015.11	4988590.25	Codington	Non-Participating	19	50	No
1419	654681.58	4990406.38	Codington	Participating	17	50	No
1420	655846.86	4989588.29	Codington	Participating	19	50	No
1425	656834.67	4990400.04	Codington	Participating	20	50	No
1434	657862.31	4991817.05	Codington	Non-Participating	18	50	No
1470	653857.99	4990720.09	Codington	Participating	23	50	No
1472	653950.59	4991543.64	Codington	Participating	24	50	No
1476	653587.51	4991975.31	Codington	Participating	25	50	No
1481	652432.12	4989894.34	Codington	Participating	17	50	No
1482	652413.64	4990050.68	Codington	Participating	20	50	No
1489	651609.43	4990364.76	Codington	Non-Participating	22	50	No
1494	650703.87	4989527.33	Codington	Non-Participating	19	50	No
1497	650662.06	4989915.49	Codington	Non-Participating	21	50	No
1498	650856.93	4990053.74	Codington	Non-Participating	21	50	No
1503	650657.74	4990852.72	Codington	Non-Participating	22	50	No
1510	650692.61	4992057.70	Codington	Non-Participating	23	50	No
1511	650706.98	4992320.66	Codington	Participating	23	50	No
1520	652311.29	4992164.18	Codington	Participating	24	50	No
1528	653394.86	4993505.03	Codington	Participating	27	50	No
1537	655804.37	4993535.65	Codington	Non-Participating	29	50	No
1540	656798.10	4994383.05	Codington	Non-Participating	31	50	No
1546	657464.70	4995163.56	Codington	Non-Participating	32	50	No
1554	658362.21	4995127.56	Codington	Non-Participating	30	50	No
1555	658578.51	4995244.25	Codington	Non-Participating	29	50	No
1564	656621.54	4995250.50	Codington	Non-Participating	36	50	No
1575	655954.93	4995240.17	Codington	Non-Participating	37	50	No
1584	654917.16	4995237.31	Codington	Non-Participating	36	50	No
1588	653838.26	4995578.48	Codington	Non-Participating	33	50	No
1590	652995.68	4995885.56	Codington	Non-Participating	31	50	No
1591	652436.54	4996047.89	Codington	Participating	30	50	No
1595	650593.29	4996054.48	Codington	Non-Participating	27	50	No
1596	650496.01	4995587.28	Codington	Non-Participating	27	50	No
1599	650636.90	4995303.04	Codington	Non-Participating	26	50	No
1614	650501.55	4994753.62	Codington	Non-Participating	26	50	No
1618	648862.47	4994649.83	Codington	Non-Participating	24	50	No
1624	648375.40	4996645.46	Codington	Non-Participating	25	50	No
1635	647647.95	4997080.29	Codington	Non-Participating	25	50	No
1639	647523.41	4997799.99	Codington	Non-Participating	26	50	No
1647	649154.79	4997753.24	Codington	Non-Participating	27	50	No
1653	650473.00	4996848.32	Codington	Participating	28	50	No
1659	650595.55	4997697.39	Codington	Non-Participating	29	50	No
1666	647488.92	4998352.98	Codington	Non-Participating	26	50	No
1669	649340.75	4999049.86	Codington	Participating	28	50	No
1675	651994.47	4999721.14	Codington	Non-Participating	34	50	No
1684	653787.02	4998022.59	Codington	Non-Participating	35	50	No
1688	653778.28	4996825.57	Codington	Non-Participating	34	50	No
1695	654384.51	4996687.82	Codington	Non-Participating	38	50	No
1697	655253.74	4997956.71	Codington	Participating	42	50	No
1698	655368.87	4998297.41	Codington	Non-Participating	42	50	No
1705	656685.45	4997836.26	Codington	Non-Participating	40	50	No
1710	656976.54	4997093.04	Codington	Non-Participating	37	50	No
1717	656867.97	4998569.91	Codington	Non-Participating	38	50	No
1721	657770.19	4996904.04	Codington	Non-Participating	34	50	No
1722	657792.58	4996940.40	Codington	Non-Participating	34	50	No
1725	656815.87	4999863.27	Codington	Non-Participating	43	50	No
1745	647461.13	5000525.45	Codington	Non-Participating	28	50	No
1746	647456.46	5000456.03	Codington	Non-Participating	28	50	No
1749	648159.89	5000058.41	Codington	Participating	28	50	No
1759	648809.41	4999992.49	Codington	Non-Participating	29	50	No
1762	649063.96	5001386.23	Codington	Non-Participating	30	50	No
1764	663178.63	5001621.05	Codington	Non-Participating	29	50	No
1772	661543.34	5000761.33	Codington	Non-Participating	29	50	No

Table B-1: Modeled Sound Pressure Levels at Sensitive Receptors in Codington County

Receptor ID	Coordinates UTM NAD83 Zone 14N		County	Participation Status	Source Only Broadband Sound Level (dBA)	Regulation Evaluation	
	X (m)	Y (m)				Limit (dBA)	Exceed Limit?
1782	658372.24	5001257.48	Codington	Non-Participating	40	50	No
1784	655170.00	5001262.14	Codington	Non-Participating	42	50	No
1787	655103.41	5000902.29	Codington	Participating	43	50	No
1791	654852.45	5000075.99	Codington	Participating	43	50	No
1794	653692.68	5000273.03	Codington	Participating	42	50	No
1799	645387.42	4999931.96	Codington	Non-Participating	25	50	No
1800	646345.40	4999959.62	Codington	Non-Participating	26	50	No
2022	650528.30	4993061.83	Codington	Non-Participating	23	50	No
2024	649871.67	4991903.75	Codington	Participating	23	50	No
2025	649921.89	4991917.62	Codington	Participating	23	50	No
2038	646743.98	4996587.90	Codington	Non-Participating	24	50	No
2315	649018.76	4991138.66	Codington	Non-Participating	21	50	No
2318	648352.31	4991902.58	Codington	Participating	22	50	No
2339	649064.44	4992930.45	Codington	Non-Participating	23	50	No
2347	649279.70	4993533.72	Codington	Non-Participating	24	50	No
2348	649271.45	4993557.43	Codington	Non-Participating	24	50	No
2353	647627.18	4993444.66	Codington	Non-Participating	22	50	No
2356	647698.06	4993969.91	Codington	Non-Participating	23	50	No
2360	647604.47	4994983.66	Codington	Non-Participating	24	50	No
2363	651937.86	5001067.18	Codington	Participating	36	50	No
2364	651457.46	4993586.61	Codington	Non-Participating	25	50	No
2368	651076.00	4993539.97	Codington	Non-Participating	24	50	No
2372	658654.33	4990392.79	Codington	Non-Participating	21	50	No

Table B-2: Modeled Sound Pressure Levels at Sensitive Receptors in Grant County

Receptor ID	Coordinates UTM NAD83 Zone 14N		County	Participation Status	Source Only Broadband Sound Level (dBA)	Regulation Evaluation	
	X (m)	Y (m)				Limit (dBA)	Exceed Limit?
689	647139.01	5014024.33	Grant	Participating	27	50	No
782	660720.97	5013271.92	Grant	Participating	22	50	No
789	660610.61	5014484.49	Grant	Participating	24	50	No
1805	644356.98	5002651.43	Grant	Participating	26	50	No
1809	647235.37	5001567.12	Grant	Participating	28	50	No
1815	648970.50	5002809.01	Grant	Participating	32	50	No
1821	649665.32	5003050.76	Grant	Non-Participating	33	50	No
1828	650524.49	5003103.91	Grant	Participating	35	50	No
1829	650075.00	5002248.60	Grant	Non-Participating	33	50	No
1832	651107.55	5003102.45	Grant	Participating	36	50	No
1837	651909.87	5003057.90	Grant	Participating	39	50	No
1840	650832.97	5001658.43	Grant	Non-Participating	33	50	No
1847	652660.85	5002765.85	Grant	Participating	41	50	No
1849	653530.94	5002924.70	Grant	Non-Participating	41	50	No
1850	653518.23	5002856.66	Grant	Non-Participating	41	50	No
1867	661784.38	5001742.15	Grant	Non-Participating	30	50	No
1870	661126.69	5001722.46	Grant	Non-Participating	31	50	No
1874	663970.35	5002019.97	Grant	Non-Participating	28	50	No
1884	664755.72	5004486.66	Grant	Participating	27	50	No
1885	664644.10	5004250.93	Grant	Non-Participating	29	50	No
1888	663576.49	5004901.72	Grant	Non-Participating	33	50	No
1895	657975.48	5004220.64	Grant	Non-Participating	36	50	No
1904	658164.88	5003370.45	Grant	Non-Participating	35	50	No
1908	655165.86	5002087.27	Grant	Non-Participating	39	50	No
1914	653600.45	5003245.37	Grant	Participating	44	50	No
1915	653456.51	5004343.87	Grant	Participating	45	50	No
1919	651979.07	5003440.36	Grant	Participating	42	50	No
1928	649363.69	5003248.44	Grant	Participating	33	50	No
1937	648977.78	5004008.60	Grant	Non-Participating	35	50	No
1938	647494.42	5004033.38	Grant	Non-Participating	32	50	No
1947	647511.12	5006001.75	Grant	Non-Participating	34	50	No
1953	648855.29	5004824.59	Grant	Non-Participating	41	50	No
1955	648976.90	5004831.73	Grant	Non-Participating	42	50	No
1957	649090.23	5004809.12	Grant	Non-Participating	41	50	No
1962	649045.78	5006117.82	Grant	Participating	39	50	No
1968	648969.51	5006429.63	Grant	Non-Participating	38	50	No
1970	646968.92	5006520.98	Grant	Non-Participating	34	50	No
1976	647303.97	5007251.04	Grant	Participating	36	50	No
1985	648480.56	5007489.68	Grant	Participating	38	50	No
1994	650684.64	5006150.39	Grant	Non-Participating	41	50	No
1995	650837.63	5006168.70	Grant	Non-Participating	41	50	No
2005	650626.79	5005202.02	Grant	Participating	45	50	No
2007	661518.31	5004784.40	Grant	Participating	38	50	No
2008	661242.84	5005002.70	Grant	Non-Participating	36	50	No
2012	661599.97	5003749.29	Grant	Participating	42	50	No
2018	659717.08	5002264.17	Grant	Non-Participating	34	50	No
2020	658319.47	5004153.08	Grant	Non-Participating	36	50	No
2041	653593.66	5006201.50	Grant	Participating	44	50	No
2066	664805.69	5006459.59	Grant	Non-Participating	24	50	No
2074	663797.17	5005085.81	Grant	Non-Participating	32	50	No
2080	657770.35	5004970.01	Grant	Non-Participating	39	50	No
2085	655202.17	5004865.99	Grant	Non-Participating	40	50	No
2086	653612.64	5006755.67	Grant	Participating	45	50	No
2099	664537.21	5007281.04	Grant	Non-Participating	25	50	No
2107	664924.28	5006725.78	Grant	Participating	22	50	No
2108	665843.59	5006677.49	Grant	Participating	24	50	No
2109	665811.13	5006675.75	Grant	Participating	24	50	No
2126	665811.13	5006675.75	Grant	Participating	24	50	No
2127	665811.13	5006675.75	Grant	Participating	24	50	No
2141	661510.62	5009229.70	Grant	Participating	26	50	No
2149	657734.58	5008810.13	Grant	Participating	43	50	No
2153	657618.71	5009594.79	Grant	Participating	44	50	No
2158	655865.10	5008248.23	Grant	Participating	45	50	No

Table B-2: Modeled Sound Pressure Levels at Sensitive Receptors in Grant County

Receptor ID	Coordinates UTM NAD83 Zone 14N		County	Participation Status	Source Only Broadband Sound Level (dBA)	Regulation Evaluation	
	X (m)	Y (m)				Limit (dBA)	Exceed Limit?
2168	653411.62	5009060.41	Grant	Participating	41	50	No
2182	652821.24	5009387.00	Grant	Non-Participating	38	50	No
2193	652045.23	5009239.11	Grant	Non-Participating	40	50	No
2195	650621.29	5009376.36	Grant	Non-Participating	39	50	No
2205	650503.26	5009033.74	Grant	Non-Participating	41	50	No
2212	650493.66	5008776.86	Grant	Non-Participating	44	50	No
2214	645840.98	5008574.90	Grant	Participating	43	50	No
2217	645708.61	5008004.25	Grant	Participating	37	50	No
2218	645720.53	5008021.46	Grant	Participating	38	50	No
2219	645631.03	5008056.63	Grant	Participating	38	50	No
2220	645560.46	5008023.00	Grant	Participating	37	50	No
2230	644920.93	5009426.30	Grant	Participating	39	50	No
2236	646374.72	5009624.58	Grant	Non-Participating	39	50	No
2239	647229.03	5010859.63	Grant	Participating	33	50	No
2240	648982.24	5010914.63	Grant	Non-Participating	34	50	No
2242	648974.09	5010822.91	Grant	Non-Participating	35	50	No
2243	650458.09	5010135.55	Grant	Non-Participating	37	50	No
2244	651399.84	5010537.19	Grant	Non-Participating	35	50	No
2251	653709.32	5011041.66	Grant	Participating	36	50	No
2257	655074.36	5009886.86	Grant	Participating	45	50	No
2260	658287.22	5009765.21	Grant	Participating	39	50	No
2267	663067.37	5009863.43	Grant	Participating	22	50	No
2270	645591.52	5011330.52	Grant	Participating	30	50	No
2271	646356.26	5011253.61	Grant	Non-Participating	31	50	No
2277	647415.35	5011482.18	Grant	Non-Participating	32	50	No
2279	653707.33	5011412.61	Grant	Non-Participating	35	50	No
2280	653706.52	5011445.93	Grant	Non-Participating	35	50	No
2281	653705.48	5011488.76	Grant	Non-Participating	35	50	No
2284	659888.06	5013103.47	Grant	Participating	27	50	No
2287	657521.45	5013443.09	Grant	Participating	30	50	No
2290	657917.63	5013363.29	Grant	Participating	29	50	No
2305	648987.99	5013202.15	Grant	Participating	29	50	No
2416	643160.20	5007930.05	Grant	Participating	29	50	No
2423	643933.96	5009635.42	Grant	Non-Participating	31	50	No
2424	643946.39	5009641.33	Grant	Non-Participating	31	50	No
2426	644853.33	5009638.98	Grant	Non-Participating	37	50	No
2427	644862.14	5009641.30	Grant	Non-Participating	37	50	No
2449	650900.06	5006334.22	Grant	Non-Participating	42	50	No
2455	651981.94	5003185.29	Grant	Non-Participating	40	50	No
2470	653647.87	5003180.53	Grant	Participating	43	51	No

SHADOW FLICKER MODELING REPORT

Dakota Range Wind Project
Codington & Grant Counties, South Dakota

Prepared for:

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1.0 EXECUTIVE SUMMARY

The Dakota Range Wind Project (the Project) is a proposed wind power electric generation facility expected to consist of 72 wind turbines in Codington and Grant Counties, South Dakota. The Project is being developed by Apex Clean Energy, Inc. (Apex). Epsilon Associates, Inc. (Epsilon) has been retained by Apex to conduct a shadow flicker modeling study for the Project. This report presents results of the study.

Shadow flicker modeling was conservatively conducted for 97 Vestas V136-4.2 wind turbines, which includes 25 alternate wind turbine locations. The purpose of this analysis is to predict the expected annual durations of wind turbine shadow flicker at nearby occupied structures ("sensitive receptors"). The design goal of the Project is to not exceed the industry guideline of 30 hours per year of expected shadow flicker at any non-participating sensitive receptor.

The maximum expected annual duration of shadow flicker at a sensitive receptor resulting from the operation of the 72 proposed and 25 alternate wind turbines is 54 hours, 7 minutes. This receptor is a Project participant. The maximum expected annual duration of flicker at a non-participating receptor is 29 hours, 0 minutes. The modeling results are conservative in that modeling receptors were treated as structures with windows on all sides ("greenhouses") and the surrounding area was assumed to be without vegetation or structures ("bare earth").

2.0 INTRODUCTION

The Dakota Range Wind Project to be located in Codington and Grant Counties, South Dakota will consist of 72 Vestas wind turbines and an electrical substation. A total of 25 alternate wind turbine locations are also proposed for the Project. The wind turbines will be Vestas V136-4.2 serrated trailing edge blade units. The V136-4.2 wind turbines have a hub height of 82 meters and a rotor diameter of 136 meters. Figure 2-1 shows the locations of the 72 proposed and 25 alternate wind turbines over aerial imagery in Codington and Grant Counties.

With respect to wind turbines, shadow flicker can be defined as an intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer experiences repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine, otherwise there is no shadow flicker. A stationary wind turbine only generates a stationary shadow similar to any other structure.

Based on the current design and operation of typical modern wind turbines, shadow flicker impacts are generally an annoyance issue and not a health effects concern. Often the public is concerned about the possibility of epileptic seizures being caused by shadow flicker. According to the Epilepsy Foundation, "Generally, flashing lights most likely to trigger seizures are between the frequency of 5 to 30 flashes per second (Hertz)."[1] The wind turbines for this Project have a maximum rotational speed of 10.4 rpm which corresponds to a shadow flicker frequency of 0.5 Hz. This frequency is well below the frequency identified by the Epilepsy Foundation; therefore, the triggering of epileptic seizures is not a concern with this Project.

This report presents the findings of a shadow flicker modeling study for the Project. The wind turbines were modeled with the WindPRO software package using information provided by Apex. The expected annual duration of shadow flicker was calculated at sensitive receptor points and shadow flicker isolines for the area surrounding the Project were generated. The results of the modeling are found within this report.

[1] Epilepsy Foundation, http://www.epilepsy.com/learn/triggers-seizures/photosensitivity-and-seizures. Accessed in December 2017.

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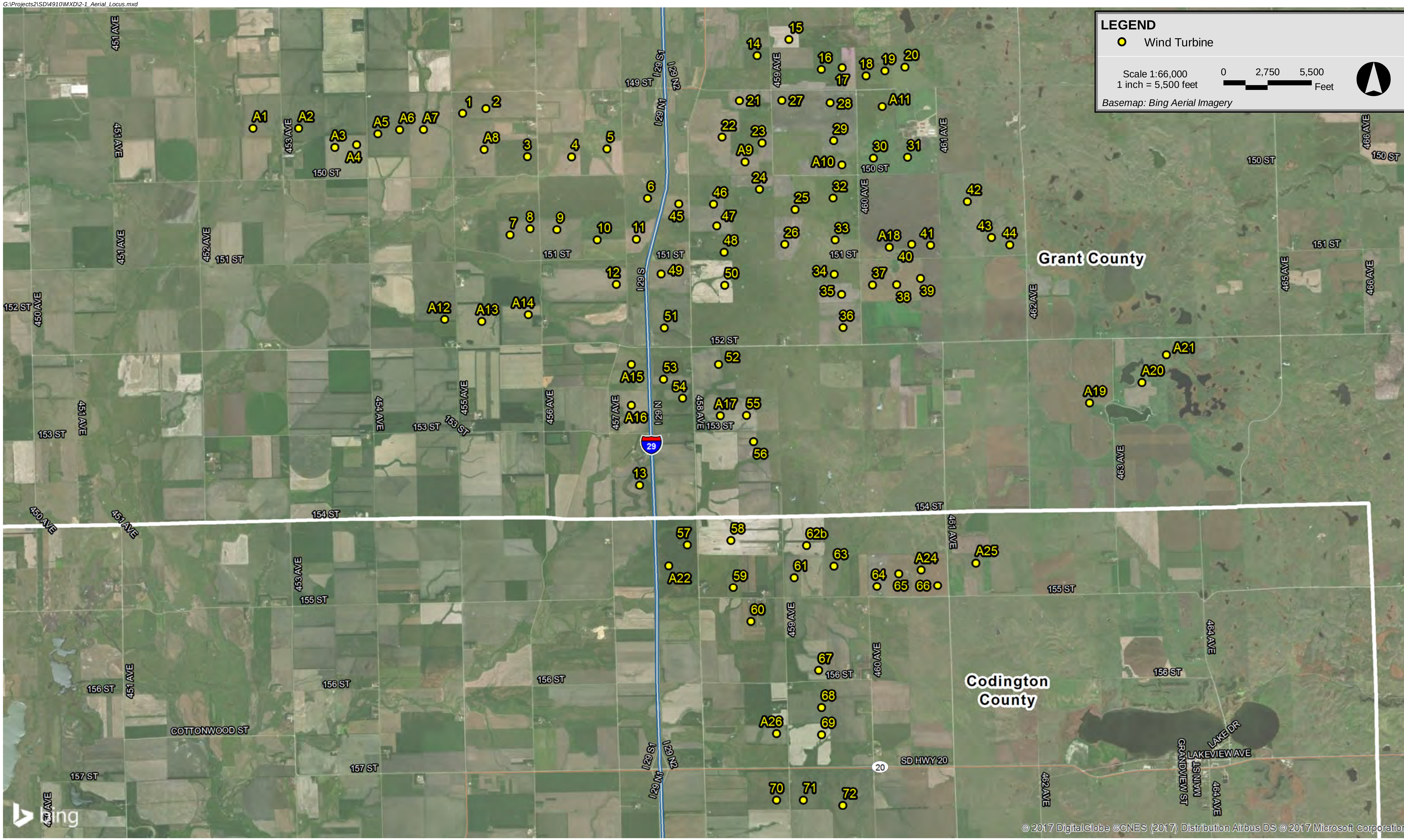

Dakota Range Wind   Grant County/Codington County, South Dakota

Epsilon ASSOCIATES INC.

Figure 2-1
Aerial Locus

3.0 SHADOW FLICKER MODELING

3.1 Modeling Methodology

Shadow flicker was modeled using a software package, WindPRO version 3.1.617. WindPRO is a software suite developed by EMD International A/S and is used for assessing potential environmental impacts from wind turbines. Using the Shadow module within WindPRO, worst-case shadow flicker in the area surrounding the wind turbines was calculated based on data inputs including: location of the wind turbines, location of discrete receptor points, wind turbine dimensions, flicker calculation limits, and terrain data. Based on these data, the model was able to incorporate the appropriate sun angle and maximum daily sunlight for this latitude into the calculations. The resulting worst-case calculations assume that the sun is always shining during daylight hours and that the wind turbine is always operating. The WindPRO Shadow module can be further refined by incorporating sunshine probabilities and wind turbine operational estimates by wind direction over the course of a year. The values produced by this further refinement, also known as the "expected" shadow flicker, are presented in this section.

The proposed wind turbine layout for the Project dated December 18, 2017 was provided by Apex. Of the 97 conservatively modeled wind turbines, 25 are alternative wind turbine locations. Locations of the turbines are shown in Figure 3-1 and the coordinates are provided in Appendix A. All wind turbines are proposed to be Vestas V136-4.2 units with an 82 meter hub height and a 136 meter rotor diameter. Each wind turbine has the following characteristics based on the technical data provided by Apex or by WindPRO:

		Vestas V136-4.0
♦ Rated Power	=	4,200 kW
♦ Hub Height	=	82 meters
♦ Rotor Diameter	=	136 meters
♦ Cut-in Wind Speed	=	3 m/s
♦ Cut-out Wind Speed	=	25 m/s
♦ Maximum RPM	=	10.4 rpm

To-date, there are no federal, state, or local regulations regarding the maximum radial distance from a wind turbine to which shadow flicker should be analyzed applicable to this Project. In the United States, shadow flicker is commonly evaluated out to a distance of ten times the rotor diameter. According to the Massachusetts Model Bylaw for wind energy facilities, shadow flicker impacts are minimal at and beyond a distance of ten rotor diameters.[2] Defining the shadow flicker calculation area has also been addressed in Europe where the ten times rotor diameter approach has been accepted in multiple European

[2] Massachusetts Department of Energy Resources, "Model As-of-Right Zoning Ordinance or Bylaw: Allowing Use of Wind Energy Facilities" 2009.

countries.[3] Some jurisdictions conservatively require a larger calculation area. The New Hampshire Site Evaluation Committee through rulemaking docket 2014-04 adopted rules on December 15, 2015 outlining application requirements and criteria for energy facilities, including wind energy facilities. As part of these revised regulations, Site 301.08(a)(2) requires an evaluation distance of at least 1 mile from a wind turbine.[4] Section 16-50j-94, part (g), of the Regulations of Connecticut State Agencies identifies the components required in a shadow flicker evaluation report which includes the calculation of shadow flicker from each proposed wind turbine to any off-site occupied structure within a 1.25 mile radius.[5] For this Project, ten times the rotor diameter of the proposed wind turbine corresponds to a distance of 0.85 miles (1,360 m). Conservatively, this analysis follows the Connecticut guidance and includes shadow flicker calculations out to 1.25 miles (2,012 m) from each wind turbine in the model for the proposed layout. This is a conservative assumption because the shadows are likely to be diffused significantly beyond a distance of ten rotor diameters.

A modeling receptor dataset with participation status information dated November 17, 2017 was provided by Apex. Only receptors within 5 miles of any wind turbine were included in the model, which accommodates the 1.25-mile calculation extent. These sensitive receptors were modeled as discrete points and are shown on Figure 3-1. Each modeling point was assumed to have a window facing all directions ("greenhouse" mode) which yields conservative results. In addition, a dataset containing parcel boundaries and lease status dated November 10, 2017 was provided by Apex. Parcels identified as "agreement signed" were included as participating and are identified on Figure 3-1. The model was set to limit calculations to 2,012 meters from a wind turbine, the equivalent of 1.25 miles. Consequently, shadow flicker at any of the 189 modeling receptors greater than the corresponding limitation distance from a wind turbine was zero. In addition to modeling discrete points, shadow flicker was calculated at grid points in the area surrounding the modeled wind turbines to generate flicker isolines. A 10-meter spacing was used for this grid.

The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey. Conservatively, obstacles, i.e. buildings and vegetation, were excluded from the analysis. This is effectively a "bare earth" scenario which is

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3 Parsons Brinckerhoff, "Update of UK Shadow Flicker Evidence Base" Prepared for Department of Energy and Climate Change, 2011.

4 State of New Hampshire Site Evaluation Committee Site 300 Rules (2015), available at http://www.gencourt.state.nh.us/rules/state_agencies/site100-300.html Accessed in October 2017.

5 State of Connecticut CSC Wind Regulations (2014), available at https://www.cga.ct.gov/aspx/CGARegulations/CGARegulations.aspx?Yr=2014&Reg=2012-054&Amd=E Accessed in October 2017.

conservative. When accounted for in the shadow flicker calculations, such obstacles may significantly mitigate or eliminate the flicker effect depending on their size, type, and location. In addition, shadow flicker durations were calculated only when the angle of the sun was at least 3° above the horizon.

Monthly sunshine probability values were input for each month from January to December. These numbers were obtained from a publicly available historical dataset for Huron, South Dakota from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI).[6] Table 3-1 shows the percentage of sunshine hours by month used in the shadow flicker modeling. These values are the percentages that the sun is expected to be shining during daylight hours.

The number of hours the wind turbines are expected to operate for the 16 cardinal wind directions was input into the model. Wind direction frequency percentages for operational wind speeds (using wind data scaled to an 82-meter height) were provided by Apex from meteorological data collected at an onsite tower over no less than 1 year. Using the percentage of wind data annually below cut-in wind speed, Epsilon calculated the number of operational hours per wind direction sector. These hours per wind direction sector are used by WindPRO to estimate the "wind direction" and "operation time" reduction factors. Based on this dataset, the wind turbines would operate 96% of the year due to cut-in and cut-out specifications of the proposed unit. Table 3-2 shows the distribution of operational hours for the 16 wind directions.

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[6] NCEI (formerly NCDC), http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.txt. Accessed in December 2017.

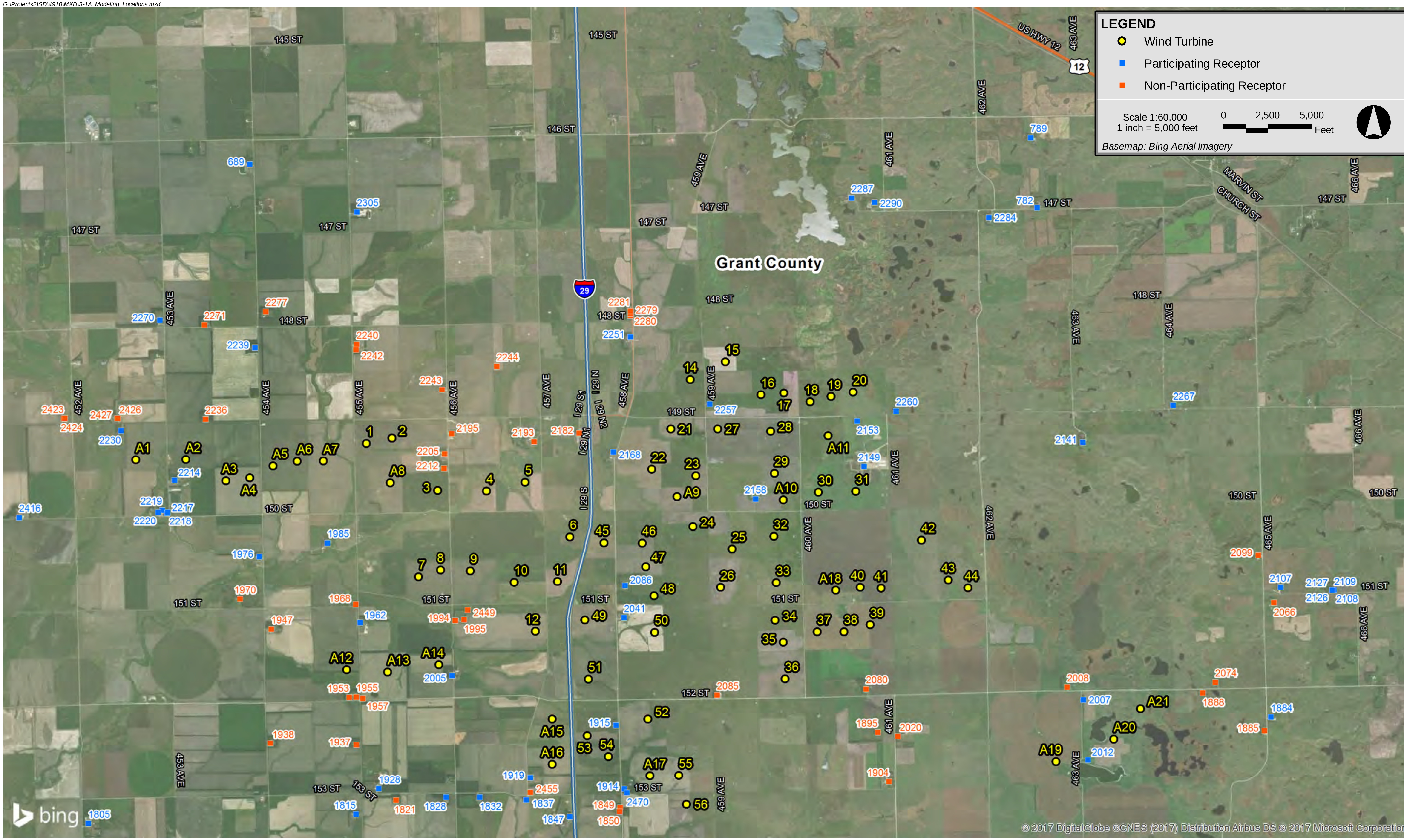
Table 3-1 Monthly Percent of Possible Sunshine

Month	Possible Sunshine
January	62%
February	62%
March	62%
April	59%
May	66%
June	69%
July	76%
August	74%
September	69%
October	59%
November	51%
December	51%

Table 3-2 Operational Hours per Wind Direction Sector

Wind Sector	Operational Hours
N	556
NNE	556
NE	324
ENE	284
E	272
ESE	414
SE	411
SSE	562
S	777
SSW	629
SW	408
WSW	387
W	518
WNW	803
NW	796
NNW	721
Annual	8,418

G:\Projects2\SD\4910\MXD\3-1A_Modeling_Locations.mxd



Dakota Range Wind **Grant County/Codington County, South Dakota**

Figure 3-1A

Shadow Flicker Modeling Locations

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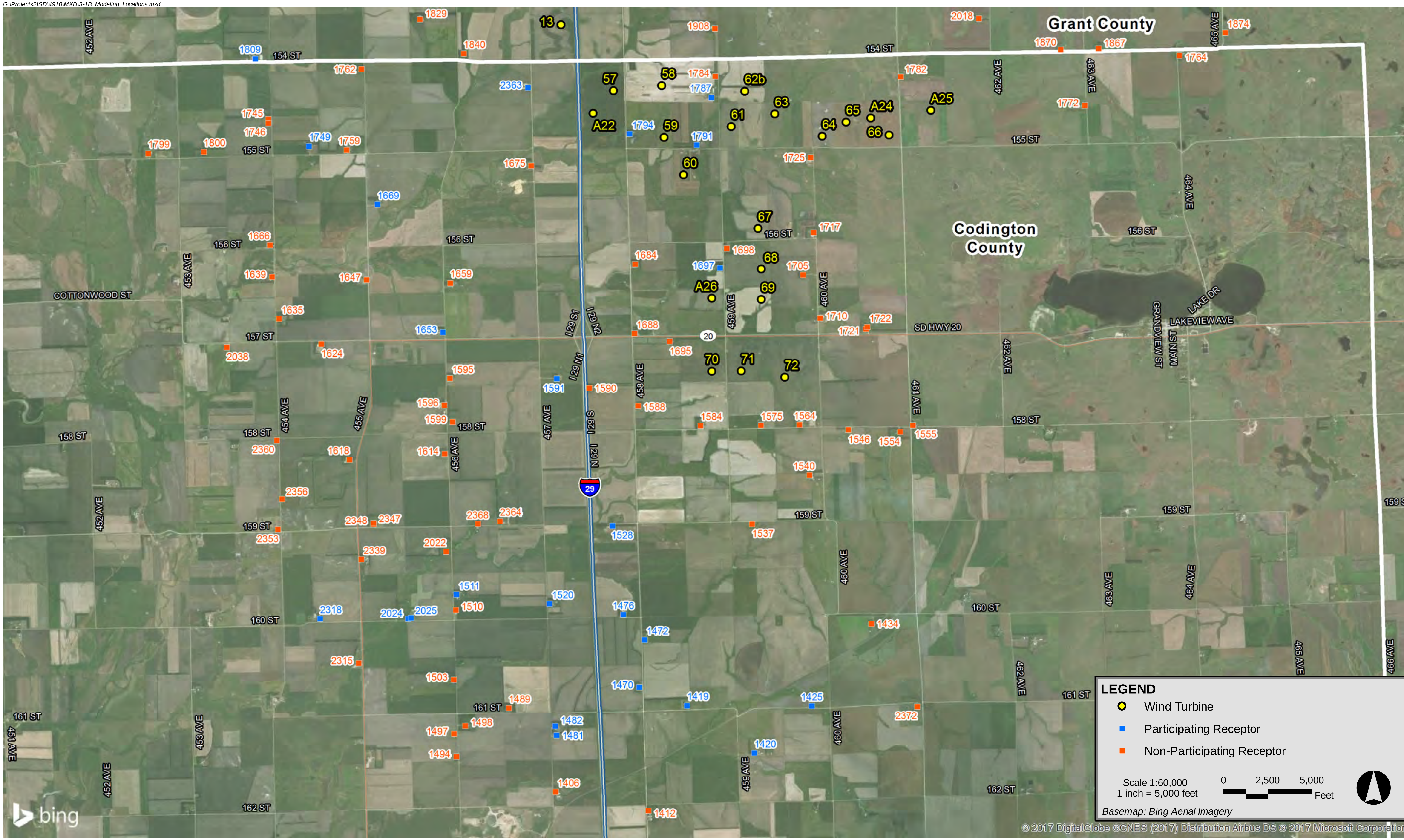


Dakota Range Wind **Grant County/Codington County, South Dakota**

Epsilon

Figure 3-1B

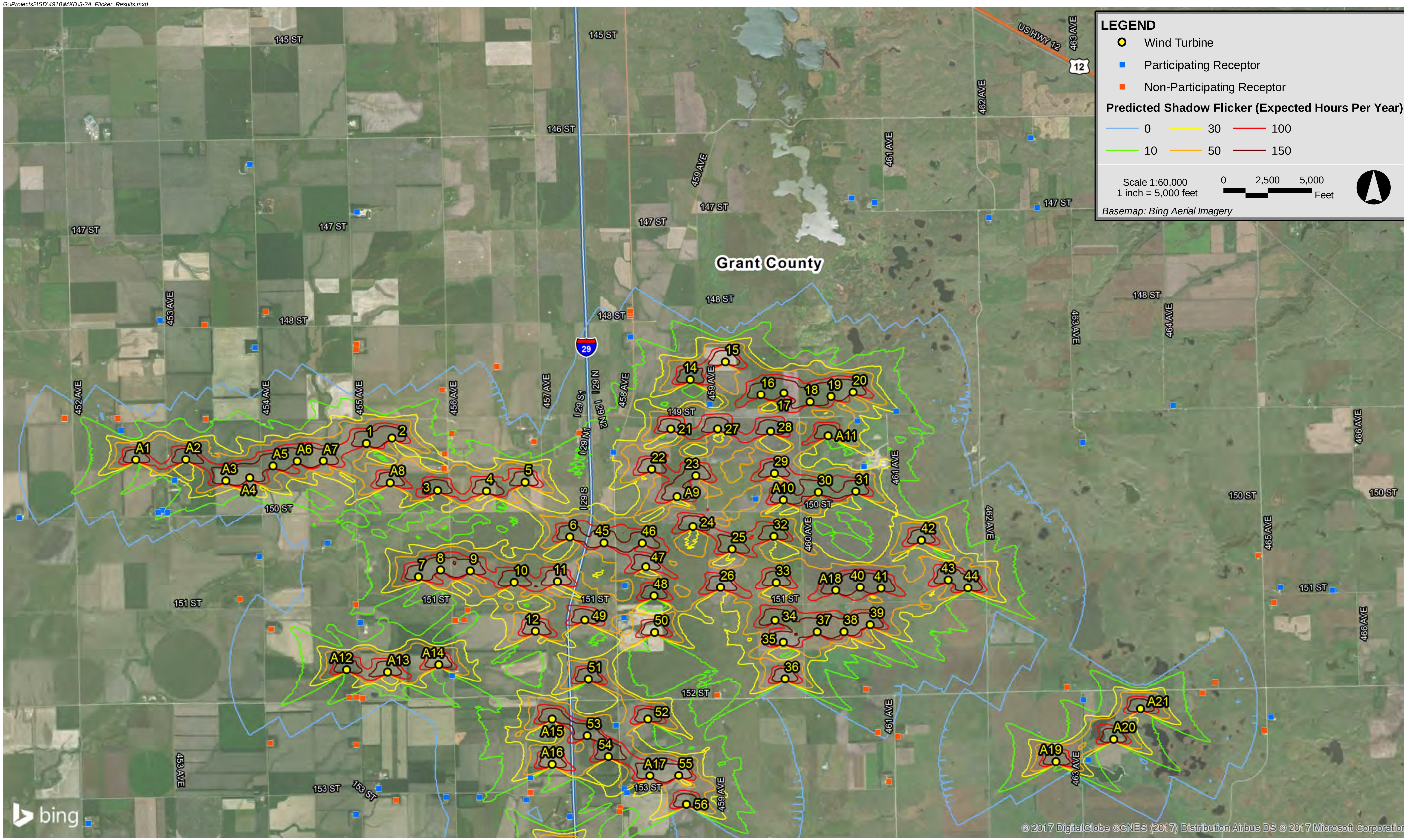
Shadow Flicker Modeling Locations

3.2 Results

Following the modeling methodology outlined in Section 3.1, WindPRO was used to calculate shadow flicker at the 189 discrete modeling points in Codington and Grant Counties and generate shadow flicker isolines based on the grid calculations.

Table B-1 in Appendix B presents the modeling results for the 189 modeling receptor locations. The predicted expected annual shadow flicker duration ranged from 0 hours, 0 minutes per year to 54 hours, 7 minutes per year. The majority of the sensitive receptors (110) were predicted to experience no annual shadow flicker. 48 locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 20 locations would be expected to have 10 to 30 hours of shadow flicker per year while 11 locations would be expected to have over 30 hours of shadow flicker per year. All of these 11 locations are participating receptors. Figure 3-2 displays the modeled flicker isolines over aerial imagery in relation to modeled wind turbines and sensitive receptors.

G:\Projects2\SD\4910\MXD\3-2A_Flicker_Results.mxd



Dakota Range Wind Grant County/Codington County, South Dakota

Epsilon ASSOCIATES INC.

Figure 3-2A

Shadow Flicker Modeling Results

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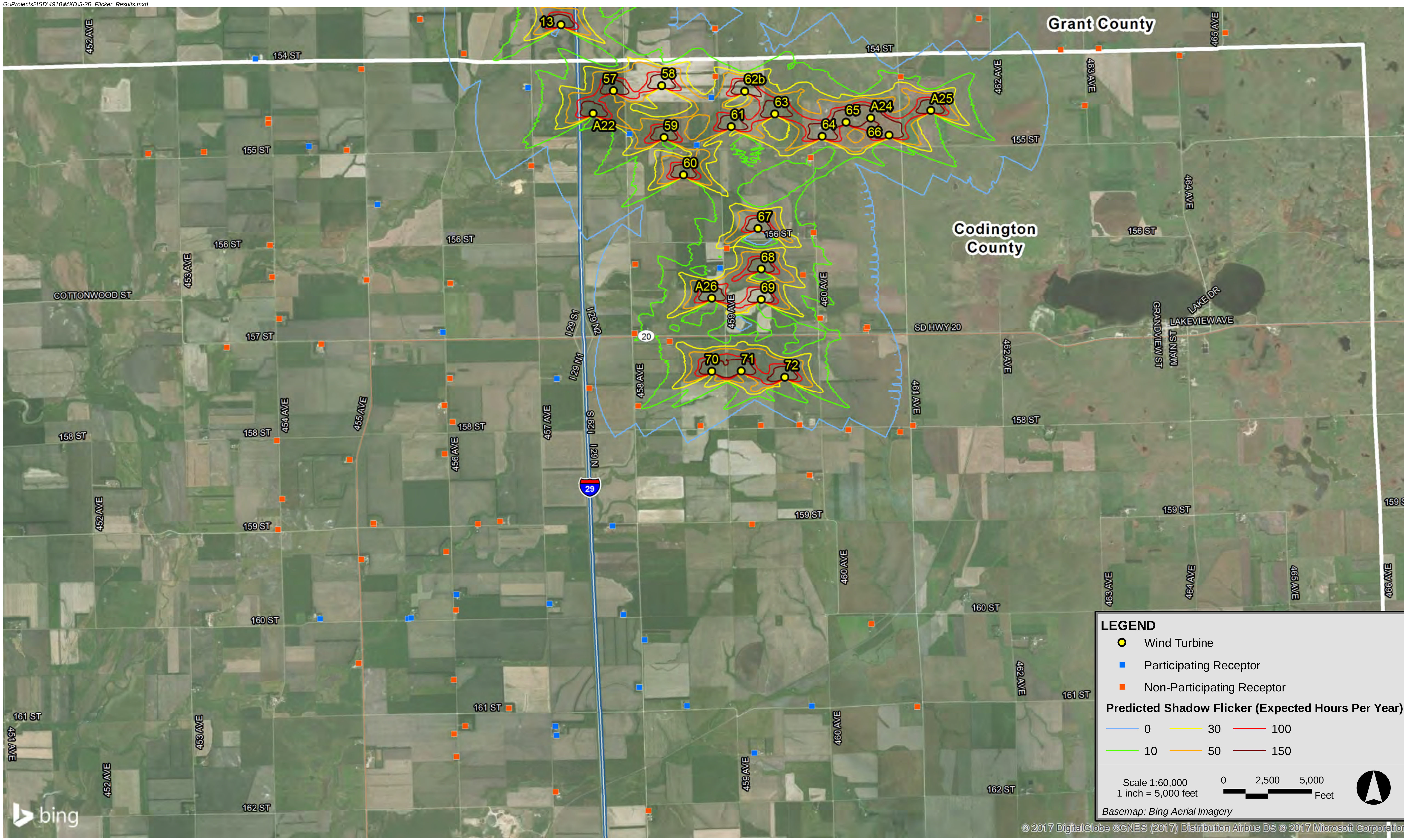

Dakota Range Wind **Grant County/Codington County, South Dakota**

Epsilon ASSOCIATES INC.

Figure 3-2B

Shadow Flicker Modeling Results

4.0 CONCLUSIONS

A shadow flicker analysis was conducted to determine the duration of shadow flicker in the vicinity of the proposed Dakota Range Wind Project within Codington and Grant Counties, SD. Shadow flicker resulting from the operation of the proposed wind turbine layout and alternate wind turbine locations was calculated at 189 occupied structures, and isolines were generated from a grid encompassing the area surrounding the wind turbines.

The shadow flicker design goal at non-participating occupied structures is 30 hours per year. The maximum expected annual duration of shadow flicker at a modeling receptor is 54 hours, 7 minutes. This receptor is a Project participant. The maximum expected annual duration of flicker at a non-participating receptor is 29 hours, 0 minutes. Therefore, the Project design goal is met. The modeling results are conservative in that modeling receptors were treated as structures with windows on all sides ("greenhouses") and the surrounding area was assumed to be without vegetation or structures ("bare earth").

Appendix A

Wind Turbine Coordinates

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
1	649150.68	5009210.55
2	649592.64	5009301.39
3	650382.14	5008394.08
4	651221.24	5008388.66
5	651887.81	5008536.33
6	652659.21	5007595.70
7	650048.07	5006906.21
8	650429.11	5007023.84
9	650941.68	5007007.69
10	651702.10	5006813.09
11	652445.44	5006824.28
12	652067.96	5005967.41
13	652508.47	5002155.46
14	654738.65	5010309.74
15	655342.56	5010617.87
16	655959.75	5010046.16
17	656353.73	5010078.42
18	656807.12	5009925.65
19	657165.19	5010016.56
20	657545.03	5010093.22
21	654403.27	5009456.11
22	654073.85	5008759.99
23	654834.57	5008649.35
24	654782.01	5007771.84
25	655461.81	5007386.09
26	655262.58	5006726.86
27	655209.73	5009458.69
28	656123.54	5009415.49
29	656190.63	5008691.29
30	656948.30	5008364.53
31	657593.24	5008379.77
32	656181.41	5007604.26
33	656220.17	5006808.38
34	656202.73	5006154.17
35	656341.29	5005779.24
36	656373.09	5005145.37
37	656928.93	5005957.45
38	657387.82	5005959.70
39	657839.76	5006079.27
40	657670.73	5006726.57
41	658031.93	5006708.57

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
42	658728.18	5007539.26
43	659189.32	5006853.26
44	659530.88	5006717.26
45	653250.85	5007492.28
46	653912.36	5007486.35
47	653971.67	5007079.89
48	654112.53	5006577.23
49	652919.63	5006162.99
50	654125.10	5005948.82
51	652979.75	5005140.46
52	654007.77	5004448.60
53	652959.73	5004165.46
54	653326.71	5003802.14
55	654539.43	5003479.34
56	654671.50	5002980.82
57	653412.66	5001019.09
58	654243.67	5001103.58
59	654285.80	5000211.18
60	654621.54	4999566.28
61	655443.20	5000399.81
62b	655678.86	5001007.79
63	656197.91	5000617.81
64	657012.96	5000231.13
65	657424.44	5000476.02
66	658166.89	5000251.64
67	655906.42	4998639.32
68	655964.72	4997936.95
69	655962.56	4997416.19
70	655110.53	4996175.39
71	655618.94	4996179.18
72	656367.12	4996073.95
A1	645172.45	5008926.68
A2	646038.25	5008927.64
A3	646726.68	5008563.81
A4	647137.99	5008616.63
A5	647539.89	5008820.59
A6	647956.98	5008901.81
A7	648409.37	5008903.36
A8	649560.48	5008528.49
A9	654509.77	5008288.83
A10	656345.65	5008235.30

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Table A-1: Wind Turbine Coordinates

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
A11	657114.06	5009343.43
A12	648810.69	5005302.13
A13	649516.40	5005259.92
A14	650398.22	5005389.99
A15	652354.92	5004448.62
A16	652353.57	5003672.36
A17	654041.01	5003475.27
A18	657249.87	5006672.81
A19	661049.92	5003716.42
A20	662041.92	5004103.34
A21	662506.37	5004630.35
A22	653061.13	5000624.85
A24	657850.58	5000545.83
A25	658890.90	5000677.60
A26	655109.25	4997437.35

Note: "A" at the front of the wind turbine ID indicates an alternate location.

Appendix B

Shadow Flicker Modeling Results: Sensitive Receptors

Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors

Modeling ID	Participation Status	County	Coordinates NAD83 UTM Zone 14N (meters)		Expected Shadow Flicker Hours per Year
			X (Easting)	Y (Northing)	(HH:MM/year)
689	Participating	Grant	647139.01	5014024.33	0:00
782	Participating	Grant	660720.97	5013271.92	0:00
789	Participating	Grant	660610.61	5014484.49	0:00
1406	Non-Participating	Codington	652415.58	4988918.69	0:00
1412	Non-Participating	Codington	654015.11	4988590.25	0:00
1419	Participating	Codington	654681.58	4990406.38	0:00
1420	Participating	Codington	655846.86	4989588.29	0:00
1425	Participating	Codington	656834.67	4990400.04	0:00
1434	Non-Participating	Codington	657862.31	4991817.05	0:00
1470	Participating	Codington	653857.99	4990720.09	0:00
1472	Participating	Codington	653950.59	4991543.64	0:00
1476	Participating	Codington	653587.51	4991975.31	0:00
1481	Participating	Codington	652432.12	4989894.34	0:00
1482	Participating	Codington	652413.64	4990050.68	0:00
1489	Non-Participating	Codington	651609.43	4990364.76	0:00
1494	Non-Participating	Codington	650703.87	4989527.33	0:00
1497	Non-Participating	Codington	650662.06	4989915.49	0:00
1498	Non-Participating	Codington	650856.93	4990053.74	0:00
1503	Non-Participating	Codington	650657.74	4990852.72	0:00
1510	Non-Participating	Codington	650692.61	4992057.70	0:00
1511	Participating	Codington	650706.98	4992320.66	0:00
1520	Participating	Codington	652311.29	4992164.18	0:00
1528	Participating	Codington	653394.86	4993505.03	0:00
1537	Non-Participating	Codington	655804.37	4993535.65	0:00
1540	Non-Participating	Codington	656798.10	4994383.05	0:00
1546	Non-Participating	Codington	657464.70	4995163.56	0:00
1554	Non-Participating	Codington	658362.21	4995127.56	0:00
1555	Non-Participating	Codington	658578.51	4995244.25	0:00
1564	Non-Participating	Codington	656621.54	4995250.50	0:00
1575	Non-Participating	Codington	655954.93	4995240.17	0:00
1584	Non-Participating	Codington	654917.16	4995237.31	4:26
1588	Non-Participating	Codington	653838.26	4995578.48	6:06
1590	Non-Participating	Codington	652995.68	4995885.56	0:00
1591	Participating	Codington	652436.54	4996047.89	0:00
1595	Non-Participating	Codington	650593.29	4996054.48	0:00
1596	Non-Participating	Codington	650496.01	4995587.28	0:00
1599	Non-Participating	Codington	650636.90	4995303.04	0:00
1614	Non-Participating	Codington	650501.55	4994753.62	0:00
1618	Non-Participating	Codington	648862.47	4994649.83	0:00
1624	Non-Participating	Codington	648375.40	4996645.46	0:00
1635	Non-Participating	Codington	647647.95	4997080.29	0:00
1639	Non-Participating	Codington	647523.41	4997799.99	0:00
1647	Non-Participating	Codington	649154.79	4997753.24	0:00
1653	Participating	Codington	650473.00	4996848.32	0:00
1659	Non-Participating	Codington	650595.55	4997697.39	0:00
1666	Non-Participating	Codington	647488.92	4998352.98	0:00

Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors

Modeling ID	Participation Status	County	Coordinates NAD83 UTM Zone 14N (meters)		Expected Shadow Flicker Hours per Year
			X (Easting)	Y (Northing)	(HH:MM/year)
1669	Participating	Codington	649340.75	4999049.86	0:00
1675	Non-Participating	Codington	651994.47	4999721.14	0:00
1684	Non-Participating	Codington	653787.02	4998022.59	2:14
1688	Non-Participating	Codington	653778.28	4996825.57	7:24
1695	Non-Participating	Codington	654384.51	4996687.82	20:07
1697	Participating	Codington	655253.74	4997956.71	24:47
1698	Non-Participating	Codington	655368.87	4998297.41	26:52
1705	Non-Participating	Codington	656685.45	4997836.26	20:21
1710	Non-Participating	Codington	656976.54	4997093.04	8:25
1717	Non-Participating	Codington	656867.97	4998569.91	9:53
1721	Non-Participating	Codington	657770.19	4996904.04	1:42
1722	Non-Participating	Codington	657792.58	4996940.40	1:35
1725	Non-Participating	Codington	656815.87	4999863.27	7:53
1745	Non-Participating	Codington	647461.13	5000525.45	0:00
1746	Non-Participating	Codington	647456.46	5000456.03	0:00
1749	Participating	Codington	648159.89	5000058.41	0:00
1759	Non-Participating	Codington	648809.41	4999992.49	0:00
1762	Non-Participating	Codington	649063.96	5001386.23	0:00
1764	Non-Participating	Codington	663178.63	5001621.05	0:00
1772	Non-Participating	Codington	661543.34	5000761.33	0:00
1782	Non-Participating	Codington	658372.24	5001257.48	13:30
1784	Non-Participating	Codington	655170.00	5001262.14	29:00
1787	Participating	Codington	655103.41	5000902.29	46:13
1791	Participating	Codington	654852.45	5000075.99	52:26
1794	Participating	Codington	653692.68	5000273.03	37:41
1799	Non-Participating	Codington	645387.42	4999931.96	0:00
1800	Non-Participating	Codington	646345.40	4999959.62	0:00
1805	Participating	Grant	644356.98	5002651.43	0:00
1809	Participating	Grant	647235.37	5001567.12	0:00
1815	Participating	Grant	648970.50	5002809.01	0:00
1821	Non-Participating	Grant	649665.32	5003050.76	0:00
1828	Participating	Grant	650524.49	5003103.91	0:49
1829	Non-Participating	Grant	650075.00	5002248.60	0:00
1832	Participating	Grant	651107.55	5003102.45	6:22
1837	Participating	Grant	651909.87	5003057.90	5:06
1840	Non-Participating	Grant	650832.97	5001658.43	1:26
1847	Participating	Grant	652660.85	5002765.85	5:42
1849	Non-Participating	Grant	653530.94	5002924.70	16:52
1850	Non-Participating	Grant	653518.23	5002856.66	11:30
1867	Non-Participating	Grant	661784.38	5001742.15	0:00
1870	Non-Participating	Grant	661126.69	5001722.46	0:00
1874	Non-Participating	Grant	663970.35	5002019.97	0:00
1884	Participating	Grant	664755.72	5004486.66	0:00
1885	Non-Participating	Grant	664644.10	5004250.93	0:00
1888	Non-Participating	Grant	663576.49	5004901.72	4:18
1895	Non-Participating	Grant	657975.48	5004220.64	1:00

Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors

Modeling ID	Participation Status	County	Coordinates NAD83 UTM Zone 14N (meters)		Expected Shadow Flicker Hours per Year
			X (Easting)	Y (Northing)	(HH:MM/year)
1904	Non-Participating	Grant	658164.88	5003370.45	0:00
1908	Non-Participating	Grant	655165.86	5002087.27	0:00
1914	Participating	Grant	653600.45	5003245.37	44:03
1915	Participating	Grant	653456.51	5004343.87	54:07
1919	Participating	Grant	651979.07	5003440.36	20:23
1928	Participating	Grant	649363.69	5003248.44	0:00
1937	Non-Participating	Grant	648977.78	5004008.60	0:00
1938	Non-Participating	Grant	647494.42	5004033.38	0:00
1947	Non-Participating	Grant	647511.12	5006001.75	2:50
1953	Non-Participating	Grant	648855.29	5004824.59	6:19
1955	Non-Participating	Grant	648976.90	5004831.73	2:08
1957	Non-Participating	Grant	649090.23	5004809.12	3:01
1962	Participating	Grant	649045.78	5006117.82	2:54
1968	Non-Participating	Grant	648969.51	5006429.63	10:20
1970	Non-Participating	Grant	646968.92	5006520.98	0:00
1976	Participating	Grant	647303.97	5007251.04	0:00
1985	Participating	Grant	648480.56	5007489.68	2:08
1994	Non-Participating	Grant	650684.64	5006150.39	9:28
1995	Non-Participating	Grant	650837.63	5006168.70	6:45
2005	Participating	Grant	650626.79	5005202.02	8:00
2007	Participating	Grant	661518.31	5004784.40	4:13
2008	Non-Participating	Grant	661242.84	5005002.70	2:05
2012	Participating	Grant	661599.97	5003749.29	18:52
2018	Non-Participating	Grant	659717.08	5002264.17	0:00
2020	Non-Participating	Grant	658319.47	5004153.08	0:00
2022	Non-Participating	Codington	650528.30	4993061.83	0:00
2024	Participating	Codington	649871.67	4991903.75	0:00
2025	Participating	Codington	649921.89	4991917.62	0:00
2038	Non-Participating	Codington	646743.98	4996587.90	0:00
2041	Participating	Grant	653593.66	5006201.50	37:43
2066	Non-Participating	Grant	664805.69	5006459.59	0:00
2074	Non-Participating	Grant	663797.17	5005085.81	2:26
2080	Non-Participating	Grant	657770.35	5004970.01	4:17
2085	Non-Participating	Grant	655202.17	5004865.99	5:10
2086	Participating	Grant	653612.64	5006755.67	39:11
2099	Non-Participating	Grant	664537.21	5007281.04	0:00
2107	Participating	Grant	664924.28	5006725.78	0:00
2108	Participating	Grant	665843.59	5006677.49	0:00
2109	Participating	Grant	665811.13	5006675.75	0:00
2126	Participating	Grant	665811.13	5006675.75	0:00
2127	Participating	Grant	665811.13	5006675.75	0:00
2141	Participating	Grant	661510.62	5009229.70	0:00
2149	Participating	Grant	657734.58	5008810.13	16:19
2153	Participating	Grant	657618.71	5009594.79	44:57
2158	Participating	Grant	655865.10	5008248.23	44:59
2168	Participating	Grant	653411.62	5009060.41	30:49

Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors

Modeling ID	Participation Status	County	Coordinates NAD83 UTM Zone 14N (meters)		Expected Shadow Flicker Hours per Year
			X (Easting)	Y (Northing)	(HH:MM/year)
2182	Non-Participating	Grant	652821.24	5009387.00	9:17
2193	Non-Participating	Grant	652045.23	5009239.11	1:20
2195	Non-Participating	Grant	650621.29	5009376.36	10:13
2205	Non-Participating	Grant	650503.26	5009033.74	23:31
2212	Non-Participating	Grant	650493.66	5008776.86	24:51
2214	Participating	Grant	645840.98	5008574.90	22:40
2217	Participating	Grant	645708.61	5008004.25	12:55
2218	Participating	Grant	645720.53	5008021.46	13:46
2219	Participating	Grant	645631.03	5008056.63	9:18
2220	Participating	Grant	645560.46	5008023.00	7:38
2230	Participating	Grant	644920.93	5009426.30	3:13
2236	Non-Participating	Grant	646374.72	5009624.58	8:17
2239	Participating	Grant	647229.03	5010859.63	0:00
2240	Non-Participating	Grant	648982.24	5010914.63	0:00
2242	Non-Participating	Grant	648974.09	5010822.91	0:00
2243	Non-Participating	Grant	650458.09	5010135.55	4:16
2244	Non-Participating	Grant	651399.84	5010537.19	0:00
2251	Participating	Grant	653709.32	5011041.66	7:46
2257	Participating	Grant	655074.36	5009886.86	21:40
2260	Participating	Grant	658287.22	5009765.21	32:47
2267	Participating	Grant	663067.37	5009863.43	0:00
2270	Participating	Grant	645591.52	5011330.52	0:00
2271	Non-Participating	Grant	646356.26	5011253.61	0:00
2277	Non-Participating	Grant	647415.35	5011482.18	0:00
2279	Non-Participating	Grant	653707.33	5011412.61	1:02
2280	Non-Participating	Grant	653706.52	5011445.93	1:02
2281	Non-Participating	Grant	653705.48	5011488.76	1:02
2284	Participating	Grant	659888.06	5013103.47	0:00
2287	Participating	Grant	657521.45	5013443.09	0:00
2290	Participating	Grant	657917.63	5013363.29	0:00
2305	Participating	Grant	648987.99	5013202.15	0:00
2315	Non-Participating	Codington	649018.76	4991138.66	0:00
2318	Participating	Codington	648352.31	4991902.58	0:00
2339	Non-Participating	Codington	649064.44	4992930.45	0:00
2347	Non-Participating	Codington	649279.70	4993533.72	0:00
2348	Non-Participating	Codington	649271.45	4993557.43	0:00
2353	Non-Participating	Codington	647627.18	4993444.66	0:00
2356	Non-Participating	Codington	647698.06	4993969.91	0:00
2360	Non-Participating	Codington	647604.47	4994983.66	0:00
2363	Participating	Codington	651937.86	5001067.18	5:26
2364	Non-Participating	Codington	651457.46	4993586.61	0:00
2368	Non-Participating	Codington	651076.00	4993539.97	0:00
2372	Non-Participating	Codington	658654.33	4990392.79	0:00
2416	Participating	Grant	643160.20	5007930.05	0:00
2423	Non-Participating	Grant	643933.96	5009635.42	3:00
2424	Non-Participating	Grant	643946.39	5009641.33	3:08

Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors

Modeling ID	Participation Status	County	Coordinates NAD83 UTM Zone 14N (meters)		Expected Shadow Flicker Hours per Year
			X (Easting)	Y (Northing)	(HH:MM/year)
2426	Non-Participating	Grant	644853.33	5009638.98	2:55
2427	Non-Participating	Grant	644862.14	5009641.30	3:01
2449	Non-Participating	Grant	650900.06	5006334.22	16:00
2455	Non-Participating	Grant	651981.94	5003185.29	3:56
2470	Participating	Grant	653647.87	5003180.53	19:05

Prepared by: Luke Muller
Codington County Zoning Officer
1910 West Kemp Avenue
Watertown, SD 57201

Letter of Assurance

A Conditional Use Permit under Codington County Zoning Ordinance 3.04.02.21., "Wind Energy Systems" has been granted by the Codington County Board of Adjustment to Dakota Range II, LLC to operate a Wind Energy System with up to 48 Wind Towers and other ancillary structures/uses.

Property location: As displayed in Exhibit "A" attached and hereby incorporated by reference.

Conditions to be placed upon the conditional use permit issued to Dakota Range II, LLC by the Codington County Board of Adjustment on June 19, 2017:

1) Effective Date and Transferability:
   a. Upon issuance of applicant permit by South Dakota Public Utilities Commission.
   b. This permit shall expire if no construction described within the application has occurred within three (3) years of issuance of a permit by South Dakota Public Utilities Commission; or if application for permit has not been made on or before June 19, 2020.
   c. The applicant may apply for an extension of this permit if the requirements of 1.b above cannot be met.
   d. The Conditional Use permit for is transferable. Subsequent owners/operators shall agree to the same conditions described herein.

2) General Requirements:
   a. There shall be no discharge of industrial processed water on the site
   b. Storage of petroleum products in quantities exceeding one hundred (100) gallons at one (1) locality in one (1) tank or series of tanks must be in elevated tanks; such tanks larger than eleven hundred (1,100) gallons must have a secondary containment system where it is deemed necessary by the Board of Adjustment.
   c. Grantor shall provide the zoning office with an updated local contact information of plant supervisor with authority to implement dust control and other necessary enforcement of the conditions of this permit.

3) Obligation to Meet Requirements:

   a. Applicant agrees to meet requirements of Section 5.22 of the Codington County Ordinance in reference to remaining obligations including but not limited to: submittal of Haul Road Agreements, Submittal of Decommissioning Plan, Final site location of towers, building permit application, meeting applicable federal and state requirements, and consideration of bond for abandonment/decommissioning after 10 years.

4) Violation and Penalties:

   a. Violations of requirements of the ordinance relating to the operations of a specific tower will result in enforcement/penalties in reference to the specific tower found to be in violation, and will be enforced in the manner as described in Section 4.b below.

b. Violation of the terms of this conditional use permit will be determined by the Codington County Zoning Officer.
   (1) The first violation substantiated by the Zoning Officer of this conditional use permit may result in a notification letter stating the violation and a prescribed period of time to remove the violation. A second violation occurring within one calendar year of the previous violation may result in a review of the validity of the conditional use permit and potential revocation of said permit. A third violation within one calendar year of the initial violation may result in revocation of the conditional use permit and cessation of all feeder operations within forty-five days (45) of notice of revocation.
   (2) The applicant may make appeal from the decision of the Zoning Officer or other agent of the Codington County Board of Adjustment to the Codington County Board of Adjustment. The applicant shall file with the Zoning Officer a notice of appeal specifying the grounds thereof. The Zoning Officer shall forthwith transmit to the Board of Adjustment all papers constituting the record upon which the action appealed from was taken. Such appeal shall be taken within thirty (30) days. Appeals from the Board of Adjustment shall be taken to Circuit Court.
   (3) Failure to comply with the decision of the Zoning Officer or other agent of the Codington County Board of Adjustment may be deemed a separate violation.

IN WITNESS WHEREOF, Codington County and the Grantor(s) have executed this Conditional Use Permit Letter of Assurance.

[signature] — July 12th 2017

Dakota Range II, LLC (Grantor) — Date
by (Name): Mark Goodwin
its (Title): President & CEO

[signature] — 8-21-17

Chairperson — Date
Codington County Board of Adjustment

STATE OF ________________
SS:
COUNTY OF ________________

This instrument was acknowledged before me on July 12th, 2017 by Mark Goodwin, on behalf of Dakota Range II, LLC (Grantor).

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Courtney Jo McReynolds Notary Public
My Commission Expires: Sept. 30th 2020

Courtney Jo McReynolds
NOTARY PUBLIC
Commonwealth of Virginia
Reg. # 7707226
My Commission Expires September 30, 2020

STATE OF SOUTH DAKOTA
SS:
COUNTY OF CODINGTON

This instrument was acknowledged before me on 8-21, 2017 by Robert Fox, representing Codington County as the Chairman of the Codington County Board of Adjustment.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

BECKY L. GOENS
NOTARY PUBLIC
SEAL SOUTH DAKOTA SEAL

Becky L. Goens Notary Public
My Commission Expires: 5-17-22

Prepared by: Luke Muller
Codington County Zoning Officer
1910 West Kemp Avenue
Watertown, SD 57201

Letter of Assurance

A Conditional Use Permit under Codington County Zoning Ordinance 3.04.02.21., "Wind Energy Systems" has been granted by the Codington County Board of Adjustment to Dakota Range I, LLC to operate a Wind Energy System with up to 48 Wind Towers and other ancillary structures/uses.

Property location: As displayed in Exhibit "A" attached and hereby incorporated by reference.

Conditions to be placed upon the conditional use permit issued to Dakota Range I, LLC by the Codington County Board of Adjustment on June 19, 2017:

1) Effective Date and Transferability:
   a. Upon issuance of applicant permit by South Dakota Public Utilities Commission.
   b. This permit shall expire if no construction described within the application has occurred within three (3) years of issuance of a permit by South Dakota Public Utilities Commission; or if application for permit has not been made on or before June 19, 2020.
   c. The applicant may apply for an extension of this permit if the requirements of 1.b above cannot be met.
   d. The Conditional Use permit for is transferable. Subsequent owners/operators shall agree to the same conditions described herein.

2) General Requirements:
   a. There shall be no discharge of industrial processed water on the site
   b. Storage of petroleum products in quantities exceeding one hundred (100) gallons at one (1) locality in one (1) tank or series of tanks must be in elevated tanks; such tanks larger than eleven hundred (1,100) gallons must have a secondary containment system where it is deemed necessary by the Board of Adjustment.
   c. Grantor shall provide the zoning office with an updated local contact information of plant supervisor with authority to implement dust control and other necessary enforcement of the conditions of this permit.

3) Obligation to Meet Requirements:

   a. Applicant agrees to meet requirements of Section 5.22 of the Codington County Ordinance in reference to remaining obligations including but not limited to: submittal of Haul Road Agreements, Submittal of Decommissioning Plan, Final site location of towers, building permit application, meeting applicable federal and state requirements, and consideration of bond for abandonment/decommissioning after 10 years.

4) Violation and Penalties:

   a. Violations of requirements of the ordinance relating to the operations of a specific tower will result in enforcement/penalties in reference to the specific tower found to be in violation, and will be enforced in the manner as described in Section 4.b below.

b. Violation of the terms of this conditional use permit will be determined by the Codington County Zoning Officer.

(1) The first violation substantiated by the Zoning Officer of this conditional use permit may result in a notification letter stating the violation and a prescribed period of time to remove the violation. A second violation occurring within one calendar year of the previous violation may result in a review of the validity of the conditional use permit and potential revocation of said permit. A third violation within one calendar year of the initial violation may result in revocation of the conditional use permit and cessation of all feeder operations within forty-five days (45) of notice of revocation.

(2) The applicant may make appeal from the decision of the Zoning Officer or other agent of the Codington County Board of Adjustment to the Codington County Board of Adjustment. The applicant shall file with the Zoning Officer a notice of appeal specifying the grounds thereof. The Zoning Officer shall forthwith transmit to the Board of Adjustment all papers constituting the record upon which the action appealed from was taken. Such appeal shall be taken within thirty (30) days. Appeals from the Board of Adjustment shall be taken to Circuit Court.

(3) Failure to comply with the decision of the Zoning Officer or other agent of the Codington County Board of Adjustment may be deemed a separate violation.

IN WITNESS WHEREOF, Codington County and the Grantor(s) have executed this Conditional Use Permit Letter of Assurance.

[signature] July 12th 2017

Dakota Range I, LLC (Grantor) Date

by (Name): Mark Goodwin

its (Title): President & CEO

Robert Fox 8-21-17

Chairperson Date

Codington County Board of Adjustment

STATE OF ________________

SS:

COUNTY OF ________________

This instrument was acknowledged before me on July 12th, 2017 by Mark Goodwin, on behalf of Dakota Range I, LLC (Grantor).

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Courtney Jo McReynolds Notary Public

My Commission Expires: Sept. 30th 2020

Courtney Jo McReynolds
NOTARY PUBLIC
Commonwealth of Virginia
Reg. # 7707226
My Commission Expires September 30, 2020

STATE OF SOUTH DAKOTA
SS:
COUNTY OF CODINGTON

This instrument was acknowledged before me on 8-21, 2017 by Robert Fox, representing Codington County as the Chairman of the Codington County Board of Adjustment.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Becky L. Goens Notary Public
My Commission Expires: 5-17-22

BECKY L. GOENS
NOTARY PUBLIC
SOUTH DAKOTA
SEAL SEAL

GRANT COUNTY SOUTH DAKOTA
PLANNING AND ZONING OFFICE
210 East 5th Avenue
Milbank, SD 57252-2499
Phone: 605-432-7580
Fax: 605-432-7515

January 3, 2018

Dear To Whom It May Concern:

As the Planning & Zoning Administrator in Grant County, South Dakota I report the satisfactory completion of the permit requirements and compliance with zoning ordinance for wind energy projects.

The Dakota Range Wind project I & II completed the public hearing requirements on June 12, 2017. The permit submitted, met all the regulations of the zoning ordinance and the facts were presented to the board during this public hearing.

The board heard testimony in support of the project from citizens of Grant County and no one reported opposition to the project when asked to testify during the public input portion of the hearing.

The Conditional Use permits received unanimous approval by the Board of Adjustment as presented which makes the CUP permits effective immediately for the Dakota Range Projects to move forward in Grant County.

Sincerely,

Krista Atyeo-Gortmaker
Planning and Zoning Officer
Grant County

COPY APPROVED

GRANT COUNTY NOTICE OF APPEAL
CONDITIONAL USE PERMIT/VARIANCE APPLICATION

DATE: May 3 , 20 17 **PERMIT NUMBER** CUP05232017A

APPLICANT (PRINT): Dakota Range I, LLC PHONE: 612-834-2680
ADDRESS (PRINT): 310 4th St. Suite 200, Charlottesville, VA 22902
OWNER (PRINT): See Tab 4 PHONE:
IF DIFFERENT THAN APPLICANT
ADDRESS (PRINT):

I/WE, THE UNDER SIGNED, DO HEREBY PETITION THE BOARD OF ADJUSTMENT OF GRANT COUNTY, SOUTH DAKOTA, TO ISSUE A [CONDITIONAL USE PERMIT] OR VARIANCE FOR
(CIRCLE APPROPRIATE REQUEST)
THE PROPERTY DESCRIBED AS: LEGAL DESCRIPTION (PRINT)
See Tab 5

PARCEL NUMBER: See Tab 4

SITE STREET ADDRESS: See Tab 6

EXISTING LAND USE: AG EXISTING ZONING: [AG] C/I PD NR *(CIRCLE ONE)*

SIZE OF PARCEL: ACRES ____ LOT DIMENSIONS: WIDTH (FRONTAGE) ____ DEPTH ____

SURROUNDING LAND USE: NORTH:
SOUTH:
EAST:
WEST:

CONDITIONAL USE PERMIT:
PLEASE DESCRIBE WHAT YOU PROPOSE TO DO AND WHY YOU ARE SEEKING A CONDITIONAL USE PERMIT (*ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY*).
The Dakota Range Wind Project is a proposed 150-turbine 300 MW Wind Energy System (WES), with up to 110 turbines located in Grant County. See Tabs 2 and 3 for further description of the proposed WES.

VARIANCE:
IF YOU ARE SEEKING A VARIANCE PLEASE PROVIDE A BRIEF STATEMENT OF THE VARIANCE DESIRED AND PLEASE STATE THE HARDSHIP REQUIRING RELIEF. *(PROOF OF HARDSHIP IS ON THE APPLICANT – HARDSHIP EXAMPLES ARE ODD SIZE OR SHAPE OF THE LOT, UNUSUAL TOPOGRAPHY, ETC. ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY).*

SIGNATURE OF APPLICANT: [signature]
SIGNATURE OF OWNER (IF DIFFERENT THAN APPLICANT):

NOTE: A SKETCH OF PROPOSED PROPERTY SHALL ACCOMPANY THIS APPLICATION, SHOWING THE FOLLOWING:
1 NORTH DIRECTION
2 DIMENSIONS OF PROPOSED STRUCTURE
3 STREET NAMES
4 OTHER INFORMATION AS MAY BE REQUESTED
5 LOCATION OF PROPOSED STRUCTURE ON LOT
6 DIMENSIONS OF FRONT AND SIDE SETBACKS
7 LOCATION OF ADJACENT EXISTING BUILDINGS
THE BOARD OF ADJUSTMENT MAY REQUIRE THAT SUCH PLANS BE PREPARED BY A REGISTERED ENGINEER OR LAND SURVEYOR

DATE FILED WITH ZONING OFFICER 5-23-2017 **FEE PAID**(NON-REFUNDABLE) ON 200 –
HEARING DATE & TIME June 12, 2017 4pm **ACTION BY BOARD** Approved

Conditions of permit: 3 special requests:
1. 2 systems treated as 1 2. Ability to install underground collection lines overhead when constructability makes it unreasonable to go underground 3. CUP become void after 3 years of SD siting permit issuance.

COPY APPROVED

GRANT COUNTY NOTICE OF APPEAL
CONDITIONAL USE PERMIT/VARIANCE APPLICATION

DATE: May 3, 2017 PERMIT NUMBER CUP 05232017B

APPLICANT (PRINT): Dakota Range II, LLC PHONE: 612-834-2680
ADDRESS (PRINT): 310 4th St. Suite 200, Charlottesville, VA 22902
OWNER (PRINT): See Tab 4 PHONE :
IF DIFFERENT THAN APPLICANT
ADDRESS (PRINT):

I/WE, THE UNDER SIGNED, DO HEREBY PETITION THE BOARD OF ADJUSTMENT OF GRANT COUNTY, SOUTH DAKOTA, TO ISSUE A [CONDITIONAL USE PERMIT] OR VARIANCE FOR
(CIRCLE APPROPRIATE REQUEST)
THE PROPERTY DESCRIBED AS: LEGAL DESCRIPTION (PRINT)
See Tab 5

PARCEL NUMBER: See Tab 4

SITE STREET ADDRESS: See Tab 6

EXISTING LAND USE: AG EXISTING ZONING: [AG] C/I PD NR
(CIRCLE ONE)

SIZE OF PARCEL: ACRES ____ LOT DIMENSIONS: WIDTH (FRONTAGE) ____ DEPTH ____

SURROUNDING LAND USE: NORTH:
SOUTH:
EAST:
WEST:

CONDITIONAL USE PERMIT:
PLEASE DESCRIBE WHAT YOU PROPOSE TO DO AND WHY YOU ARE SEEKING A CONDITIONAL USE PERMIT (*ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY*).
The Dakota Range Wind Project is a proposed 150-turbine 300 MW Wind Energy System (WES), with up to 110 turbines located in Grant County. See Tabs 2 and 3 for further description of the proposed WES.
VARIANCE:
IF YOU ARE SEEKING A VARIANCE PLEASE PROVIDE A BRIEF STATEMENT OF THE VARIANCE DESIRED AND PLEASE STATE THE HARDSHIP REQUIRING RELIEF. *(PROOF OF HARDSHIP IS ON THE APPLICANT – HARDSHIP EXAMPLES ARE ODD SIZE OR SHAPE OF THE LOT, UNUSUAL TOPOGRAPHY, ETC. ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY).*

SIGNATURE OF APPLICANT: M Foster
SIGNATURE OF OWNER (IF DIFFERENT THAN APPLICANT):

NOTE: A SKETCH OF PROPOSED PROPERTY SHALL ACCOMPANY THIS APPLICATION, SHOWING THE FOLLOWING:
1 NORTH DIRECTION
2 DIMENSIONS OF PROPOSED STRUCTURE
3 STREET NAMES
4 OTHER INFORMATION AS MAY BE REQUESTED
5 LOCATION OF PROPOSED STRUCTURE ON LOT
6 DIMENSIONS OF FRONT AND SIDE SETBACKS
7 LOCATION OF ADJACENT EXISTING BUILDINGS
THE BOARD OF ADJUSTMENT MAY REQUIRE THAT SUCH PLANS BE PREPARED BY A REGISTERED ENGINEER OR LAND SURVEYOR

DATE FILED WITH ZONING OFFICER 5-23 2017 **FEE PAID**(NON-REFUNDABLE) [Y] N 200 –
HEARING DATE & TIME June 12, 2017 4pm **ACTION BY BOARD** Approved

Conditions of permit: 3 Special requests:
1. 2 systems treated as 1 2. Ability to install underground collection lines overhead when constructability makes it unreasonable to go underground 3. CUP become void after 3 years of SD siting permit issuance.

COPY APPROVED

GRANT COUNTY NOTICE OF APPEAL
CONDITIONAL USE PERMIT/VARIANCE APPLICATION

DATE: May 3, 20 17 **PERMIT NUMBER** CUP05232017C

APPLICANT (PRINT): Dakota Range I, LLC PHONE: 612-834-2680
ADDRESS (PRINT): 310 4th St. Suite 200, Charlottesville, VA 22902
OWNER (PRINT): See Tab 4 PHONE: ____
IF DIFFERENT THAN APPLICANT
ADDRESS (PRINT): ____

I/WE, THE UNDER SIGNED, DO HEREBY PETITION THE BOARD OF ADJUSTMENT OF GRANT COUNTY, SOUTH DAKOTA, TO ISSUE A **CONDITIONAL USE PERMIT** OR **VARIANCE** FOR
(CIRCLE APPROPRIATE REQUEST)
THE PROPERTY DESCRIBED AS: LEGAL DESCRIPTION (PRINT)
See Tab 5

PARCEL NUMBER: See Tab 4

SITE STREET ADDRESS: See Tab 6

EXISTING LAND USE: AG EXISTING ZONING: AG C/I PD NR *(CIRCLE ONE)*

SIZE OF PARCEL: ACRES ____ LOT DIMENSIONS: WIDTH (FRONTAGE) ____ DEPTH ____

SURROUNDING LAND USE:
NORTH: ____
SOUTH: ____
EAST: ____
WEST: ____

CONDITIONAL USE PERMIT:
PLEASE DESCRIBE WHAT YOU PROPOSE TO DO AND WHY YOU ARE SEEKING A CONDITIONAL USE PERMIT (*ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY*).
The Dakota Range Wind Project proposes to build a 345 kV interconnection transmission line between the collector substation and interconnection switching station in conjunction with the WES. See Tabs 2 and 3 for further description.

VARIANCE:
IF YOU ARE SEEKING A VARIANCE PLEASE PROVIDE A BRIEF STATEMENT OF THE VARIANCE DESIRED AND PLEASE STATE THE HARDSHIP REQUIRING RELIEF. *(PROOF OF HARDSHIP IS ON THE APPLICANT – HARDSHIP EXAMPLES ARE ODD SIZE OR SHAPE OF THE LOT, UNUSUAL TOPOGRAPHY, ETC. ATTACH A SEPARATE SHEET OF PAPER IF NECESSARY).*

SIGNATURE OF APPLICANT: [signature]
SIGNATURE OF OWNER (IF DIFFERENT THAN APPLICANT): ____

NOTE: A SKETCH OF PROPOSED PROPERTY SHALL ACCOMPANY THIS APPLICATION, SHOWING THE FOLLOWING:
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7 LOCATION OF ADJACENT EXISTING BUILDINGS
THE BOARD OF ADJUSTMENT MAY REQUIRE THAT SUCH PLANS BE PREPARED BY A REGISTERED ENGINEER OR LAND SURVEYOR

DATE FILED WITH ZONING OFFICER 5-23 2017 **FEE PAID**(NON-REFUNDABLE) Y N 200-
HEARING DATE & TIME June 12, 2017 4pm **ACTION BY BOARD** Approved

Conditions of permit: 3 special requests
1. 2 systems treated as 1 2. Ability to install underground collection lines overhead when constructability makes it unreasonable to go underground.
3. CUP become void after 3 years of SD siting permit issuance.

GRANT COUNTY *SOUTH DAKOTA*

OFFICE OF COUNTY COMMISSIONERS
210 East 5th Avenue
Milbank, SD 57252-2499
Phone: 605-432-6711
Fax: 605-432-9004

October 4, 2017

To: The SD Public Utilities Commission

RE: Letter of Support

The Grant County Commission understands the need for the county to find new and creative business solutions to generate additional revenue. The County has noticed the benefits of South Dakota's strong wind resource and the exceptional economic opportunities it has delivered to communities (across the Midwest) and is excited to hear that APEX has entered into an agreement with Xcel Energy. Grant County is pleased to have been working closely with Apex Clean Energy on their plans to develop Dakota Range Wind. As such, the County endorses the project and looks forward to continuing our partnership with Apex to ensure Grant County's first wind farm is a success.

We believe Dakota Range Wind will significantly benefit our county for the next thirty years or more. After working with the Apex team, we are confident this development will be completed with minimal impacts to the natural environment and minimal disturbance to citizens. The Commission endorses this project and looks forward to the benefits that Grant County will experience upon completion of the project.

Thank you for your consideration.

Sincerely,

Marty Buttke

Marty Buttke, Vice-Chairman
Grant County Commission

LBNL-2829E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

Ben Hoen, Ryan Wiser, Peter Cappers, Mark Thayer, and Gautam Sethi

Environmental Energy Technologies Division

December 2009

The work described in this report was funded by the Office of Energy Efficiency and Renewable Energy (Wind & Hydropower Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123.

Disclaimer

LBNL-2829E

The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

Prepared for the

Office of Energy Efficiency and Renewable Energy
Wind & Hydropower Technologies Program
U.S. Department of Energy
Washington, D.C.

Principal Authors:

Ben Hoen, Ryan Wiser, Peter Cappers
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1 Cyclotron Road, MS 90R4000
Berkeley CA 94720-8136

December 2009

The work described in this report was funded by the Office of Energy Efficiency and Renewable Energy (Wind & Hydropower Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123.

Abstract

With wind energy expanding rapidly in the U.S. and abroad, and with an increasing number of communities considering wind power development nearby, there is an urgent need to empirically investigate common community concerns about wind project development. The concern that property values will be adversely affected by wind energy facilities is commonly put forth by stakeholders. Although this concern is not unreasonable, given property value impacts that have been found near high voltage transmission lines and other electric generation facilities, the impacts of wind energy facilities on residential property values had not previously been investigated thoroughly. The present research collected data on almost 7,500 sales of single-family homes situated within 10 miles of 24 existing wind facilities in nine different U.S. states. The conclusions of the study are drawn from eight different hedonic pricing models, as well as both repeat sales and sales volume models. The various analyses are strongly consistent in that none of the models uncovers conclusive evidence of the existence of any widespread property value impacts that might be present in communities surrounding wind energy facilities. Specifically, neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices. Although the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact.

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Executive Summary

Overview

Wind power development in the United States has expanded dramatically in recent years. If that growth is to continue it will require an ever-increasing number of wind power projects to be sited, permitted, and constructed. Most permitting processes in the U.S. require some form of environmental impact assessment as well as public involvement in the siting process. Though public opinion surveys generally show that acceptance towards wind energy is high, a variety of concerns with wind power development are often expressed on the local level during the siting and permitting process. One such concern is the potential impact of wind energy projects on the property values of nearby residences.

Concerns about the possible impact of wind power facilities on residential property values can take many forms, but can be divided into the following non-mutually exclusive categories:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

Although concerns about the possible impact of wind energy facilities on the property values of nearby homes are reasonably well established, the available literature[1] that has sought to quantify the impacts of wind projects on residential property values has a number of shortcomings:

1) Many studies have relied on surveys of homeowners or real estate professionals, rather than trying to quantify real price impacts based on market data;
2) Most studies have relied on simple statistical techniques that have limitations and that can be dramatically influenced by small numbers of sales transactions or survey respondents;
3) Most studies have used small datasets that are concentrated in only one wind project study area, making it difficult to reliably identify impacts that might apply in a variety of areas;
4) Many studies have not reported measurements of the statistical significance of their results, making it difficult to determine if those results are meaningful;
5) Many studies have concentrated on an investigation of the existence of Area Stigma, and have ignored Scenic Vista and/or Nuisance Stigmas;
6) Only a few studies included field visits to homes to determine wind turbine visibility and collect other important information about the home (e.g., the quality of the scenic vista); and
7) Only two studies have been published in peer-reviewed academic journals.

[1] This literature is briefly reviewed in Section 2 of the full report, and includes: Jordal-Jorgensen (1996); Jerabek (2001); Grover (2002); Jerabek (2002); Sterzinger et al. (2003); Beck (2004); Haughton et al. (2004); Khatri (2004); DeLacy (2005); Poletti (2005); Goldman (2006); Hoen (2006); Firestone et al. (2007); Poletti (2007); Sims and Dent (2007); Bond (2008); McCann (2008); Sims et al. (2008); and Kielisch (2009).

This report builds on the previous literature that has investigated the potential impact of wind projects on residential property values by using a hedonic pricing model and by avoiding many of the shortcomings enumerated above. The hedonic pricing model is one of the most prominent and reliable methods for identifying the marginal impacts of different housing and community characteristics on residential property values (see side bar). This approach dates to the seminal work of Rosen (1974) and Freeman (1979), and much of the available literature that has investigated the impacts of potential disamenities on property values has relied on this method.[2]

What Is a Hedonic Pricing Model?

Hedonic pricing models are frequently used by economists and real estate professionals to assess the impacts of house and community characteristics on property values by investigating the sales prices of homes. A house can be thought of as a bundle of characteristics (e.g., number of square feet, number of bathrooms). When a price is agreed upon by a buyer and seller there is an implicit understanding that those characteristics have value. When data from a large number of residential transactions are available, the individual marginal contribution to the sales price of each characteristic for an average home can be estimated with a hedonic regression model. Such a model can statistically estimate, for example, how much an additional bathroom adds to the sale price of an average home. A particularly useful application of the hedonic model is to value non-market goods – goods that do not have transparent and observable market prices. For this reason, the hedonic model is often used to derive value estimates of amenities such as wetlands or lake views, and disamenities such as proximity to and/or views of high-voltage transmission lines, roads, cell phone towers, and landfills. It should be emphasized that the hedonic model is not typically designed to appraise properties (i.e., to establish an estimate of the market value of a home at a specified point in time), as would be done with an automated valuation model. Instead, the typical goal of a hedonic model is to estimate the marginal contribution of individual house or community characteristics to sales prices.

To seed the hedonic model with appropriate market data, this analysis collects information on a large quantity of residential home sales (i.e., transactions) (n = 7,459) from ten communities surrounding 24 existing wind power facilities spread across multiple parts of the U.S. (e.g., nine states). Homes included in this sample are located from 800 ft to over five miles from the nearest wind energy facility, and were sold at any point from before wind facility announcement to over four years after the construction of the nearby wind project. Each of the homes that sold was visited to determine the degree to which the wind facility was likely to have been visible at the time of sale and to collect other essential data.

To assess the potential impacts of all three of the property value stigmas described earlier, a base hedonic model is applied as well as seven alternative hedonic models each designed to investigate the reliability of the results and to explore other aspects of the data (see Table ES - 1 below). In addition, a repeat sales model is analyzed, and an investigation of possible impacts on sales volumes is

[2] Many of these studies are summarized in the following reviews: Kroll and Priestley (1992); McCann (1999); Bateman et al. (2001); Boyle and Kiel (2001); Jackson (2001); Simons and Saginor (2006); and Leonard et al. (2008). For further discussion of the hedonic model and its application to the quantification of environmental stigmas see Jackson (2005) and Simons (2006a).

conducted. Though some limitations to the analysis approach and available data are acknowledged, the resulting product is the most comprehensive and data-rich analysis to date in the U.S. or abroad on the impacts of wind projects on nearby property values.

Analysis Findings

Table ES - 1 describes the ten resulting statistical models that are employed to investigate the effects of wind facilities on residential sales prices, and the specific stigmas that those models investigate. Though all models test some combination of the three possible stigmas, they do so in different ways. For instance, the Base Model asks the question, “All else being equal, do homes near wind facilities sell for prices different than for homes located farther away?”, while the All Sales Model asks, “All else being equal, do homes near wind facilities that sell after the construction of the wind facility sell for prices different from similar homes that sold before the announcement and construction of the facility?” Each model is therefore designed to not only test for the reliability of the overall results, but also to explore the myriad of potential effects from a variety of perspectives. Table ES-2 summarizes the results from these models.

Table ES - 1: Description of Statistical Models

Statistical Model	Description
Base Hedonic Model	Using only "post-construction" transactions (those that occurred after the wind facility was built), this model investigates all three stigmas in a straightforward manner
Alternative Hedonic Models	
View Stability	Using only post-construction transactions, this model investigates whether the Scenic Vista Stigma results from the Base Model are independent of the Nuisance and Area Stigma results
Distance Stability	Using only post-construction transactions, this model investigates whether the Nuisance and Area Stigma results from the Base Model are independent of the Scenic Vista Stigma results
Continuous Distance	Using only post-construction transactions, this model investigates Area and Nuisance Stigmas by applying a continuous distance parameter as opposed to the categorical variables for distance used in the previous models
All Sales	Using all transactions, this model investigates whether the results for the three stigmas change if transactions that occurred before the announcement and construction of the wind facility are included in the sample
Temporal Aspects	Using all transactions, this model further investigates Area and Nuisance Stigmas and how they change for homes that sold more than two years pre-announcement through the period more than four years post-construction
Orientation	Using only post-construction transactions, this model investigates the degree to which a home’s orientation to the view of wind turbines affects sales prices
Overlap	Using only post-construction transactions, this model investigates the degree to which the overlap between the view of a wind facility and a home’s primary scenic vista affects sales prices
Repeat Sales Model	Using paired transactions of homes that sold once pre-announcement and again post-construction, this model investigates the three stigmas, using as a reference transactions of homes located outside of five miles of the nearest wind turbine and that have no view of the turbines
Sales Volume Model	Using both pre-announcement and post-construction transactions, this model investigates whether the rate of home sales (not the price of those sales) is affected by the presence of nearby wind facilities

Table ES-2: Impact of Wind Projects on Property Values: Summary of Key Results

Statistical Model	Is there statistical evidence of: Area Stigma?	Scenic Vista Stigma?	Nuisance Stigma?	Section Reference
Base Model	No	No	No	*Section 4*
View Stability	Not tested	No	Not tested	*Section 5.1*
Distance Stability	No	Not tested	No	*Section 5.1*
Continuous Distance	No	No	No	*Section 5.2*
All Sales	No	No	Limited	*Section 5.3*
Temporal Aspects	No	No	No	*Section 5.4*
Orientation	No	No	No	*Section 5.5*
Overlap	No	Limited	No	*Section 5.6*
Repeat Sales	No	Limited	No	*Section 6*
Sales Volume	No	Not tested	No	*Section 7*

"No"…………………. No statistical evidence of a negative impact
"Yes"………………… Strong statistical evidence of a negative impact
"Limited"…………… Limited and inconsistent statistical evidence of a negative impact
"Not tested"………… This model did not test for this stigma

Base Model Results

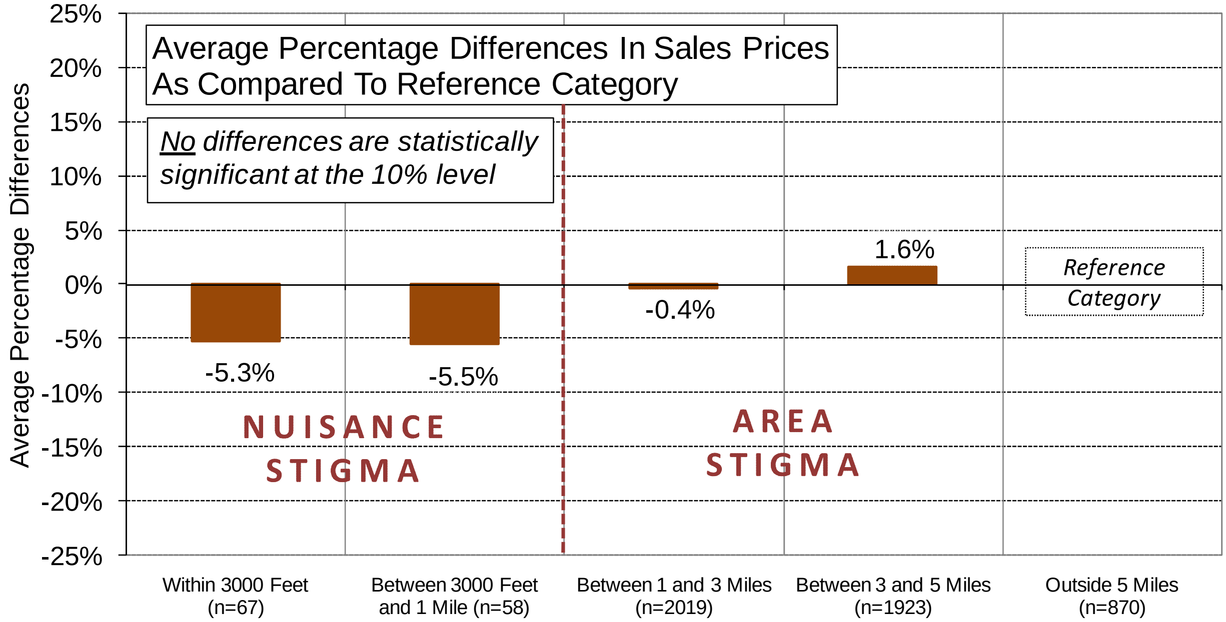
The Base Model serves as the primary model and allows all three stigmas to be explored. In sum, this model finds no persuasive evidence of any of the three potential stigmas: neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices.

- Area Stigma: To investigate Area Stigma, the model tests whether the sales prices of homes situated anywhere outside of one mile and inside of five miles of the nearest wind facility are measurably different from the sales price of those homes located outside of five miles. No statistically significant differences in sales prices between these homes are found (see Figure ES-1).
- Scenic Vista Stigma: For Scenic Vista Stigma, the model is first used to investigate whether the sales prices of homes with varying scenic vistas - absent the presence of the wind facility - are measurably different. The model results show dramatic and statistically significant differences in this instance (see Figure ES-2); not surprisingly, home buyers and sellers consider the scenic vista of a home when establishing the appropriate sales price. Nonetheless, when the model tests for whether homes with minor, moderate, substantial, or extreme views of wind turbines have measurably different sales prices, no statistically significant differences are apparent (see Figure ES-3).
- Nuisance Stigma: Finally, for Nuisance Stigma, the model is used to test whether the sales prices of homes situated inside of one mile of the nearest wind energy facility are measurably different from those homes located outside of five miles. Although sample size is somewhat limited in this case,[3] the model again finds no persuasive statistical evidence that wind

[3] 125 homes were located inside of one mile of the nearest wind facility and sold post-construction.

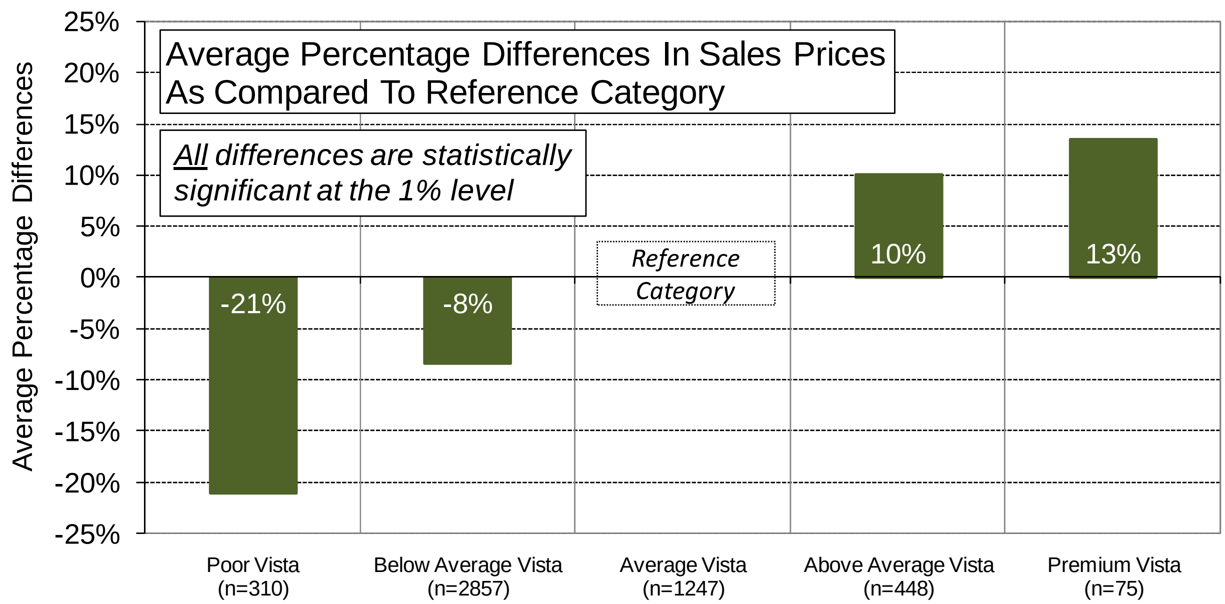
facilities measurably and broadly impact residential sales prices (see Figure ES-1 and later results).

Figure ES-1: Base Model Results: Area and Nuisance Stigma



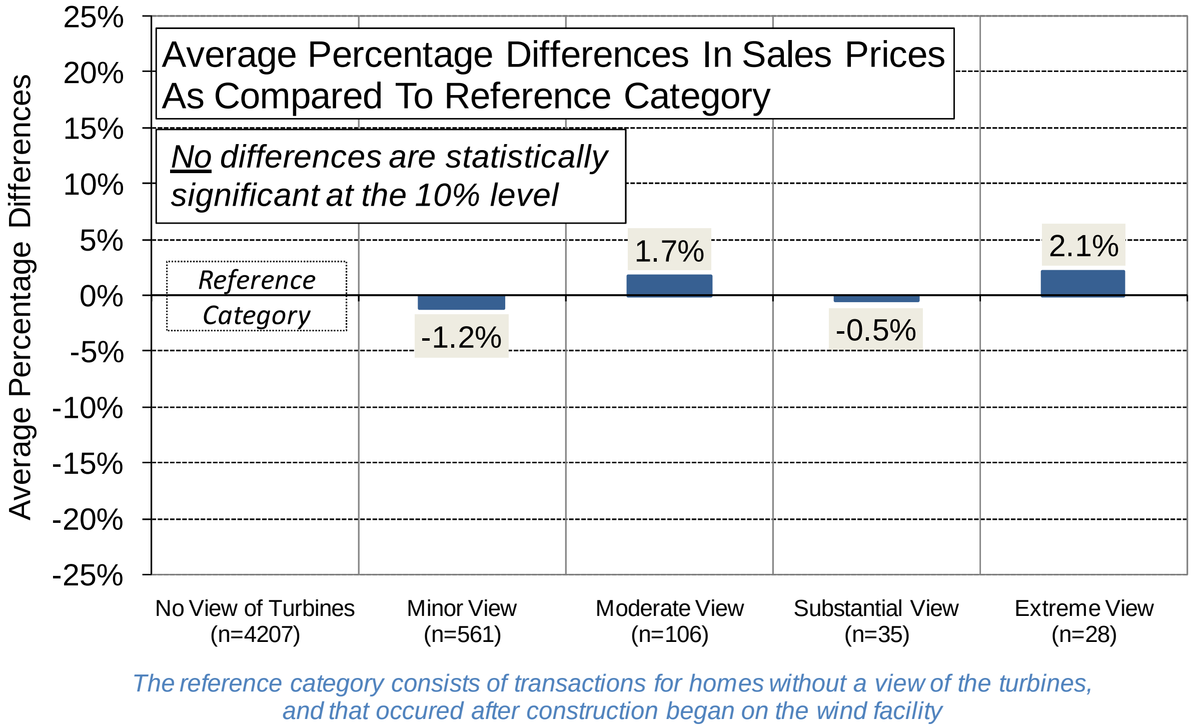
The reference category consists of transactions for homes situated more than five miles from the nearest turbine, and that occured after construction began on the wind facility

Figure ES-2: Base Model Results: Scenic Vista



The reference category consists of transactions for homes with an Average Vista, and that occured after construction began on the wind facility

Figure ES-3: Base Model Results: Scenic Vista Stigma



The seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models (see Table ES-2) provide a fuller picture of the three stigmas and the robustness of the Base Model results.

Area Stigma: Other Model Results

Concentrating first on Area Stigma, the results from all of the models are similar: there is no statistical evidence of a widespread Area Stigma among the homes in this sample. Homes in the study areas analyzed here do not appear to be measurably stigmatized by the arrival of a wind facility, regardless of when those homes sold in the wind project development process and regardless of whether the homes are located one mile or five miles away from the nearest facility.

In the All Sales Model, for example, after adjusting for inflation,[4] homes that sold after wind facility construction and that had no view of the turbines are found to have transacted for higher prices - not lower - than those homes that sold prior to wind facility construction. Moreover, in the Temporal Aspects Model, homes that sold more than two years prior to the announcement of the wind facility and that were located more than five miles from where the turbines were eventually located are found to have transacted for lower prices - not higher - than homes situated closer to the turbines and that sold at any time after the announcement and construction of the wind facility (see Figure ES - 4). Further, in the Repeat Sales Model, homes located near the wind facilities that transacted more than once were found to have appreciated between those sales by an amount that was no different from that experienced by homes located in an area

[4] All sales prices in all models are adjusted for inflation, but because this model (and the Temporal Aspects Model) deals with time explicitly, it is mentioned specifically here.

many miles away from the wind facilities. Finally, as shown in Table ES-2, none of the other models identified evidence of a broadly negative and statistically significant Area Stigma.

Scenic Vista Stigma: Other Model Results

With respect to Scenic Vista Stigma, the seven alternative hedonic models and the additional analysis contained in the Repeat Sales Model find little consistent evidence of a broadly negative and statistically significant impact. Although there are 730 residential transactions in the sample that involve homes that had views of a wind facility at the time of sale, 160 of which had relatively significant views (i.e., a rating higher than Minor), none of the various models finds strong statistical evidence that the view of a nearby wind facility impacts sales prices in a significant and consistent manner.

When concentrating only on the view of the wind facilities from a home (and not testing for Area and Nuisance Stigmas simultaneously), for example, the results from the View Stability Model are very similar to those derived from the Base Model, with no evidence of a Scenic Vista Stigma. Similarly, the All Sales Model finds that homes that sold after wind facility construction and that had a view of the facility transacted for prices that are statistically indistinguishable from those homes that sold at any time prior to wind facility construction. The Orientation Model, meanwhile, fails to detect any difference between the sales prices of homes that had either a front, back, or side orientation to the view of the wind facility. As shown in Table ES-2, the Continuous Distance and Temporal Aspects models also do not uncover any evidence of a broadly negative and statistically significant Scenic Vista Stigma.

In the Repeat Sales Model, some limited evidence is found that a Scenic Vista Stigma may exist, but those effects are weak, fairly small, somewhat counter-intuitive, and are at odds with the results of other models. This finding is likely driven by the small number of sales pairs that are located within one mile of the wind turbines and that experience a dramatic view of those turbines. Finally, in the Overlap Model, where the degree to which a view of the wind facility overlaps the primary scenic vista from the home is accounted for, no statistically significant differences in sales prices are detected between homes with somewhat or strongly overlapping views when compared to those homes with wind turbine views that did not overlap the primary scenic vista. Though this model produces some weak evidence of a Scenic Vista Stigma among homes with Minor views of wind facilities, the same model finds that the sales prices of those homes with views that barely overlap the primary scenic vista are positively impacted by the presence of the wind facility. When these two results are combined, the overall impact is negligible, again demonstrating no persuasive evidence of a Scenic Vista Stigma.

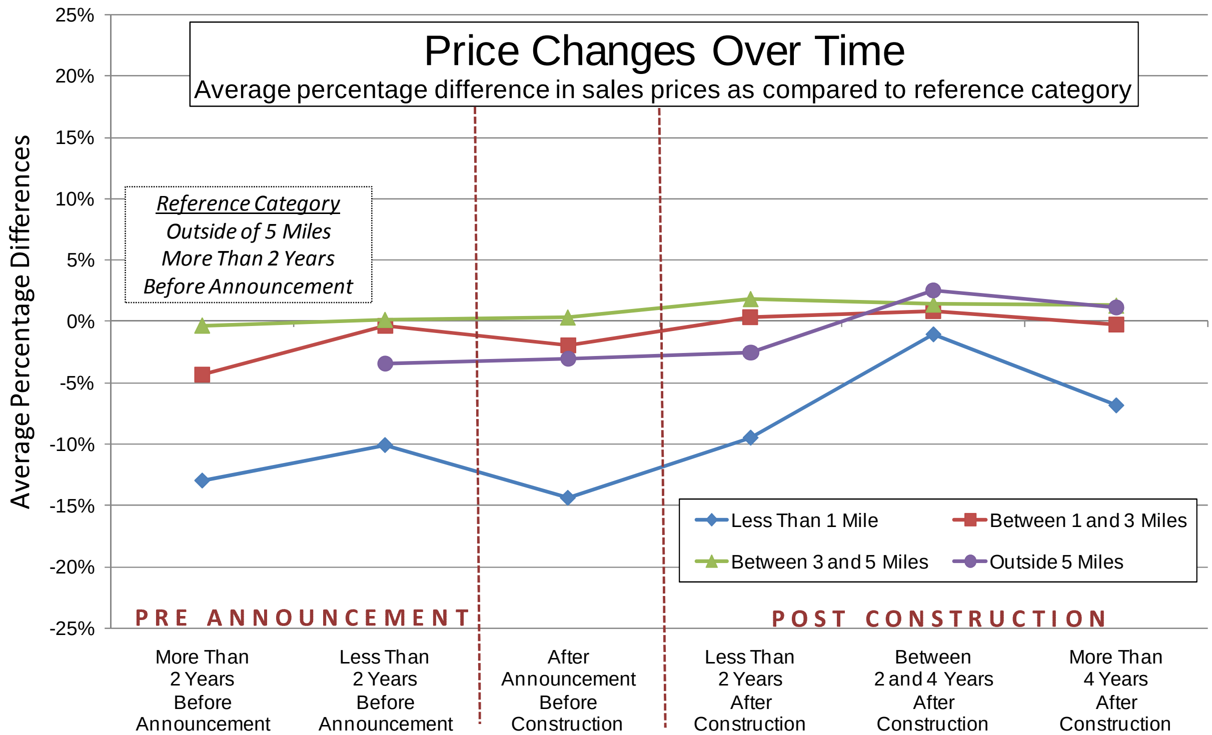
Nuisance Stigma: Other Model Results

Results for Nuisance Stigma from the seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models support the Base Model results. Taken together, these models present a consistent set of results: homes in this sample that are within a mile of the nearest wind facility, where various nuisance effects have been posited, have not been broadly and measurably affected by the presence of those wind facilities. These results imply that Nuisance Stigma effects are either not present in this sample, or are too small and/or infrequent to be statistically distinguished.

In the Distance Stability Model, for example, when concentrating only on the distance from homes to the nearest wind turbine (and not testing for Scenic Vista Stigma simultaneously), the results are very similar to those derived from the Base Model, with no statistical evidence of a Nuisance Stigma. These results are corroborated by the Continuous Distance, Orientation, Overlap, and Repeat Sales Models, none of which find a statistically significant relationship between distance and either sales prices or appreciation rates. Relatedly, the Sales Volume analysis finds no evidence that homes located within one mile of the nearest wind turbine are sold any more or less frequently than homes located farther away from the wind facilities.

In the All Sales Model, a weakly significant difference is found between the sales prices of homes located between 3000 feet and one mile of the nearest wind facility and the homes that sold before the announcement of the wind facility. This effect, however, is largely explained by the results of the Temporal Aspects Model, shown in Figure ES - 4. The Temporal Aspects Model finds that homes located within one mile of where the wind turbines would eventually be located sold for depressed prices well before the wind facility was even announced or constructed. In all time periods following the commencement of wind facility construction, however, inflation-adjusted sales prices increased - not decreased - relative to pre-announcement levels, demonstrating no statistical evidence of a Nuisance Stigma. The results from the All Sales Model (and, for that matter, the negative, albeit statistically insignificant coefficients inside of one mile in the Base Model, see Figure ES-1) are therefore an indication of sales price levels that preceded wind facility announcement construction, and that are not sustained after construction.

Figure ES - 4: Temporal Aspects Model Results: Area and Nuisance Stigma



The reference category consists of transactions of homes situated more than five miles from where the nearest turbine would eventually be located and that occurred more than two years before announcement of the facility

Conclusions and Further Research Needs

Though each of the analysis techniques used in this report has strengths and weaknesses, the results as a whole are strongly consistent in that none of the models uncovers conclusive evidence of the presence of any of the three property value stigmas that might be present in communities surrounding wind power facilities. Therefore, based on the data sample and analysis presented here, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact. Moreover, to the degree that homes and wind facilities in this sample are similar to homes and facilities in other areas of the United States, the results presented here are expected to be transferable to other areas.

This work builds on the existing literature in a number of respects, but there remain a number of areas for further research. The primary goal of subsequent research should be to concentrate on those homes located closest to wind facilities, where the data sample herein was the most limited. Additional research of the nature reported in this paper could be pursued, but with a greater number of transactions, especially for homes particularly close to wind facilities. A more detailed analysis of sales volume impacts may also be fruitful, as would an assessment of the potential impact of wind facilities on the length of time homes are on the market in advance of an eventual sale. Finally, it would be useful to conduct a survey of those homeowners living close to existing wind facilities, and especially those residents who have bought and sold homes in proximity to wind facilities after facility construction, to assess their opinions on the impacts of wind project development on their home purchase and sales decisions.

1. Introduction

Wind power development has expanded dramatically in recent years (GWEC, 2009). Although the percent of electricity supplied to the U.S. and globally from wind power projects installed through 2008 remains relatively low (1.9% and 1.5%, respectively) (Wiser and Bolinger, 2009), there are expectations that those percentages will rise and that wind energy could contribute a significant percentage of future electricity supply (GWEC, 2008; Wiser and Hand, 2010). Most recently, President Obama, in his 2009 State of the Union address, called for a doubling of renewable energy in three years (by 2012), and in 2008 the U.S. Department of Energy produced a report that analyzed the feasibility of meeting 20% of U.S. electricity demand with wind energy by 2030 (US DOE, 2008).

To meet these goals, a significant amount of wind project development activity would be required. The average size of wind power projects built in the U.S. in 2007 and 2008 was approximately 100 MW (Wiser and Bolinger, 2009) and the total amount of capacity required to reach 20% wind electricity is roughly 300,000 MW (US DOE, 2008). Therefore, to achieve 20% wind electricity by 2030, a total of 3,000 wind facilities may need to be sited and permitted. Most permitting processes in the U.S. require some form of environmental impact assessment, and some form of public involvement in the siting process. Though surveys show that public acceptance is high in general for wind energy (e.g., Wolsink, 2000; Firestone and Kempton, 2006), a variety of concerns are often expressed on the local level that can impact the length and outcome of the siting and permitting process. These concerns range from the potential impacts of wind projects on wildlife habitat and mortality, radar and communications systems, ground transportation and historic and cultural resources, to aesthetic and property value concerns as well as potential nuisance and health impacts. As a result, a variety of siting and permitting guidelines (AWEA, 2008) and impact assessments (NAS, 2007) have been completed.

Surveys of local communities considering wind facilities have consistently ranked adverse impacts on aesthetics and property values in the top tier of concerns (e.g., BBC R&C, 2005; Firestone and Kempton, 2006). Developers of wind energy echo this assessment: they ranked aesthetics and property values as two of the top concerns (first and third respectively) for individuals or communities opposed to wind power development (Paul, 2006). Local residents have even brought suit against a developer over property values (Dale Rankin v. FPL, 2008), and some developers have responded to these concerns by offering “neighbor agreements” that compensate nearby homeowners for the potential impacts of wind projects.

The two concerns of aesthetics and property values are intrinsically linked. It is well established that a home’s value will be increased if a high-quality scenic vista is enjoyed from the property (e.g., Seiler et al., 2001). Alternatively, it is reasonable to assume that if a home’s scenic vista overlaps with a view of a disamenity, the home might be devalued, as has been found for high-voltage transmission lines (HVTL) (Kroll and Priestley, 1992; Des-Rosiers, 2002). Whether a view of wind turbines similarly impacts home values is a key topic of debate in local siting decisions. Aesthetics alone, however, is not the only pathway through which wind projects might impact residential property values. Distance to the nearest wind turbine, for example, might also have an impact if various nuisance effects are prominent, such as turbine noise, shadow flicker,[5] health or safety concerns, or other impacts, real or perceived. In this way, property values near wind turbines might be impacted in the same way as homes near roads might be devalued (Bateman et al., 2001). Additionally, there is evidence that proximity to a disamenity, even if that disamenity is not visible and is not so close as to have obvious nuisance effects, may still decrease a home's sales price, as has been found to be the case for landfills (Thayer et al., 1992).

Taken together, these general concerns about the possible impacts of wind projects on residential property values can be loosely categorized into three potential stigmas:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

These three potential stigmas are not mutually exclusive and could, in theory, be present in part or in combination for any single home. Consequently, all three potential impacts must be considered when analyzing the effects of wind facilities on residential sales prices.

Although concerns about the potential impact of wind projects on residential property values are often mentioned in siting cases, the state of the existing literature on this topic leaves much to be desired. To some extent, the growing body of research investigating this topic has come to opposing conclusions. The most recent and comprehensive of these studies have often concluded that no widespread impacts of wind projects on residential property values are apparent (Hoen, 2006; Sims and Dent, 2007; Sims et al., 2008). At the same time, pre-construction surveys of both homeowners and real estate experts have sometimes found an expectation of negative impacts (e.g. Haughton et al., 2004), and post-construction appraisals have sometimes come to similar conclusions (McCann, 2008; Kielisch, 2009). Given the state of the literature, it is not uncommon for local siting and permitting processes to involve contradicting testimony from experts, as occurred in 2004 when the Public Service Commission of Wisconsin heard opposing conclusions from two studies conducted by experienced home valuation experts (Poletti, 2005; Zarem, 2005).

This report contains the most comprehensive and data-rich analysis to date on the potential impacts of wind projects on nearby residential sales prices. Data from 7,459 residential transactions were collected from the surrounding communities of 24 individual wind projects in nine states and 14 counties in the United States.[6] Because of the large sample size, the diversity of wind projects included in the analysis, and the depth of information collected, a number of different analyses were possible. Specifically, this report relies heavily on a hedonic regression

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[5] Shadow flicker occurs when the sun shines through the wind turbine blades when at a low angle to the horizon and shadows are cast on a window or interior wall of a residence (NAS, 2007).

[6] The majority of the analysis only includes homes that sold after wind facility construction began, totaling 4,937 transactions.

model[7] and uses various forms of that model to investigate potential effects and to confirm the robustness of the resulting findings. To further investigate the robustness of the results, a repeat sales model[8] and a sales volume model[9] are also utilized. In sum, this work builds and improves on the previous literature, and provides an in-depth assessment of the question of whether residential property values in the United States have been affected, in a statistically measurable way, by views of and proximity to wind power facilities.

The remainder of this report is structured as follows. The next section discusses the hedonic model in general, its application to environmental disamenities research, and some potentially analogous results drawn from these studies. This is followed by a summary of the existing literature that has investigated the effects of wind energy on residential property values. The report then turns to the data used in the analysis, a discussion of the primary (or "base") hedonic model, and an analysis of the results from that statistical model. Following that, a set of alternative hedonic models are estimated, as well as a repeat sales model and sales volume model, to test for the robustness of the "base" model results and to explore other aspects of the data. Taking into account the full set of results presented earlier, the report then discusses the three stigmas that may lead to wind projects impacting residential property values, and summarizes how the analysis informs the existence and magnitude of these potential effects. The report ends with a brief conclusion, and a discussion of future research possibilities. A number of appendices follow the conclusion, and contain detailed information on each wind project study area, the data collection instrument and qualitative rating systems used in the field research, the investigation of the best "base" model, the hedonic model assumptions and related tests, and full results from all of the additional statistical models estimated in the report.

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[7] The hedonic regression model, which was briefly described in a sidebar in the Executive Summary, is described in detail in Section 2.1.

[8] A repeat sales model uses, as its dataset, only those homes that have sold more than once. By comparing annual appreciation rates of homes that sold once before facility announcement, and again after construction, it can be tested, in an alternative fashion, if home values are affected by the distance to or view of nearby wind turbines.

[9] Sales volume can be defined as the percentage of homes that fit a certain criteria (e.g. single family, on less than 25 acres, zoned residential, assessed for more than $10,000) that actually did sell. By comparing sales volumes at various distances to wind facilities, before and after the facility was built, a further robustness test is possible.

2. Previous Research

Hedonic pricing models are frequently used to assess the marginal impacts of house and community characteristics on sales prices and by extension on property values in general. Because the hedonic model is the primary statistical method used in this report, this section begins by describing the model in more detail and providing some relevant examples of its use. The section then reviews the existing literature on the effects of wind energy facilities on surrounding property values, highlights the shortcomings of that literature, and outlines how the present research addresses those shortcomings.

2.1. Hedonic Models and Environmental Disamenities

A house can be thought of as a bundle of characteristics (e.g., number of square feet, number of bathrooms, number of fireplaces, and amount of acreage). When a price is agreed upon between a buyer and seller there is an implicit understanding that those characteristics have value. When data from a number of sales transactions are available, the individual marginal contribution to the sales price of each characteristic can be estimated with a hedonic regression model (Rosen, 1974; Freeman, 1979). This relationship takes the basic form:

Sales price = *f* (house structural characteristics, other factors)

where "house structural characteristics" might include, but are not limited to, the number of square feet of living area, bathrooms, and fireplaces, the presence of central AC and the condition of the home, and "other factors" might include, but are not limited to, home site characteristics (e.g., number of acres), neighborhood characteristics (e.g., school district), market conditions at the time of sale (e.g., prevailing mortgage interest rates), and surrounding environmental conditions (e.g., proximity to a disamenity or amenity).

The relationship between the sales price of homes and the house characteristics and other factors can take various forms. The most common functional form is the semi-log construction where the dependent variable is the natural log of the inflation adjusted sales price, and the independent variables are unadjusted (not transformed) home characteristics and other factors. The usefulness of this form of hedonic model is well established (Malpezzi, 2003; Sirmans et al., 2005b; Simons and Saginor, 2006) assuming that certain threshold assumptions are met.[10] The model is used commonly by academics, real estate assessors, appraisers, and realtors when large datasets are available on past residential sales transactions, and when estimates of the marginal impact of certain house characteristics and other factors on sales prices are desired.[11]

[10] These assumptions, which are discussed in greater detail in Section 4.2 and Appendix G, include absence of outliers and/or influencers, presence of homoskedastic variances, absence of spatial and temporal autocorrelation, and absence of collinearity between the variables of interest and other independent variables.

[11] It should be emphasized that a hedonic model is not designed to appraise properties (i.e., to establish an estimate of the market value of a home at a specified point in time), as would be done with an automated valuation model (AVM). Rather, hedonic models are designed to estimate the marginal contribution of individual house or community characteristics to sales prices, which requires hedonic models to rely upon large data sets with a sizable number of explanatory variables. Appraisal models, on the other hand, are generally based on small, localized data sets (i.e., "comps") and a limited number of explanatory variables that pertain to nearby properties. Due to their higher level of accuracy through the use of significantly more information (e.g., diverse spatial, temporal, and

A particularly useful application of the hedonic regression model is to value non-market goods – goods that do not have transparent and observable market prices. For this reason, the hedonic model is often used to derive value estimates of amenities such as wetlands (e.g., Mahan et al., 2000) or lake views (e.g., Seiler et al., 2001), and disamenities, such as proximity to and/or views of high-voltage transmission lines (HVTLs) (e.g. Des-Rosiers, 2002), fossil fuel power plants (Davis, 2008), roads (e.g. Bateman et al., 2001), cell phone towers (e.g. Bond and Wang, 2007), and landfills (e.g., Thayer et al., 1992; Ready and Abdalla, 2005).

There are a number of useful reviews that describe the application of hedonic models in these circumstances (Kroll and Priestley, 1992; Farber, 1998; McCann, 1999; Bateman et al., 2001; Boyle and Kiel, 2001; Jackson, 2001; Ready and Abdalla, 2005; Simons and Saginor, 2006; Simons, 2006b; Leonard et al., 2008).[12] The large number of studies covered in these reviews demonstrate that hedonic models are regularly used to investigate the interplay between home values and distance to potential disamenities, teasing out if and how sales prices are adversely affected depending on the distance of a typical home from a disamenity. For example, Carroll et al. (1996) use a hedonic model to estimate a devaluation of 16% for homes "close to" a chemical plant, with a 6.5% increase in sales price per mile away out to 2.5 miles, at which point effects fade entirely. Dale et al. (1999) find a maximum effect of -4% near a lead smelter, with sales prices increasing 2% for each mile away out to two miles, where effects again fade. Ready and Abdalla (2005) find maximum effects near landfills of -12.4%, which fade entirely outside 2,400 feet, and maximum effects near confined animal feeding operations of -6.4%, which fade entirely outside of 1,600 feet. Meanwhile, studies of other energy infrastructure, such as HVTLs, find maximum effects of -5.7% for homes adjacent to a HVTL tower, and an increase in prices of 0.018% per foot away from the tower out to 300 feet (Hamilton and Schwann, 1995), and maximum effects of -14% for homes within 50 feet of a HVTL, but no effect for similar homes at 150 feet (Des-Rosiers, 2002). Further, for fossil fuel power plants, Davis (2008) finds average adverse effects of between 3 and 5% inside of two miles but that those effects fade entirely outside of that distance range.

In addition to investigating how sales prices change with distance to a disamenity, hedonic models have been used to investigate how prices have changed over time. For instance, sales prices have sometimes been found to rebound after the removal of a disamenity, such as a lead smelter (Dale et al., 1999), or to fade over time, as with HVTLs (Kroll and Priestley, 1992) or spent fuel storage facilities (Clark and Allison, 1999). Finally, hedonic models have been used to estimate how views of a disamenity affect sales prices. Des-Rosiers (2002), for example, finds that homes adjacent to a power line and facing a HVTL tower sell for as much as 20% less than similar homes that are not facing a HVTL tower.

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characteristic information) and rigorous methodology, hedonic models can also be used as appraisal models. Automated valuation models cannot, however, be reliably used to measure marginal effects because they do not employ sufficient information to do so, and, more importantly, AVMs do not hold controlling characteristics constant, which could bias any resulting estimates of marginal effects.

[12] For further discussion of the hedonic model and its application to the quantification of environmental stigmas in comparison to other methods see Jackson (2005).

It is unclear how well the existing hedonic literature on other disamenities applies to wind turbines, but there are likely some similarities. For instance, in general, the existing literature seems to suggest that concerns about lasting health effects provide the largest diminution in sales prices, followed by concerns for one's enjoyment of the property, such as auditory and visual nuisances, and that all effects tend to fade with distance to the disamenity - as the perturbation becomes less annoying. This might indicate that property value effects from wind turbines are likely to be the most pronounced quite close to them, but fade quickly as their auditory and visual impacts fade. The existing hedonic literature also, in general, finds that effects fade with time as self-selecting buyers without prejudice towards the disamenity move into the area, or as the real or perceived risks of the disamenity are lessoned (Jackson, 2001). This implies that any stigmas related to wind turbines might also fade over time as local communities come to accept their presence.

2.2. Impacts of Wind Projects on Property Values

Turning to the literature that has investigated the potential property value effects from wind facilities directly, it deserves note that few studies have been academically peer-reviewed and published; in some cases, the work has been performed for a party on one side or the other of the permitting process (e.g., the wind developer or an opposition group). Nonetheless, at a minimum, a brief review of this existing literature will set the stage for and motivate the later discussion of the methods and results of the present work. The literature described below is summarized in Table 1. To frame this discussion, where possible, the three potential stigmas discussed earlier are used:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

In one of the most recent studies, Sims et al. (2008) used a hedonic model to investigate Scenic Vista Stigma using 199 residential transactions within ¼ of a mile of the 16-turbine Bears Down wind facility in Cornwall, UK. They found both large positive and smaller negative significant relationships between views of the turbines and sales prices depending on whether the view is seen from the front or rear of the home, respectively, but found no relationship between the number of wind turbines visible and sales prices. Previously, Sims and Dent (2007) used a hedonic model to investigate Nuisance and Scenic Vista Stigma with 919 transactions for homes within five miles of two wind facilities in the UK, finding only limited evidence of a relationship between proximity to and views of turbines and sales prices, which local real estate experts attributed to other causes. Hoen (2006) investigated Scenic Vista Stigma using a hedonic model to analyze 280 residential transactions occurring near a wind facility in Madison County, NY, and found no evidence that views of turbines significantly affects prices. Jordal-Jorgensen (1996) investigated Nuisance Stigma in Denmark, and found an adverse effect for homes located "close" to the turbines, but no statistical significance was reported.[13]

[13] A copy of this report could not be obtained and therefore its findings are reported based on other citations.

Using different statistical methods, Poletti (2005; 2007) used a *t*-Test to investigate Nuisance and Area Stigma by comparing the mean sales prices of 187 and 256 homes in Illinois and Wisconsin, respectively, located near wind facilities (target group) to those further away (control group).[14, 15] He split these target and control groups into respective smaller and more-homogenous sub-groups, such as large and small tracts, with and without homes, finding no statistical evidence that homes near the wind facilities sold for different prices than those farther away. Sterzinger et al. (2003) analyzed roughly 24,000 residential transactions, which were divided between those within five miles of a wind facility and those outside of five miles in an effort to assess Area Stigma. They compared residential appreciation rates over time, and found no apparent difference between those homes within and outside of five miles from a wind facility, but the statistical significance of this comparison was not reported.

Other authors have used smaller samples of residential transactions and a variety of simple statistical techniques, without reporting statistical significance, and have found a lack of evidence of effects from Nuisance Stigma (Jerabek, 2001; Jerabek, 2002; Beck, 2004) and Area Stigma (DeLacy, 2005; Goldman, 2006). These results, however, are somewhat contrary to what one appraiser has found. In his investigation of Nuisance Stigma around a wind facility in Lee County, IL, McCann (2008) found that two homes nearby a wind facility had lengthy selling periods that, he believes, also adversely affected transaction prices. Additionally, Kielisch (2009) investigated Nuisance Stigma by comparing twelve transactions of undeveloped land near two wind facilities in Wisconsin (Blue Sky Green Field and Forward) to undeveloped land transactions farther away. He found that land tracts near the wind facilities sold for dramatically lower prices ($/acre) than the comparable group, but the statistical significance of the comparison was not reported.

In addition to these revealed preference studies, a number of stated preference surveys (e.g., contingent valuation) and general opinion surveys have investigated the existence of potential effects.[16] A survey of <u>local residents</u>, conducted after the wind facilities were erected, found no evidence of Area Stigma (Goldman, 2006), while another found limited evidence of these stigmas (Bond, 2008).[17] Similarly, some surveys of <u>real estate experts</u> conducted after facility

[14] A *t*-Test is used to compare two sample means by discerning if one is significantly different from the other.

[15] The 2007 study used the data contained in the 2005 study in combination with new data consisting of transactions that occurred in the interim period.

[16] Contingent valuation is a survey based technique to value non-market goods (e.g., an environmental disamenity) that asks respondents what their "willingness to pay" (or "willingness to accept") is to have, for instance, a disamenity removed from (or to have it remain in) their neighborhood. This technique is distinct from a general opinion survey, which might ask whether respondents believe property values have been impacted by an environmental disamenity and, if so, "by how much." Although there are important distinctions between the two techniques, with the contingent valuation method often preferred by economic practitioners, for simplicity no distinction is made here between these two approaches. Finally, another subset of the survey literature focuses on public acceptance (i.e., opinion). Though these public acceptance surveys sometimes cover possible impacts on property values, those impacts are not quantified in economic terms. As a result, public acceptance survey results are not reported here.

[17] Bond (2008) asked respondents to declare if the wind facility, which is located roughly 7 miles away, would effect what they would be willing to pay for their house and 75% said either they would pay the same or more for their house, while the remainder would pay less. When those latter respondents were asked to estimate the percentage difference in value, their estimates averaged roughly 5%.

construction have found no evidence of Area or Nuisance Stigmas (Grover, 2002; Goldman, 2006). These results, however, are contrary to the expectations for Area, Scenic Vista, and Nuisance Stigma effects predicted by local residents (Haughton et al., 2004; Firestone et al., 2007) and real estate experts (Haughton et al., 2004; Khatri, 2004; Kielisch, 2009) prior to construction found elsewhere.[18] The difference between predicted and actual effects might be attributable, at least in part, to the fear of the unknown. For instance, Wolsink (1989) found that public attitudes toward wind power, on average, are at their lowest for local residents during the wind project planning stage, but return almost to pre-announcement levels after the facilities are built. This result is echoed by Exeter-Enterprises-Ltd. (1993) and Palmer (1997), whose post-construction surveys found higher approval than those conducted pre-construction. Others, however, have found that perceptions do not always improve, attributing the lack of improvement to the perceived "success" or lack therefore of the project, with strong disapproval forming if turbines sit idle (Thayer and Freeman, 1987) or are perceived as a waste of taxpayer dollars (Devine-Wright, 2004).

When this literature is looked at as a whole, it appears as if wind projects have been predicted to negatively impact residential property values when pre-construction surveys are conducted, but that sizable, widespread, and statistically significant negative impacts have largely failed to materialize post-construction when actual transaction data become available for analysis. The studies that have investigated Area Stigma with market data have failed to uncover any pervasive effect. Of the studies focused on Scenic Vista and Nuisance Stigmas, only one is known to have found statistically significant adverse effects, yet the authors contend that those effects are likely driven by variables omitted from their analysis (Sims and Dent, 2007). Other studies that have relied on market data have sometimes found the possibility of negative effects, but the statistical significance of those results have rarely been reported.

Despite these findings, the existing literature leaves much to be desired. First, many studies have relied on surveys of homeowners or real estate professionals, rather than trying to quantify real price impacts based on market data. Second, a number of studies conducted rather simplified analyses of the underlying data, potentially not controlling for the many drivers of residential sales prices. Third, many of the studies have relied upon a very limited number of residential sales transactions, and therefore may not have had an adequate sample to statistically discern any property value effects, even if effects did exist. Fourth, and perhaps as a result, many of the studies did not conduct, or at least have not published, the statistical significance of their results. Fifth, when analyzed, there has been some emphasis on Area Stigma, and none of the studies have investigated all three possible stigmas simultaneously. Sixth, only a few of the studies (Hoen, 2006; Sims and Dent, 2007; Sims et al., 2008; Kielisch, 2009) conducted field visits to the homes to assess the quality of the scenic vista from the home, and the degree to which the wind facility might impact that scenic vista. Finally, with two exceptions (Sims and Dent, 2007; Sims et al., 2008), none of the studies have been academically peer-reviewed and published.

[18] It should be noted that the samples used by both Khatri and Kielisch contained a subset of respondents who did have some familiarity with valuing homes near wind facilities.

Table 1: Summary of Existing Literature on Impacts of Wind Projects on Property Values

Document Type / Author(s)	Year	Number of Transactions or Respondents	Before or After Wind Facility Construction Commenced	Area Stigma	Scenic Vista Stigma	Nuisance Stigma
Homeowner Survey						
Haughton et al.	2004	501	Before	- *	- *	
Goldman	2006	50	After	**none**		
Firestone et al.	2007	504	Before	- *	- *	
Bond	2008	~300	After		- ?	- ?
Expert Survey						
Grover	2002	13	After	**none**		**none**
Haughton et al.	2004	45	Before	- *	- *	
Khatri	2004	405	Before‡	- ?		- ?
Goldman	2006	50	After	**none**		**none**
Kielisch	2009	57	Before‡			- ?
Transaction Analysis - Simple Statistics						
Jerabek	2001	25	After			**none**
Jerabek	2002	7	After			**none**
Sterzinger et al.	2003	24,000	After	**none**		
Beck	2004	2	After			**none**
Poletti	2005	187	After	**none**		**none**
DeLacy	2005	21	Before†	**none**		
Goldman	2006	4	After	**none**		
Poletti	2007	256	After	**none**		**none**
McCann	2008	2	After			- ?
Kielisch	2009	103	After			- ?
Transaction Analysis - Hedonic Model						
Jordal-Jorgensen	1996	?	After			- ?
Hoen	2006	280	After		**none**	
Sims & Dent	2007	919	After			- *
Sims et al.	2008	199	After		-/+ *	

" none " indicates the majority of the respondents do not believe properties have been affected (for surveys) or that no effect was detected at 10% significance level (for transaction analysis)

"- ?" *indicates a negative effect without statistical significance provided*

"- *" *indicates statistically significant negative effect at 10% significance level*

"-/+ *" *indicates positive and negative statistically significant effects at 10% significance level*

† *Sales were collected after facility announcement but before construction*

‡ *Some respondents had experience with valuations near facilities while others did not*

3. Data Overview

The methods applied in the present work are intended to overcome many of the limitations of the existing literature. First, a large amount of data is collected from residential transactions within 10 miles of 24 different wind projects in the U.S., allowing for a robust statistical analysis across a pooled dataset that includes a diverse group of wind project sites. Second, all three potential stigmas are investigated by exploring the potential impact of wind projects on home values based both on the distance to and view of the projects from the homes. Third, field visits are made to every home in the sample, allowing for a solid assessment of the scenic vista enjoyed by each home and the degree to which the wind facility can be seen from the home, and to collect other value-influencing data from the field (e.g., if the home is situated on a cul-de-sac). Finally, a number of hedonic regression models are applied to the resulting dataset, as are repeat sales and sales volume analyses, in order to assess the robustness of the results.

Testing for the three potential stigmas requires a significant sample of residential transactions within close proximity to existing wind facilities. Unfortunately for the study, most wind power projects are not located near densely populated areas. As a result, finding a single wind project site with enough transaction data to rigorously analyze was not possible. Instead, the approach was to collect data from multiple wind project sites, with the resulting data then pooled together to allow for robust statistical analyses.[19] The remainder of this section describes the site selection process that is used, and provides a brief overview of both the selected study areas and the data that were collected from these areas. Also provided is a description of how scenic vista, views of turbines, and distances from turbines were quantified for use in the hedonic analysis, and a summary of the field data collection effort. The section ends with a brief summary of the resulting dataset.

3.1. Site Selection

For the purpose of this study, an ideal wind project area would:

1) Have a large number of residential transactions both before and, more importantly, after wind facility construction, and especially in close proximity (e.g., within 2 miles) of the facility;
2) Have comprehensive data on home characteristics, sales prices, and locations that are readily available in electronic form; and
3) Be reasonably representative of the types of wind power projects being installed in the United States.

To identify appropriate sites that met these criteria, and that also provided a diversity of locations, the authors obtained from Energy Velocity, LLC a set of Geographic Information System (GIS) coordinates representing 241 wind projects in the U.S. that each had a total nameplate capacity greater than 0.6 megawatts (MW) and had gone online before 2006.[20] Also provided were facility capacity, number of turbines, and announcement, construction, and operational dates. These data were cross-checked with a similar dataset provided by the American Wind Energy Association (AWEA), which also included some turbine hub-height information.

[19] A thorough discussion of this "pooled" approach is contained in Section 4.2 and in Appendix F.

[20] Energy Velocity, LLC was owned at the time by Global Energy Decisions, which was later purchased by Ventyx. The dataset is available as Velocity Suite 2008 from Ventyx.

By using a variety of different GIS sorting techniques involving nearby towns with populations greater than, for example, 2,500 people, using census tract population densities, and having discussions with wind energy stakeholders, a prospective list of 56 possible study areas was generated, which were then ranked using two scales: "highly desirable" to "least desirable," and "feasible" to "potentially unfeasible."[21] Then, through an iterative process that combined calls to county officials to discuss the number of residential transactions and data availability, with investigations using mapping software to find the location of individual wind turbines, and, in some cases, preliminary visits, a list of 17 prospective study areas were chosen as both "highly desirable" and "feasible." Ultimately, three of these proved to be "unfeasible" because of data availability issues and four "undesirable" because the study area was considered not representative. This effort ultimately resulted in a final set of ten study areas that encompass a total of 24 distinct wind facilities (see Figure 1 and Table 2).[22] A full description of each study area is provided in Appendix A.

[21] "Desirability" was a combination of a number of factors: the wind facility having more than one turbine; the study area having greater than 350 sales within 5 miles and within 10 years, 250 of which transacted following construction of the facility; having some transaction data old enough to pre-date facility announcement; having data on the core home and site characteristics (e.g., square feet, acres); and, where possible, having a concentration of sales within 1 mile of the facility. "Feasibility" was also a combination of factors: having home characteristic and sales data in electronic form; having GIS shapefiles of the parcel locations; and being granted ready access to this information.

[22] The "unfeasible" study areas were Cerro Gordo County, IA, Bennington County, VT, and Atlantic County, NJ. Cerro Gordo County, IA contained multiple wind projects totaling 140 MW. Although the data at this site were available in electronic form, the county only agreed to share data in paper form, which would have created an enormous data entry burden. Because another site in the sample was considered similar to the Cerro Gordo site (IABV), Cerro Gordo County was dropped from the prospective sites. Bennington County, VT contained the 11 turbine Searsburg Wind Project (6 MW) but had no electronic records. Atlantic County, NJ contained the five turbine Jersey Atlantic Wind Farm (7.5 MW), but had data in paper records only and the county was unresponsive to inquiries regarding the study. The "undesirable" study areas were Plymouth County, MA, Wood County, OH, Cascade County, MT, and Riverside County, CA. Although the data in Plymouth County, MA were more than adequate, this small, on-land, yet coastal Hull Wind facility (2 turbines, 2.5 MW) was not considered to be particularly representative of wind development across the US. Wood County's four turbine Bowling Green facility (7 MW) met the appropriate data requirements, but ultimately it was decided that this facility was too small and remote to be representative. Cascade County's six turbine Horseshoe Bend Wind Park (9 MW) did not have enough transactions to justify study. Riverside, CA, where roughly 2500 turbines are located, had less-than-desired home characteristic data, had transactions that came more than 10 years after large scale development began, and despite having homes that were within 1 mile of the turbines, those homes typically had limited views because of high subdivision walls.

Figure 1: Map of Study Areas and Potential Study Areas

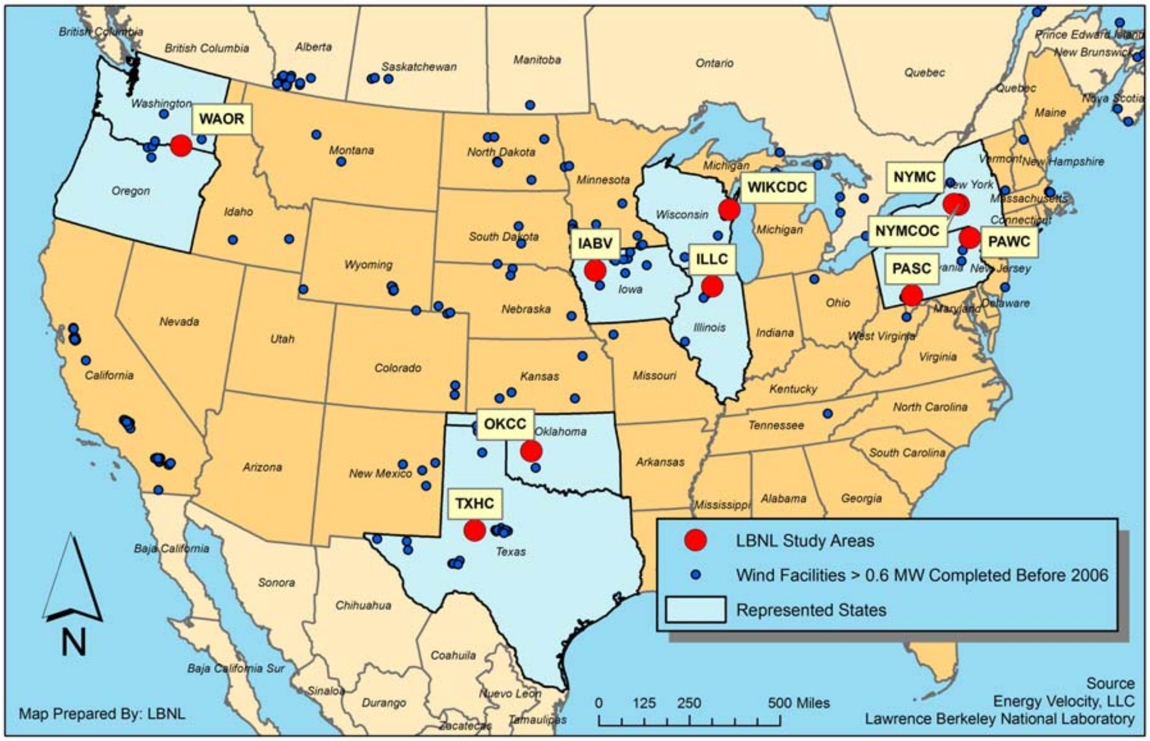

Table 2: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)	Max Hub Height (feet)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60	197
TXHC	Howard County, TX	Big Spring I & II	46	34	80	262
OKCC	Custer County, OK	Weatherford I & II	98	147	80	262
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65	213
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78	256
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65	213
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80	262
PAWC	Wayne County, PA	Waymart	43	65	65	213
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67	220
NYMC	Madison County, NY	Fenner	20	30	66	218
		TOTAL	**1345**	**1286**		

These 10 study areas and 24 projects are located in nine separate states, and include projects in the Pacific Northwest, upper Midwest, the Northeast, and the South Central region. The wind projects included in the sample total 1,286 MW, or roughly 13% of total U.S. wind power capacity installed at the time (the end of 2005). Turbine hub heights in the sample range from a minimum of 164 feet (50 meters) in the Washington/Oregon (WAOR) study area, to a maximum of 262 (80 meters) (TXHC, OKCC and PASC), with nine of the ten study areas having hub heights of at least 213 feet (65 meters). The sites include a diverse variety of land types, including combinations of ridgeline (WAOR, PASC, and PAWC), rolling hills (ILLC, WIKCDC, NYMCOC, and NYMC), mesa (TXHC), and windswept plains (OKCC, IABV).[23]

3.2. Data Collection

In general, for each study area, residential transaction data in as close proximity to the wind turbines as possible was sought, from both before and after wind facility construction. To balance the cost and quantity of data collection in each study area with the desire to cover as many study areas as possible, the research effort sought to collect data on 400 to 1,250 transactions in each study area.[24] In some instances, this meant including all residential transactions within ten miles of the wind turbines. In others, only transactions within five miles were included. In some extreme instances, when the number of transactions inside of five miles far exceeded the 1,250 limit, all transactions in close proximity to the wind turbines (e.g., inside three miles) were included in combination with a random sample of transactions outside of that distance band (e.g., between three and five miles).[25] The data selection processes for each Study Area are contained in Appendix A.

Three primary sets of data are used in the analysis: tabular data, GIS data, and field data, each of which is discussed below. Following that, this subsection highlights the two qualitative variables that are essential to this analysis and that therefore require special attention, scenic vista and views of turbines, and then discusses the field data collection process.

3.2.1. Tabular Data

Berkeley Lab obtained tabular transaction data from participating counties[26] containing 7,459 "valid" [27] transactions of single family residential homes, on less than 25 acres,[28] which were

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[23] Some areas, such as PASC, had both a ridgeline and rolling hills on which wind facilities were located.

[24] This range was chosen to ensure that a minimum of data were present in each study area to allow for a robust analysis, and yet not too much so as to make data collection (e.g., the visiting of each home) inordinately time and resource consuming in any individual study area.

[25] An alternative method would have been to collect data on every sale that occurred. Although in most cases this would be preferred, in ours it would not have added one additional transaction within close proximity or with dramatic views of wind turbine, the focus of the study. Rather, it would have added an overwhelming majority of transactions of homes without views and at distances outside of three miles from the turbines, all of which would have come at considerably cost and, more importantly, would not likely have influenced the results significantly while perhaps necessitating a reduction in the total number of study areas that could be included in the sample.

[26] In some cases, the county officials, themselves, extracted data from their database, and in some cases a company engaged to manage a county's data provided the necessary information. In either case the provider is referred to as "county." Detailed descriptions of the providers are presented in Appendix A.

[27] Validity was determined by each individual county data provider. A sale that is considered "valid" for county purposes would normally meet the minimum requirements of being arm's length; being a transfer of all rights and warrants associated with the real estate; containing an insignificant amount of personal property so as not to affect the price; demonstrating that neither party in the sale acting under duress or coercion; not being the result of a liquidation of assets or any other auction, a mortgage foreclosure, a tax sale, or a quit claim; and being appropriate for use in calculating the sales price to assessed value ratios that are reported to the state. Due to the formal requirements associated with this calculation, "validity" is often defined by a state's Department of Revenue, as shown, for example, here: http://www.orps.state.ny.us/assessor/manuals/vol6/rfv/index.htm. In addition, though the

sold for a price of more than $10,000,[29] which occurred after January 1, 1996,[30] and which had fully populated "core" home characteristics. These core characteristics are: number of square feet of the living area (not including finished basement), acres of land, bathrooms, and fireplaces, the year the home was built,[31] if the home had exterior wallsthatwere stone, a central air conditioning unit, and/or a finished basement, and the exterior condition of the home. The 7,459 residential transactions in the sample consist of 6,194 homes (a number of the homes in the sample sold more than once in the selected study period). Because each transaction had a corresponding set of the core home characteristic data, they could all be pooled into a single model. In addition to the home characteristic data, each county provided, at a minimum, the home's physical address and sales price. The counties often also provided data on homes in the study area that did not sell in the study period.[32] Finally, market-specific quarterly housing inflation indexes were obtained from Freddie Mac, which allowed nominal sales prices to be adjusted to 1996 dollars.[33]

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sample originally contained 7,498 sales, 34 homes sold twice in a 6 month period and, after discussions with local officials, these transactions were considered likely to have been "invalid" despite the county coding them to the contrary. Additionally, five transactions produced standardized residuals that were more than six standard deviations away from the mean, indicating that these sales were abnormal and likely not valid. Both of these sets of transactions, totaling 39, were removed from the final dataset. Of the 39 sales, 32 sold following construction, 10 were concentrated in IABV and nine in TXHC with the others spread between seven of the remaining eight study areas. One of the homes was inside of one mile from the turbines at the time of sale, and two had views of the turbines (both of which were MINOR). The home that was located within one mile was surrounded by a number of other homes – at similar distances from the turbines - that transacted both before and after the wind facilities were built and were included in the sample. A more thorough discussion of the screening techniques used to ensure the appropriateness of the final data set are presented in detail in Appendix G under "Outliers/Influencers." Finally, it should be noted that the authors are aware of four instances in the study areas when homes were sold to wind developers. In two cases the developer did not resell the home; in the other two, the developer resold the home at a lower price than which it was purchased. But, because the sales were to a related party, these transactions were not considered "valid' and are therefore not included here. One might, however, reasonably expect that the property values of these homes were impacted by the presence of the wind turbines.

[28] Single family residences on more than 25 acres were considered to be likely candidates for alternative uses, such as agricultural and recreational, which could have an influence on sales price that was outside of the capabilities of the model to estimate. Because all records were for parcels that contained a residence, the model did not contain any "land-only" transactions. Further, none of the transactions provided for this research were for parcels on which a turbine was located.

[29] A sales price of $10,000 was considered the absolute minimum amount an improved parcel (one containing a residential structure) would sell for in any of the study areas and study periods. This provided an additional screen over and above the "valid" screen that the counties performed.

[30] This provided a maximum of 12 years of data. Some counties did not have accessible data back to 1996 but in all cases these countries had data on transactions that occurred before the wind facilities were erected.

[31] "Year Built" was used to construct a variable for the age of the home at the time of the sale.

[32] These data were used to calculate the "Sales Volume" percentages referred to in Section 7.

[33] Freddie Mac Conventional Mortgage Home Price Index: municipal statistical area (MSA) series data are available from the following site: http://www.freddiemac.com/finance/cmhpi/. Because most of the study areas do not fall within the MSAs, a collection of local experts was relied upon, including real estate agents, assessors, and appraisers, to decide which MSA most-closely matched that of the local market. In all cases the experts had consensus as to the best MSA to use. In one case (NYMCOC) the sample was split between two MSAs. These indexes are adjusted quarterly, and span the entire sample period. Therefore, during the housing boom, insofar as a boom occurred in the sample areas, the indexes increased in value. Subsequently when the market began falling, the index retracted.

3.2.2. GIS Data

GIS data on parcel location and shape were also required, and were obtained from the counties. The counties also often provided GIS layers for roads, water courses, water bodies, wind turbines (in some cases), house locations, and school district and township/town/village delineations. GIS data on census tract and school district delineations were obtained from the U.S. Census Bureau, if not provided by the county.[34] GIS data were obtained on water courses, water bodies, land elevations, and satellite imagery, as was necessary, from the U.S. Department of Agriculture.[35] Combined, these data allowed each home to be identified in the field, the construction of a GIS layer of wind turbine locations for each facility, and the calculation of the distance from each home to the nearest wind turbine.[36] Determining the distance from each home to the nearest wind turbine was a somewhat involved process, and is discussed in detail in Appendix B. Suffice it to say that each transaction had a unique distance ("DISTANCE")[37] that was determined as the distance between the home and nearest wind turbine at the time of sale, and that these distances are grouped into five categories: inside of 3000 feet (0.57 miles), between 3000 feet and one mile, between one and three miles, between three and five miles, and outside of five miles.[38] Finally, the GIS data were used to discern if the home was situated on a cul-de-sac and had water frontage, both of which were corroborated in the field.

3.2.3. Field Data

Additional data had to be collected through field visits to all homes in the sample. Two qualitative measures in particular – for scenic vista and for view of the wind turbines – are worth discussing in detail because each is essential to the analysis and each required some amount of professional judgment in its creation.

The impact or severity of the view of wind turbines ("VIEW") [39] may be related to some combination of the number of turbines that are visible, the amount of each turbine that is visible (e.g., just the tips of the blades or all of the blades and the tower), the distance to the nearest turbines, the direction that the turbines are arrayed in relation to the viewer (e.g., parallel or perpendicular), the contrast of the turbines to their background, and the degree to which the turbine arrays are harmoniously placed into the landscape (Gipe, 2002). Recent efforts have made some progress in developing quantitative measures of the aesthetic impacts of wind turbines (Torres-Sibillea et al., 2009),[40] but, at the time this project began, few measures had

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[34] These data were sourced from the U.S. Census Bureau's Cartographic Boundary Files Webpage: http://www.census.gov/geo/www/cob/bdy_files.html.

[35] These data were sourced from the USDA Geospatial Data Gateway: http://datagateway.nrcs.usda.gov/GatewayHome.html.

[36] Although in some cases the county provided a GIS layer containing wind turbine points, often this was not available. A description of the turbine mapping process is provided in Appendix B.

[37] Distance measures are collectively and individually referred to as "DISTANCE" from this point forward.

[38] The minimum distance of "inside 3000 feet" was chosen because it was the closest cutoff that still provided an ample supply of data for analysis.

[39] View of turbines ratings are collectively and individually referred to as "VIEW" from this point forward.

[40] In addition to these possible field techniques, previous studies have attempted to use GIS to estimate wind turbine visibility using "line-of-sight" algorithms. For example, Hoen (2006) used these algorithms after adding ground cover to the underlying elevation layer. He found that the GIS method differed substantially from the data collected in the field. Seemingly, small inaccuracies in the underlying elevation model, errors in the software's algorithm, and the existence of ground cover not fully accounted for in the GIS, substantially biased GIS-based assessments of

been developed, and what had been developed was difficult to apply in the field (e.g., Bishop, 2002). As a result, the authors opted to develop an ordered qualitative VIEW rating system that consisted of placing the view of turbines into one of five possible categories: NO VIEW, MINOR, MODERATE, SUBSTANTIAL, and EXTREME. These ratings were developed to encompass considerations of distance, number of turbines visible, and viewing angle into one ordered categorical scale, and each rating is defined in Table 3:[41]

Table 3: Definition of VIEW Categories

NO VIEW	The turbines are not visible at all from this home.
MINOR VIEW	The turbines are visible, but the scope (viewing angle) is narrow, there are many obstructions, or the distance between the home and the facility is large.
MODERATE VIEW	The turbines are visible, but the scope is either narrow or medium, there might be some obstructions, and the distance between the home and the facility is most likely a few miles.
SUBSTANTIAL VIEW	The turbines are dramatically visible from the home. The turbines are likely visible in a wide scope and most likely the distance between the home and the facility is short.
EXTREME VIEW	This rating is reserved for sites that are unmistakably dominated by the presence of the wind facility. The turbines are dramatically visible from the home and there is a looming quality to their placement. The turbines are often visible in a wide scope or the distance to the facility is very small.

Photographic examples of each of the categories are contained in Appendix E.

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visibility. This was corroborated elsewhere by Maloy and Dean (2001) and Riggs and Dean (2007). As a result of these findings, it was determined that field collection of VIEW data was essential.

[41]In addition to the qualitative rating system that was ultimately used in this study, a variety of quantitative data were collected that might describe the nature of the view of wind turbines, including the total number of turbines visible, the distance of the home to the nearest wind turbine, and the view scope/viewing angle (i.e., the degree to which the turbines spread out in front of the home: narrow, medium, or wide). To explore the validity of the qualitative rating scale two tests were conducted. First, a pre-study survey was conducted by showing 10 different off-site respondents 15 randomly selected photographs from the field representing the various rated VIEW categories. The higher VIEW ratings were oversampled to create a roughly equal distribution among the categories. The respondents rated the views into one of the qualitative categories. The on-site / field collected ratings matched the off-site responses 65% of the time, with 97% of the rankings differing by no more than one category. Ninety-eight percent of the on-site-ranked MINOR VIEWs and 89% of the EXTREME VIEWs were similarly ranked by off-site respondents. The on-site rankings were less than the off-site rankings 97% of the time; it is assumed that this is because on-site ratings took into account a greater portion of the panorama than were captured in the photos, which translated into a lower ranking. Secondly, a post hoc Multinomial Logistic Regression model was created that used the qualitative on-site VIEW ratings as the dependent variable and the quantitative measures of distance to nearest turbine, number of turbines visible, and view scope as the independent variables. This model produced high Pseudo R^2 statistics (Cox and Snell 0.88, Nagelkerke 0.95, and McFadden 0.79) and predicted values that were highly correlated with the actual qualitative rating (Pearson's 0.88). Therefore, both tests corroborated the appropriateness of the simpler qualitative VIEW rankings used herein.

In addition to the qualitative VIEW measurements, a rating for the quality of the scenic vista ("VISTA")[42] from each home, absent the existence of the wind facilities, was also collected in the field. An assessment of the quality of the VISTA from each home was needed because VIEW and VISTA are expected to be correlated; for example, homes with a PREMIUM VISTA are more likely to have a wide viewing angle in which wind turbines might also be seen. Therefore, to accurately measure the impacts of the VIEW of wind turbines on property values a concurrent control for VISTA (independent of any views of turbines) is required. Drawing heavily on the landscape-quality rating system developed by Buhyoff et al. (1994) and to a lesser degree on the systems described by others (Daniel and Boster, 1976; USDA, 1995), an ordered VISTA rating system consisting of five categories was developed: POOR, BELOW AVERAGE, AVERAGE, ABOVE AVERAGE, and PREMIUM, with each rating defined in Table 4:[43]

Table 4: Definition of VISTA Categories

POOR VISTA	These vistas are often dominated by visually discordant man-made alterations (not considering turbines), or are uncomfortable spaces for people, lack interest, or have virtually no recreational potential.
BELOW AVERAGE VISTA	These scenic vistas contain visually discordant man-made alterations (not considering turbines) but are not dominated by them. They are not inviting spaces for people, but are not uncomfortable. They have little interest or mystery and have minor recreational potential.
AVERAGE VISTA	These scenic vistas include interesting views that can be enjoyed often only in a narrow scope. These vistas may contain some visually discordant man-made alterations (not considering turbines), are moderately comfortable spaces for people, have some interest, and have minor recreational potential.
ABOVE AVERAGE VISTA	These scenic vistas include interesting views that often can be enjoyed in a medium to wide scope. They might contain some man-made alterations (not considering turbines), yet still possess significant interest and mystery, are moderately balanced and have some potential for recreation.
PREMIUM VISTA	These scenic vistas would include "picture postcard" views that can be enjoyed in a wide scope. They are often free or largely free of any discordant man made alterations (not considering turbines), possess significant interest, memorable qualities, and mystery and are well balanced and likely have a high potential for recreation.

Photographic examples of each of the categories are contained in Appendix D.

[42] Scenic vista ratings are individually and collectively referred to as "VISTA" from this point forward.

[43] The appropriateness of these rankings were tested in two ways. First, a set of 34 pictures taken on-site and representing various categories of VISTA were shown to 10 off-site respondents who were asked to rank them using the same categories, and then explain why they rated them as such. Although the off-site ratings matched the on-site ratings only 51% of the time, 94% of on- and off-site rankings differed by no more than one category, with 17% of the off-site rankings below the on-site and 26% ranked above. The descriptions of why the rankings where chosen by the off-site respondents illuminated the fact that off-site ratings did not take into account a number of aspects that were not adequately captured in the photos, but that were apparent in the field. This finding was borne out by a second test that had five individuals visit seven homes in the field to rank their scenic vistas. When all respondents were on-site, they similarly ranked the vista 72% of the time, with a rankingthat differed by no more than one category occurring one hundred percent of the time.

In addition to the VIEW and VISTA ratings, it was assumed that the orientation of the home to the view of turbines (e.g., front, back, or side) ("ORIENTATION"), and the degree to which the view of the turbines overlapped the primary scenic vista (e.g., not at all, barely, somewhat or strongly) ("OVERLAP"), might influence residential property values. As such, information on ORIENTATION and OVERLAP were also collected in the field.

3.2.4. Field Data Collection

Field data collection was conducted on a house-by-house basis. Each of the 6,194 homes was visited by the same individual to remove bias among field ratings. Data collection was conducted in the fall of 2006, and the spring, summer, and fall of 2007 and 2008. Each house was photographed and, when appropriate, so too were views of turbines and the prominent scenic vista.[44] Data on VIEW were collected only for those homes that sold after at least one wind power facility had been erected in the study area. When multiple wind facilities, with different construction dates, were visible from a home, field ratings for VIEW were made by taking into account which turbines had been erected at the time of sale. Additionally, if the season at the time of sale differed from that of data collection and, for example, if leaves were off the trees for one but on for the other, an effort was made to modulate the VIEW rating accordingly if necessary.[45]

Both VIEW and VISTA field ratings were arrived at through a Q-Sort method (Pitt and Zube, 1979), which is used to distinguish relatively similar rankings. For views of turbines, the rater first determined if the ranking was MINOR or EXTREME. If neither of these two rankings was appropriate, then only a choice between MODERATE and SUBSTANTIAL was required. Similarly, for VISTA rankings, first POOR and PREMIUM were distinguished from the others; if neither applied then BELOW AVERAGE or ABOVE AVERAGE could be selected. If neither of those were appropriate the VISTA, by default, was considered AVERAGE. In all cases, if wind turbines were visible from the home, the VISTA rankings were made as if those turbines did not exist.

3.3. Data Summary

The final dataset consists of 7,459 valid and screened residential transactions occurring between January 2, 1996 and June 30, 2007. Those transactions are arrayed across time and the ten wind project study areas as shown in Table 5. The sample of valid residential transactions ranges from 412 in Lee County, Illinois (ILLC) to 1,311 in Howard County, Texas (TXHC).[46] Of the total 7,459 transactions, 4,937 occurred after construction commenced on the relevant wind facilities. More specifically, 23% of the transactions (*n*=1,755) took place before any wind facility was announced and 10% occurred after announcement but before construction commenced (*n*=767),

[44] In many cases the prominent VISTA was homogenous across groups of home, for instance urban homes on the same road. In those cases a picture of the VISTA of one home was applied to all of the homes. All pictures were taken with a Canon EOS Rebel XTi Single Lens Reflex Camera with a 18-55mm lens. VIEW and VISTA pictures were taken with the lens set to 18mm, with the camera at head height, and with the center of the camera pointed at the center of the prominent VISTA or VIEW. Examples of the various VISTA and VIEW categories are contained in Appendices D and E respectively.

[45] This "modulation" occurred only for trees in the foreground, where, for instance, a single tree could obscure the view of turbines; this would not be the case for trees nearer the horizon.

[46] See description of "valid" in footnote 27 on page 13.

with the rest of the transactions occurring after construction commenced (66%, *n*=4,937).[47] Of that latter group, 17% (*n*=824, 11% of total) sold in the first year following the commencement of construction, 16% in the second year (*n*=811, 11% of total), and the remainder (67%) sold more than two years after construction commenced (*n*=3,302, 44% of total).

Table 5: Summary of Transactions across Study Areas and Development Periods

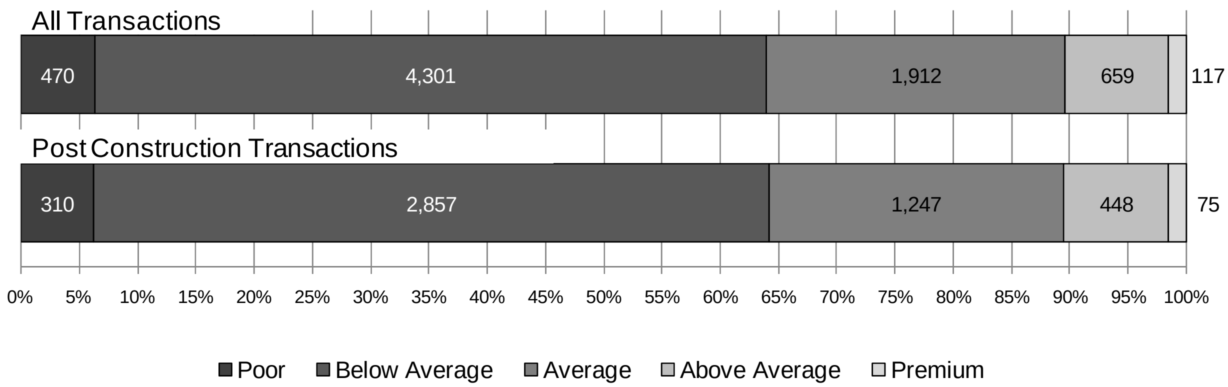
	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	226	45	76	59	384	**790**
Howard, TX (TXHC)	169	71	113	131	827	**1311**
Custer, OK (OKCC)	484	153	193	187	96	**1113**
Buena Vista, IA (IABV)	152	65	80	70	455	**822**
Lee, IL (ILLC)	115	84	62	71	80	**412**
Kewaunee/Door, WI (WIKCDC)	44	41	68	62	595	**810**
Somerset, PA (PASC)	175	28	46	60	185	**494**
Wayne, PA (PAWC)	223	106	64	71	87	**551**
Madison/Oneida, NY (MYMCOC)	108	9	48	30	268	**463**
Madison, NY (NYMC)	59	165	74	70	325	**693**
TOTAL	**1755**	**767**	**824**	**811**	**3302**	**7459**

A basic summary of the resulting dataset, including the many independent variables used in the hedonic models described later, is contained in Table 6 and Table 7. These tables present summary information for the full dataset (7,459 transactions) as well as the post-construction subset of that dataset (4,937 transactions); the latter is provided because much of the analysis that follows focuses on those homes that sold after wind facility construction. The mean nominal residential transaction price in the sample is $102,968, or $79,114 in 1996 dollars. The average house in the sample can be described as follows: it is 46 years old, has 1,620 square feet of finished living area above ground, is situated on 1.13 acres, has 1.74 bathrooms, and has a

[47] The announcement date (as well as construction and online dates) was provided by Energy Velocity with the GIS files as described in footnote 20 on page 10. The date corresponds to the first time the facility appears in the public record, which was often the permit application date. This constitutes the first well established date when the existing wind facility would have been likely known by the public, and therefore is appropriate to use for this analysis, but there remain a number of areas for potential bias in this date. First, the permit application date might be preceded by news reports of the impending application; alternatively, if the public record was not published online (that Energy Velocity used to establish their date), the "announcement" date – as used here - could, in fact, follow the permit application date. To address this, when possible, the authors had discussions with the developer of the facility. In most cases, the Energy Velocity dates were found to be accurate, and when they were not they were adjusted to reflect the dates provided by the developer. A second potential source of bias is the possibility that a different project was proposed but never built, but that influenced the residential market in the study area prior to the "announcement" date. Although this is likely rarer, we are aware of at least a few projects that fit that description in the study areas. A final source of bias might revolve around the likelihood that awareness of a project could occur even before the facility is formally announced. For example, a community member might know that a wind facility is being considered because they had been approached by the wind development company well ahead of a public announcement. In turn, they might have had private discussions regarding the facility with other members of the community. Taken together, it is appropriate to assume that there is some bias in the "announcement" date, and that awareness of the project might precede the date used in this analysis. How this bias might affect the results in this report is addressed further in Section 5.3 and footnote 74 on page 38.

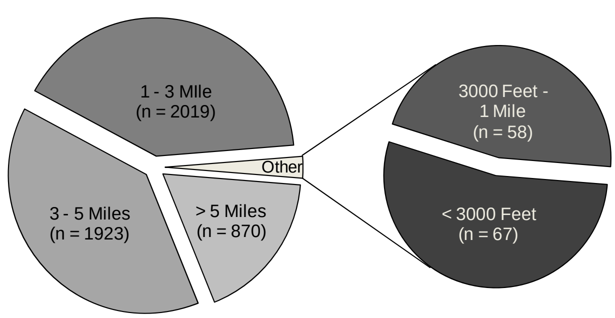
slightly better than average condition.[48] Within the full sample, 6% and 58% of homes had a poor or below average VISTA rating, respectively; 26% of homes received an average rating on this scale, with 9% above average and 2% experiencing premium vistas (see Figure 2).

Figure 2: Frequency of VISTA Ratings for All and Post-Construction Transactions



With respect to the variables of interest, among the post-construction subset of 4,937 transactions, the frequency of the DISTANCE categories is found to follow geometry with the smallest numbers of transactions occurring near the wind turbines and ever increasing numbers further away (see Figure 3). 67 transactions (1%) are situated inside of 3,000 feet (< 0.57 Miles), 58 (1%) are between 3,000 feet and one mile (0.57-1 mile), 2,019 (41%) occur outside of one mile but inside of three miles (1-3 miles), 1,923 (39%) occur between three and five miles (3-5 miles), and 870 (18%) occur outside of five miles (>5 miles).[49] In this same post-construction group, a total of 730 homes that sold (15%) have a view of the wind turbines (see Figure 4). A large majority of those homes have MINOR view ratings (*n* = 561, 11% of total), with 2% having MODERATE ratings (*n*=106) and the remaining transactions roughly split between SUBSTANTIAL and EXTREME ratings (*n*=35, 0.6%, and *n*=28, 0.5%, respectively). A full description of the variables of interest and how they are arrayed at the study area level is contained in Appendix A.

Figure 3: Frequency of DISTANCE Ratings for Post-Construction Transactions



[48] The variable for the condition of the home was not uniform across study areas because, in some cases, it took into account construction grade while in others it did not.

[49] These numbers and percentages are skewed slightly from the overall population of transactions because homes outside of three miles were often under-sampled to reduce field data collection burdens. Further, higher numbers of homes fall into each of the categories when the post-announcement-pre-construction transactions are included, as they are in some models. These additional transactions are described below in Table 7 under “All Sales.”

Figure 4: Frequency of VIEW Ratings for Post-Construction Transactions

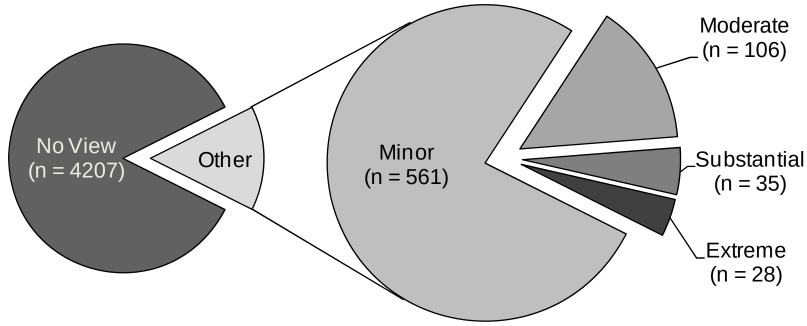


Table 6: Summary Statistics: All Sales and Post-Construction Sales

		All Sales			Post Construction Sales		
Variable Name	**Description**	**Freq. ***	**Mean**	**Std. Dev.**	**Freq. ***	**Mean**	**Std. Dev.**
SalePrice	The unadjusted sale price of the home (in US dollars)	7,459	102,968	64,293	4,937	110,166	69,422
SalePrice96	The sale price of the home adjusted to 1996 US dollars	7,459	79,114	47,257	4,937	80,156	48,906
LN_SalePrice96	The natural log transformation of the sale price of the home adjusted to 1996 US dollars	7,459	11.12	0.58	4,937	11.12	0.60
AgeatSale	The age of the home at the time of sale	7,459	46	37	4,937	47	36
AgeatSale_Sqrd	The age of the home at the time of sale squared	7,459	3,491	5,410	4,937	3,506	5,412
Sqft_1000	The number of square feet of above grade finished living area (in 1000s)	7,459	1.623	0.59	4,937	1.628	0.589
Acres	The number of Acres sold with the residence	7,459	1.13	2.42	4,937	1.10	2.40
Baths	The number of Bathrooms (Full Bath = 1, Half Bath = 0.5)	7,459	1.74	0.69	4,937	1.75	0.70
ExtWalls_Stone	If the home has exterior walls of stone, brick or stucco (Yes = 1, No = 0)	2,287	0.31	0.46	1,486	0.30	0.46
CentralAC	If the home has a Central AC unit (Yes = 1, No = 0)	3,785	0.51	0.50	2,575	0.52	0.50
Fireplace	The number of fireplace openings	2,708	0.39	0.55	1,834	0.40	0.55
Cul_De_Sac	If the home is situated on a cul-de-sac (Yes = 1, No = 0)	990	0.13	0.34	673	0.14	0.34
FinBsmt	If finished basement square feet is greater than 50% times first floor square feet (Yes = 1, No = 0)	1,472	0.20	0.40	992	0.20	0.40
Water_Front	If the home shares a property line with a body of water or river (Yes = 1, No = 0)	107	0.01	0.12	87	0.02	0.13
Cnd_Low	If the condition of the home is Poor (Yes = 1, No = 0)	101	0.01	0.12	69	0.01	0.12
Cnd_BAvg	If the condition of the home is Below Average (Yes = 1, No = 0)	519	0.07	0.25	359	0.07	0.26
Cnd_Avg	If the condition of the home is Average (Yes = 1, No = 0)	4,357	0.58	0.49	2,727	0.55	0.50
Cnd_AAvg	If the condition of the home is Above Average (Yes = 1, No = 0)	2,042	0.27	0.45	1,445	0.29	0.46
Cnd_High	If the condition of the home is High (Yes = 1, No = 0)	440	0.06	0.24	337	0.07	0.25
Vista_Poor	If the Scenic Vista from the home is Poor (Yes = 1, No = 0)	470	0.06	0.24	310	0.06	0.24
Vista_BAvg	If the Scenic Vista from the home is Below Average (Yes = 1, No = 0)	4,301	0.58	0.49	2,857	0.58	0.49
Vista_Avg	If the Scenic Vista from the home is Average (Yes = 1, No = 0)	1,912	0.26	0.44	1,247	0.25	0.44
Vista_AAvg	If the Scenic Vista from the home is Above Average (Yes = 1, No = 0)	659	0.09	0.28	448	0.09	0.29
Vista_Prem	If the Scenic Vista from the home is Premium (Yes = 1, No = 0)	117	0.02	0.12	75	0.02	0.12
SaleYear	The year the home was sold	7,459	2002	2.9	4,937	2004	2.3

** "Freq." applies to the number of cases the parameter's value is not zero*

Table 7: Summary of Variables of Interest: All Sales and Post-Construction Sales

		All Sales			Post Construction Sales		
Variable Name	**Description**	**Freq. ***	**Mean**	**Std. Dev.**	**Freq. ***	**Mean**	**Std. Dev.**
View_None	If the home sold after construction began and had no view of the turbines (Yes = 1, No = 0)	4,207	0.56	0.50	4,207	0.85	0.36
View_Minor	If the home sold after construction began and had a Minor View of the turbines (Yes = 1, No = 0)	561	0.08	0.26	561	0.11	0.32
View_Mod	If the home sold after construction began and had a Moderate View of the turbines (Yes = 1, No = 0)	106	0.01	0.12	106	0.02	0.15
View_Sub	If the home sold after construction began and had a Substantial View of the turbines (Yes = 1, No = 0)	35	-	0.07	35	0.01	0.08
View_Extrm	If the home sold after construction began and had a Extreme View of the turbines (Yes = 1, No = 0)	28	-	0.06	28	0.01	0.08
DISTANCE †	Distance to nearest turbine if the home sold after facility "announcement", otherwise 0	5,705	2.53	2.59	4,895	3.57	1.68
Mile_Less_0.57 †	If the home sold after facility "announcement" and was within 0.57 miles (3000 feet) of the turbines (Yes = 1, No = 0)	80	0.01	0.09	67	0.01	0.12
Mile_0.57to1 †	If the home sold after facility "announcement" and was between 0.57 miles (3000 feet) and 1 mile of the turbines (Yes = 1, No = 0)	65	0.01	0.09	58	0.01	0.11
Mile_1to3 †	If the home sold after facility "announcement" and was between 1 and 3 miles of the turbines (Yes = 1, No = 0)	2,359	0.27	0.44	2,019	0.41	0.49
Mile_3to5 †	If the home sold after facility "announcement" and was between 3 and 5 miles of the turbines (Yes = 1, No = 0)	2,200	0.26	0.44	1,923	0.39	0.49
Mile_Gtr5 †	If the home sold after facility "announcement" and was outside 5 miles of the turbines (Yes = 1, No = 0)	1,000	0.12	0.32	870	0.18	0.38

** "Freq." applies to the number of cases the parameter's value is not zero*

† "All Sales" freq., mean and standard deviation DISTANCE and DISTANCE fixed effects variables (e.g., Mile_1to3) include transactions that occurred after facility "announcement" and before "construction" as well as those that occured post-construction

4. Base Hedonic Model

This section uses the primary hedonic model ("Base Model") to assess whether residential sales prices are affected, in a statistically measurable way, by views of and proximity to wind power facilities. In so doing, it simultaneously tests for the presence of the three potential property value stigmas associated with wind power facilities: Area, Scenic Vista, and Nuisance. This section begins with a discussion of the dataset that is used and the form of the model that is estimated, and then turns to the results of the analysis. Various alternative hedonic models are discussed and estimated in Section 5, with Sections 6 and 7 providing a discussion of and results from the repeat sales and sales volume models.

4.1. Dataset

The data used for the Base Model were described in Section 3.3. A key threshold question is whether or not to include the residential transactions that pre-date the relevant wind facility. Specifically, though the complete dataset consists of 7,459 residential transactions, a number of these transactions (n = 2,522) occurred before the wind facility was constructed. Should these homes which, at the time of sale, would not have had any view of or distance to the wind facility, be included? Two approaches could be applied to address this issue. First, pre-construction transactions could be included in the hedonic model either as part of the reference category within which no wind-project property value impacts are assumed to exist, or instead by specifically identifying these pre-construction transactions through an indicator variable. Second, and alternatively, pre-construction transactions could simply be excluded from the analysis altogether.

For the purpose of the Base Model, the latter approach is used, therefore relying on only the post-construction subset of 4,937 residential transactions. This approach, as compared to the others, results in somewhat more intuitive findings because all homes have a distance greater than zero and have a possibility of some view of the turbines. More importantly, this approach minimizes the chance of inaccuracies that may otherwise exist due to inflation adjustment concerns or outdated home characteristics information.[50] Nonetheless, to test for the implications of this choice of datasets, alternative hedonic models that use the full dataset were estimated, and are discussed in detail in Sections 5.3 and 5.4.

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[50] Home characteristics were obtained as of the last property assessment. The timing of that assessment relative to the timing of the home sale transaction dictates how representative the assessed home characteristics are of the subject home when it was sold. For example, if a home sold early in the study period but subsequently had significant improvements made that are reflected in the current assessment data used in the analysis, the model would assign value to these home characteristics at the time of sale when, in fact, those characteristics were inaccurate. Additionally, the inflation adjustment index used in this analysis to translate home values to real 1996 dollars came from the nearest or more appropriate municipal statistical area (MSA). Many of the wind projects in the analysis are located in relatively rural parts of the country, and the housing market in the nearest metropolitan area could be different than the market surrounding wind projects. Although these areas have – in many instances – recently begun to attract home buyers willing to commute back to the metropolitan areas on which the index is based, the older index adjustments are likely less accurate than the more recent adjustments. Using a subset of the data for the majority of the analyses that removes the older, pre-construction, homes minimizes both of these biases.

4.2. Model Form

A standard semi-log functional form is used for the hedonic models (as was discussed in Section 2.1), where the dependent variable (sales price in inflation-adjusted 1996 dollars) is transformed to its natural log form and the independent variables (e.g., square feet and acres) are not transformed. Using this form to examine the effect that views of, and distance to, wind facilities have on sales prices, the following basic model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_{s} \beta_2 \mathrm{S} + \sum_{k} \beta_3 \mathrm{X} + \sum_{v} \beta_4 \mathrm{VIEW} + \sum_{d} \beta_5 \mathrm{DISTANCE} + \varepsilon \quad (1)$$

where

P represents the inflation-adjusted sales price,
N is the spatially weighted neighbors' predicted sales price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
VIEW is a vector of *v* categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),
DISTANCE is a vector of *d* categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a parameter estimate for the spatially weighted neighbor's predicted sales price,
β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to homes sold in the Washington/Oregon (WAOR) study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles, and
ε is a random disturbance term.

As such, this model, and all subsequent hedonic models, has four primary groups of parameters: variables of interest, spatial adjustments, study-area fixed effects, and home and site characteristics.

The variables of interest, VIEW and DISTANCE, are the focus of this study, and allow the investigation of the presence of Area, Scenic Vista, and Nuisance Stigmas. These variables were defined in Section 3, and are summarized in Table 8. Both VIEW and DISTANCE appear in the model together because a home's value may be affected in part by the magnitude of the view of the wind turbines, and in part by the distance from the home to those turbines, and both variables appear in the Base Model as ordered categorical values. The coefficients associated with these two vectors of variables (β_4 and β_5) represent the marginal impact of views of, and distances to, wind turbines on sales prices, as compared to a "reference" category of residential transactions, and should be ordered monotonically from low to high.[51] This form of variable was used to

[51] "Reference category" refers to the subset of the sample to which other observations are compared, and is pertinent when using categorical or "fixed effect" variables.

impose the least structure on the underlying data.[52] For the purpose of the Base Model, the reference category for the DISTANCE variables are those transactions of homes that were situated outside of five miles from the nearest wind turbine. The reference category for the VIEW variables are those transactions of homes that did not have a view of the wind facility upon sale. Among the post-construction sample of homes, these reference homes are considered the least likely to be affected by the presence of the wind facilities.[53]

Table 8: List of Variables of Interest Included in the Base Model

Variable Name	Description	Type	Expected Sign
View_None	If the home sold after construction began and had no view of the turbines (Yes = 1, No = 0)	Reference	n/a
View_Minor	If the home sold after construction began and had a Minor View of the turbines (Yes = 1, No = 0)	OC	-
View_Mod	If the home sold after construction began and had a Moderate View of the turbines (Yes = 1, No = 0)	OC	-
View_Sub	If the home sold after construction began and had a Substantial View of the turbines (Yes = 1, No = 0)	OC	-
View_Extrm	If the home sold after construction began and had an Extreme View of the turbines (Yes = 1, No = 0)	OC	-
Mile_Less_0.57	If the home sold after facility "construction" and was within 0.57 miles (3000 feet) of the turbines (Yes = 1, No = 0)	OC	-
Mile_0.57to1	If the home sold after facility "construction" and was between 0.57 miles (3000 feet) and 1 mile of the turbines (Yes = 1, No = 0)	OC	-
Mile_1to3	If the home sold after facility "construction" and was between 1 and 3 miles of the turbines (Yes = 1, No = 0)	OC	-
Mile_3to5	If the home sold after facility "construction" and was between 3 and 5 miles of the turbines (Yes = 1, No = 0)	OC	-
Mile_Gtr5	If the home sold after facility "construction" and was outside 5 miles of the turbines (Yes = 1, No = 0)	Reference	n/a

"OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the reference categorical case and are expected to have a monotonic order from low to high.

The three stigmas are investigated though these VIEW and DISTANCE variables. Scenic Vista Stigma is investigated through the VIEW variables. Area and Nuisance Stigmas, on the other hand, are investigated through the DISTANCE variables. To distinguish between Area and

[52] In place of the ordered categorical DISTANCE variables, practitioners often rely on a continuous DISTANCE form (e.g., Sims et al., 2008). Similar to ordered categorical variables, continuous variables have a natural ordering, either ascending or descending, but, unlike categorical variables, these "continuous" values are on a scale. Therefore, given any two of its values X_1 and X_2 and a specific functional form, the ratio "X_1/X_2" and the distance "$X_1 - X_2$" have a fixed meaning. Examples of continuous variables other than DISTANCE that are commonly used include the number of square feet of living area (in 1000s) in a home (SQFT_1000) or the acres in the parcel (ACRES). A continuous functional form of this nature "imposes structure" because practitioners must decide how price is related to the underlying variables through the selection of a specific functional relationship between the two. For instance, in the case of DISTANCE, is there a linear relationship (which would imply a similar marginal difference between two distances both near and far from the turbines), does it decay slowly as distance grows, or does it fade completely at some fixed distance? Because of the lack of literature in this area, no *a priori* expectations for which functional form is the best were established, and therefore unstructured categorical variables are used in the Base Model. Nonetheless, a continuous DISTANCE form is explored in Section 5.2.

[53] It is worth noting that these reference homes are situated in both rural and urban locales and therefore are not uniquely affected by influences from either setting. This further reinforces their worthiness as a reference category.

Nuisance Stigma, it is assumed that Nuisance effects are concentrated within one mile of the nearest wind turbine, while Area effects will be considered for those transactions outside of one mile. Any property value effects discovered outside of one mile and based on the DISTANCE variables are therefore assumed to indicate the presence of Area Stigma, while impacts within a mile may reflect the combination of Nuisance and Area Stigma.

The second set of variables in the Base Model - spatial adjustments - correct for the assumed presence of spatial autocorrelation in the error term (ε). It is well known that the sales price of a home can be systematically influenced by the sales prices of those homes that have sold nearby. Both the seller and the buyer use information from comparable surrounding sales to inform them of the appropriate transaction price, and nearby homes often experience similar amenities and disamenities. This lack of independence of home sale prices could bias hedonic regression results and, to help correct for this bias, a spatially (i.e., distance) weighted neighbors' sales price (N) is included in the model. Empirically, the neighbors' price has been found to be a strong (and sometimes even the strongest) predictor of home values (Leonard and Murdoch, forthcoming), and the coefficient β_1 is expected to be positive, indicating a positive correlation between the neighbors' and subject home's sales price. A more-detailed discussion of the importance of this variable, and how it was created, is contained in Appendix G.

The third group of variables in the Base Model - study area fixed effects - control for study area influences and the differences between them. The vector's parameters β_2 represent the marginal impact of being in any one of the study areas, as compared to a reference category. In this case, the reference category is the Washington/Oregon (WAOR) study area.[54] The estimated coefficients for this group of variables represent the combined effects of school districts, tax rates, crime, and other locational influences across an entire study area. Although this approach greatly simplifies the estimation of the model, because of the myriad of influences captured by these study-area fixed effects variables, interpreting the coefficient can be difficult. In general, though, the coefficients simply represent the mean difference in sales prices between the study areas and the reference study area (WAOR). These coefficients are expected to be strongly influential, indicating significant differences in sales prices across study areas.

The fourth group of variables in the Base Model are the core home and site characteristics (X), and include a range of continuous ("C"),[55] discrete ("D"),[56] binary ("B"),[57] and ordered categorical ("OC") variables. The specific home and site variables included in the Base Model are listed in Table 9 along with the direction of expected influence.[58] Variables included are age

[54] Because there is no intent to focus on the coefficients of the study area fixed effect variables, the reference case is arbitrary. Further, the results for the other variables in the model are completely independent of this choice.

[55] See discussion in footnote 52 on previous page.

[56] Discrete variables, similar to continuous variables, are ordered and the distance between the values, such as X_1 and X_2, have meaning, but for these variables, there are only a relatively small number of discrete values that the variable can take, for example, the number of bathrooms in a home (BATHROOMS).

[57] Binary variables have only two conditions: "on" or "off" (i.e., "1" or "0" respectively). Examples are whether the home has central air conditioning ("CENTRAL_AC") or if the home is situated on a cul-de-sac ("CUL_DE_SAC"). The coefficients for these variables are interpreted in relation to when the condition is "off."

[58] For those variables with a "+" sign it is expected that as the variable increases in value (or is valued at "1" as would be the case for fixed effects variables) the price of the home will increase, and the converse is true for the variables with a "-" sign. The expected signs of the variables all follow conventional wisdom (as discussed in

of the home, home and lot size, number of bathrooms and fireplaces, the condition of the home, the quality of the scenic vista from the home, if the home has central AC, a stone exterior, and/or a finished basement, and whether the home is located in a cul-de-sac and/or on a water way.[59]

Table 9: List of Home and Site Characteristics Included in the Base Model

Variable Name	Description	Type	Expected Sign
AgeatSale	The age of the home at the time of sale in years	C	-
AgeatSale_Sqrd	The age of the home at the time of sale squared	C	+
Sqft_1000	The number of square feet of above grade finished living area (in 1000s)	C	+
Acres	The number of Acres sold with the residence	C	+
Baths	The number of Bathrooms (Full Bath = 1, Half Bath = 0.5)	D	+
ExtWalls_Stone	If the home has exterior walls of stone, brick or stucco (Yes = 1, No = 0)	B	+
CentralAC	If the home has a Central AC unit (Yes = 1, No = 0)	B	+
Fireplace	The number of fireplace openings	D	+
Cul_De_Sac	If the home is situated on a cul-de-sac (Yes = 1, No = 0)	B	+
FinBsmt	If finished basement sqft > 50% times first floor sqft (Yes = 1, No = 0)	B	+
Water_Front	If the home shares a property line with a body of water or river (Yes = 1, No = 0)	B	+
Cnd_Low	If the condition of the home is Poor (Yes = 1, No = 0)	OC	-
Cnd_BAvg	If the condition of the home is Below Average (Yes = 1, No = 0)	OC	-
Cnd_Avg	If the condition of the home is Average (Yes = 1, No = 0)	Reference	n/a
Cnd_AAvg	If the condition of the home is Above Average (Yes = 1, No = 0)	OC	+
Cnd_High	If the condition of the home is High (Yes = 1, No = 0)	OC	+
Vista_Poor	If the Scenic Vista from the home is Poor (Yes = 1, No = 0)	OC	-
Vista_BAvg	If the Scenic Vista from the home is Below Average (Yes = 1, No = 0)	OC	-
Vista_Avg	If the Scenic Vista from the home is Average (Yes = 1, No = 0)	Reference	n/a
Vista_AAvg	If the Scenic Vista from the home is Above Average (Yes = 1, No = 0)	OC	+
Vista_Prem	If the Scenic Vista from the home is Premium (Yes = 1, No = 0)	OC	+

"C" Continuous, "D" Discrete, and "B" Binary (1 = yes, 0 = no) values are interpreted in relation to "No"

"OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the reference categorical case and are expected to have a monotonic order from low to high.

Sirmans et al., 2005a), save AgeatSale and AgeatSale_Sqrd, which are expected to be negative and positive, respectively. The magnitude of the coefficient of AgeatSale is expected to be larger than that of AgeatSale_Sqrd indicating an initial drop in value as a home increases in age, and then an increase in value as the home becomes considerably older and more “historic.”

[59] Some characteristics, such as whether the home had a deck, a pool, or is located on a public sewer, are not available consistently across the dataset and therefore are not incorporated into the model. Other characteristics, such as the number of bedrooms, the number of stories, or if the home had a garage, are available but are omitted from the final model because they are highly correlated with characteristics already included in the model and therefore do not add significantly to the model’s explanatory power. More importantly, and as discussed in Appendix G, when their inclusion or exclusion are tested, the results are stable with those derived from the Base Model.

It should be emphasized that in the Base Hedonic Model - equation (1) - and in all subsequent models presented in Section 5, all variables of interest, spatial adjustments, and home and site characteristics are pooled, and therefore their estimates represent the average across all study areas. Ideally, one would have enough data to estimate a model at the study area level - a fully unrestricted model - rather than pooled across all areas. This fully unrestricted model form, along with 15 other model forms (with some variables restricted and others not), are discussed in detail in Appendix F. In total, these 16 different models were estimated to explore which model was the most parsimonious (had the fewest parameters), performed the best (e.g., had the highest adjusted R^2 and the lowest Schwarz information criterion[60]), and had the most stable coefficients and standard errors. The basic pooled model described by equation (1) is found to fit that description, and that model is therefore chosen as the Base Model to which others are compared. By making this choice the effort concentrates on identifying the presence of potential property value impacts across all of the study areas in the sample as opposed to any single study area.[61]

Finally, to assure that the model produces the best linear unbiased parameter estimates, the underlying assumptions of Ordinary Least Squares (OLS) regression techniques must be verified:

1) Homoskedastic error term;
2) Absence of temporal serial correlation;
3) Reasonably limited multicollinearity; and
4) Appropriate controls for outliers and influencers.[62]

These assumptions, and the specific approaches that are used to address them, are discussed in detail in Appendix G.

4.3. Analysis of Results

Table 10 (on page 32) presents the results of the Base Model (equation 1).[63] The model performs well, with an adjusted R^2 of 0.77.[64] The spatial adjustment coefficient (β_1) of 0.29 (*p* value 0.00) indicates that a 10% increase in the spatially weighted neighbor's price increases the subject home's value by an average of 2.9%. The study-area fixed effects (β_2) variables are all significant at the one percent level, demonstrating important differences in home valuations

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[60] The Schwarz information criterion measures relative parsimony between similar models (Schwarz, 1978).

[61] Because effects might vary between study areas, and the models estimate an average across all study areas, the full range of effects in individual study areas will go undetermined. That notwithstanding, there is no reason to suspect that effects will be completely "washed out." For that to occur, an effect in one study area would have to be positive while in another area it would have to be negative, and there is no reason to suspect that sales prices would increase because of the turbines in one community while decreasing in other communities.

[62] The absence of spatial autocorrelation is often included in the group of assumptions, but because it was discussed above (and in Appendix G), and is addressed directly by the variable (N_i) included in the model, it is not included in this list.

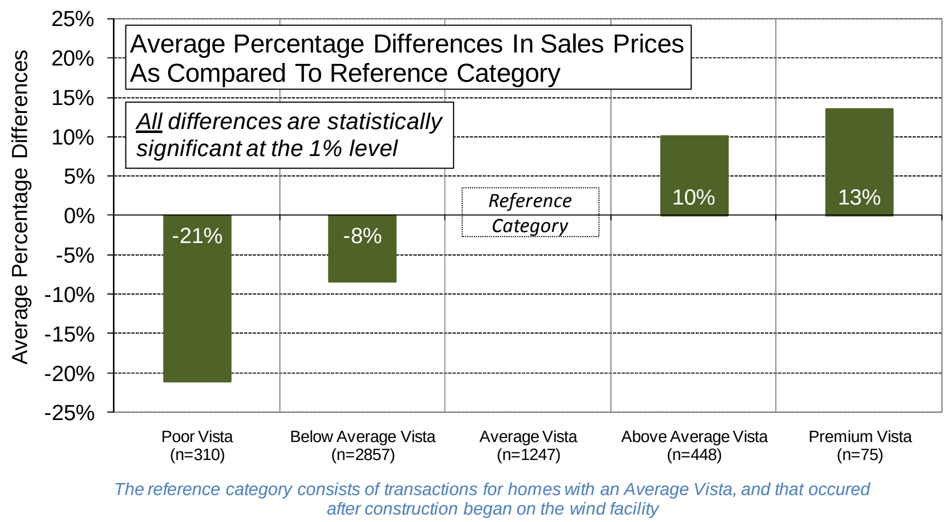
[63] This model and all subsequent models were estimated using the PROC REG procedure of SAS Version 9.2 TS1M0, which produces White's corrected standard errors.

[64] The appropriateness of the R^2 of 0.77 for this research is validated by the extensive hedonic literature that precedes it (see e.g., Kroll and Priestley, 1992; Boyle and Kiel, 2001; Simons, 2006b).

between the reference study area (WAOR) and the other nine study areas.[65] The sign and magnitudes of the home and site characteristics are all appropriate given the *a priori* expectations, and all are statistically significant at the one percent level.[66]

Of particular interest are the coefficient estimates for scenic vista (VISTA) as shown in Figure 5. Homes with a POOR vista rating are found, on average, to sell for 21% less (*p* value 0.00) than homes with an AVERAGE rating, while BELOW AVERAGE homes sell for 8% less (*p* value 0.00). Conversely, homes with an ABOVE AVERAGE vista are found to sell for 10% more (*p* value 0.00) than homes with an AVERAGE vista, while PREMIUM vista homes sell for 13% more than AVERAGE homes (*p* value 0.00). Based on these results, it is evident that home buyers and sellers capitalize the quality of the scenic vista in sales prices.[67]

Figure 5: Results from the Base Model for VISTA



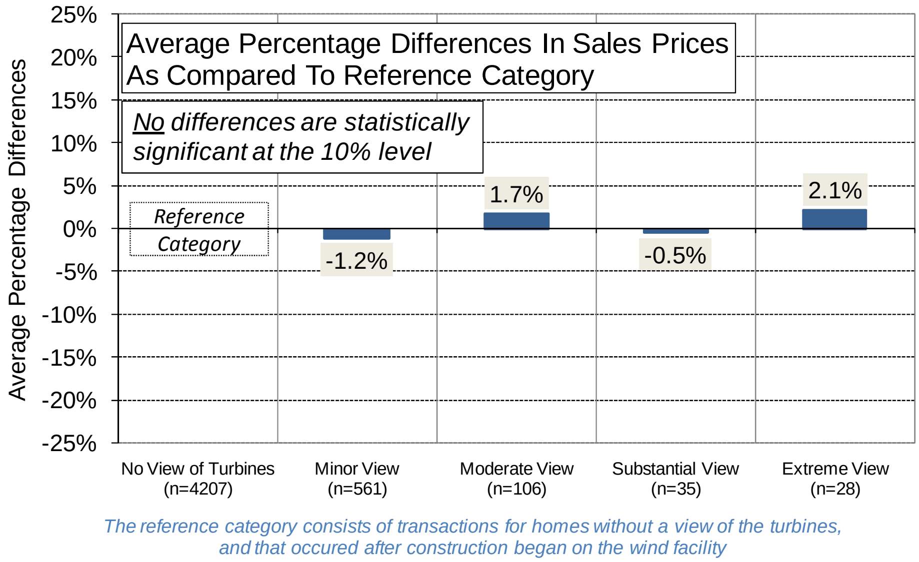
[65] The reference category WAOR study area has the highest mean and median house values in the sample (as shown in Appendix A) so the negative coefficients for all the study area fixed effect variables are appropriate.

[66] To benchmark the results against those of other practitioners the research by Sirmans et al. (2005a; 2005b) was consulted. They conducted a meta-analysis of 64 hedonic studies carried out in multiple locations in the U.S. during multiple time periods, and investigated the coefficients of ten commonly used characteristics, seven of which were included in the model. The similarities between their mean coefficients (i.e., the average across all 64 studies) and those estimated in the present Base Model are striking. The analysis presented here estimates the effect of square feet (in 1000s) on log of sales price at 0.28 and Sirmans et al. provide an estimate of 0.34, while ACRES was similarly estimated (0.02 to 0.03, Base Model and Sirmans et al., respectively). Further, AGEATSALE (age at the time of sale) (-0.006 to -0.009), BATHROOMS (0.09 to 0.09), CENTRALAC (0.09 to 0.08), and FIREPLACE (0.11 to 0.09) all similarly compare. As a group, the Base Model estimates differ from Sirmans et al. estimates in all cases by no more than a third of the Sirmans et al. mean estimate's standard deviation. This, taken with the relatively high adjusted R^2 of the Base Model, demonstrates the appropriateness of the model's specification.

[67] To benchmark these results they are compared to the few studies that have investigated the contribution of inland scenic vistas to sales prices. Benson et al. (2000) find that a mountain vista increases sales price by 8%, while Bourassa et al. (2004) find that wide inland vistas increase sales price by 7.6%. These both compare favorably to the 10% and 14% above average and premium rated VISTA estimates. Comparable studies for below average and poor VISTA were not found and therefore no benchmarking of those coefficients is conducted. Finally, it should again be noted that a home's scenic vista, as discussed in Section 3.2.3, was ranked without taking the presence of the wind turbines into consideration, even if those turbines were visible at the time of home sale.

Despite this finding for scenic vista, however, no statistically significant relationship is found between views of wind turbines and sales prices.[68] The coefficients for the VIEW parameters (β_4) are all relatively small, none are statistically significant, and they are not monotonically ordered (see Figure 6). Homes with EXTREME or SUBSTANTIAL view ratings, for which the Base Model is expected to find the largest differences, sell for, on average, 2.1% more (*p* value 0.80) and 0.5% less (*p* value 0.94) than NO VIEW homes that sold in the same post-construction period. Similarly, homes with MODERATE or MINOR view ratings sell, on average, for 1.7% more (*p* value 0.58) and 1.2% less (*p* value 0.40) than NO VIEW homes, respectively. None of these coefficients are sizable, and none are statistically different from zero. These results indicate that, among this sample at least, a statistically significant relationship between views of wind turbines and residential property values is not evident. In other words, there is an absence of evidence of a Scenic Vista Stigma in the Base Model.

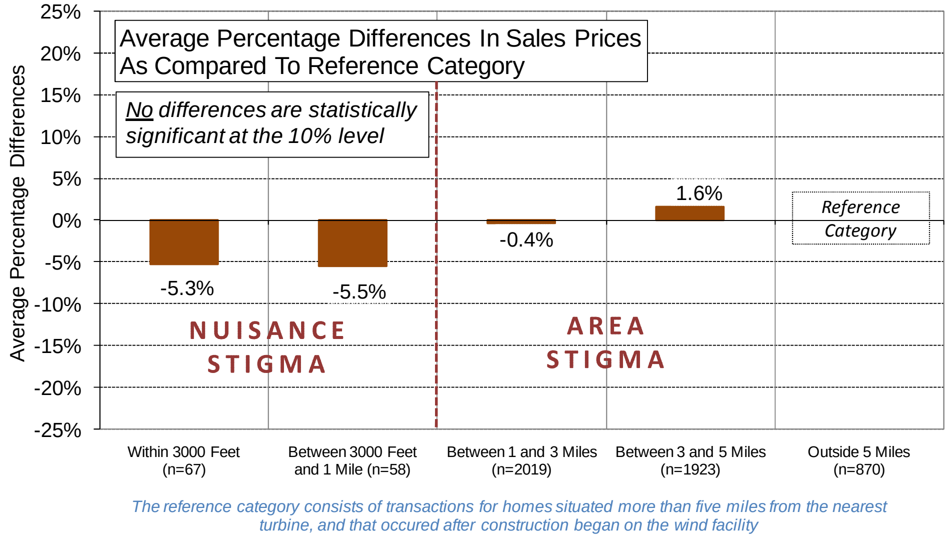
Figure 6: Results from the Base Model for VIEW



The coefficients for the DISTANCE parameters (β_5) are also all relatively small and none are statistically significant (see Figure 7). Homes that are situated within 3000 feet (0.57 miles) of the nearest wind turbine, at the time of sale, are found to sell for 5.3% less (*p* value 0.40), on average, than homes outside of 5 miles that sold in the same "post-construction" period. Meanwhile, homes between 3000 feet and 1 mile sold for 5.5% less (*p* value 0.30), on average, than homes more than 5 miles away. Homes that are within 1 to 3 miles of the nearest turbine, as compared to homes outside of 5 miles, sold for essentially the same, on average (coefficient = 0.004, *p* value 0.80), while homes between 3 and 5 miles sold for 1.6% more (*p* value 0.23).

[68] A significance level of 10% is used throughout this report, which corresponds to a *p*-value at or above 0.10. Although this is more liberal than the often used 5% (*p*-value at or above 0.05), it was chosen to give more opportunities for effects that might be fairly weak to be considered significant.

Figure 7: Results from the Base Model for DISTANCE



Looking at these results as a whole, a somewhat monotonic order from low to high is found as homes are situated further away from wind facilities, but all of the coefficients are relatively small and none are statistically different from zero. This suggests that, for homes in the sample at least, there is a lack of statistical evidence that the distance from a home to the nearest wind turbine impacts sales prices, and this is true regardless of the distance band.[69] As such, an absence of evidence of an Area or Nuisance Stigma is found in the Base Model. That notwithstanding, the -5% coefficients for homes that sold within one mile of the nearest wind turbine require further scrutiny. Even though the differences are not found to be statistically significant, they might point to effects that exist but are too small for the model to deem statistically significant due to the relatively small number of homes in the sample within 1 mile of the nearest turbine. Alternatively, these homes may simply have been devalued even before the wind facility was erected, and that devaluation may have carried over into the post construction period (the period investigated by the Base Model). To explore these possibilities, transactions that occurred well before the announcement of the wind facility to well after construction are investigated in the Temporal Aspects Model in the following "Alternative Models" section.

[69] It is worth noting that the number of cases in each of these categories (e.g., *n* = 67 for homes inside of 3000 feet and *n* = 58 between 3000 feet and one mile) are small, but are similar to the numbers of cases for other variables in the same model (e.g., LOW CONDITION, *n* = 69; PREMIUM VISTA, *n* = 75), the estimates of which were found to be significant above the 1% level.

Table 10: Results from the Base Model

	Coef.	SE	p Value	*n*
Intercept	7.62	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.33	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.14	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Post Con NoView	Omitted	Omitted	Omitted	4,207
View Minor	-0.01	0.01	0.40	561
View Mod	0.02	0.03	0.58	106
View Sub	-0.01	0.07	0.94	35
View Extrm	0.02	0.09	0.80	28
Mile Less 0 57	-0.05	0.06	0.40	67
Mile 0 57to1	-0.05	0.05	0.30	58
Mile 1to3	0.00	0.02	0.80	2,019
Mile 3to5	0.02	0.01	0.23	1,923
Mile Gtr5	Omitted	Omitted	Omitted	870

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**37**
F Statistic	**442.8**
Adjusted R Squared	**0.77**

5. Alternative Hedonic Models

The Base Hedonic Model presented in Section 4 found that residential property values have, on average, not been measurably affected by the presence of nearby wind facilities. To test the robustness of this result and to test for other possible impacts from nearby wind projects, the report now turns to a number of other hedonic models. These Alternative Models were created to investigate different approaches to exploring the impact of the variables of interest (#1 and #2, below) and to assess the presence of impacts that are not otherwise fully captured by the Base Model (#3 through #6, below).

1) **View and Distance Stability Models:** Using only post-construction transactions (the same as the Base Model) these models investigate whether the Scenic Vista Stigma (as measured with VIEW) results are independent of the Nuisance and Area Stigma results (as measured by DISTANCE) and vice versa.[70]
2) **Continuous Distance Model:** Using only post-construction transactions, this model investigates Area and Nuisance Stigmas by applying a continuous distance parameter as opposed to the categorical variables for distance used in the previous models.
3) **All Sales Model:** Using all transactions, this model investigates whether the results for the three stigmas change if transactions that occurred before the announcement and construction of the wind facility are included in the sample.
4) **Temporal Aspects Model:** Using all transactions, this model further investigates Area and Nuisance Stigmas and how they change for homes that sold more than two years pre-announcement through the period more than four years post-construction.
5) **Home Orientation Model:** Using only post-construction transactions, this model investigates the degree to which a home's orientation to the view of wind turbines affects sales prices.
6) **View and Vista Overlap Model:** Using only post-construction transactions, this model investigates the degree to which the overlap between the view of a wind facility and a home's primary scenic vista affects sales prices.

Each of these models is described in more depth in the pages that follow. Results are shown for the variables of interest only; full results are contained in Appendix H.

5.1. View and Distance Stability Models

The Base Model (equation 1) presented in Section 4 includes both DISTANCE and VIEW variables because a home's value might be affected in part by the magnitude of the view of a nearby wind facility and in part by the distance from the home to that facility. These two variables may be related, however, in-so-far as homes that are located closer to a wind facility are likely to have a more-dominating view of that facility. To explore the degree to which these two sets of variables are independent of each other (i.e. not collinear) and to further test the robustness of the Base Model results two alternative hedonic models are run, each of which includes only one of the sets of parameters (DISTANCE or VIEW). Coefficients from these models are then compared to the Base Model results.

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[70] Recall that the qualitative VIEW variable incorporated the visible distance to the nearest wind facility.

5.1.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing again on post-construction transactions (*n* = 4,937). To investigate DISTANCE effects alone the following model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{d}\beta_5\mathrm{DISTANCE} + \varepsilon \qquad (2)$$

where
P represents the inflation-adjusted sales price,
N is the spatially weighted neighbors' predicted sales price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a parameter estimate for the spatially weighted neighbor's predicted sales price,
β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to transactions of homes in the WAOR study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes situated outside of five miles, and
ε is a random disturbance term.

The parameters of primary interest are β_5, which represent the marginal differences between home values at various distances from the wind turbines as compared to the reference category of homes outside of five miles. These coefficients can then be compared to the same coefficients estimated from the Base Model.

Alternatively, to investigate the VIEW effects alone, the following model is estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{v}\beta_4\mathrm{VIEW} + \varepsilon \qquad (3)$$

where
VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
β_4 is a vector of *v* parameter estimates for the VIEW variables, and
all other components are as defined in equation (2).

The parameters of primary interest in this model are β_4, which represent the marginal differences between home values for homes with varying views of wind turbines at the time of sale as compared to the reference category of homes without a view of those turbines. Again, these coefficients can then be compared to the same coefficients estimated from the Base Model.

Our expectation for both of the models described here is that the results will not be dramatically different from the Base Model, given the distribution of VIEW values across the DISTANCE values, and vice versa, as shown in Table 11. Except for EXTREME view, which is concentrated inside of 3000 feet, all view ratings are adequately distributed among the distance categories.

Table 11: Frequency Crosstab of VIEW and DISTANCE Parameters

	Inside 3000 Feet	Between 3000 Feet and 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles	Outside 5 Miles	Total
No View	6	12	1653	1695	841	**4207**
Minor View	14	24	294	202	27	**561**
Moderate View	8	13	62	21	2	**106**
Substantial View	11	9	10	5	0	**35**
Extreme View	28	0	0	0	0	**28**
TOTAL	**67**	**58**	**2019**	**1923**	**870**	**4937**

5.1.2. Analysis of Results

Summarized results for the variables of interest from the Base Model and the two Alternative Stability Models are presented in Table 12. (For brevity, the full set of results for the models is not shown in Table 12, but is instead included in Appendix H.) The adjusted R^2 for the View and Distance Stability Models is the same as for the Base Model, 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in magnitude to the estimates presented earlier for the Base Model.

The DISTANCE and VIEW coefficients, β_5 and β_4, are stable, changing no more than 3%, with most (7 out of 8) not experiencing a change greater than 1%. In all cases, changes to coefficient estimates for the variables of interest are considerably less than the standard errors. Based on these results, there is confidence that the correlation between the VIEW and DISTANCE variables is not responsible for the findings and that these two variables are adequately independent to be included in the same hedonic model regression. As importantly, no evidence of Area, Scenic Vista, or Nuisance Stigma is found in the sample, as none of the VIEW or DISTANCE variables are found to be statistically different from zero.

Table 12: Results from Distance and View Stability Models

		Base Model			Distance Stability			View Stability		
Variables of Interest	***n***	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**
No View	4207	Omitted	Omitted	Omitted				Omitted	Omitted	Omitted
Minor View	561	-0.01	0.01	0.39				-0.02	0.01	0.24
Moderate View	106	0.02	0.03	0.57				0.00	0.03	0.90
Substantial View	35	-0.01	0.07	0.92				-0.04	0.06	0.45
Extreme View	28	0.02	0.09	0.77				-0.03	0.06	0.58
Inside 3000 Feet	67	-0.05	0.06	0.31	-0.04	0.04	0.25			
Between 3000 Feet and 1 Mile	58	-0.05	0.05	0.20	-0.06	0.05	0.17			
Between 1 and 3 Miles	2019	0.00	0.02	0.80	-0.01	0.02	0.71			
Between 3 and 5 Miles	1923	0.02	0.01	0.26	0.01	0.01	0.30			
Outside 5 Miles	870	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted			

"Omitted" = reference category for fixed effects variables. "n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**2**	**3**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**	**4937**
Number of Predictors (k)	**37**	**33**	**33**
F Statistic	**442.8**	**496.7**	**495.9**
Adjusted R Squared	**0.77**	**0.77**	**0.77**

5.2. Continuous Distance Model

The potential impact of wind facilities on residential property values based on Area and Nuisance effects was explored with the Base Model by using five ordered categorical DISTANCE variables. This approach was used in order to impose the least restriction on the functional relationship between distance and property values (as discussed in footnote 52 on page 25). The literature on environmental disamenities, however, more commonly uses a continuous distance form (e.g., Sims et al., 2008), which imposes more structure on this relationship. To be consistent with the literature and to test if a more rigid structural relationship might uncover an effect that is not otherwise apparent with the five distance categories used in the Base Model, a hedonic model that relies upon a continuous distance variable is presented here. One important benefit of this model is that a larger amount of data (e.g., *n* = 4,937) is used to estimate the continuous DISTANCE coefficient then was used to estimate any of the individual categorical estimates in the Base Model (e.g., *n* = 67 inside 3000 feet, *n* = 2019 between one and three miles). The Continuous Distance Model therefore provides an important robustness test to the Base Model results.

5.2.1. Dataset and Model Form

A number of different functional forms can be used for a continuous DISTANCE variable, including linear, inverse, cubic, quadratic, and logarithmic. Of the forms that are considered, an inverse function seemed most appropriate.[71] Inverse functions are used when it is assumed that any effect is most pronounced near the disamenity and that those effects fade asymptotically as distance increases. This form has been used previously in the literature (e.g., Leonard et al., 2008) to explore the impact of disamenities on home values, and is calculated as follows:

$$\text{InvDISTANCE} = 1/\text{DISTANCE} \qquad (4)$$

where
DISTANCE is the distances to the nearest turbine from each home as calculated at the time of sale for homes that sold in the post-construction period.

For the purpose of the Continuous Distance Model, the same dataset is used as in the Base Model, focusing again on post-construction transactions (*n* = 4,937). InvDISTANCE has a maximum of 6.67 (corresponding to homes that were 0.15 miles, or roughly 800 feet, from the nearest wind turbine), a minimum of 0.09 (corresponding to a distance of roughly 11 miles), and a mean of 0.38 (corresponding to a distance of 2.6 miles). This function was then introduced into the hedonic model in place of the DISTANCE categorical variables as follows:

$$\ln(\text{P}) = \beta_0 + \beta_1\text{N} + \sum_s \beta_2\text{S} + \sum_k \beta_3\text{X} + \sum_v \beta_4\text{VIEW} + \beta_5\text{InvDISTANCE} + \varepsilon \qquad (5)$$

where
InvDISTANCE_i is the inverse of the distance to the nearest turbine,
β_5 is a parameter estimate for the inverse of the distance to the nearest turbine, and

[71] The other distance functions (e.g., linear, quadratic, cubic & logarithmic) were also tested. Additionally, two-part functions with interactions between continuous forms (e.g., linear) and categorical (e.g., less than one mile) were investigated. Results from these models are briefly discussed below in footnote 72.

all other components are as defined in equation (1).

The coefficient of interest in this model is β_5, which, if effects exist, would be expected to be negative, indicating an adverse effect from proximity to the wind turbines.

5.2.2. Analysis of Results

Results for the variables of interest in the Continuous Distance Model and the Base Model are shown in Table 13. (For brevity, the full set of results for the model is not shown in Table 13, but is instead included in Appendix H.) The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at the one percent level. The coefficients for VIEW are similar to those found in the Base Model, demonstrating stability in results, and none are statistically significant. These results support the previous findings of a lack of evidence of a Scenic Vista Stigma.

Our focus variable InvDISTANCE produces a coefficient (β_5) that is slightly negative at -1%, but that is not statistically different from zero (*p* value 0.41), implying again that there is no statistical evidence of a Nuisance Stigma effect nor an Area Stigma effect and confirming the results obtained in the Base Model.[72]

Table 13: Results from Continuous Distance Model

	Base Model				**Continuous Distance**			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.01	0.01	0.32	561
Moderate View	0.02	0.03	0.57	106	0.01	0.03	0.77	106
Substantial View	-0.01	0.07	0.92	35	-0.02	0.07	0.64	35
Extreme View	0.02	0.09	0.77	28	0.01	0.10	0.85	28
Inside 3000 Feet	-0.05	0.06	0.31	67				
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58				
Between 1 and 3 Miles	0.00	0.02	0.80	2,019				
Between 3 and 5 Miles	0.02	0.01	0.26	1,923				
Outside 5 Miles	Omitted	Omitted	Omitted	870				
InvDISTANCE					-0.01	0.02	0.41	4,937

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Continuous Distance
Model Equation Number	**1**	**5**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**34**
F Statistic	**442.8**	**481.3**
Adjusted R Squared	**0.77**	**0.77**

5.3. All Sales Model

The Base Model presented earlier relied on only those transactions that occurred after the construction of the relevant wind facility. This approach, however, leaves open two key questions. First, it is possible that the property values of all of the post-construction homes in the

[72] As mentioned in footnote 71 on page 36, a number of alternative forms of the continuous distance function were also explored, including two-part functions, with no change in the results presented here. In all cases the resulting continuous distance function was not statistically significant.

sample have been affected by the presence of a wind facility, and therefore that the reference homes in the Base Model (i.e., those homes outside of five miles with no view of a wind turbine) are an inappropriate comparison group because they too have been impacted.[73] Using only those homes that sold before the announcement of the wind facility (pre-announcement) as the reference group would, arguably, make for a better comparison because the sales price of those homes are not plausibly impacted by the presence of the wind facility.[74] Second, the Base Model does not consider homes that sold in the post-announcement but pre-construction period, and previous research suggests that property value effects might be very strong during this period, during which an assessment of actual impacts is not possible and buyers and sellers may take a more-protective and conservative stance (Wolsink, 1989). This subsection therefore presents the results of a hedonic model that uses the full set of transactions in the dataset, pre- and post-construction.

5.3.1. Dataset and Model Form

Unlike the Base Model, in this instance the full set of 7,459 residential transactions is included. The following model is then estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_{s} \beta_2 \mathrm{S} + \sum_{k} \beta_3 \mathrm{X} + \sum_{v} \beta_4 \mathrm{VIEW} + \sum_{d} \beta_5 \mathrm{DISTANCE} + \varepsilon \qquad (6)$$

where

VIEW is a vector of *v* categorical view variables (e.g., NONE, MINOR, MODERATE, etc.),

DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, outside of five mile, etc.),

β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to pre-construction transactions,

β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to pre-announcement transactions, and

all other components are as defined in equation (1).

It is important to emphasize that the VIEW and DISTANCE parameters in equation (6) have different reference categories than they do in the Base Model - equation (1). In the Base Model, DISTANCE and VIEW are estimated in the post-construction period in reference to homes that sold outside of five miles and with no view of the turbines respectively.[75] In the All Sales Model, on the other hand, the coefficients for VIEW (β_4) are estimated in reference to all pre-construction transactions (spanning the pre-announcement and post-announcement-pre-construction periods) and the coefficients for DISTANCE (β_5) are estimated in reference to all pre-announcement transactions. In making a distinction between the reference categories for VIEW and DISTANCE, it is assumed that awareness of the view of turbines and awareness of

[73] This might be the case if there is an Area Stigma that includes the reference homes.

[74] As discussed in footnote 47 on page 19, it is conceivable that awareness might occur prior to the "announcement" date used for this analysis. If true, this bias is likely to be sporadic in nature and less of an issue in this model, when all pre-announcement transactions are pooled (e.g., both transactions near and far away from where the turbines were eventually located) than in models presented later (e.g., temporal aspects model). Nonetheless, if present, this bias may weakly draw down the pre-announcement reference category.

[75] See Section 4.1 and also footnote 51 on page 24 for more information on why the post-construction dataset and five-mile-no-view homes reference category are used in the Base Model.

the distance from them might not occur at the same point in the development process. Specifically, it is assumed that VIEW effects largely occur after the turbines are erected, in the post-construction period, but that DISTANCE effects might occur in the post-announcement-pre-construction timeframe. For example, after a wind facility is announced, it is not atypical for a map of the expected locations of the turbines to be circulated in the community, allowing home buyers and sellers to assess the distance of the planned facility from homes. Because of this assumed difference in when awareness begins for VIEW and DISTANCE, the DISTANCE variable is populated for transactions occurring in the post-announcement-pre-construction period as well as the post-construction period (see Table 14 below), but the VIEW variable is populated only for transactions in the post-construction period – as they were in the Base Model.[76]

Table 14: Frequency Summary for DISTANCE in All Sales Model

	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Post-Construction	67	58	2019	1923	870	**4937**
Post-Announcement-Pre-Construction	13	7	340	277	130	**767**
TOTAL	**80**	**65**	**2359**	**2200**	**1000**	**5704**

One beneficial consequence of the differences in reference categories for the VIEW and DISTANCE variables in this model, as opposed to the Base Model, is that this model can accommodate all of the possible VIEW and DISTANCE categories, including NO VIEW transactions and transactions of homes outside of five miles. Because of the inclusion of these VIEW and DISTANCE categories, the tests to investigate Area, Scenic Vista, and Nuisance Stigmas are slightly different in this model than in the Base Model. For Area Stigma, for example, how homes with no view of the turbines fared can now be tested; if they are adversely affected by the presence of the wind facility, then this would imply a pervasive Area Stigma impact. For Scenic Vista Stigma, the VIEW coefficients (MINOR, MODERATE, etc.) can be compared (using a *t*-Test) to the NO VIEW results; if they are significantly different, a Scenic Vista Stigma would be an obvious culprit. Finally, for Nuisance Stigma, the DISTANCE coefficients inside of one mile can be compared (using a *t*-Test) to those outside of five miles; if there is a significant difference between these two categories of homes, then homes are likely affected by their proximity to the wind facility.

5.3.2. Analysis of Results

Results for the variables of interest for this hedonic model are summarized in Table 15, and Base Model results are shown for comparison purposes. (For brevity, the full set of results for the model is not shown in Table 15, but is instead included in Appendix H.) The adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e. less explanatory power) modeling transactions that occurred pre-

[76] It is conceivable that VIEW effects could occur before the turbines are constructed. In some cases, for example, developers will simulate what the project will look like after construction during the post-announcement but pre-construction timeframe. In these situations, home buyers and sellers might adjust home values accordingly based on the expected views of turbines. It is assumed, however, that such adjustments are likely to be reasonably rare, and VIEW effects are therefore estimated using only post-construction sales.

construction.[77] All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in sign and magnitude to the estimates derived from the post-construction Base Model.

The VIEW coefficients (β_4) are clearly affected by the change in reference category. All of the VIEW parameter estimates are higher than the Base Model estimates for the same categories. Of particular interest is the NO VIEW coefficient, which represents the values of homes without a view of the turbines and that sold in the post-construction period, as compared to the mean value of homes that sold in the pre-construction period, all else being equal. These homes, on average, are estimated to sell for 2% (*p* value 0.08) more than similar pre-construction homes. If an Area Stigma existed, a negative coefficient for these NO VIEW homes would be expected. Instead, a positive and statistically significant coefficient is found.[78] It is outside the ability of this study to determine whether the increase is directly related to the wind turbines, or whether some other factor is impacting these results, but in either instance, no evidence of a pervasive Area Stigma associated with the presence of the wind facilities is found.

To test for the possibility of Scenic Vista Stigma, the coefficients for MINOR, MODERATE, SUBSTANTIAL, and EXTREME views can be compared to the NO VIEW coefficient using a simple *t*-Test. Table 16 presents these results. As shown, no significant difference is found for any of the VIEW coefficients when compared to NO VIEW transactions. This reinforces the findings earlier that, within the sample at least, there is no evidence of a Scenic Vista Stigma.

The DISTANCE parameter estimates (β_5) are also found to be affected by the change in reference category, and all are lower than the Base Model estimates for the same categories. This result likely indicates that the inflation-adjusted mean value of homes in the pre-announcement period is slightly higher, on average, than for those homes sold outside of five miles in the post-construction period. This difference could be attributed to the inaccuracy of the inflation index, a pervasive effect from the wind turbines, or to some other cause. Because the coefficients are not systematically statistically significant, however, this result is not pursued further. What is of interest, however, is the negative 8% estimate for homes located between 3000 feet and one mile of the nearest wind turbine (*p* value 0.03). To correctly interpret this result, and to compare it to the Base Model, one needs to discern if this coefficient is significantly different from the estimate for homes located outside of five miles, using a *t*-Test.

The results of this *t*-Test are shown in Table 17. The coefficient differences are found to be somewhat monotonically ordered. Moving from homes within 3000 feet (-0.06, *p* value 0.22), and between 3000 feet and one mile (-0.08, *p* value 0.04), to between one and three miles (0.00, *p* value 0.93) and between three and five miles (0.01, *p* value 0.32) the DISTANCE coefficients are found to generally increase. Nonetheless, none of these coefficients are statistically significant except one, homes that sold between 3000 feet and one mile. The latter finding suggests the possibility of Nuisance Stigma. It is somewhat unclear why an effect would be found in this model, however, when one was not evident in the Base Model. The most likely

[77] This slight change in performance is likely due to the inaccuracies of home and site characteristics and the inflation adjustment for homes that sold in the early part of the study period. This is discussed in more detail in footnote 50 on page 23.

[78] For more on the significance level used for this report, see footnote 68 on page 30.

explanation is that the additional homes that are included in this model, specifically those homes that sold post-announcement but pre-construction, are driving the results. A thorough investigation of these "temporal" issues is provided in the next subsection.

In summation, no evidence is found of an Area or Scenic Vista Stigma in this alternative hedonic model, but some limited not-conclusive evidence of a Nuisance Stigma is detected. To further explore the reliability of this latter result, the analysis now turns to the Temporal Aspects Model.

Table 15: Results from All Sales Model

	Base Model				All Sales			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
Pre-Construction Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	2,522
No View	Omitted	Omitted	Omitted	4,207	0.02	0.01	0.08	4,207
Minor View	-0.01	0.01	0.39	561	0.00	0.02	0.77	561
Moderate View	0.02	0.03	0.57	106	0.03	0.03	0.41	106
Substantial View	-0.01	0.07	0.92	35	0.03	0.07	0.53	35
Extreme View	0.02	0.09	0.77	28	0.06	0.08	0.38	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.06	0.05	0.18	80
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.08	0.05	0.03	65
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.01	0.80	2,359
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.01	0.01	0.59	2,200
Outside 5 Miles	Omitted	Omitted	Omitted	870	0.00	0.02	0.78	1,000
Pre-Announcement Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	1,755

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	All Sales
Model Equation Number	**1**	**6**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**7459**
Number of Predictors (k)	**37**	**39**
F Statistic	**442.8**	**579.9**
Adjusted R Squared	**0.77**	**0.75**

Table 16: Results from Equality Test of VIEW Coefficients in the All Sales Model

	No View	**Minor View**	**Moderate View**	**Substantial View**	**Extreme View**
n	4,207	561	106	35	28
Coefficient	0.02	0.00	0.03	0.03	0.06
Coefficient Difference *	Reference	-0.02	0.00	0.01	0.04
Variance	0.0001	0.0003	0.0009	0.0030	0.0050
Covariance	n/a	0.00011	0.00010	0.00009	0.00008
Df	n/a	7419	7419	7419	7419
***t*-Test**	n/a	-1.20	0.17	0.23	0.58
Significance	n/a	0.23	0.87	0.82	0.57

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

Table 17: Results from Equality Test of DISTANCE Coefficients in the All Sales Model

	Inside 3000 Feet	Between 3000 Feet and 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles	Outside 5 Miles
n	80	65	2,359	2,200	1,000
Coefficient	-0.06	-0.08	0.00	0.01	0.00
Coefficient Difference *	-0.05	-0.08	0.00	0.01	Reference
Variance	0.0019	0.0015	0.0002	0.0002	0.0003
Covariance	0.00010	0.00013	0.00013	0.00015	n/a
Df	7419	7419	7419	7419	n/a
***t* Test**	-1.23	-2.06	0.09	1.00	n/a
Significance	0.22	0.04	0.93	0.32	n/a

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

5.4. Temporal Aspects Model

Based on the results of the All Sales Model, a more thorough investigation of how Nuisance and Area Stigma effects might change throughout the wind project development period is warranted. As discussed previously, there is some evidence that property value impacts may be particularly strong after the announcement of a disamenity, but then may fade with time as the community adjusts to the presence of that disamenity (e.g., Wolsink, 1989). The Temporal Aspects Model presented here allows for an investigation of how the different periods of the wind project development process affect estimates for the impact of DISTANCE on sales prices.

5.4.1. Dataset and Model Form

Here the full set of 7,459 residential transactions is used, allowing an exploration of potential property value impacts (focusing on the DISTANCE variable) throughout time, including in the pre-construction period. The following model is then estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_s \beta_2 \mathrm{S} + \sum_k \beta_3 \mathrm{X} + \sum_v \beta_4 \mathrm{VIEW} + \sum_y \beta_5 (\mathrm{DISTANCE} \cdot \mathrm{PERIOD}) + \varepsilon \qquad (7)$$

where
DISTANCE is a vector of categorical distance variables (e.g., less than one mile, between one and three miles, etc.),
PERIOD is a vector of categorical development period variables (e.g., after announcement and before construction, etc.),
β_5 is a vector of *y* parameter estimates for each DISTANCE and PERIOD category as compared to the transactions more than two years before announcement and outside of five miles, and
all other components are as defined in equation (1).

The PERIOD variable contains six different options:
1) More than two years before announcement;
2) Less than two years before announcement;
3) After announcement but before construction;
4) Less than two years after construction;
5) Between two and four years after construction; and

6) More than four years after construction.

In contrast to the Base Model, the two DISTANCE categories inside of one mile are collapsed into a single "less than one mile" group. This approach increases the number of transactions in each crossed subcategory of data, and therefore enhances the stability of the parameter estimates and decreases the size of the standard errors, thus providing an increased opportunity to discover statistically significant effects. Therefore, in this model the DISTANCE variable contains four different options:

1) Less than one mile;
2) Between one and three miles;
3) Between three and five miles; and
4) Outside of five miles.[79]

The number of transactions in each of the DISTANCE and PERIOD categories is presented in Table 18.

The coefficients of interest are β_5, which represent the vector of marginal differences between homes sold at various distances from the wind facility (DISTANCE) during various periods of the development process (PERIOD) as compared to the reference group. The reference group in this model consists of transactions that occurred more than two years before the facility was announced for homes that were situated more than five miles from where the turbines were ultimately constructed. It is assumed that the value of these homes would not be affected by the future presence of the wind facility. The VIEW parameters, although included in the model, are not interacted with PERIOD and therefore are treated as controlling variables.[80]

Although the comparisons of these categorical variables between different DISTANCE and PERIOD categories is be interesting, it is the comparison of coefficients within each PERIOD and DISTANCE category that is the focus of this section. Such comparisons, for example, allow one to compare how the average value of homes inside of one mile that sold two years before announcement compare to the average value of homes inside of one mile that sold in the post-announcement-pre-construction period. For this comparison, a *t*-Test similar to that in the All Sales Model is used.

[79] For homes that sold in the pre-construction time frame, no turbines yet existed, and therefore DISTANCE is created using a proxy: the Euclidian distance to where the turbines were eventually constructed. This approach introduces some bias when there is more than one facility in the study area. Conceivably, a home that sold in the post-announcement-pre-construction period of one wind facility could also be assigned to the pre-announcement period of another facility in the same area. For this type of sale, it is not entirely clear which PERIOD and DISTANCE is most appropriate, but every effort was made to apply the sale to the wind facility that was most likely to have an impact. In most cases this meant choosing the closest facility, but in some cases, when development periods were separated by many years, simply the earliest facility was chosen. In general, any bias created by these judgments is expected to be minimal because, in the large majority of cases, the development process in each study area was more-or-less continuous and focused in a specific area rather then being spread widely apart.

[80] As discussed earlier, the VIEW variable was considered most relevant for the post-construction period, so delineations based on development periods that extended into the pre-construction phase were unnecessary. It is conceivable, however, that VIEW effects vary in periods following construction, such as in the first two years or after that. Although this is an interesting question, the numbers of cases for the SUBSTANTIAL and EXTREME ratings – even if combined – when divided into the temporal periods were too small to be fruitful for analysis.

Table 18: Frequency Crosstab of DISTANCE and PERIOD

	More Than 2 Years Before Announcement	Less Than 2 Years Before Announcement	After Announcement Before Construction	Less Than 2 Years After Construction	Between 2 and 4 Years After Construction	More Than 4 Years After Construction	Total
Less Than 1 Mile	38	40	20	39	45	43	**225**
Between 1 and 3 Miles	283	592	340	806	502	709	**3,232**
Between 3 and 5 Miles	157	380	277	572	594	757	**2,737**
Outside of 5 Miles	132	133	130	218	227	425	**1,265**
TOTAL	**610**	**1,145**	**767**	**1,635**	**1,368**	**1,934**	**7,459**

5.4.2. Analysis of Results

Results for the variables of interest for this hedonic model are presented in Table 19; as with previous models, the full set of results is contained in Appendix H. Similar to the All Sales Model discussed in the previous section, the adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e., less explanatory power) modeling transactions that occurred before wind facility construction. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

All of the DISTANCE / PERIOD interaction coefficients for distances outside of one mile are relatively small ($-0.04 < \beta_5 < 0.02$) and none are statistically significant. This implies that there are no statistically significant differences in property values between the reference category homes – homes sold more than two years before announcement that were situated outside of five miles from where turbines were eventually erected – and any of the categories of homes that sold outside of one mile at any other period in the wind project development process. These comparisons demonstrate, arguably more directly than any other model presented in this report that Area Stigma effects likely do not exist in the sample.

The possible presence of a Nuisance Stigma is somewhat harder to discern. For homes that sold inside of one mile of the nearest wind turbine, in three of the six periods there are statistically significant negative differences between average property values when compared to the reference category. Transactions completed more than two years before facility announcement are estimated to be valued at 13% less (*p* value 0.02) than the reference category, transactions less than two years before announcement are 10% lower (*p* value 0.06), and transactions after announcement but before construction are 14% lower (*p* value 0.04). For other periods, however, these marginal differences are considerably smaller and are not statistically different from the reference category. Sales prices in the first two years after construction are, on average, 9% less (*p* value 0.15), those occurring between three and four years following construction are, on average, 1% less (*p* value 0.86), and those occurring more than four years after construction are, on average, 7% less (*p* value 0.37).

Table 19: Results from Temporal Aspects Model

Variables of Interest		Temporal Aspects Coef	SE	p Value	*n*
Inside 1 Mile	More Than 2 Years Before Announcement	-0.13	0.06	0.02	38
	Less Than 2 Years Before Announcement	-0.10	0.05	0.06	40
	After Announcement Before Construction	-0.14	0.06	0.04	21
	2 Years After Construction	-0.09	0.07	0.11	39
	Between 2 and 4 Years After Construction	-0.01	0.06	0.85	44
	More Than 4 Years After Construction	-0.07	0.08	0.22	42
Between 1-3 Miles	More Than 2 Years Before Announcement	-0.04	0.03	0.18	283
	Less Than 2 Years Before Announcement	0.00	0.03	0.91	592
	After Announcement Before Construction	-0.02	0.03	0.54	342
	2 Years After Construction	0.00	0.03	0.90	807
	Between 2 and 4 Years After Construction	0.01	0.03	0.78	503
	More Than 4 Years After Construction	0.00	0.03	0.93	710
Between 3-5 Miles	More Than 2 Years Before Announcement	0.00	0.04	0.92	157
	Less Than 2 Years Before Announcement	0.00	0.03	0.97	380
	After Announcement Before Construction	0.00	0.03	0.93	299
	2 Years After Construction	0.02	0.03	0.55	574
	Between 2 and 4 Years After Construction	0.01	0.03	0.65	594
	More Than 4 Years After Construction	0.01	0.03	0.67	758
Outside 5 Miles	More Than 2 Years Before Announcement	Omitted	Omitted	Omitted	132
	Less Than 2 Years Before Announcement	-0.03	0.04	0.33	133
	After Announcement Before Construction	-0.03	0.03	0.39	105
	2 Years After Construction	-0.03	0.03	0.44	215
	Between 2 and 4 Years After Construction	0.03	0.03	0.44	227
	More Than 4 Years After Construction	0.01	0.03	0.73	424

"Omitted" = reference category for fixed effects variables.
"n" indicates number of cases in category when category = "1"

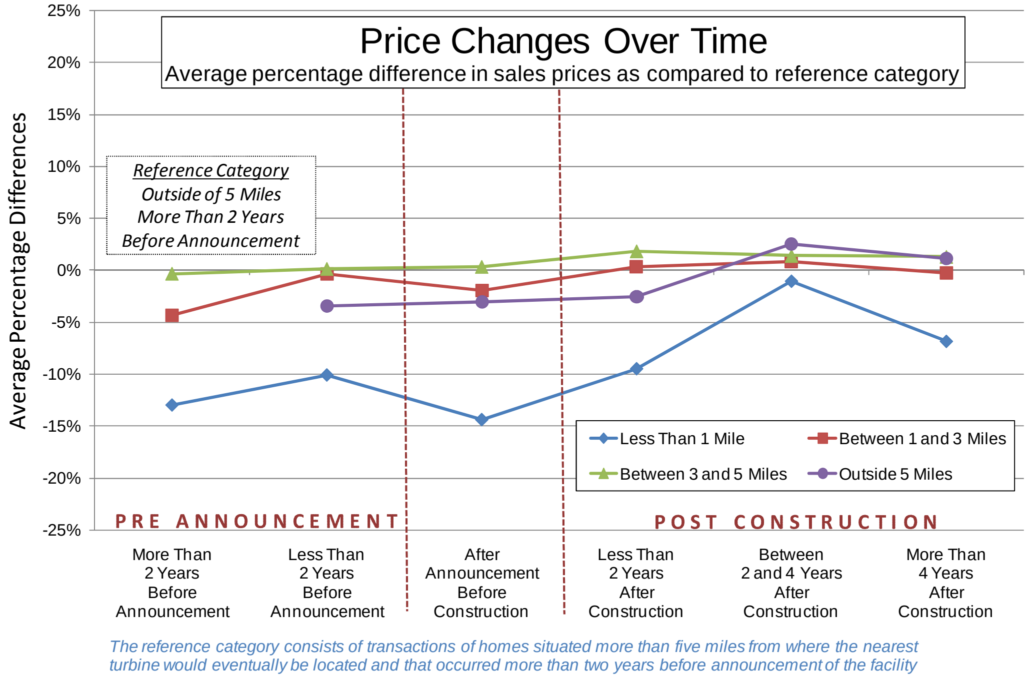
Model Information

Model Equation Number	7
Dependent Variable	LN_SalePrice96
Number of Cases	7459
Number of Predictors (k)	56
F Statistic	404.5
Adjusted R Squared	0.75

What these results suggest (as shown in Figure 8) is that homes inside of one mile in the sample, on average, were depressed in value (in relation to the reference category) before and after the announcement of the wind facility and up to the point that construction began, but that those values rebounded somewhat after construction commenced.[81] This conclusion also likely explains why a significant and negative effect for homes that sold between 3000 feet and one mile is found in the All Sales Model presented in Section 5.3: homes within this distance range that sold prior to facility construction were depressed in value and most likely drove the results for homes that sold after announcement. Regardless, these results are not suggestive of a pervasive Nuisance Stigma.

[81] As discussed in footnotes 47 (on page 19) and 74 (on page 38), the "announcement date" often refers to the first time the proposed facility appeared in the press. "Awareness" of the project in the community may precede this date, however, and therefore transactions occurring in the period "less than two years before announcement" could conceivably have been influenced by the prospective wind project, but it is considerably less likely that those in the period more than two years before announcement would have been influenced.

Figure 8: Results from the Temporal Aspects Model



To explore Nuisance Stigma further, the analysis again turns to the *t*-Test and compares the coefficients for transactions that occurred more than two years before wind facility announcement (during which time the future wind facility is not expected to have any impact on sales prices) to the estimates for the DISTANCE coefficients in the periods that follow. These results are shown in Table 20. Focusing on those transactions inside of one mile, it is found that all coefficients are greater in magnitude than the reference category except during the post-announcement-pre-construction period (which is 1% less and is not statistically significant; *p* value 0.90), indicating, on average, that home values are increasing or staying stable from the pre-announcement reference period onward. These increases, however, are not statistically significant except in the period of two to four years after construction (0.12, *p* value 0.08). With respect to Nuisance Stigma, the more important result is that, relative to homes that sold well before the wind facility was announced, no statistically significant adverse effect is found in any period within a one mile radius of the wind facility. Therefore, the -5% (albeit not statistically significant) average difference that is found in the Base Model, and the -8% (statistically significant) result that is found in the All Sales Model (for homes between 3000 feet and one mile) appear to both be a reflection of depressed home prices that preceded the construction of the relevant wind facilities. If construction of the wind facilities were downwardly influencing the sales prices of these homes, as might be deduced from the Base or All Sales Models alone, a diminution in the inflation adjusted price would be seen as compared to pre-announcement levels. Instead, an increase is seen. As such, no persuasive evidence of a Nuisance Stigma is evident among this sample of transactions.[82]

[82] It should be noted that the numbers of study areas represented for homes situated inside of one mile but in the periods "more than two years before announcement" and "more than four years after construction" are fewer (n = 5) than in the other temporal categories (n = 8). Further, the "more than two years before announcement – inside of one mile" category is dominated by transactions from one study area (OKCC). For these reasons, there is less

Turning to the coefficient differences for distances greater than one mile in Table 20, again, no statistical evidence of significant adverse impacts on home values is uncovered. Where statistically significant differences are identified, the coefficients are greater than the reference category. These findings corroborate the earlier Area Stigma results, and re-affirm the lack of evidence for such an effect among the sample of residential transactions included in this analysis.

Table 20: Results from Equality Test of Temporal Aspects Model Coefficients

	More Than 2 Years Before Announcement	Less Than 2 Years Before Announcement	After Announcement Before Construction	Less Than 2 Years After Construction	Between 2 and 4 Years After Construction	More Than 4 Years After Construction
Less Than 1 Mile	Reference	0.03 (0.45)	-0.01 (-0.13)	0.04 (0.56)	0.12 (1.74)*	0.06 (0.88)
Between 1 and 3 Miles	Reference	0.04 (1.92)*	0.02 (0.86)	0.05 (2.47)**	0.05 (2.27)**	0.04 (1.82)*
Between 3 and 5 Miles	Reference	0.01 (0.37)	0.01 (0.34)	0.02 (0.77)	0.02 (0.78)	0.02 (0.79)
Outside of 5 Miles †	Reference	-0.04 (-0.86)	-0.03 (-0.91)	-0.03 (-0.77)	0.03 (0.81)	0.01 (0.36)

*Numbers in parenthesis are t-Test statistics. Significance = *** 1% level, ** 5% level, * 10% level, <blank> below the 10% level.*

† For homes outside of 5 miles, the coefficient differences are equal to the coefficients in the Temporal Aspects Model, and therefore the t-values were produced via the OLS.

5.5. Orientation Model

All of the hedonic models presented to this point use a VIEW variable that effectively assumes that the impact of a view of wind turbines on property values will not vary based on the orientation of the home to that view; the impact will be the same whether the view is seen from the side of the home or from the back or front. Other literature, however, has found that the impact of wind projects on property values may be orientation-dependent (Sims et al., 2008). To investigate this possibility further a parameter for orientation is included in the model.

5.5.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing on post-construction transactions (n = 4,937). To investigate whether the orientation of a home to the turbines (ORIENTATION) has a marginal impact on residential property values, over and above that of the VIEW impacts alone, the following hedonic model is estimated:[83]

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confidence in these two estimates (-13% and -7% respectively) than for the estimates for other temporal periods inside of one mile. Based on additional sensitivity analysis not included here, it is believed that if they are biased, both of these estimates are likely biased downward. Further, as discussed in footnote 47 on page 19, there is a potential for bias in the "announcement" date in that awareness of a project may precede the date that a project enters the public record (i.e., the "announcement" date used for this analysis). Taken together, these two issues might imply that the curve shown in Figure 8 for "less than one mile" transactions, instead of having a flat and then increasing shape, may have a more of an inverse parabolic (e.g., "U") shape. This would imply that a relative minimum in sales prices is reached in the period after awareness began of the facility but before construction commenced, and then, following construction, prices recovered to levels similar to those prior to announcement (and awareness). These results would be consistent with previous studies (e.g., Wolsink, 1989; Devine-Wright, 2004) but cannot be confirmed without the presence of more data. Further research on this issue is warranted. In either case, such results would not change the conclusion here of an absence of evidence of a pervasive Nuisance Stigma in the post-construction period.

[83] The various possible orientations of the home to the view of turbines will be, individually and collectively, referred to as "ORIENTATION" in this report.

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_s \beta_2 \mathrm{S} + \sum_k \beta_3 \mathrm{X} + \sum_v \beta_4 \mathrm{VIEW} + \sum_d \beta_5 \mathrm{DISTANCE} + \sum_o \beta_6 \mathrm{ORIENTATION} + \varepsilon \quad (8)$$

where
ORIENTATION is a vector of *o* ORIENTATION variables (e.g., SIDE, FRONT, and BACK),
β_6 is a vector of *o* parameter estimates for ORIENTATION variables, and
all other components are as defined in equation (1).[84]

The ORIENTATION categories include FRONT, BACK, and SIDE, and are defined as follows:

- SIDE: The orientation of the home to the view of the turbines is from the side.
- FRONT: The orientation of the home to the view of the turbines is from the front.
- BACK: The orientation of the home to the view of the turbines is from the back.

The orientation of the home to the view of the wind facilities was determined in the course of the field visits to each home. If more than one orientation to the turbines best described the home (e.g., back and side, or front, back, and side) they were coded as such (e.g., turbines visible from back and side: SIDE = 1; BACK = 1; FRONT = 0).[85]

Not surprisingly, ORIENTATION is related to VIEW. Table 21 and Table 22 provide frequency and percentage crosstabs of ORIENTATION and VIEW. As shown, those homes with more dramatic views of the turbines generally have more ORIENTATION ratings applied to them. For instance, 25 out of 28 EXTREME VIEW homes have all three ORIENTATION ratings (i.e., FRONT, BACK, and SIDE). Virtually all of the MINOR VIEW homes, on the other hand, have only one ORIENTATION. Further, MINOR VIEW homes have roughly evenly spread orientations to the turbines across the various possible categories of FRONT, BACK, and SIDE. Conversely, a majority of the MODERATE and SUBSTANTIAL VIEW ratings coincide with an ORIENTATION from the back of the house.[86]

[84] Ideally, one would enter ORIENTATION in the model through an interaction with VIEW. There are two ways that could be accomplished: either with the construction of multiple fixed effects ("dummy") variables, which capture each sub-category of VIEW and ORIENTATION, or through a semi-continuous interaction variable, which would be created by multiplying the ordered categorical variable VIEW by an ordered categorical variable ORIENTATION. Both interaction scenarios are problematic, the former because it requires increasingly small subsets of data, which create unstable coefficient estimates, and the latter because there are no *a priori* expectations for the ordering of an ordered categorical ORIENTATION variable and therefore none could be created and used for the interaction. As a result, no interaction between the two variables is reported here.

[85] An "Angle" orientation was also possible, which was defined as being between Front and Side or Back and Side. An Angle orientation was also possible in combination with Back or Front (e.g., Back-Angle or Front-Angle). In this latter case, the orientation was coded as one of the two prominent orientations (e.g., Back or Front). An Angle orientation, not in combination with Front or Back, was coded as Side.

[86] The prevalence of BACK orientations for MODERATE and SUBSTANTIAL VIEW homes may be because BACK views might more-frequently be kept without obstruction, relative to SIDE views.

Table 21: Frequency Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	Moderate	Substantial	Extreme	Total
ORIENTATION	Front	217	33	17	27	**294**
	Back	164	67	24	25	**280**
	Side	194	17	15	27	**253**
	Total	**561**	**106**	**35**	**28**	**730**

Note: Total of ORIENTATION does not sum to 730 because multiple orientations are possible for each VIEW.

Table 22: Percentage Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	Moderate	Substantial	Extreme	Total
ORIENTATION	Front	39%	31%	49%	96%	**40%**
	Back	29%	63%	69%	89%	**38%**
	Side	35%	16%	43%	96%	**35%**

Note: Percentages are calculated as a portion of the total for each VIEW ratings (e.g., 24 of the 35 SUBSTANTIAL rated homes have a BACK ORIENTATION = 69%). Columns do not sum to 100% because multiple orientations are possible for each VIEW.

The parameter estimates of interest in this hedonic model are those for ORIENTATION (β_6) and VIEW (β_4). β_6 represent the marginal impact on home value, over and above that of VIEW alone, of having a particular orientation to the turbines. In the Base Model the VIEW coefficients effectively absorb the effects of ORIENTATION, but in this model they are estimated separately. Because a home's surrounding environment is typically viewed from the front or back of the house, one would expect that, to the extent that wind facility VIEW impacts property values, that impact would be especially severe for homes that have FRONT or BACK orientations to those turbines. If this were the case, the coefficients for these categories would be negative, while the coefficient for SIDE would be to be close to zero indicating little to no incremental impact from a SIDE ORIENTATION.

5.5.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 23; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model. The coefficients for DISTANCE and VIEW are stable, in sign and magnitude, when compared to the Base Model results, and none of the marginal effects are statistically significant.

The coefficients for the variables of interest (β_6) do not meet the *a priori* expectations. The estimated effect for SIDE ORIENTATION, instead of being close to zero, is -3% (*p* value 0.36), while BACK and FRONT, instead of being negative and larger, are estimated at 3% (*p* value 0.37) and -1% (*p* value 0.72), respectively. None of these variables are found to be even marginally statistically significant, however, and based on these results, it is concluded that there is no evidence that a home's orientation to a wind facility affects property values in a measurable way. Further, as with previous models, no statistical evidence of a Scenic Vista Stigma is found among this sample of sales transactions.

Table 23: Results from Orientation Model

	Base Model				Orientation Model			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4207	Omitted	Omitted	Omitted	4207
Minor View	-0.01	0.01	0.39	561	-0.01	0.06	0.88	561
Moderate View	0.02	0.03	0.57	106	0.00	0.06	0.96	106
Substantial View	-0.01	0.07	0.92	35	-0.01	0.09	0.85	35
Extreme View	0.02	0.09	0.77	28	0.02	0.17	0.84	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.04	0.07	0.46	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.26	58
Between 1 and 3 Miles	0.00	0.02	0.80	2019	0.00	0.02	0.83	2019
Between 3 and 5 Miles	0.02	0.01	0.26	1923	0.02	0.01	0.26	1923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Front Orientation					-0.01	0.06	0.72	294
Back Orientation					0.03	0.06	0.37	280
Side Orientation					-0.03	0.06	0.36	253

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Orientation Model
Model Equation Number	**1**	**8**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**410.0**
Adjusted R Squared	**0.77**	**0.77**

5.6. Overlap Model

The Orientation Model, presented above, investigated, to some degree, how the potential effects of wind turbines might be impacted by how a home is oriented to the surrounding environment. In so doing, this model began to peel back the relationship between VIEW and VISTA, but stopped short of looking at the relationship directly. It would be quite useful, though, to understand the explicit relationship between the VISTA and VIEW variables. In particular, one might expect that views of wind turbines would have a particularly significant impact on residential property values when those views strongly overlap ("OVERLAP") the prominent scenic vista from a home. To investigate this possibility directly, and, in general, the relationship between VIEW and VISTA, a parameter for OVERLAP is included in the model.

5.6.1. Dataset and Model Form

Data on the degree to which the view of wind turbines overlaps with the prominent scenic vista from the home (OVERLAP) were collected in the course of the field visits to each home.[87] The categories for OVERLAP included NONE, BARELY, SOMEWHAT, and STRONGLY, and are described in Table 24: [88]

Table 24: Definition of OVERLAP Categories

OVERLAP - NONE	The scenic vista does not contain any view of the turbines.
OVERLAP - BARELY	A small portion (~ 0 - 20%) of the scenic vista is overlapped by the view of turbines, and might contain a view of a few turbines, only a few of which can be seen entirely.
OVERLAP - SOMEWHAT	A moderate portion (~20-50%) of the scenic vista contains turbines, and likely contains a view of more than one turbine, some of which are likely to be seen entirely.
OVERLAP - STRONGLY	A large portion (~50-100%) of the scenic vista contains a view of turbines, many of which likely can be seen entirely.

A crosstab describing the OVERLAP designations and the VIEW categories is shown in Table 25. As would be expected, the more dramatic views of wind turbines, where the turbines occupy more of the panorama, are coincident with the OVERLAP categories of SOMEWHAT or STRONGLY. Nonetheless, STRONGLY are common for all VIEW categories. Similarly, SOMEWHAT is well distributed across the MINOR and MODERATE rated views, while BARELY is concentrated in the MINOR rated views.

The same dataset is used as in the Base Model, focusing on post-construction transactions (*n* = 4,937). To investigate whether the overlap of VIEW and VISTA has a marginal impact on residential property values, over and above that of the VIEW and VISTA impacts alone, the following hedonic model is estimated:[89]

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{v}\beta_4\mathrm{VIEW} + \sum_{d}\beta_5\mathrm{DISTANCE} + \sum_{t}\beta_6\mathrm{VISTA} + \sum_{p}\beta_7\mathrm{OVERLAP} + \varepsilon \quad (9)$$

where

VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
VISTA is a vector of *t* categorical scenic vista variables (e.g., POOR, BELOW-AVERAGE, etc.),
OVERLAP is a vector of *p* categorical overlap variables (e.g., BARELY, SOMEWHAT, etc.),

[87] Scenic vista was rated while taking into account the entire panorama surrounding a home. But, for each home, there usually was a prominent direction that offered a preferred scenic vista. Often, but not always, the home was orientated to enjoy that prominent scenic vista. Overlap is defined as the degree to which the view of the wind facility overlaps with this prominent scenic vista.

[88] "…can be seen entirely" refers to being able to see a turbine from the top of the sweep of its blade tips to below the nacelle of the turbine where the sweep of the tips intersects the tower.

[89] Although VISTA appears in all models, and is usually included in the vector of home and site characteristics represented by X, it is shown separately here so that it can be discussed directly in the text that follows.

β_4 is a vector of *v* parameter estimates for VIEW fixed effects variables as compared to transactions of homes without a view of the turbines,
β_6 is a vector of *t* parameter estimates for VISTA fixed effect variables as compared to transactions of homes with an AVERAGE scenic vista,
β_7 is a vector of *o* parameter estimates for OVERLAP fixed effect variables as compared to transactions of homes where the view of the turbines had no overlap with the scenic vista, and all other components are as defined in equation (1).

The variables of interest in this model are VIEW, VISTA and OVERLAP, and the coefficients β_4, β_6, and β_7 are therefore the primary focus. Theory would predict that the VISTA coefficients in this model would be roughly similar to those derived in the Base Model, but that the VIEW coefficients may be somewhat more positive as the OVERLAP variables explain a portion of any negative impact that wind projects have on residential sales prices. In that instance, the OVERLAP coefficients would be negative, indicating a decrease in sales price when compared to those homes that experience no overlap between the view of wind turbines and the primary scenic vista.

Table 25: Frequency Crosstab of OVERLAP and VIEW

		VIEW					
		None	**Minor**	**Moderate**	**Substantial**	**Extreme**	**Total**
OVERLAP	**None**	4,207	317	3	0	0	**4,527**
	Barely	0	139	10	1	0	**150**
	Somewhat	0	81	42	7	2	**132**
	Strongly	0	24	51	27	26	**128**
	Total	**4,207**	**561**	**106**	**35**	**28**	**4,937**

5.6.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 26; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

As expected from theory, the VISTA parameters are stable across models with no change in coefficient sign, magnitude, or significance. Counter to expectations, however, the VIEW coefficients, on average, decrease in value. MINOR VIEW is now estimated to adversely affect a home's sale price by 3% (*p* value 0.10) and is weakly significant, but none of the other VIEW categories are found to be statistically significant. Oddly, the OVERLAP rating of BARELY is found to significantly increase home values by 5% (*p* value 0.08), while none of the other OVERLAP ratings are found to have a statistically significant impact.

Taken at face value, these results are counterintuitive. For instance, absent any overlap of view with the scenic vista (NONE), a home with a MINOR view sells for 3% less than a home with no view of the turbines. If, alternatively, a home with a MINOR view BARELY overlaps the prominent scenic vista, it not only enjoys a 2% increase in value over a home with NO VIEW of the turbines but a 5% increase in value over homes with views of the turbines that do not overlap with the scenic vista. In other words, the sales price increases when views of turbines overlap the prominent scenic vista, at least in the BARELY category. A more likely explanation for these results are that the relatively high correlation (0.68) between the VIEW and OVERLAP parameters is spuriously driving one set of parameters up and the other down. More importantly, when the parameters are combined, they offer a similar result as was found in the Base Model. Therefore, it seems that the degree to which the view of turbines overlaps the scenic vista has a negligible effect on sales prices among the sample of sales transactions analyzed here.[90]

Despite these somewhat peculiar results, other than MINOR, none of the VIEW categories are found to have statistically significant impacts, even after accounting for the degree to which those views overlap the scenic vista. Similarly, none of the OVERLAP variables are simultaneously negative and statistically significant. This implies, once again, that a Scenic Vista Stigma is unlikely to be present in the sample. Additionally, none of the DISTANCE coefficients are statistically significant, and those coefficients remain largely unchanged from the Base Model, reaffirming previous results in which no significant evidence of either an Area or a Nuisance Stigma was found.

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[90] An alternative approach to this model was also considered, one that includes an interaction term between VIEW and VISTA. For this model it is assumed that homes with higher rated scenic vistas might have higher rated views of turbines, and that these views of turbines would decrease the values of the scenic vista. To construct the interaction, VISTA, which can be between one and five (e.g., POOR=1,…PREMIUM=5), was multiplied by VIEW, which can be between zero and four (e.g. NO VIEW=0, MINOR=1,…EXTREME=4). The resulting interaction (VIEW*VISTA) therefore was between zero and sixteen (there were no PREMIUM VISTA homes with an EXTREME VIEW), with zero representing homes without a view of the turbines, one representing homes with a POOR VISTA and a MINOR VIEW, and sixteen representing homes with either a PREMIUM VISTA and a SUBSTANTIAL VIEW or an ABOVE AVERAGE VISTA and an EXTREME VIEW. The interaction term, when included in the model, was relatively small (-0.013) and weakly significant (*p* value 0.10 – not White's corrected). The VISTA estimates were unchanged and the VIEW parameters were considerably larger and positive. For instance, EXTREME was 2% in the Base Model and 16% in this "interaction" model. Similarly, SUBSTANTIAL was -1% in the Base Model and 13% in this model. Therefore, although the interaction term is negative and weakly significant, the resulting VIEW estimates, to which it would need to be added, fully offset this negative effect. These results support the idea that the degree to which a VIEW overlaps VISTA has a likely negligible effect on sales prices, while also confirming that there is a high correlation between the interaction term and VIEW variables.

Table 26: Results from Overlap Model

Variables of Interest	Base Model				Overlap Model			
	Coef	SE	p Value	*n*	Coef	SE	p Value	*n*
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.03	0.02	0.10	561
Moderate View	0.02	0.03	0.57	106	-0.02	0.04	0.65	106
Substantial View	-0.01	0.07	0.92	35	-0.05	0.09	0.43	35
Extreme View	0.02	0.09	0.77	28	-0.03	0.10	0.73	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.05	0.06	0.32	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.27	58
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.02	0.82	2,019
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.02	0.01	0.26	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Poor Vista	-0.21	0.02	0.00	310	-0.21	0.02	0.00	310
Below Average Vista	-0.08	0.01	0.00	2,857	-0.08	0.01	0.00	2,857
Average Vista	Omitted	Omitted	Omitted	1,247	Omitted	Omitted	Omitted	1,247
Above Average Vista	0.10	0.02	0.00	448	0.10	0.02	0.00	448
Premium Vista	0.13	0.04	0.00	75	0.13	0.04	0.00	75
View Does Not Overlap Vista					Omitted	Omitted	Omitted	320
View Barely Overlaps Vista					0.05	0.03	0.08	150
View Somewhat Overlaps Vista					0.01	0.03	0.66	132
View Strongly Overlaps Vista					0.05	0.05	0.23	128

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

	Base Model	Overlap Model
Model Equation Number	**1**	**9**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**409.7**
Adjusted R Squared	**0.77**	**0.77**

6. Repeat Sales Analysis

In general, the Base and Alternative Hedonic Models presented in previous sections come to the same basic conclusion: wind power facilities in this sample have no demonstrable, widespread, sizable, and statistically significant affect on residential property values. These hedonic models contain 29 or more controlling variables (e.g., house and site characteristics) to account for differences in home values across the sample. Although these models perform well and explain nearly 80% of the variation in sales prices among homes in the sample, it is always possible that variables not included in (i.e., "omitted from") the hedonic models could be correlated with the variables of interest, therefore biasing the results.

A common method used to control for omitted variable bias in the home assessment literature is to estimate a repeat sales model (Palmquist, 1982). This technique focuses on just those homes that have sold on more than one occasion, preferably once before and once after the introduction of a possible disamenity, and investigates whether the price appreciation between these transactions is affected by the presence of that disamenity. In this section a repeat sales analysis is applied to the dataset, investigating in a different way the presence of the three possible property value stigmas associated with wind facilities, and therefore providing an important cross-check to the hedonic model results. The section begins with a brief discussion of the general form of the Repeat Sales Model and a summary of the literature that has employed this approach to investigate environmental disamenities. The dataset and model used in the analysis is then described, followed by a summary of the results from that analysis.

6.1. Repeat Sales Models and Environmental Disamenities Literature

Repeat sales models use the annual sales-price appreciation rates of homes as the dependent variable. Because house, home site, and neighborhood characteristics are relatively stable over time for any individual home, many of those characteristics need not be included in the repeat sales model, thereby increasing the degrees of freedom and allowing sample size requirements to be significantly lower and coefficient estimates to be more efficient (Crone and Voith, 1992). A repeat sales analysis is not necessarily preferred over a traditional hedonic model, but is rather an alternative analysis approach that can be used to test the robustness of the earlier results (for further discussion see Jackson, 2003). The repeat sales model takes the basic form:

Annual Appreciation Rate (AAR) = *f* (TYPE OF HOUSE, OTHER FACTORS)

where
TYPE OF HOUSE provides an indication of the segment of the market in which the house is situated (e.g., high end vs. low end), and
OTHER FACTORS include, but are not limited to, changes to the environment (e.g., proximity to a disamenity).

The dependent variable is the adjusted annual appreciation rate and is defined as follows:

$$AAR = \exp\left[\frac{\ln\left(P_1 / P_2\right)}{t_1 - t_2}\right] - 1 \tag{10}$$

where

P_1 is the adjusted sales price at the first sale (in 1996 dollars),
P_2 is the adjusted sales price at the second sale (in 1996 dollars),
t_1 is the date of the first sale,
t_2 is the date of the second sale, and
$(t_1 - t_2)$ is determined by calculating the number of days that separate the sale dates and dividing by 365.

As with the hedonic regression model, the usefulness of the repeat sales model is well established in the literature when investigating possible disamenities. For example, a repeat sales analysis was used to estimate spatial and temporal sales price effects from incinerators by Kiel and McClain (1995), who found that appreciation rates, on average, are not sensitive to distance from the facility during the construction phase but are during the operation phase. Similarly, McCluskey and Rausser (2003) used a repeat sales model to investigate effects surrounding a hazardous waste site. They found that appreciation rates are not sensitive to the home's distance from the disamenity before that disamenity is identified by the EPA as hazardous, but that home values are impacted by distance after the EPA's identification is made.

6.2. Dataset

The 7,459 residential sales transactions in the dataset contain a total of 1,253 transactions that involve homes that sold on more than one occasion (i.e., a "pair" of sales of the same home). For the purposes of this analysis, however, the key sample consists of homes that sold once before the announcement of the wind facility, and that subsequently sold again after the construction of that facility. Therefore any homes that sold twice in either the pre-announcement or post-construction periods were not used in the repeat sales sample.[91] These were excluded because either they occurred before the effect would be present (for pre-announcement pairs) or after (for post-announcement pairs). This left a total of 368 pairs for the analysis, which was subsequently reduced to 354 usable pairs.[92]

The mean AAR for the sample is 1.0% per year, with a low of -10.5% and a high of 13.4%. Table 27 summarizes some of the characteristics of the homes used in the repeat sales model. The average house in the sample has 1,580 square feet of above-ground finished living area, sits on a parcel of 0.67 acres, and originally sold for $70,483 (real 1996 dollars). When it sold a second time, the average home in the sample was located 2.96 miles from the nearest wind turbine (14 homes were within one mile, 199 between one and three miles, 116 between three and five miles, and 25 outside of five miles). Of the 354 homes, 14% (n = 49) had some view of the facility (35 were rated MINOR, five MODERATE, and nine either SUBSTANTIAL or EXTREME). Because of the restriction to those homes that experienced repeat sales, the sample is relatively small for those homes in close proximity to and with dramatic views of wind facilities.

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[91] 752 pairs occurred after construction began, whereas 133 pairs occurred before announcement.

[92] Of the 368 pairs, 14 were found to have an AAR that was either significantly above or below the mean for the sample (mean +/- 2 standard deviations). These pairs were considered highly likely to be associated with homes that were either renovated or left to deteriorate between sales, and therefore were removed from the repeat sales model dataset. Only two of these 14 homes had views of the wind turbines, both of which were MINOR. All 14 of the homes were situated either between one and three miles from the nearest turbine (n = 8) or between three and five miles away (n = 6).

Table 27: List of Variables Included in the Repeat Sales Model

Variable Name	Description	Type	Sign	Freq.	Mean	Std. Dev.	Min.	Max.
SalePrice96_Pre	The Sale Price (adjusted for inflation into 1996 dollars) of the home as of the first time it had sold	C	+	354	$ 70,483	$ 37,798	$ 13,411	$ 291,499
SalePrice96_Pre_Sqr	SalePrice96_Pre Squared (shown in millions)	C	–	354	$ 6,393	$ 8,258	$ 180	$ 84,972
Acres	Number of Acres that sold with the residence	C	+	354	0.67	1.34	0.07	10.96
Sqft_1000	Number of square feet of finished above ground living area (in 1000s)	C	+	354	1.58	0.56	0.59	4.06
No View	If the home had no view of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	305	0.86	0.35	0	1
Minor View	If the home had a Minor View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	35	0.10	0.30	0	1
Moderate View	If the home had a Moderate View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	5	0.01	0.12	0	1
Substantial/Extreme View	If the home had a Substantial or Extreme View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	9	0.03	0.12	0	1
Less than 1 Mile	If the home was within 1 mile (5280 feet) of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	14	0.02	0.13	0	1
Between 1 and 3 Miles	If the home was between 1 and 3 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	199	0.56	0.50	0	1
Between 3 and 5 Miles	If the home was between 3 and 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	116	0.33	0.47	0	1
Outside 5 Miles	If the home was outside 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	25	0.07	0.26	0	1

"C" Continuous, "OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the "Omitted" category. This table does not include the study area fixed effects variables that are included in the model (e.g., WAOR, TXHC, NYMC). The reference case for these variables is the WAOR study area.

6.3. Model Form

To investigate the presence of Area, Scenic Vista, and Nuisance Stigmas, the adjusted annual appreciation rate (AAR) is calculated for the 354 sales pairs in the manner described in equation (10), using inflation adjusted sales prices. The following model is then estimated:

$$\mathrm{AAR} = \beta_0 + \sum_s \beta_1 \mathrm{S} + \sum_k \beta_2 \mathrm{X} + \sum_v \beta_3 \mathrm{VIEW} + \sum_d \beta_4 \mathrm{DISTANCE} + \varepsilon \qquad (11)$$

where

AAR represents the inflation-adjusted Annual Appreciation Rate for repeat sales,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home, site and sale characteristics (e.g., acres, square feet, original sales price),
VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
DISTANCE is a vector of *d* categorical distance variables (e.g., less than one mile, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a vector of *s* parameter estimates for the study area fixed effects as compared to sales that occurred in the WAOR study area,
β_2 is a vector of *k* parameter estimates for the home, site, and sale characteristics,
β_3 is a vector of *v* parameter estimates for the VIEW variables as compared to transactions of homes with no view of the turbines,
β_4 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes outside of five miles, and
ε is a random disturbance term.

Effectively, this model seeks to identify reasons that AARs vary among those sales pairs in the sample. Reasons for such differences in AARs might include variations in home and site characteristics, the study area in which the sale occurs, or the degree to which the home is in proximity to or has a dramatic view of a wind facility. As such, the model as shown by equation (11) has three primary groups of parameters: variables of interest; home, site, and sale characteristics; and study area fixed effects.

The variables of interest are VIEW and DISTANCE, and the coefficients β_3 and β_4 are therefore the primary focus of this analysis. Because of the small numbers of homes in the sample situated inside of 3000 feet and between 3000 feet and one mile, they are collapsed into a single category (inside one mile). For the same reason, homes with SUBSTANTIAL or EXTREME VIEWS are collapsed into a single category (SUBSTANTIAL/EXTREME). In this model, therefore, the influence on appreciation rates of the following variables of interest is estimated: MINOR, MODERATE, and SUBSTANTIAL/EXTREME VIEWS, and less than one mile, between one and three mile, and between three and five mile DISTANCES. For the VIEW fixed-effects variables, the reference category is NO VIEW; for DISTANCE, it is homes outside of five miles. As with previous models, if effects exist, it is expected that all of the coefficients would be negative and monotonically ordered.

The number of home, site, and sale characteristics included in a repeat sales model is typically substantially lower than in a hedonic model. This is to be expected because, as discussed earlier, the repeat sales model explores variations in AARs for sales pairs from individual homes, and home and site characteristics are relatively stable over time for any individual home. Nonetheless, various characteristics have been found by others (e.g., Kiel and McClain, 1995; McCluskey and Rausser, 2003) to affect appreciation rates. For the purposes of the Repeat Sales Model, these include the number of square feet of living space (SQFT_1000), the number of acres (ACRES), the inflation-adjusted price of the home at the first sale (SalePrice96_Pre), and that sales price squared (SalePrice96_Pre_Sqr). Of those characteristics, the SQFT_1000 and ACRES coefficients are expected to be positive indicating that, all else being equal, an increase in living area and lot size increases the relative appreciation rate. Conversely, it is expected that the combined estimated effect of the initial sales prices (SalePrice96_Pre and SalePrice96_Pre_Sqr) will trend downward, implying that as the initial sales price of the house increases the appreciation rate decreases. These expectations are in line with the previous literature (Kiel and McClain, 1995; McCluskey and Rausser, 2003).

Finally, the study-area fixed effects variables (β_1) are included in this model to account for differences in inflation adjusted appreciation rates that may exist across study areas (e.g., WAOR, TXHC, NYMC). The WAOR study area is the reference category, and all study-area coefficients therefore represent the marginal change in AARs compared to WAOR (the intercept represents the marginal change in AAR for WAOR by itself). These study area parameters provide a unique look into Area Stigma effects. Recall that the appreciation rates used in this model are adjusted for inflation by using an inflation index from the nearby municipal statistical area (MSA). These MSAs are sometimes quite far away (as much as 20 miles) and therefore would be unaffected by the wind facility. As such, any variation in the study area parameters (and the intercept) would be the result of local influences not otherwise captured in the inflation adjustment, and represent another test for Area Stigma; if effects exist, it is expected that the β_0 and β_1 coefficients will be negative.

As with the hedonic models presented earlier, the assumptions of homoskedasticity, absence of spatial autocorrelation, reasonably little multicollinearity, and appropriate controls for outliers are addressed as described in the associated footnote and in Appendix G.[93]

6.4. Analysis of Results

The results from the Repeat Sales Model are presented in Table 28. The model performs relatively poorly overall, with an Adjusted R^2 of just 0.19 (and an *F*-test statistic of 5.2). Other similar analyses in the literature have produced higher performance statistics but have done so with samples that are considerably larger or more homogenous than ours.[94] The low R^2 found here should not be cause for undue concern, however, given the relatively small sample spread across ten different study areas. Moreover, many of the home and site characteristics are found to be statistically significant, and of the appropriate sign. The coefficient for the adjusted initial sales price (SalePrice96_Pre), for example, is statistically significant, small, and negative (-0.000001, *p* value 0.00), while the coefficient for the adjusted initial sales price squared (SalePrice96_Pre_Sqr) is also statistically significant and considerably smaller (<0.000000, *p* value 0.00). These results imply, consistent with the prior literature, that for those homes in the sample, an increase in initial adjusted sales price decreases the average percentage appreciation rate. ACRES (0.002, *p* value 0.10) and SQFT_1000 (0.02, *p* value 0.00) are both positive, as expected, and statistically significant.

Of particular interest are the intercept term and the associated study-area fixed effect coefficients, and what they collectively say about Area Stigma. The coefficient for the intercept (β_0) is 0.005 (*p* value 0.81), which is both extremely small and not statistically significant. Likewise, the study-area fixed effects are all relatively small (less than 0.03 in absolute terms) and none are statistically significant. As discussed above, if a pervasive Area Stigma existed, it would be expected to be represented in these coefficients. Because all are small and statistically insignificant, it can again be concluded that there is no persuasive evidence of an Area Stigma among this sample of home transactions.

[93] All results are produced using White's corrected standard errors to control for heteroskedasticity. Spatial autocorrelation, with this small sample, is impossible to control. Because of the small sample, an even smaller number of neighboring sales exist, which are required to construct the spatial matrix. As such, spatial autocorrelation is not addressed in the repeat sales model. As with the hedonic models, some multicollinearity might exist, but that multicollinearity is unlikely to be correlated with the variables of interest. Outliers are investigated and dealt with as discussed in footnote 91 on page 56.

[94] McCluskey and Rausser (2003) had a sample of over 30,000 repeat sales and had an *F*-test statistic of 105; Kiel and McClain (1995) produced an R^2 that ranged from 0.40 to 0.63 with samples ranging from 53 to 145, but all sales took place in North Andover, MA.

Table 28: Results from Repeat Sales Model

	Coef.	SE	p Value	*n*
Intercept	0.005	0.02	0.81	354
WAOR	Omitted	Omitted	Omitted	6
TXHC	-0.01	0.02	0.63	57
OKCC	0.03	0.02	0.11	102
IABV	0.02	0.02	0.14	59
ILLC	-0.01	0.02	0.38	18
WIKCDC	0.02	0.03	0.50	8
PASC	-0.01	0.02	0.67	32
PAWC	0.02	0.02	0.16	35
NYMCOC	0.02	0.02	0.23	24
NYMC	0.03	0.02	0.13	13
SalePrice96_Pre	-0.000001	0.0000002	0.00	354
SalePrice96_Pre_Sqr	0.0000000	0.0000000	0.00	354
Acres	0.002	0.001	0.10	354
Sqft_1000	0.02	0.01	0.00	354
No View	Omitted	Omitted	Omitted	305
Minor View	-0.02	0.01	0.02	35
Moderate View	0.03	0.03	0.29	5
Substantial/Extreme View	-0.02	0.01	0.09	9
Less than 1 Mile	0.03	0.01	0.01	14
Between 1 and 3 Miles	0.01	0.01	0.59	199
Between 3 and 5 Miles	0.01	0.01	0.53	116
Outside 5 Miles	Omitted	Omitted	Omitted	25

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**11**
Dependent Variable	**SalePrice96_AAR**
Number of Cases	**354**
Number of Predictors (k)	**19**
F Statistic	**5.2**
Adjusted R2	**0.19**

Turning to the variables of interest, mixed results (see Figure 9 and Figure 10) are found. For homes with MINOR or SUBSTANTIAL/EXTREME VIEWS, despite small sample sizes, appreciation rates after adjusting for inflation are found to decrease by roughly 2% annually (*p* values of 0.02 and 0.09, respectively) compared to homes with NO VIEW. Though these findings initially seem to suggest the presence of Scenic Vista Stigma, the coefficients are not monotonically ordered, counter to what one might expect: homes with a MODERATE rated view appreciated on average 3% annually (*p* value 0.29) compared to homes with NO VIEW. Adding to the suspicion of these VIEW results, the DISTANCE coefficient for homes situated inside of one mile, where eight out of the nine SUBSTANTIAL/EXTREME rated homes are located, is positive and statistically significant (0.03, *p* value 0.01). If interpreted literally, these results suggest that a home inside of one mile with a SUBSTANTIAL/EXTREME rated view would experience a decrease in annual appreciation of 2% compared to homes with no views of turbines, but simultaneously would experience an increase of 3% in appreciation compared to homes outside of five miles. Therefore, when compared to those homes outside of five miles and with no view of the wind facilities, these homes would experience an overall increase in AAR by 1%. These results are counterintuitive and are likely driven by the small number of sales pairs that are located within one mile of the wind turbines and experience a dramatic view of those turbines.

Figure 9: Repeat Sales Model Results for VIEW

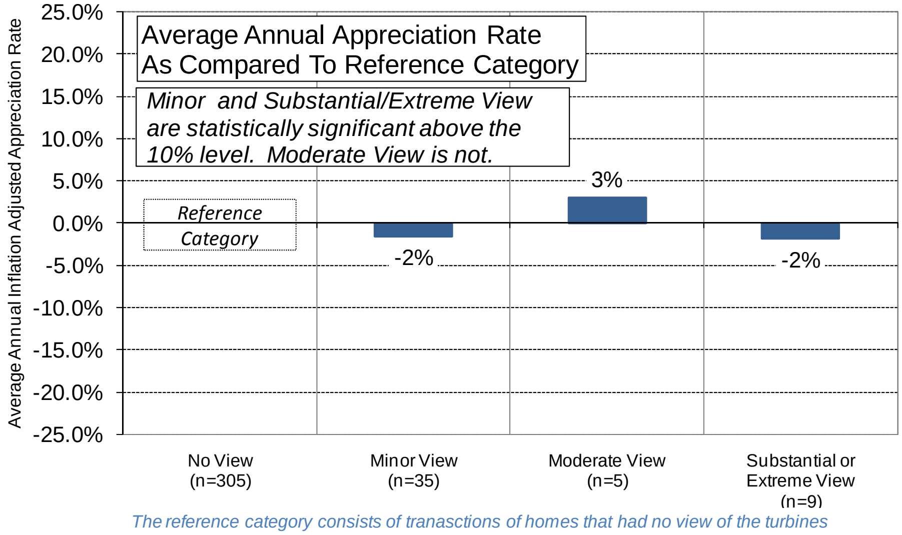
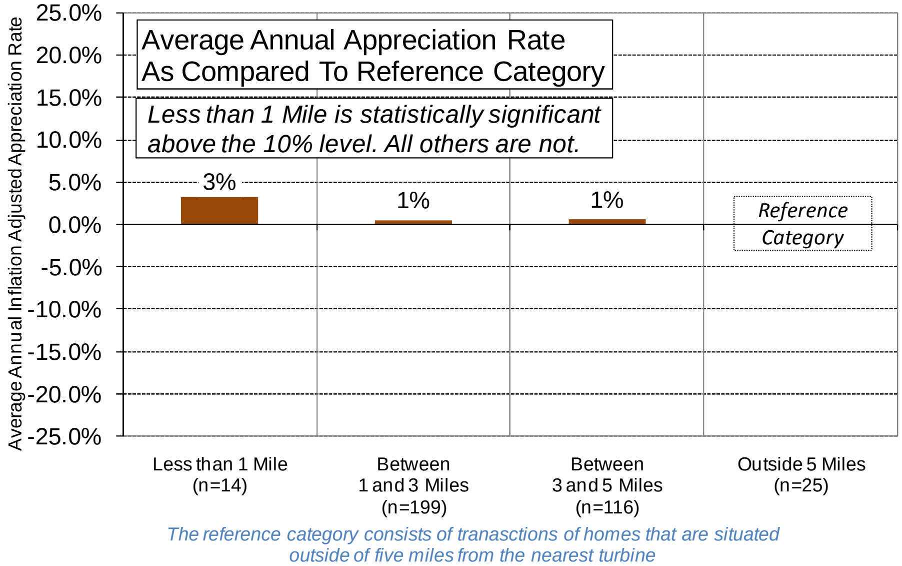


Figure 10: Repeat Sales Model Results for DISTANCE



Regardless of the reason for this result, again no persuasive evidence of consistent and widespread adverse effects is found from the presence of the wind facilities in the sample, reinforcing the findings from the previous hedonic analysis. Specifically, there is no evidence that an Area Stigma exists in that homes outside of one mile and inside of five miles do not appreciate differently than homes farther away. Similarly, there is no evidence of a Nuisance Stigma. Appreciation rates for homes inside of one mile are not adversely affected; in fact, significantly higher appreciation rates are found for these homes than for those homes located outside of five miles from the nearest wind facility. Finally, though some evidence is found that a Scenic Vista Stigma may exist in the sample of repeat sales, it is weak, fairly small, and somewhat counter-intuitive. This result is likely driven by the small number of sales pairs that are located within one mile of the wind turbines and that experience a dramatic view of those turbines.

7. Sales Volume Analysis

The analysis findings to this point suggest that, among the sample of sales transactions analyzed in this report, wind facilities have had no widespread and statistically identifiable impact on residential property values. A related concern that has not yet been addressed is that of sales volume: does the presence of wind facilities either increase or decrease the rate of home sales transactions? On the one hand, a decrease in sales volumes might be expected. This might occur if homeowners expect that their property values will be impacted by the presence of the wind facility, and therefore simply choose not to sell their homes as a result, or if they try to sell but are not easily able to find willing buyers. Alternatively, an increase in sales volume might be expected if homeowners that are located near to or have a dominating view of wind turbines are uncomfortable with the presence of those turbines. Though those homes may sell at a market value that is not impacted by the presence of the wind facilities, self-selection may lead to accelerated transaction volumes shortly after facility announcement or construction as homeowners who view the turbines unfavorably sell their homes to individuals who are not so stigmatized. To address the question of whether and how sales volumes are impacted by nearby wind facilities, sales volumes are analyzed for those homes located at various distances from the wind facilities in the sample, during different facility development periods.

7.1. Dataset

To investigate whether sales volumes are affected by the presence of wind facilities two sets of data are assembled: (1) the number of homes available to sell annually within each study area, and (2) the number of homes that actually did sell annually in those areas. Homes potentially "available to sell" are defined as all single family residences within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that had a market value (for land and improvements) above $10,000.[95] Homes that "did sell" are defined as every valid sale of a single family residence within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that sold for more than $10,000.

The sales data used for this analysis are slightly different from those used in the hedonic analysis reported earlier. As mentioned in Section 3.3, a number of study areas were randomly sampled to limit the transactions outside of 3 miles if the total number of transactions were to exceed that which could efficiently be visited in the field (*n* ~1,250). For the sales volume analysis, however, field data collection was not required, and all relevant transactions could therefore be used. Secondly, two study areas did not provide the data necessary for the sales volume analysis (WAOR and OKCC), and are therefore excluded from the sample. Finally, data for some homes that were "available to sell" were not complete, and rather than including only a small selection of these homes, these subsets of data were simply excluded from the analysis. These excluded homes include those located outside of five miles of the nearest wind turbine, and those available to sell or that did sell more than three years before wind facility announcement.[96] The resulting

[95] "Market value" is the estimated price at which a home would sell as of a given point in time.

[96] For instance, some providers supplied sales data out to ten miles, but only provided homes available to sell out to five miles. As well, data on homes that did sell were not consistently available for periods many years before announcement.

dataset spans the period starting three years prior to facility announcement and ending four years after construction. All homes in this dataset are situated inside of five miles, and each is located in one of the eight represented study areas.[97]

The final set of homes potentially "available to sell" and that actually "did sell" are then segmented into three distance categories: inside of one mile, between one and three miles, and between three and five miles. For each of these three distance categories, in each of the eight study areas, and for each of the three years prior to announcement, the period between announcement and construction, and each of the four years following construction, the number of homes that sold as a percentage of those available to sell is calculated.[98] This results in a total of 24 separate sales volume calculations in each study area, for a total of 192 calculations across all study areas. Finally, these sales volumes are averaged across all study areas into four development period categories: less than three years before announcement, after announcement but before construction, less than two years after construction, and between two and four years after construction.[99] The resulting average annual sales volumes, by distance band and development period, are shown in Table 29 and Figure 11.

Table 29: Sales Volumes by PERIOD and DISTANCE

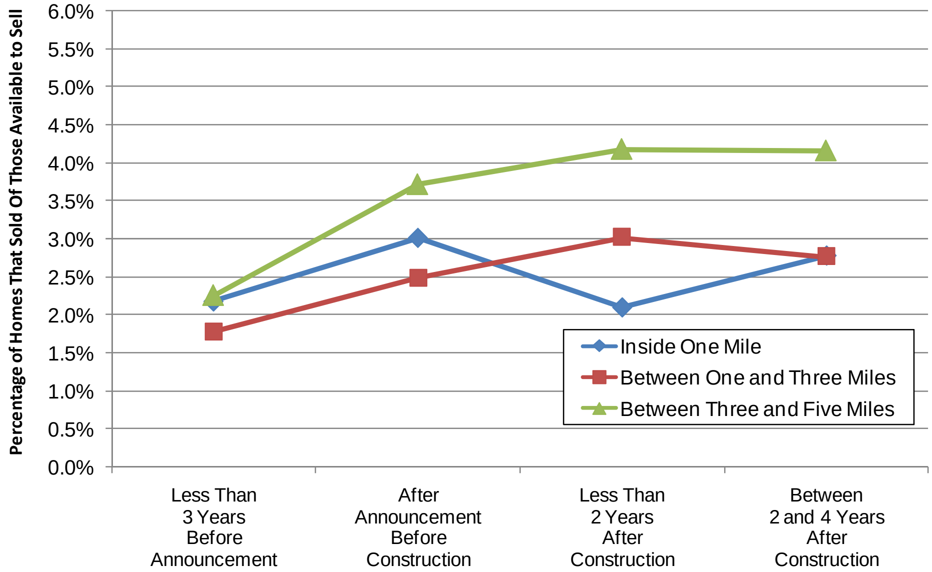
	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	2.2%	1.8%	2.3%
After Announcement Before Construction	3.0%	2.5%	3.7%
Less Than 2 Years After Construction	2.1%	3.0%	4.2%
Between 2 and 4 Years After Construction	2.8%	2.8%	4.2%

[97] The number of homes "available to sell" is constructed for each year after 1996 based on the year the homes in each study area were built. For many homes in the sample, the year built occurred more than three years before wind facility announcement, and therefore those homes are "available to sell" in all subsequent periods. For some homes, however, the home was built during the wind facility development process, and therefore becomes "available" some time after the first period of interest. For those homes, the build year is matched to the development dates so that it becomes "available" during the appropriate period. For this reason, the number of homes "available to sell" increases in later periods.

[98] For the period after announcement and before construction, which in all study areas was not exactly 12 months, the sales volume numbers are adjusted so that they corresponded to an average over a 12 month period.

[99] These temporal groupings are slightly different from those used in the hedonic Temporal Aspects Model. Namely, the period before announcement is not divided into two parts – more than two years before announcement and less than two years before announcement – but rather only one – less than three years before announcement. This simplification is made to allow each of the interaction categories to have enough data to be meaningful.

Figure 11: Sales Volumes by PERIOD and DISTANCE



7.2. Model Form

To investigate whether the rate of sales transactions is measurably affected by the wind facilities, the various resulting sales volumes shown above in Table 29 and Figure 11 are compared using a *t*-Test, as follows:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (12)$$

where

$\bar{x}_1$ and $\bar{x}_2$ are the mean sales volumes from the two categories being compared,

s_1^2 and s_2^2 are variances of the sales volumes from the two categories being compared, and

n_1 and n_2 are numbers of representative volumes in the two categories.[100]

The degrees of freedom used to calculate the *p*-value of the *t* statistic equals the lower of $(n_1 - 1)$ or $(n_2 - 1)$.

Three sets of *t*-Tests are conducted. First, to test whether sales volumes have changed with time and are correlated with wind facility construction, the volumes for each DISTANCE group in later periods (x_1) are compared to the volume in that same group in the pre-announcement period (x_2). Second, to test whether sales volumes are impacted by distance to the nearest wind turbine, the volumes for each PERIOD group at distances closer to the turbines (x_1) are compared to the volume in that same group in the three to five mile distance band (x_2). Finally, for reasons that will become obvious later, the sales volumes for each PERIOD group at distances within one

[100] The number of representative volumes could differ between the two categories. For instance, the "less than three years before announcement" category represents three years – and therefore three volumes – for each study area for each distance band, while the "less than two years after construction" category represents two years – and therefore two volumes – for each study area for each distance band.

mile and outside of three miles of the turbines (x_1) are compared to the sales volume in that same group in the one to three mile distance band (x_2). These three tests help to evaluate whether sales volumes are significantly different after wind facilities are announced and constructed, and whether sales volumes near the turbines are affected differently than for those homes located farther away.[101]

7.3. Analysis of Results

Table 29 and Figure 11 above show the sales volumes in each PERIOD and DISTANCE category, and can be interpreted as the percentage of homes that are available to sell that did sell in each category, on an annual average basis. The sales volume between one and three miles and before facility announcement is the lowest, at 1.8%, whereas the sales volumes for homes located between three and five miles in both periods following construction are the highest, at 4.2%.

The difference between these two sales volumes can be explained, in part, by two distinct trends that are immediately noticeable from the data presented in Figure 11. First, sales volumes in all periods are highest for those homes located in the three to five mile distance band. Second, sales volumes at virtually all distances are higher after wind facility announcement than they were before announcement.[102]

To test whether these apparent trends are borne out statistically the three sets of *t*-Tests described earlier are performed, the results of which are shown in Table 30, Table 31, and Table 32. In each table, the difference between the subject volume (x_1) and the reference volume (x_2) is listed first, followed by the *t* statistic, and whether the statistic is significant at or above the 90% level ("*").

Table 30 shows that mean sales volumes in the post-announcement periods are consistently greater than those in the pre-announcement period, and that those differences are statistically significant in four out of the nine categories. For example, the post-construction sales volumes for homes in the three to five mile distance band in the period less than two years after construction (4.2%) and between three and four years after construction (4.2%) are significantly greater than the pre-announcement volume of 2.3% (1.9%, t = 2.40; 1.9%, t = 2.31). Similarly, the post-construction sales volumes between one and three miles are significantly greater than the pre-announcement volume. These statistically significant differences, it should be noted, could be as much related to the low reference volume (i.e., sales volume in the period less than

[101] An alternative method to this model would be to pool the homes that "did sell" with the homes "available to sell" and construct a Discrete Choice Model where the dependent variable is zero (for "no sale") or one (for "sale") and the independent variables would include various home characteristics and the categorical distance variables. This would allow one to estimate the probability that a home sells dependent on distance from the wind facility. Because home characteristics data for the homes "available to sell," was not systematically collected it was not possible to apply this method to the dataset.

[102] It is not entirely clear why these trends exist. Volumes may be influenced upward in areas farther from the wind turbines, where homes, in general, might be more densely sited and homogenous, both of which might be correlated with greater home sales transactions. The converse might be true in more rural areas, nearer the wind turbines, where homes may be more unique or homeowners less prone to move. The increasing sales volumes seen in periods following construction, across all distance bands, may be driven by the housing bubble, when more transactions were occurring in general.

three years before announcement), as they are to the sales volumes to which the reference category is compared. Finally, when comparing post-construction volumes inside of a mile, none are statistically different than the 2.2% pre-announcement level.

Table 30: Equality Test of Sales Volumes between PERIODS

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	Reference	Reference	Reference
After Announcement Before Construction	0.8% (0.72)	0.7% (0.99)	1.5% (1.49)
Less Than 2 Years After Construction	-0.1% (-0.09)	1.2% (2.45) *	1.9% (2.4) *
Between 2 and 4 Years After Construction	0.6% (0.54)	1% (2.24) *	1.9% (2.31) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Turning to sales volumes in the same development period but between the different distance bands, consistent but less statistically significant results are uncovered (see Table 31). Although all sales volumes inside of three miles, for each period, are less than their peers outside of three miles, those differences are statistically significant in only two out of eight instances. Potentially more important, when one compares the sales volumes inside of one mile to those between one and three miles (see Table 32), small differences are found, none of which are statistically significant. In fact, on average, the sales volumes for homes inside of one mile are greater or equal to the volumes of those homes located between one and three miles in two of the three post-announcement periods. Finally, it should be noted that the volumes for the inside one mile band, in the period immediately following construction, are less than those in the one to three mile band in the same period. Although not statistically significant, this difference might imply an initial slowing of sales activity that, in later periods, returns to more normal levels. This possibility is worth investigating further and is therefore recommended for future research.

Table 31: Equality Test of Volumes between DISTANCES using 3-5 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	-0.1% (-0.09)	-0.5% (-0.88)	Reference
After Announcement Before Construction	-0.7% (-0.56)	-1.2% (-1.13)	Reference
Less Than 2 Years After Construction	-2.1% (-2.41) *	-1.2% (-1.48)	Reference
Between 2 and 4 Years After Construction	-1.4% (-1.27)	-1.4% (-1.82) *	Reference

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Table 32: Equality Test of Sales Volumes between DISTANCES using 1-3 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	0.4% (0.49)	Reference	0.5% (0.88)
After Announcement Before Construction	0.5% (0.47)	Reference	1.2% (1.13)
Less Than 2 Years After Construction	-0.9% (-1.38)	Reference	1.2% (1.48)
Between 2 and 4 Years After Construction	0% (0.01)	Reference	1.4% (1.82) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Taken together, these results suggest that sales volumes are not conclusively affected by the announcement and presence of the wind facilities analyzed in this report. At least among this sample, sales volumes increased in all distance bands after the announcement and construction of the wind facilities. If this result was driven by the presence of the wind facilities, however, one would expect that such impacts would be particularly severe for those homes in close proximity to wind facilities. In other words, sales volumes would be the most affected inside of one mile, where views of the turbines are more frequent and where other potential nuisances are more noticeable than in areas farther away. This is not borne out in the data - no statistically significant differences are found for sales volumes inside of one mile as compared to those between one and three miles, and sales volumes outside of three miles are higher still. Therefore, on the whole, this analysis is unable to find persuasive evidence that wind facilities have a widespread and identifiable impact on overall residential sales volumes. It is again concluded that neither Area nor Nuisance Stigma are in evidence in this analysis.

8. Wind Projects and Property Values: Summary of Key Results

This report has extensively investigated the potential impacts of wind power facilities on the value (i.e., sales prices) of residential properties that are in proximity to and/or that have a view of those wind facilities. In so doing, three different potential impacts of wind projects on property values have been identified and analyzed: Area Stigma, Scenic Vista Stigma, and Nuisance Stigma. To assess these potential impacts, a primary (Base) hedonic model has been applied, seven alternative hedonic models have been explored, a repeat sales analysis has been conducted, and possible impacts on sales volumes have been evaluated. Table 33 outlines the resulting ten tests conducted in this report, identifies which of the three potential stigmas those tests were designed to investigate, and summarizes the results of those investigations. This section synthesizes these key results, organized around the three potential stigmas.

Table 33: Impact of Wind Projects on Property Values: Summary of Key Results

	Is there statistical evidence of:			
Statistical Model	**Area Stigma?**	**Scenic Vista Stigma?**	**Nuisance Stigma?**	**Section Reference**
Base Model	No	No	No	*Section 4*
View Stability	Not tested	No	Not tested	*Section 5.1*
Distance Stability	No	Not tested	No	*Section 5.1*
Continuous Distance	No	No	No	*Section 5.2*
All Sales	No	No	Limited	*Section 5.3*
Temporal Aspects	No	No	No	*Section 5.4*
Orientation	No	No	No	*Section 5.5*
Overlap	No	Limited	No	*Section 5.6*
Repeat Sales	No	Limited	No	*Section 6*
Sales Volume	No	Not tested	No	*Section 7*

"No"…………………. No statistical evidence of a negative impact
"Yes"………………… Strong statistical evidence of a negative impact
"Limited"…………… Limited and inconsistent statistical evidence of a negative impact
"Not tested"……….. This model did not test for this stigma

8.1. Area Stigma

Area Stigma is defined as a concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines. Though these impacts might be expected to be especially severe at close range to the turbines, the impacts could conceivably extend for a number of miles around a wind facility. Modern wind turbines are visible from well outside of five miles in many cases, so if an Area Stigma exists, it is possible that all of the homes in the study areas inside of five miles would be affected.

As summarized in Table 33, Area Stigma is investigated with the Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, and Overlap hedonic models. It is also tested, somewhat differently, with the Repeat Sales and Sales Volume analyses. In each case, if an Area Stigma exists, it is expected that the sales prices (and/or sales volume) of homes located near wind facilities would be broadly affected by the presence of those facilities, with effects decreasing with distance.

The Base Model finds little evidence of an Area Stigma, as the coefficients for the DISTANCE variables are all relatively small and none are statistically different from zero. For homes in this sample, at least, there is no statistical evidence from the Base Model that the distance from a home to the nearest wind turbine impacts sales prices, regardless of the distance band. Perhaps a more direct test of Area Stigma, however, comes from the Temporal Aspects Model. In this model, homes in all distance bands that sold after wind facility announcement are found to sell, on average, for prices that are not statistically different from those for homes that sold more than two years prior to wind facility announcement. Again, no persuasive evidence of an Area Stigma is evident.

The Repeat Sales and Sales Volume Models also investigate Area Stigma. The Repeat Sales Model's 354 homes, each of which sold once before facility announcement and again after construction, show average inflation-adjusted annual appreciation rates that are small and not statistically different from zero. If homes in all study areas were subject to an Area Stigma, one would expect a negative and statistically significant intercept term. Similarly, if homes in any individual study area experienced an Area Stigma, the fixed effect terms would be negative and statistically significant. Neither of these expectations is borne out in the results. The Sales Volume Model tells a similar story, finding that the rate of residential transactions is either not significantly different between the pre- and post-announcement periods, or is greater in later periods, implying, in concert with the other tests, that increased levels of transactions do not signify a rush to sell, and therefore lower prices, but rather an increase in the level of transactions with no appreciable difference in the value of those homes.

The All Sales, Distance Stability, Continuous Distance, Orientation, and Overlap Models corroborate these basic findings. In the All Sales and Distance Stability Models, for example, the DISTANCE coefficients for homes that sold outside of one mile but within five miles, compared to those that sold outside of five miles, are very similar: they differ by no more than 2%, and this small disparity is not statistically different from zero. The same basic findings resulted from the Orientation and Overlap Models. Further, homes with No View as estimated in the All Sales Model are found to appreciate in value, after adjusting for inflation, when compared to homes that sold before wind facility construction (0.02, p value 0.06); an Area Stigma effect should be reflected as a negative coefficient for this parameter. Finally, despite using all 4,937 cases in a single distance variable and therefore having a correspondingly small standard error, the Continuous Distance Model discovers no measurable relationship between distance from the nearest turbine and the value of residential properties.

Taken together, the results from these models are strikingly similar: there is no evidence of a widespread and statistically significant Area Stigma among the homes in this sample. Homes in these study areas are not, on average, demonstrably and measurably stigmatized by the arrival of a wind facility, regardless of when they sold in the wind project development process and regardless of whether those homes are located one mile or five miles away from the nearest wind facility.

Drawing from the previous literature on environmental disamenities discussed in Section 2.1, one likely explanation for this result is simply that any effects that might exist may have faded to a level indistinguishable from zero at distances outside of a mile from the wind facilities. For other disamenities, some of which would seemingly be more likely to raise concerns, effects have been found to fade quickly with distance. For example, property value effects near a chemical plant have been found to fade outside of two and a half miles (Carroll et al., 1996), near a lead smelter (Dale et al., 1999) and fossil fuel plants (Davis, 2008) outside of two miles, and near landfills and confined animal feeding operations outside of 2,400 feet and 1,600 feet, respectively (Ready and Abdalla, 2005). Further, homes outside of 300 feet (Hamilton and Schwann, 1995) or even as little as 150 feet (Des-Rosiers, 2002) from a high voltage transmission line have been found to be unaffected. A second possible explanation for these results could be related to the view of the turbines. In the sample used for this analysis, a large majority of the homes outside of one mile (n = 4,812) that sold after wind-facility construction commenced cannot see the turbines (n = 4,189, 87%), and a considerably larger portion have – at worst – a minor view of the turbines (n = 4,712, 98%). Others have found that the sales prices for homes situated at similar distances from a disamenity (e.g., HVTL) depend, in part, on the , view of that disamenity (Des-Rosiers, 2002). Similarly, research has sometimes found that annoyance with a wind facility decreases when the turbines cannot be seen (Pedersen and Waye, 2004). Therefore, for the overwhelming majority of homes outside of a mile that have either a minor rated view or no view at all of the turbines, the turbines may simply be out of sight, and therefore, out of mind.

8.2. Scenic Vista Stigma

Scenic Vista Stigma is defined as concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista. It has as its basis an admission that home values are, to some degree, derived from the quality of what can be seen from the property and that if those vistas are altered, sales prices might be measurably affected. The Base, View Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, and Repeat Sales Models each test whether Scenic Vista Stigma is present in the sample.

The Base Model, as well as subsequent Alternative Hedonic Models, demonstrates persuasively that the quality of the scenic vista – absent wind turbines – impacts sales prices. Specifically, compared to homes with an AVERAGE VISTA, those having a POOR or a BELOW AVERAGE rating are estimated to sell for 21% (p value 0.00) and 8% (p value 0.00) less, on average. Similarly, homes with an ABOVE AVERAGE or PREMIUM rating are estimated to sell for 10% (p value 0.00) and 13% (p value 0.00) more than homes with an AVERAGE vista rating. Along the same lines, homes in the sample with water frontage or situated on a cul-de-sac sell for 33% (p value 0.00) and 10% (p value 0.00) more, on average, than those homes that lack these characteristics. Taken together, these results demonstrate that home buyers and sellers consistently take into account what can be seen from the home when sales prices are established, and that the models presented in this report are able to clearly identify those impacts.[103]

[103] Of course, cul-de-sacs and water frontage bestow other benefits to the home owner beyond the quality of the scenic vista, such as safety and privacy in the case of a cul-de-sac, and recreational potential and privacy in the case of water frontage.

Despite this finding, those same hedonic models are unable to identify a consistent and statistically significant Scenic Vista Stigma associated with wind facilities. Home buyers and sellers, at least among this sample, do not appear to be affected in a measurable way by the visual presence of wind facilities. Regardless of which model was estimated, the value of homes with views of turbines that were rated MODERATE, SUBSTANTIAL, or EXTREME are found to be statistically indistinguishable from the prices of homes with no view of the turbines. Specifically, the 25 homes with EXTREME views in the sample, where the home site is "unmistakably dominated by the [visual] presence of the turbines," are not found to have measurably different property values, and neither are the 31 homes with a SUBSTANTIAL view, where "the turbines are dramatically visible from the home."[104] The same finding holds for the 106 homes that were rated as having MODERATE views of the wind turbines. Moreover, the Orientation and Overlap Models show that neither the orientation of the home with respect to the view of wind turbines, nor the overlap of that view with the prominent scenic vista, have measurable impacts on home prices.

The All Sales Model compares homes with views of the turbines (in the post-construction period) to homes that sold before construction (when no views were possible), and finds no statistical evidence of adverse effects within any VIEW category. Moreover, when a *t*-Test is performed to compare the NO VIEW coefficient to the others, none of the coefficients for the VIEW ratings are found to be statistically different from the NO VIEW homes. The Repeat Sales Model comes to a similar result, with homes with MODERATE views appreciating at a rate that was not measurably different from that of homes with no views (0.03, *p* value 0.29). The same model also finds that homes with SUBSTANTIAL/EXTREME views appreciate at a rate 2% slower per year (*p* value 0.09) than their NO VIEW peers. Homes situated inside of one mile, however, are found to appreciate at a rate 3% more (*p* value 0.01) than reference homes located outside of five miles. Eight of the nine homes situated inside of one mile had either a SUBSTANTIAL or EXTREME view. Therefore, to correctly interpret these results, one would add the two coefficients for these homes, resulting in a combined 1% increase in appreciation as compared to the reference homes situated outside of five miles with no view of turbines, and again yielding no evidence of a Scenic Vista Stigma.

Although these results are consistent across most of the models, there are some individual coefficients from some models that differ. Specifically, homes with MINOR rated views in the Overlap and Repeat Sales Models are estimated to sell for 3% less (*p* value 0.10) and appreciate at a rate 2% less (*p* value 0.02) than NO VIEW homes. Taken at face value, these MINOR VIEW findings imply that homes where "turbines are visible, but, either the scope is narrow, there are many obstructions, or the distance between the home and the facility is large" are systematically impacted in a modest but measurable way. Homes with more dramatic views of a wind facility in the same models, on the other hand, are found to not be measurably affected. Because of the counterintuitive nature of this result, and because it is contradicted in the results of other models presented earlier, it is more likely that there is some aspect of these homes that was not modeled appropriately in the Overlap and Repeat Sales Models, and that the analysis is picking up the effect of omitted variable(s) rather than a systematic causal effect from the wind facilities.

[104] See Section 3.2.3 and Appendix C for full description of VIEW ratings.

Taken together, the results from all of the models and all of the VIEW ratings support, to a large degree, the Base Model findings of no evidence of a Scenic Vista Stigma. Although there are 160 residential transactions in the sample with more dramatic views than MINOR, none of the model specifications is able to find any evidence that those views of wind turbines measurably impacted average sales prices, despite the fact that those same models consistently find that home buyers and sellers place value on the quality of the scenic vista.

8.3. Nuisance Stigma

Nuisance Stigma is defined as a concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values. If these factors impact residential sales prices, those impacts are likely to be concentrated within a mile of the wind facilities. The Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, Repeat Sales, and Sales Volume Models all investigate the possible presence of a Nuisance Stigma.

The Base Model finds that those homes within 3000 feet and those between 3000 feet and one mile of the nearest wind turbine sold for roughly 5% less than similar homes located more than five miles away, but that these differences are not statistically significant (*p* values of 0.40 and 0.30, respectively). These results remain unchanged in the Distance Stability Model, as well as in the Orientation and Overlap Models. Somewhat similarly, in the All Sales Model, when all transactions occurring after wind facility announcement are assumed to potentially be impacted (rather than just those occurring after construction, as in the Base Model), and a comparison is made to the average of all transactions occurring pre-announcement (rather than the average of all transactions outside of five miles, as in the Base Model), these same coefficients grow to -6% (*p* value 0.23) and -8% (*p* value 0.08) respectively. Although only one of these coefficients was statistically significant, they are large enough to warrant further scrutiny.

The Temporal Aspects Model provides a clearer picture of these findings. It finds that homes that sold prior to wind facility announcement and that were situated within one mile of where the turbines were eventually located sold, on average, for between 10% and 13% less than homes located more than five miles away and that sold in the same period. Therefore, the homes nearest the wind facility's eventual location were already depressed in value before the announcement of the facility. Most telling, however, is what occurred after construction. Homes inside of one mile are found to have inflation-adjusted sales prices that were either statistically undistinguishable from, or in some cases greater than, pre-announcement levels. Homes sold in the first two years after construction, for example, have higher prices (0.07, *p* value 0.32), as do those homes that sold between two and four years after construction (0.13, *p* value 0.06) and more than four years after construction (0.08, *p* value 0.24). In other words, there is no indication that these homes experienced a decrease in sales prices after wind facility construction began. Not only does this result fail to support the existence of a Nuisance Stigma, but it also indicates that the relatively large negative coefficients estimated in the Base and All Sales Models are likely caused by conditions that existed prior to wind facility construction and potentially prior to facility announcement.[105]

[105] See footnote 82 on page 46 for a discussion of possible alternative explanations to this scenario.

These results are corroborated by the Continuous Distance Model, which finds no statistically significant relationship between an inverse DISTANCE function and sales prices (-0.01, sig 0.46). Similarly, in the Repeat Sales Model, homes within one mile of the nearest turbine are not found to be adversely affected; somewhat counter-intuitively, they are found to appreciate faster (0.03, *p* value 0.01) than their peers outside of five miles. Finally, the Sales Volume analysis does not find significant and consistent results that would suggest that the ability to sell one's home within one mile of a wind facility is substantially impacted by the presence of that facility.

Taken together, these models present a consistent set of results: the sales prices of homes in this sample that are within a mile of wind turbines, where various nuisance effects have been posited, are not measurably affected compared to those homes that are located more than five miles away from the facilities or that sold well before the wind projects were announced. These results imply that widespread Nuisance Stigma effects are either not present in the sample, or are too small or sporadic to be statistically identifiable.

Though these results may appear counterintuitive, it may simply be that property value impacts fade rapidly with distance, and that few of the homes in the sample are close enough to the subject wind facilities to be substantially impacted. As discussed earlier, studies of the property value impacts of high voltage transmission lines often find that effects fade towards zero at as little distance as 200 feet (see, e.g., Gallimore and Jayne, 1999; Watson, 2005). None of the homes in the present sample are closer than 800 feet to the nearest wind turbine, and all but eight homes are located outside of 1000 feet of the nearest turbine. It is therefore possible that, if any effects do exist, they exist at very close range to the turbines, and that those effects are simply not noticeable outside of 800 feet. Additionally, almost half of the homes in the sample that are located within a mile of the nearest turbine have either no view or a minor rated view of the wind facilities, and some high voltage transmission line (HVTL) studies have found a decrease in adverse effects if the towers are <u>not</u> visible (Des-Rosiers, 2002) and, similarly, decreases in annoyance with wind facility sounds if turbines cannot be seen (Pedersen and Waye, 2004). Finally, effects that existed soon after the announcement or construction of the wind facilities might have faded over time. More than half of the homes in the sample sold more than three years after the commencement of construction, while studies of HVTLs have repeatedly found that effects fade over time (Kroll and Priestley, 1992) and studies of attitudes towards wind turbines have found that such attitudes often improve after facility construction (Wolsink, 1989). Regardless of the explanation, the fact remains that, in this sizable sample of residential transactions, no persuasive evidence of a widespread Nuisance Stigma is found, and if these impacts do exist, they are either too small or too infrequent to result in any widespread and consistent statistically observable impact.

9. Conclusions

Though surveys generally show that public acceptance towards wind energy is high, a variety of concerns with wind development are often expressed at the local level. One such concern that is often raised in local siting and permitting processes is related to the potential impact of wind projects on the property values of nearby residences.

This report has investigated the potential impacts of wind power facilities on the sales prices of residential properties that are in proximity to and/or that have a view of those wind facilities. It builds and improve on the previous literature that has investigated these potential effects by collecting a large quantity of residential transaction data from communities surrounding a wide variety of wind power facilities, spread across multiple parts of the U.S. Each of the homes included in this analysis was visited to clearly determine the degree to which the wind facility was visible at the time of home sale and to collect other essential data. To frame the analysis, three potentially distinct impacts of wind facilities on property values are considered: Area, Scenic Vista, and Nuisance Stigma. To assess these potential impacts, the authors applied a base hedonic model, explored seven alternative hedonic models, conducted a repeat sales analysis, and evaluated possible impacts on sales volumes. The result is the most comprehensive and data-rich analysis to date on the potential impacts of wind projects on nearby property values.

Although each of the analysis techniques used in this report has strengths and weaknesses, the results are strongly consistent in that each model fails to uncover conclusive evidence of the presence of any of the three property value stigmas. Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact. Moreover, to the degree that homes in the present sample are similar to homes in other areas where wind development is occurring, the results herein are expected to be transferable.

Finally, although this work builds on the existing literature in a number of respects, there remain a number of areas for further research. The primary goal of subsequent research should be to concentrate on those homes located closest to wind facilities, where the least amount of data are available. Additional research of the nature reported in this paper could be pursued, but with a greater number of transactions, especially for homes particularly close to wind facilities. Further, it is conceivable that cumulative impacts might exist whereby communities that have seen repetitive development are affected uniquely, and these cumulative effects may be worth investigating. A more detailed analysis of sales volume impacts may also be fruitful, as would an assessment of the potential impact of wind facilities on the length of time homes are on the market in advance of an eventual sale. Finally, it would be useful to conduct a survey of those homeowners living close to existing wind facilities, and especially those residents who have bought and sold homes in proximity to wind facilities after facility construction, to assess their opinions on the impacts of wind project development on their home purchase and sales decisions.

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Appendix A: Study Area Descriptions

The analysis reported in the body of the report used data from ten different wind-project study areas, across nine different states and 14 counties, and surrounding 24 different wind facilities. Each of the study areas is unique, but as a group they provide a good representation of the range of wind facility sizes, hub heights, and locations of recent wind development activity in the U.S. (see Figure A - 1 and Table A - 1). This appendix describes each of the ten study areas, and provides the following information: a map of the study area; a description of the area; how the data were collected; statistics on home sales prices in the sample and census-reported home values for the towns, county, and state that encompass the area; data on the wind facilities contained within the study area; and frequency tables for the variables of interest (i.e., views of turbines, distance to nearest turbine ,and development period).

Figure A - 1: Map of Study Areas

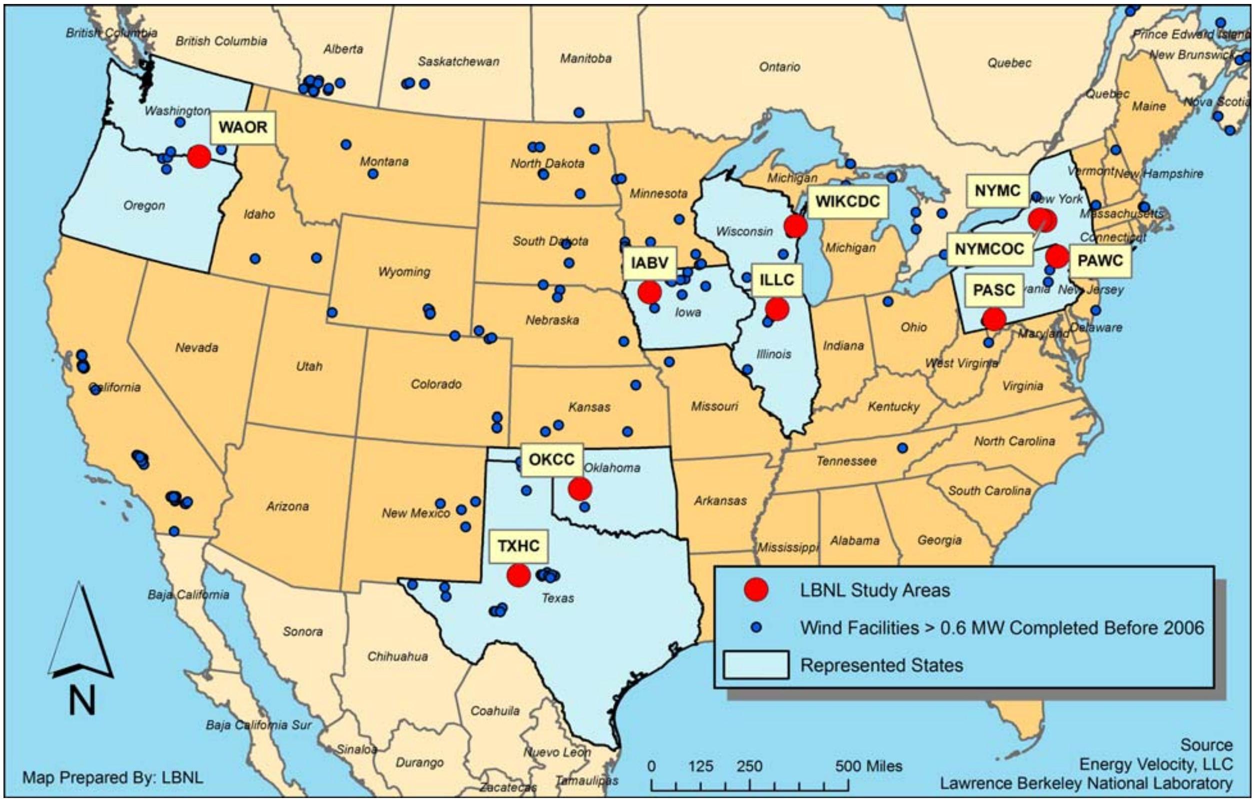
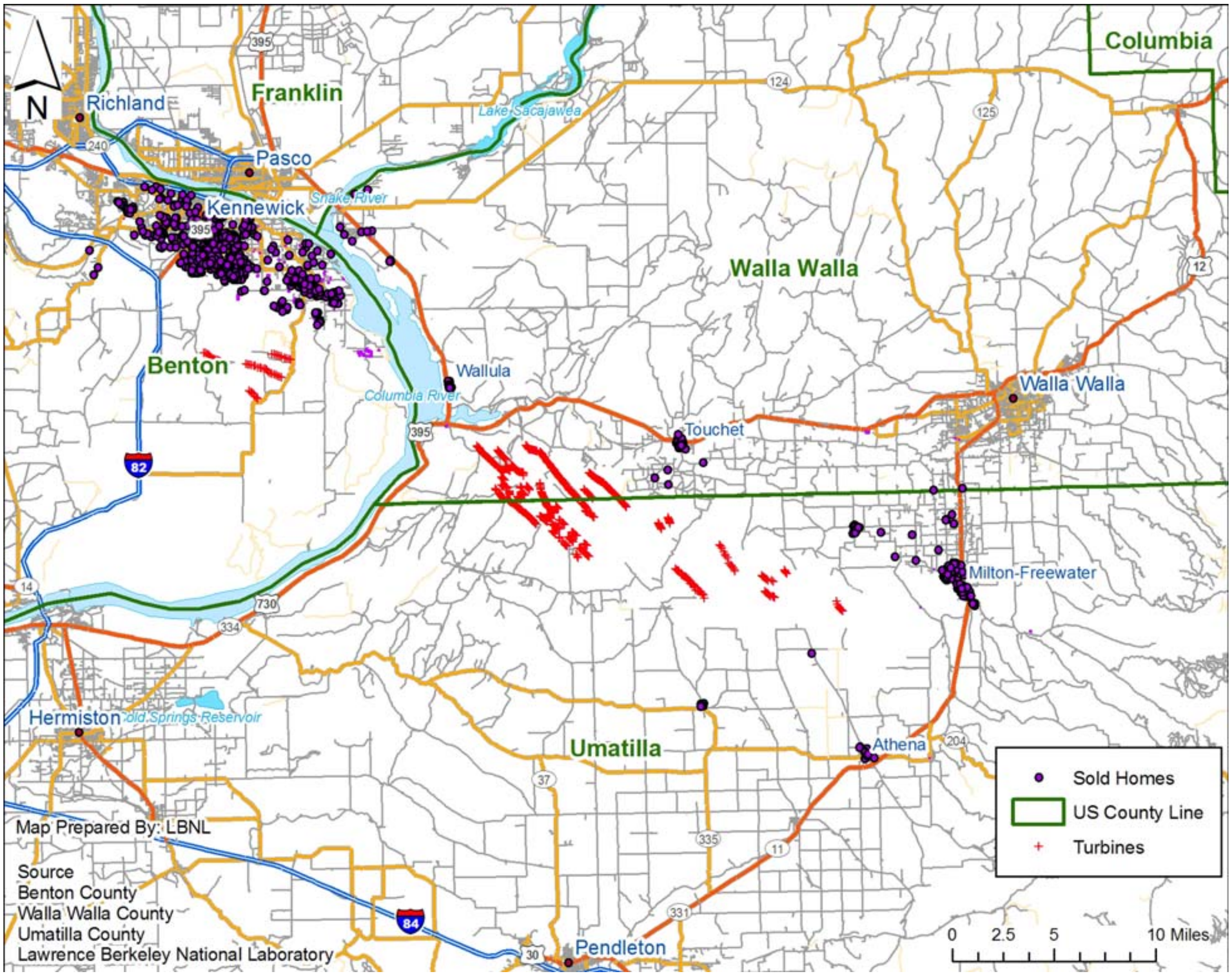


Table A - 1: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)	Max Hub Height (feet)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60	197
TXHC	Howard County, TX	Big Spring I & II	46	34	80	262
OKCC	Custer County, OK	Weatherford I & II	98	147	80	262
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65	213
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78	256
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65	213
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80	262
PAWC	Wayne County, PA	Waymart	43	65	65	213
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67	220
NYMC	Madison County, NY	Fenner	20	30	66	218
		TOTAL	**1345**	**1286**		

A.1 WAOR Study Area: Benton and Walla Walla Counties (Washington), and Umatilla County (Oregon)

Figure A - 2: Map of WAOR Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area combines data from the three counties - Benton and Walla Walla in Washington, and Umatilla in Oregon - that surround the Vansycle Ridge, Stateline, Combine Hills, and Nine Canyon wind projects. Wind development began in this area in 1997 and, within the sample of wind projects, continued through 2003. In total, the wind facilities in this study area include 582 turbines and 429 MW of nameplate capacity, with hub heights that range from 164 feet to almost 200 feet. The wind facilities are situated on an East-West ridge that straddles the Columbia River, as it briefly turns South. The area consists of undeveloped highland/plateau grassland, agricultural tracks for winter fruit, and three towns: Kennewick (Benton County), Milton-Freewater (Umatilla County), and Walla Walla (Walla Walla County). Only the first two of these towns are represented in the dataset because Walla Walla is situated more than 10 miles from the nearest wind turbine. Also in the area are Touchet and Wallula, WA, and Athena, OR, all very small communities with little to no services. Much of the area to the North and South of the ridge, and outside of the urban areas, is farmland, with homes situated on small parcels adjoining larger agricultural tracts.

Data Collection and Summary

Data for this study area were collected from a myriad of sources. For Benton County, sales and home characteristic data and GIS parcel shapefiles were collected with the assistance of county officials Eric Beswick, Harriet Mercer, and Florinda Paez, while state official Deb Mandeville (Washington Department of State) provided information on the validity of the sales. In Walla Walla County, county officials Bill Vollendorff and Tiffany Laposi provided sales, house characteristic, and GIS data. In Umatilla County, county officials Jason Nielsen, Tracie Diehl, and Tim McElrath provided sales, house characteristic, and GIS data.

Based on the data collection, more than 8,500 homes are found to have sold within ten miles of the wind turbines in this study area from January 1996 to June 2007. Completing field visits to this number of homes would have been overly burdensome; as a result, only a sample of these home sales was used for the study. Specifically, all valid sales within three miles of the nearest turbine are used, and a random sample of those homes outside of three miles but inside of five miles in Benton County and inside ten miles in Walla Walla and Umatilla Counties. This approach resulted in a total of 790 sales, with prices that ranged from $25,000 to $647,500, and a mean of $134,244. Of those 790 sales, 519 occurred after wind facility construction commenced, and 110 could see the turbines at the time of sale, though all but four of these homes had MINOR views. No homes within this sample were located within one mile of the nearest wind turbine, with the majority occurring outside of three miles.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/23/1996	6/29/2007	790	$ 125,803	$ 134,244	$ 25,000	$ 647,500

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Vansycle Ridge	25	38	Aug-97	Feb-98	Aug-98	Vestas	50
Stateline Wind Project, Phase I (OR)	83	126	Jun-00	Sep-01	Dec-01	Vestas	50
Stateline Wind Project, Phase I (WA)	177	268	Jun-00	Feb-01	Dec-01	Vestas	50
Stateline Wind Project, Phase II	40	60	Jan-02	Sep-02	Dec-02	Vestas	50
Nine Canyon Wind Farm	48	37	Jun-01	Mar-02	Sep-02	Bonus	60
Combine Hills Turbine Ranch I	41	41	Apr-02	Aug-03	Dec-03	Mitsubishi	55
Nine Canyon Wind Farm II	16	12	Jun-01	Jun-03	Dec-03	Bonus	60

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**226**	**45**	**76**	**59**	**384**	**790**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**271**	**409**	**106**	**4**	**0**	**0**	**790**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**271**	**0**	**0**	**20**	**277**	**222**	**790**

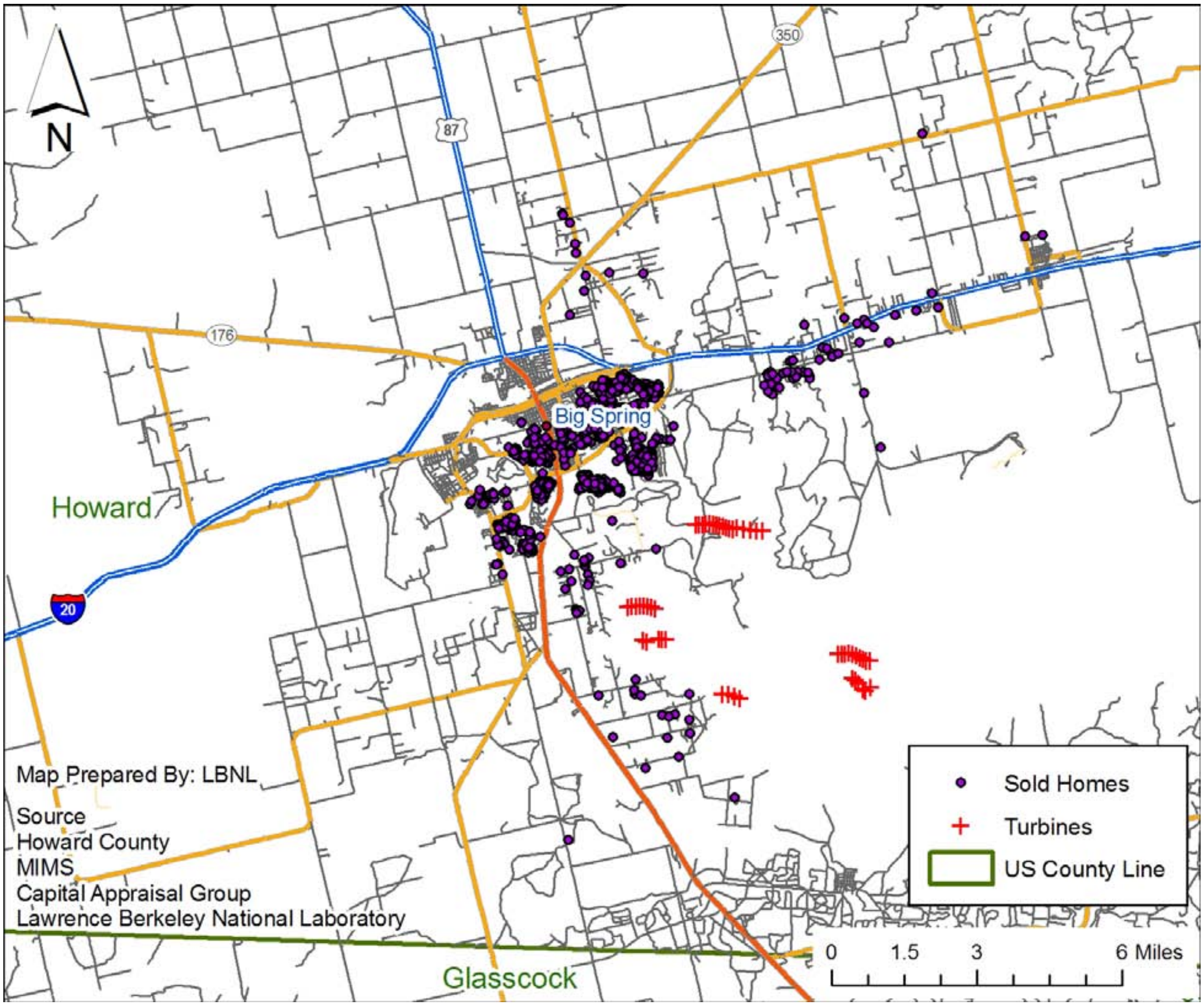
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Kennewich, WA	City	62,182	12.5%	2,711	32.3	$ 45,085	$ 155,531	46%
Walla Walla, WA	City	30,794	4.0%	2,847	33.8	$ 38,391	$ 185,706	91%
Milton Freewater, OR	Town	6,335	-2.0%	3,362	31.7	$ 30,229	$ 113,647	47%
Touchet, WA	Town	413	n/a	340	33.6	$ 47,268	$ 163,790	81%
Benton	County	159,414	3.6%	94	34.4	$ 51,464	$ 162,700	46%
Walla Walla	County	57,709	1.0%	45	34.9	$ 43,597	$ 206,631	89%
Umatilla	County	73,491	0.6%	23	34.6	$ 38,631	$ 138,200	47%
Washington	State	6,488,000	10.1%	89	35.3	$ 55,591	$ 300,800	79%
Oregon	State	3,747,455	9.5%	36	36.3	$ 48,730	$ 257,300	69%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.2 TXHC Study Area: Howard County (Texas)

Figure A - 3: Map of TXHC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is entirely contained within Howard County, Texas, and includes the city of Big Spring, which is situated roughly 100 miles South of Lubbock and 275 miles West of Dallas in West Texas. On top of the Northern end of the Edwards Plateau, which runs from the Southeast to the Northwest, sits the 46 turbine (34 MW) Big Spring wind facility, which was constructed in 1998 and 1999. Most of the wind turbines in this project have a hub height of 213 feet, but four are taller, at 262 feet. The plateau and the wind facility overlook the city of Big Spring which, when including its suburbs, wraps around the plateau to the South and East. Surrounding the town are modest farming tracks and arid, undeveloped land. These lands, primarily to the South of the facility towards Forsan (not shown on map), are dotted with small oil rigs. Many of the homes in Big Spring do not have a view of the wind facility, but others to the South and East do have such views.

Data Collection and Summary

County officials Brett McKibben, Sally Munoz, and Sheri Proctor were extremely helpful in answering questions about the data required for this project, and the data were provided by two firms that manage it for the county. Specifically, Erin Welch of the Capital Appraisal Group provided the sales and house characteristic data and Paul Brandt of MIMS provided the GIS data.

All valid single-family home sales transactions within five miles of the nearest turbine and occurring between January 1996 and March 2007 were included in the dataset, resulting in 1,311 sales.[106] These sales ranged in price from $10,492 to $490,000, with a mean of $74,092. Because of the age of the wind facility, many of the sales in the sample occurred after wind facility construction had commenced (*n* = 1,071). Of those, 104 had views of the turbines, with 27 having views more dramatic than MINOR. Four homes sold within a mile of the facility, with the rest falling between one and three miles (*n* = 584), three to five miles (*n* = 467), and outside of five miles (*n* = 16).

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/2/1996	3/30/2007	1,311	$66,500	$74,092	$10,492	$490,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Big Spring I	27.7	42	Jan-98	Jul-98	Jun-99	Vestas	65
Big Spring II	6.6	4	Jan-98	Jul-98	Jun-99	Vestas	80

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Howard, TX (TXHC)	169	71	113	131	827	1311

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Howard, TX (TXHC)	240	967	77	22	5	0	1311

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Howard, TX (TXHC)	240	0	4	584	467	16	1311

[106] If parcels intersected the five mile boundary, they were included in the sample, but were coded as being outside of five miles.

Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Big Spring	City	24,075	-5.4%	1,260	35.1	$ 32,470	$ 54,442	50%
Forsan	Town	220	-4.0%	758	36.8	$ 50,219	$ 64,277	84%
Howard	County	32,295	-1.9%	36	36.4	$ 36,684	$ 60,658	58%
Texas	State	23,904,380	14.6%	80	32.3	$ 47,548	$ 120,900	47%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

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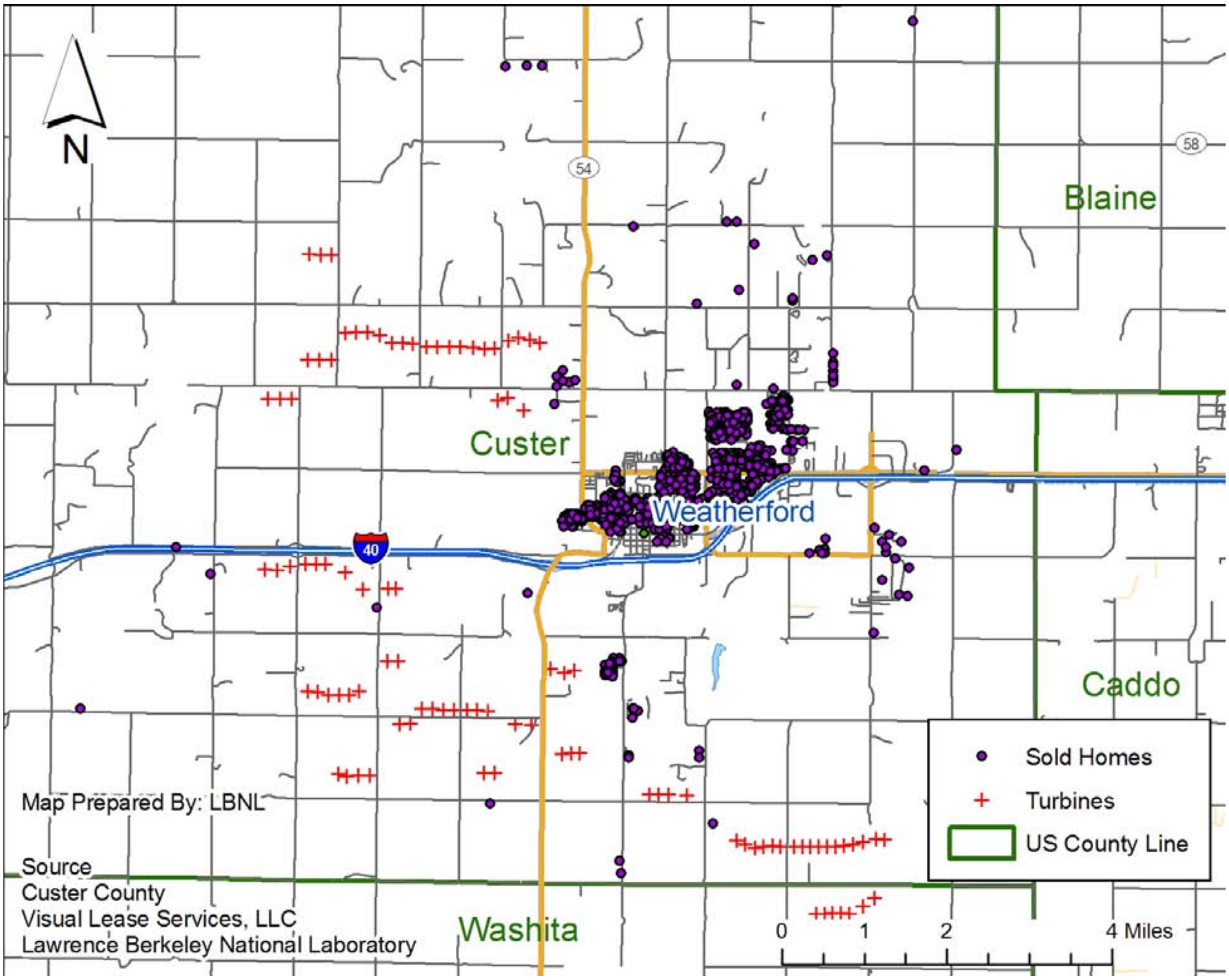
A.3 OKCC Study Area: Custer County (Oklahoma)

Figure A - 4: Map of OKCC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is entirely contained within Custer County, Texas, and includes the Weatherford wind facility, which is situated near the city of Weatherford, 70 miles due west of Oklahoma City and near the western edge of the state. The 98 turbine (147 MW) Weatherford wind facility straddles Highway 40, which runs East-West, and U.S. County Route 54, which runs North-South, creating an "L" shape that is more than six miles long and six miles wide. Development began in 2004, and was completed in two phases ending in 2006. The turbines are some of the largest in the sample, with a hub height of 262 feet. The topography of the study area is mostly flat plateau, allowing the turbines to be visible from many parts of the town and the surrounding rural lands. There are a number of smaller groupings of homes that are situated to the North and South of the city, many of which are extremely close to the turbines and have dramatic views of them.

Data Collection and Summary

County Assessor Debbie Collins and mapping specialist Karen Owen were extremely helpful in gathering data and answering questions at the county level. Data were obtained directly from the county and from Visual Lease Services, Inc and OKAssessor, where representatives Chris Mask, Terry Wood, Tracy Leniger, and Heather Brown helped with the request.

All valid single-family residential transactions within five miles of the nearest wind turbine and occurring between July 1996 and June 2007 were included in the dataset, resulting in 1,113 sales.[107] These sales ranged in price from $11,000 to $468,000, with a mean of $100,445. Because of the relatively recent construction of the facility, 58% of the sales (n = 637) occurred before construction, leaving 476 sales with possible views of the turbines. Of those 476 sales, 25 had more-dramatic view ratings than MINOR and 17 sales occurred inside of one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
7/7/1996	6/29/2007	1,113	$91,000	$100,445	$11,000	$468,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Weatherford Wind Energy Center	106.5	71	Mar-04	Dec-04	May-05	GE Wind	80
Weatherford Wind Energy Center Expansion	40.5	27	May-05	Oct-05	Jan-06	GE Wind	80

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Custer, OK (OKCC)	484	153	193	187	96	1113

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Custer, OK (OKCC)	637	375	76	6	7	12	1113

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Custer, OK (OKCC)	637	16	1	408	50	1	1113

[107] Portions of the town of Weatherford, both North and South of the town center, were not included in the sample due to lack of available data. The homes that were mapped, and for which electronic data were provided, however, were situated on all sides of these unmapped areas and were similar in character to those that were omitted. None of the unmapped homes were within a mile of the nearest wind turbine.

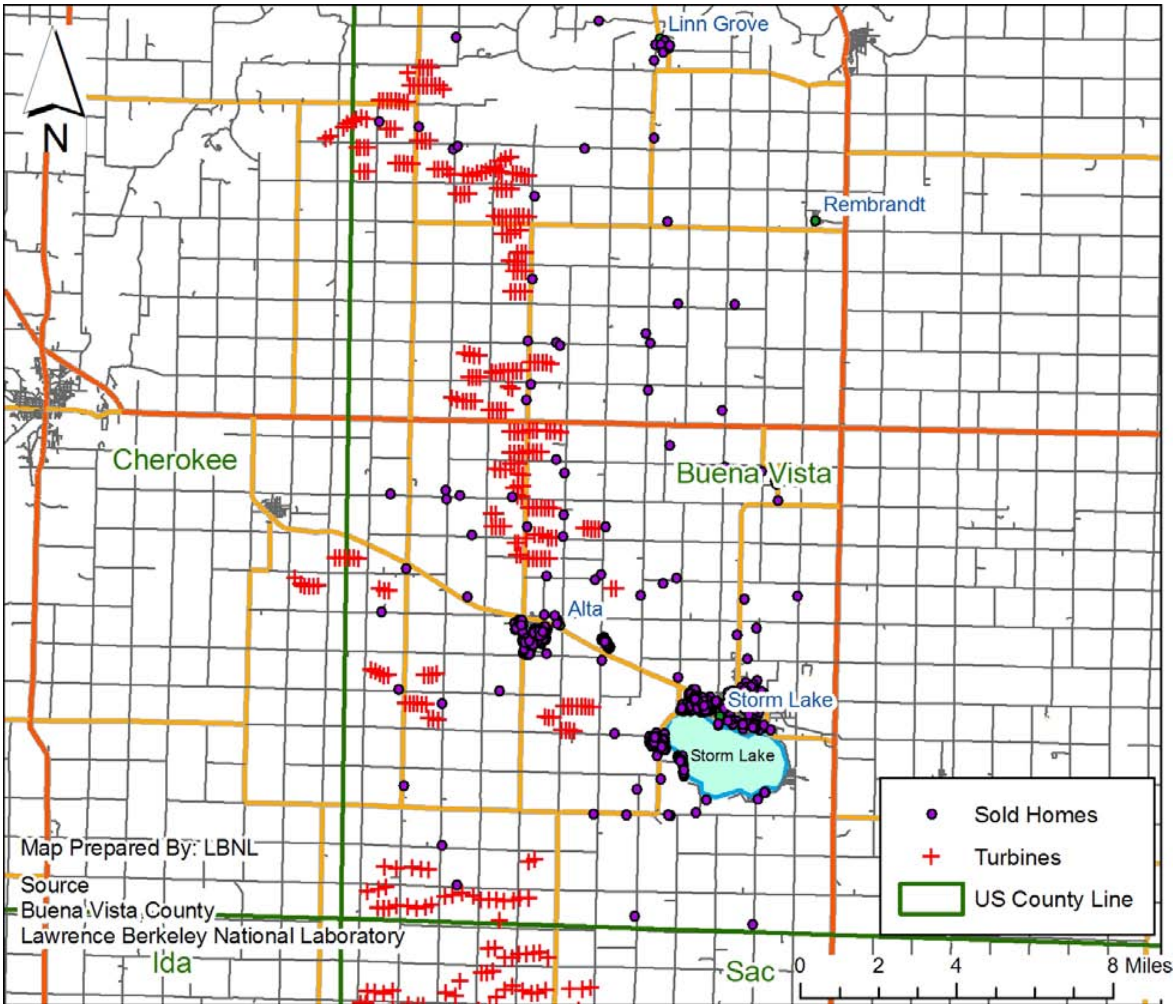
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Weatherford	City	10,097	1.2%	1,740	24.1	$ 32,543	$ 113,996	45%
Hydro	Town	1,013	-3.7%	1,675	39.2	$ 35,958	$ 66,365	68%
Custer	County	26,111	3.6%	26	32.7	$ 35,498	$ 98,949	52%
Oklahoma	State	3,617,316	4.8%	53	35.5	$ 41,567	$ 103,000	46%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

A.4 IABV Study Area: Buena Vista County (Iowa)

Figure A - 5: Map of IABV Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area includes the sizable Storm Lake and Intrepid wind facilities, which are mostly situated in Buena Vista County, located in Northwestern Iowa, 75 miles East of Sioux City. The facilities also stretch into Sac County to the South and Cherokee County to the West. The facilities total 381 turbines (370 MW) and are more than 30 miles long North to South and eight miles wide East to West. Development began on the first Storm Lake facility in 1998 and the last of the Intrepid development was completed in 2006. The largest turbines have a hub height of 213 feet at the hub, but most are slightly smaller at 207 feet. The majority of the homes in the sample surround Storm Lake (the body of water), but a large number of homes are situated on small residential plots located outside of the town and nearer to the wind facility. Additionally, a number of sales occurred in Alta - a small town to the East of Storm Lake -thatis straddled by the wind facilities and therefore provides dramatic views of the turbines. In general, except for the depression in which Storm Lake sits, the topography is very flat, largely made up corn fields, and the turbines are therefore visible from quite far away. The housing market is driven, to some extent, by the water body, Storm Lake, which is a popular recreational tourist destination, and therefore development is occurring to the East and South of the lake. Some development is also occurring, to a lesser degree, to the East of Alta.

Data Collection and Summary

County Assessor Kathy A. Croker and Deputy Assessor Kim Carnine were both extremely helpful in answering questions and providing GIS data. Sales and home characteristic data were provided by Vanguard Appraisals, Inc., facilitated by the county officials. David Healy from MidAmerican provided some of the necessary turbine location GIS files.

The county provided data on valid single-family residential transactions between 1996 and 2007 for 1,743 homes inside of five miles of the nearest wind turbine. This sample exceeded the number for which field data could reasonably be collected; as a result, only a sample of these homes sales was used for the study. Specifically, all transactions that occurred within three miles of the nearest turbine were used, in combination with a random sample (totaling roughly 10%) of those homes between three and five miles. This approach resulted in 822 sales, with prices that ranged from $12,000 to $525,000, and a mean of $94,713. Development of the wind facilities in this area occurred relatively early in the sample period, and therefore roughly 75% of the sales (*n* = 605) occurred after project construction had commenced. Of those 605 sales, 105 had views of the turbines, 37 of which were ranked with a view rating more dramatic than MINOR, and 30 sales occurred within one mile of the nearest wind turbine.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/2/1996	3/30/2007	822	$79,000	$94,713	$12,000	$525,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Storm Lake I	112.5	150	Feb-98	Oct-98	Jun-99	Enron	63
Storm Lake II	80.3	107	Feb-98	Oct-98	Apr-99	Enron	63
Waverly	1.5	2	Feb-98	Oct-98	Jun-99	Enron	65
Intrepid	160.5	107	Mar-03	Oct-04	Dec-04	GE Wind	65
Intrepid Expansion	15.0	15	Jan-05	Apr-05	Dec-05	Mitsubishi	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Buena Vista, IA (IABV)	152	65	80	70	455	822

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Buena Vista, IA (IABV)	217	500	68	18	8	11	822

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Buena Vista, IA (IABV)	217	22	8	472	101	2	822

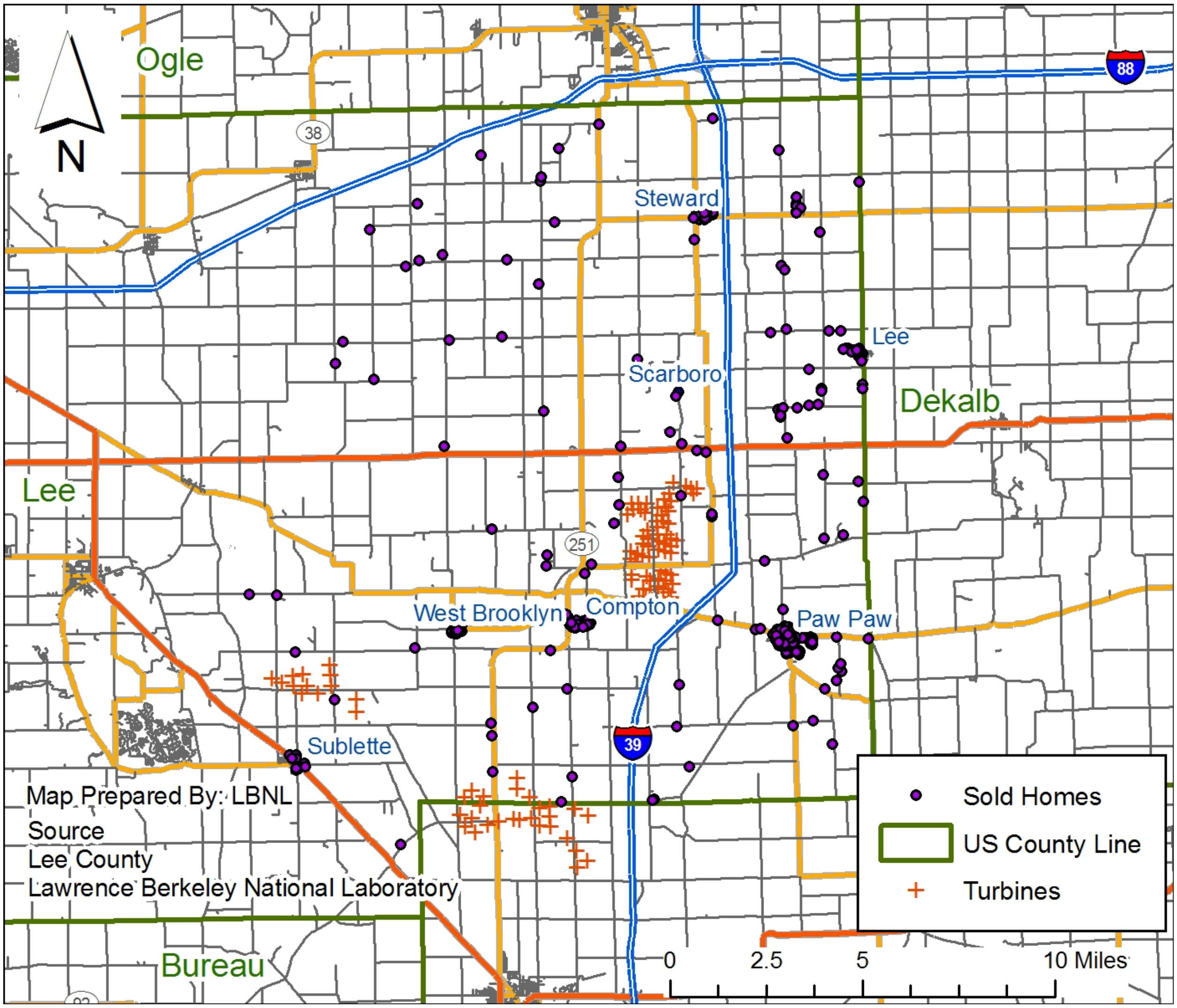
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Storm Lake	City	9,706	-3.9%	2,429	31.7	$ 39,937	$ 99,312	41%
Alta	Town	1,850	-1.0%	1,766	35.1	$ 40,939	$ 98,843	48%
Buena Vista	County	19,776	-3.1%	36	36.4	$ 42,296	$ 95,437	45%
Iowa	State	3,002,555	2.6%	52	36.6	$ 47,292	$ 117,900	43%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

A.5 ILLC Study Area: Lee County (Illinois)

Figure A - 6: Map of ILLC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area is situated roughly 80 miles due West of Chicago, in Lee County, Illinois, and includes two wind facilities. The 63 turbine (53 MW) Mendota Hills Wind Project sits just West of North-South Highway 39, and 10 miles South of East-West Highway 88. Development began on the facility in 2001 and was completed in 2003. The second facility, the 40 turbine (80 MW) GSG Wind Farm is South and West of the Mendota Hills facility, and is broken into two parts: roughly one third of the turbines are situated two miles due north of the small town of Sublette, with the remainder located roughly six miles to the southeast and spanning the line separating Lee from La Salle County. Development began on this project in the fall of 2006 and was completed in April of the following year. The town of Paw Paw, which is East of Highway 38 and both facilities, is the largest urban area in the study area, but is further away from the facilities than the towns of Compton, West Brooklyn, Scarboro, and Sublette. Also, to the North of the facilities are the towns of Lee, to the East of Highway 38, and Steward, just to the West. Although many home sales occurred in these towns, a significant number of additional sales occurred on small residential tracts in more-rural areas or in small developments. The topography of the area is largely flat, but falls away slightly to the East towards Paw Paw. The area enjoyed significant development during the real estate boom led by commuters from the Chicago metropolitan area, which was focused in the Paw Paw area but was also seen in semi-rural subdivisions to the Southwest and North of the wind facility.

Data Collection and Summary

County Supervisor Wendy Ryerson was enormously helpful in answering questions and providing data, as were Carmen Bollman and GIS Director, Brant Scheidecker, who also work in the county office. Wendy and Carmen facilitated the sales and home characteristic data request and Brant provided the GIS data. Additionally, real estate brokers Neva Grevengoed of LNG Realtor, Alisa Stewart of AC Corner Stone, and Beth Einsely of Einsely Real Estate were helpful in understanding the local market.

The county provided information on 412 valid single-family transactions that occurred between 1998 and 2007 within 10 miles of the nearest wind turbine, all of which were included in the sample.[108] These sales ranged in price from $14,500 to $554,148, with a mean of $128,301. Of those sales, 213 occurred after construction commenced on the wind facility and, of those, 36 had views of the turbines – nine of which were rated more dramatically than MINOR. Only two sales occurred within one mile of the nearest wind turbine.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
5/1/1998	3/2/2007	412	$113,250	$128,301	$14,500	$554,148

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Mendota Hills	50.4	63	Nov-01	Aug-03	Nov-03	Gamesa	65
GSG Wind Farm	80	40	Dec-05	Sep-06	Apr-07	Gamesa	78

Source: AWEA & Ventyx Inc.

[108] This county was not able to provide data electronically back to 1996, as would have been preferred, but because wind project development did not occur until 2001, there was ample time in the study period to establish pre-announcement sale price levels.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Lee, IL (ILLC)	115	84	62	71	80	412

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Lee, IL (ILLC)	199	177	27	7	1	1	412

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Lee, IL (ILLC)	199	1	1	85	69	57	412

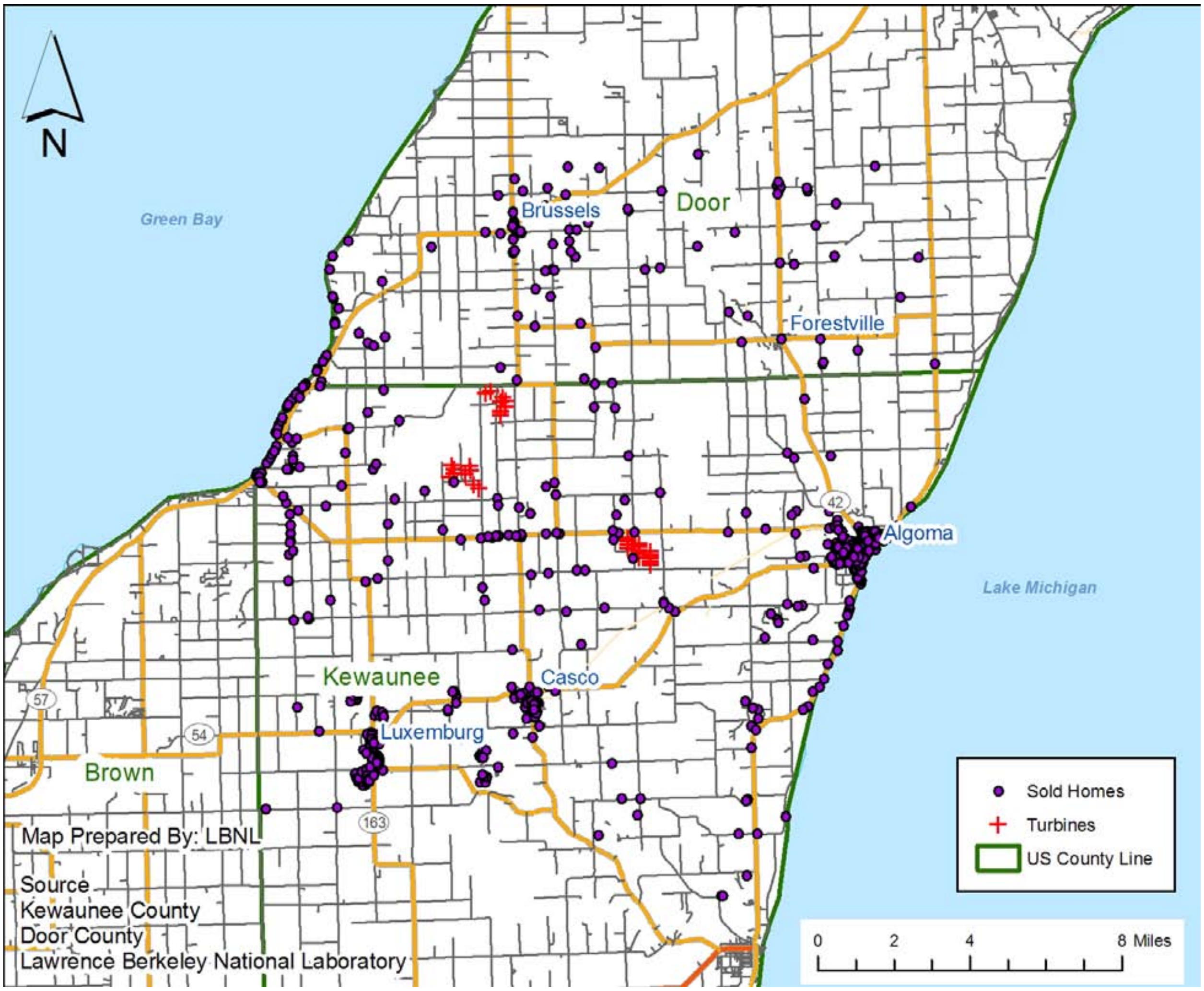
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Paw Paw	Town	884	2.6%	1,563	38.0	$ 48,399	$ 151,954	n/a
Compton	Town	337	-2.9%	2,032	32.8	$ 44,023	$ 114,374	n/a
Steward	Town	263	-3.0%	2,116	35.2	$ 59,361	$ 151,791	n/a
Sublette	Town	445	-2.4%	1,272	37.7	$ 55,910	$ 133,328	n/a
Lee	County	35,450	-1.7%	49	37.9	$ 47,591	$ 136,778	64%
Illinois	State	12,852,548	3.5%	223	34.7	$ 54,124	$ 208,800	60%
US	Country	301,139,947	7.0%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.6 WIKCDC Study Area: Kewaunee and Door Counties (Wisconsin)

Figure A - 7: Map of WIKCDC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area includes the Red River (17 turbines, 14 MW) and Lincoln (14 turbines, 9 MW) wind facilities. It is situated on the "thumb" jutting into Lake Michigan, Northeast of Green Bay, Wisconsin, and spans two counties, Kewaunee and Door. There is a mix of agricultural, small rural residential, waterfront, and urban land use in this area. The three largest towns are Algoma to the East of the facilities and on the lake, Casco, which is six miles due South of the turbines, and Luxemburg, four miles West of Casco. There is a smaller village, Brussels, to the North in Door County. The remainder of the homes is situated on the water or in small rural residential parcels between the towns. Topographically, the "thumb" is relatively flat except for a slight crown in the middle, and then drifting lower to the edges. The East edge of the "thumb" ends in bluffs over the water, and the western edge drops off more gradually, allowing those parcels to enjoy small beaches and easy boat access. There is some undulation of the land, occasionally allowing for relatively distant views of the wind turbines, which stand at a hub height of 213 feet.

Data Collection and Summary

Kewaunee and Door Counties did not have a countywide system of electronic data storage for either sales or home characteristic data. Therefore, in many cases, data had to be collected directly from the town or city assessor. In Kewaunee County, Joseph A. Jerabek of the town of Lincoln, Gary Taicher of the town of Red River, Melissa Daron of the towns of Casco, Pierce, and West Kewaunee, Michael Muelver of the town of Ahnapee and the city of Algoma, William Gerrits of the town of Casco, Joseph Griesbach Jr. of the town of Luxemburg, and David Dorschner of the city of Kewaunee all provided information. In Door County, Scott Tennessen of the town of Union and Gary Maccoux of the town of Brussels were similarly very helpful in providing information. Additionally, Andy Pelkey of Impact Consultants, Inc., John Holton of Associated Appraisal Consultants, Andy Bayliss of Dash Development Group, and Lue Van Asten of Action Appraisers & Consultants all assisted in extracting data from the myriad of storage systems used at the town and city level. The State of Wisconsin provided additional information on older sales and sales validity, with Mary Gawryleski, James Bender, and Patrick Strabala from the Wisconsin Department of Revenue being extremely helpful. GIS data were obtained from Steve Hanson from Kewaunee County and Tom Haight from Door County.

After collecting data from each municipality, a total of 810 valid single-family home sales transactions were available for analysis, ranging in time from 1996 to 2007. These sales ranged in price from $20,000 to $780,000, with a mean of $116,698. Because development of the wind facilities occurred relatively early in the study period, a large majority of the sales transactions, 75% (n = 725), occurred after project construction had commenced. Of those, 64 had views of the turbines, 14 of which had more dramatic than MINOR views, and 11 sales occurred within one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
2/2/1996	6/30/2007	810	$98,000	$116,698	$20,000	$780,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Red River	11.2	17	Apr-98	Jan-99	Jun-99	Vestas	65
Lincoln	9.2	14	Aug-98	Jan-99	Jun-99	Vestas	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Kewaunee/Door, WI (WIKCDC)	**44**	**41**	**68**	**62**	**595**	**810**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Kewaunee/Door, WI (WIKCDC)	**85**	**661**	**50**	**9**	**2**	**3**	**810**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Kewaunee/Door, WI (WIKCDC)	**85**	**7**	**4**	**63**	**213**	**438**	**810**

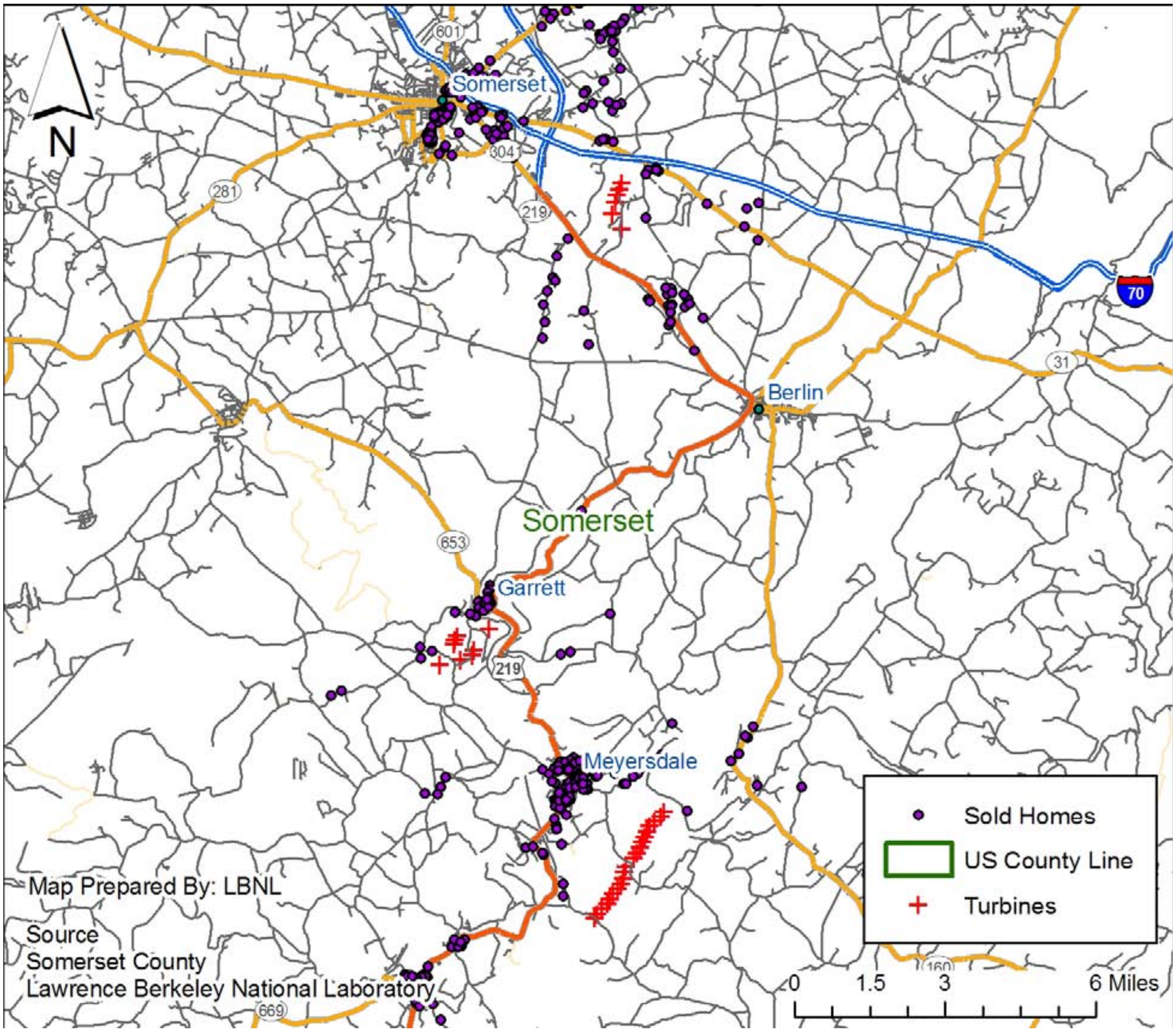
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Algoma	Town	3,186	-4.7%	1,305	41.8	$ 39,344	$ 112,295	51%
Casco	Town	551	-2.8%	985	35.6	$ 53,406	$ 141,281	n/a
Luxemburg	Town	2,224	15.3%	1,076	32.0	$ 53,906	$ 167,403	n/a
Kewaunee	County	20,533	1.4%	60	37.5	$ 50,616	$ 148,344	57%
Door	County	27,811	2.4%	58	42.9	$ 44,828	$ 193,540	57%
Wisconsin	State	5,601,640	0.3%	103	36.0	$ 50,578	$ 168,800	50%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.7 PASC Study Area: Somerset County (Pennsylvania)

Figure A - 8: Map of PASC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area includes three wind facilities, Somerset (6 turbines, 9 MW, 210 ft hub height) to the North, Meyersdale (20 turbines, 30 MW, 262 ft hub height) to the South, and Green Mountain (8 turbines, 10 MW, 197 ft hub height) between them. All of the projects are located in Somerset County, roughly 75 miles southeast of Pittsburg in the Southwest section of Pennsylvania. None of the three facilities are separated by more than 10 miles, so all were included in one study area. To the North of the facilities is East-West U.S. Highway 70, which flanks the city of Somerset. Connecting Somerset with points South is County Route 219, which zigzags Southeast out of Somerset to the smaller towns of Berlin (not included in the data), Garret to the Southwest, and Meyersdale, which is Southeast of Garret. These towns are flanked by two ridges that run from the Southwest to the Northeast. Because of these ridges and the relatively high elevations of all of the towns, this area enjoys winter recreation, though the coal industry, which once dominated the area, is still an integral part of the community with mining occurring in many places up and down the ridges. Although many of the home sales in the sample occurred in the towns, a number of the sales are for homes situated outside of town corresponding to either rural, rural residential, or suburban land uses.

Data Collection and Summary

The County Assessor, Jane Risso, was extremely helpful, and assisted in providing sales and home characteristic data. Glen Wagner, the IT director, worked with Gary Zigler, the county GIS specialist, to extract both GIS and assessment data from the county records. Both Gary and Jane were extremely helpful in fielding questions and providing additional information as needs arose.

The county provided a total of 742 valid residential single-family home sales transactions within four miles of the nearest wind turbine. All of the sales within three miles were used (n = 296), and a random sample (~ 44%) of those between three and four miles were used, yielding a total of 494 sales that occurred between May 1997 and March 2007. These sales ranged in price from $12,000 to $360,000, with a mean of $69,770. 291 sales (~ 60% of the 494) occurred after construction commenced on the nearest wind facility. Of these 291 sales, 73 have views of the turbines, 18 of which are more dramatic than MINOR, and 35 sales occurred within one mile.[109]

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
5/1/1997	3/1/2007	494	$62,000	$69,770	$12,000	$360,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
GreenMountain Wind Farm	10.4	8	Jun-99	Dec-99	May-00	Nordex	60
Somerset	9.0	6	Apr-01	Jun-01	Oct-01	Enron	64
Meyersdale	30.0	20	Jan-03	Sep-03	Dec-03	NEG Micon	80

Source: AWEA & Ventyx Inc.

[109] This study area was one of the earliest to have field work completed, and therefore the field data collection process was slower resulting in a lower number of transactions than many other study areas.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Somerset, PA (PASC)	175	28	46	60	185	494

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Somerset, PA (PASC)	203	218	55	15	2	1	494

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Somerset, PA (PASC)	203	17	18	132	124	0	494

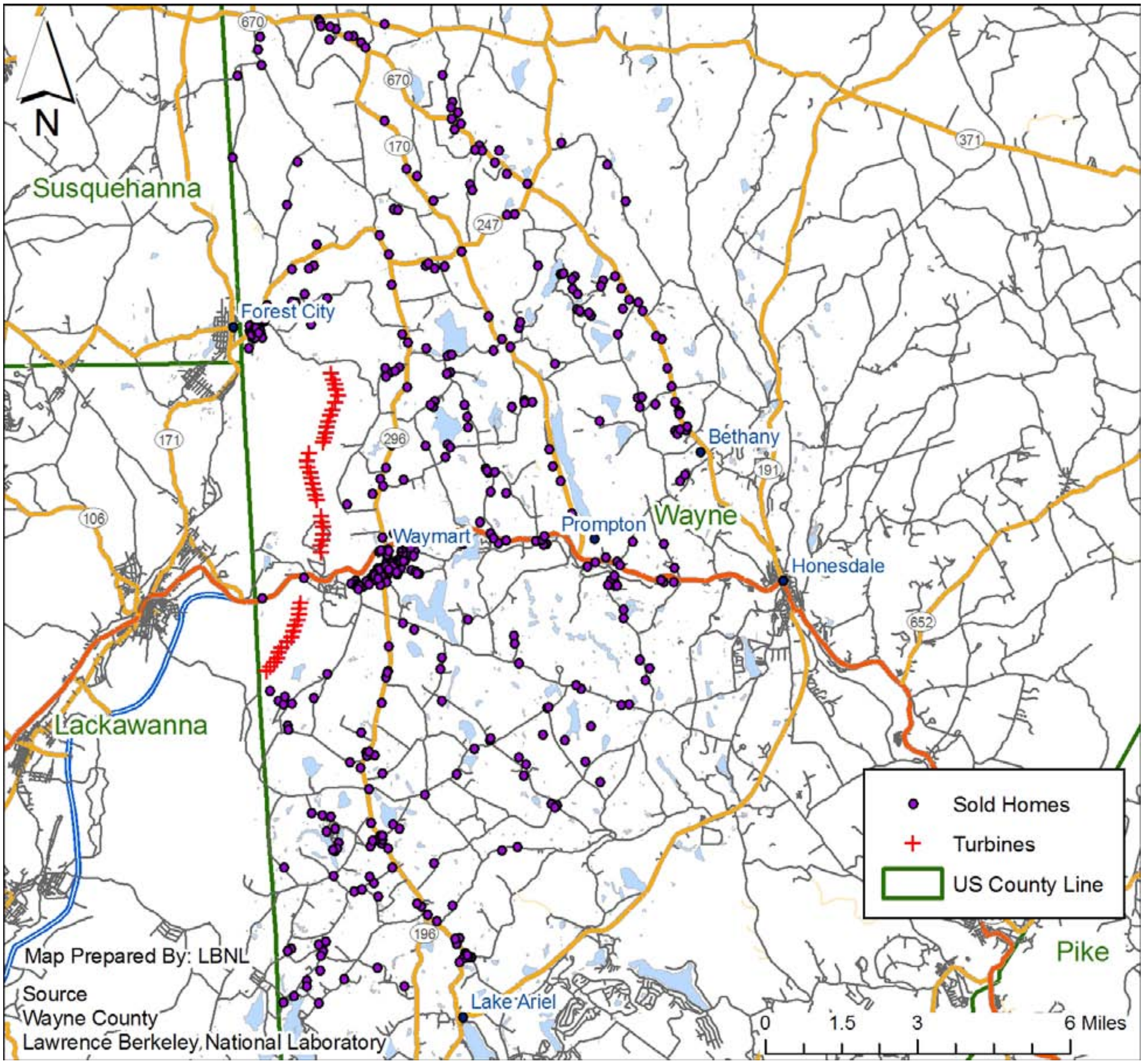
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Somerset	Town	6,398	-4.8%	2,333	40.2	$ 35,293	$ 123,175	n/a
Berlin	Town	2,092	-4.0%	2,310	41.1	$ 35,498	$ 101,704	n/a
Garrett	Town	425	-4.7%	574	34.5	$ 29,898	$ 54,525	n/a
Meyersdale	Town	2,296	-6.6%	2,739	40.9	$ 29,950	$ 79,386	n/a
Somerset Co	County	77,861	-2.7%	72	40.2	$ 35,293	$ 94,500	41%
Pennsylvania	State	12,440,621	1.3%	277	38.0	$ 48,576	$ 155,000	60%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.8 PAWC Study Area: Wayne County (Pennsylvania)

Figure A - 9: Map of PAWC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area includes the Waymart wind facility, which sits atop the North-South ridge running along the line separating Wayne County from Lackawanna and Susquehanna Counties in Northeast Pennsylvania. The 43 turbine (65 MW, 213 ft hub height) facility was erected in 2003, and can be seen from many locations in the study area and especially from the towns of Waymart, which sits East of the facility, and Forest City, which straddles Wayne and Susquehanna Counties North of the facility. The study area is dominated topographically by the ridgeline on which the wind turbines are located, but contains rolling hills and many streams, lakes, and natural ponds. Because of the undulating landscape, views of the wind facility can be maintained from long distances, while some homes relatively near the turbines have no view of the turbines whatsoever. The area enjoys a substantial amount of second home ownership because of the bucolic scenic vistas, the high frequency of lakes and ponds, and the proximity to larger metropolitan areas such as Scranton, roughly 25 miles to the Southwest, and Wilkes-Barre a further 15 miles Southwest.

Data Collection and Summary

John Nolan, the County Chief Assessor, was very helpful in overseeing the extraction of the data from county records. GIS specialist Aeron Lankford provided the GIS parcel data as well as other mapping layers, and Bruce Grandjean, the IT and Data Specialist, provided the sales and home characteristic data as well as fielding countless questions as they arose. Additionally, real estate brokers Dotti Korpics of Bethany, Kent Swartz of Re Max, and Tom Cush of Choice #1 Country Real Estate were instrumental providing context for understanding the local market.

The county provided data on 551 valid single-family transactions that occurred between 1996 and 2007, all of which were included in the sample. These sales ranged in price from $20,000 to $444,500, with a mean of $111,522. Because of the relatively recent development of the wind facility, only 40% (*n* = 222) of the sales transaction occurred after the construction of the facility had commenced. Of those sales, 43 (19%) had views of the turbines, ten of which had more dramatic than MINOR views, and 11 were situated within one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
7/12/1996	9/25/2006	551	$96,000	$111,522	$20,000	$444,500

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Waymart Wind Farm	64.5	43	Feb-01	Jun-03	Oct-03	GE Wind	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Wayne, PA (PAWC)	223	106	64	71	87	551

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Wayne, PA (PAWC)	329	179	33	8	2	0	551

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Wayne, PA (PAWC)	329	1	10	95	55	61	551

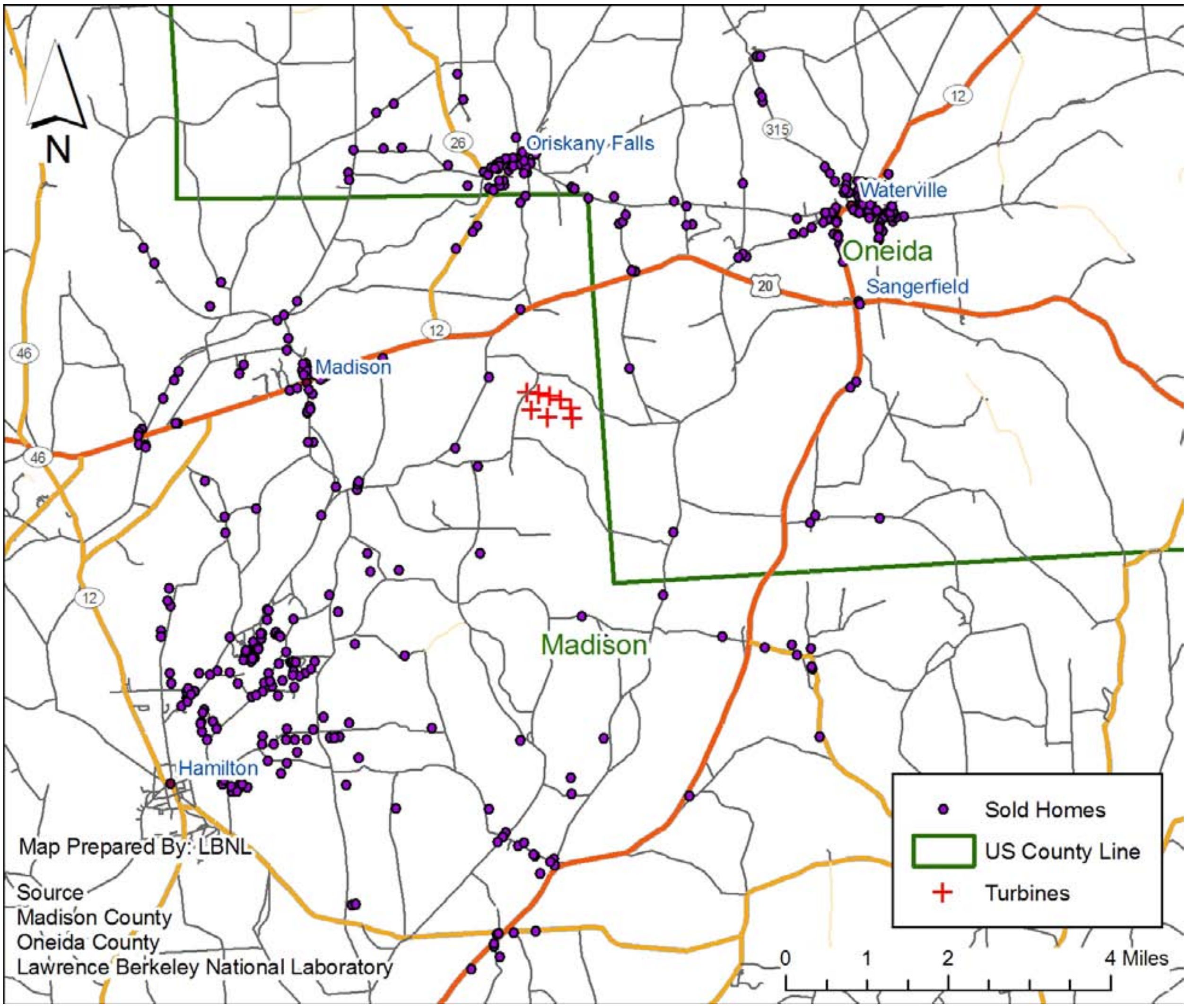
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Waymart	Town	3,075	116.0%	1,111	41.7	$ 43,797	$ 134,651	56%
Forest City	Town	1,743	-5.2%	1,929	45.6	$ 32,039	$ 98,937	67%
Prompton	Town	237	-1.6%	149	41.9	$ 30,322	$ 162,547	56%
Wayne	County	51,708	5.9%	71	40.8	$ 41,279	$ 163,060	57%
Lackawanna	County	209,330	-1.9%	456	40.3	$ 41,596	$ 134,400	48%
Pennsylvania	State	12,440,621	1.3%	277	38.0	$ 48,576	$ 155,000	60%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

A.9 NYMCOC Study Area: Madison and Oneida Counties (New York)

Figure A - 10: Map of NYMCOC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area surrounds the seven turbine (12 MW, 220 ft hub height) Madison wind facility, which sits atop an upland rise in Madison County, New York. The area is roughly 20 miles Southwest of Utica and 40 miles Southeast of Syracuse. The facility is flanked by the towns moving from the Southwest, clockwise around the rise, from Hamilton and Madison in Madison County, NY, to Oriskany Falls, Waterville, and Sangerfield in Oneida County, NY. Hamilton is the home of Colgate University, whose staff lives throughout the area around Hamilton and stretching up into the town of Madison. Accordingly, some development is occurring near the college. To the Northeast, in Oneida County, the housing market is more depressed and less development is apparent. The study area in total is a mix of residential, rural residential, and rural landscapes, with the largest portion being residential homes in the towns or immediately on their outskirts. The topography, although falling away from the location of the wind facility, does not do so dramatically, so small obstructions can obscure the views of the facility.

Data Collection and Summary

Data were obtained from both Madison and Oneida Counties for this study area. In Madison County, Kevin Orr, Mike Ellis, and Carol Brophy, all of County's Real Property Tax Services Department, were extremely helpful in obtaining the sales, home characteristic, and GIS data. In Oneida County, Jeff Quackenbush and Richard Reichert in the Planning Department were very helpful in obtaining the county data. Additionally, discussions with real estate brokers Susanne Martin of Martin Real Estate, Nancy Proctor of Prudential, and Joel Arsenault of Century 21 helped explain the housing market and the differences between Madison and Oneida Counties.

Data on 463 valid sales transactions of single family residential homes that occurred between 1996 and 2006 were obtained, all of which were located within seven miles of the wind facility. These sales ranged in price from $13,000 to $380,000, with a mean of $98,420. Roughly 75% (*n* = 346) of these sales occurred after construction commenced on the wind facility, of which 20 could see the turbines, all of which were rated as having MINOR views, except one which had a MODERATE rating; only two sales involved homes that were situated inside of one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/6/1996	12/26/2006	463	$77,500	$98,420	$13,000	$380,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Madison Windpower	11.6	7	Jan-00	May-00	Sep-00	Vestas	67

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Madison/Oneida, NY (MYMCOC)	108	9	48	30	268	463

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Madison/Oneida, NY (MYMCOC)	117	326	19	1	0	0	463

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Madison/Oneida, NY (MYMCOC)	117	1	1	80	193	71	463

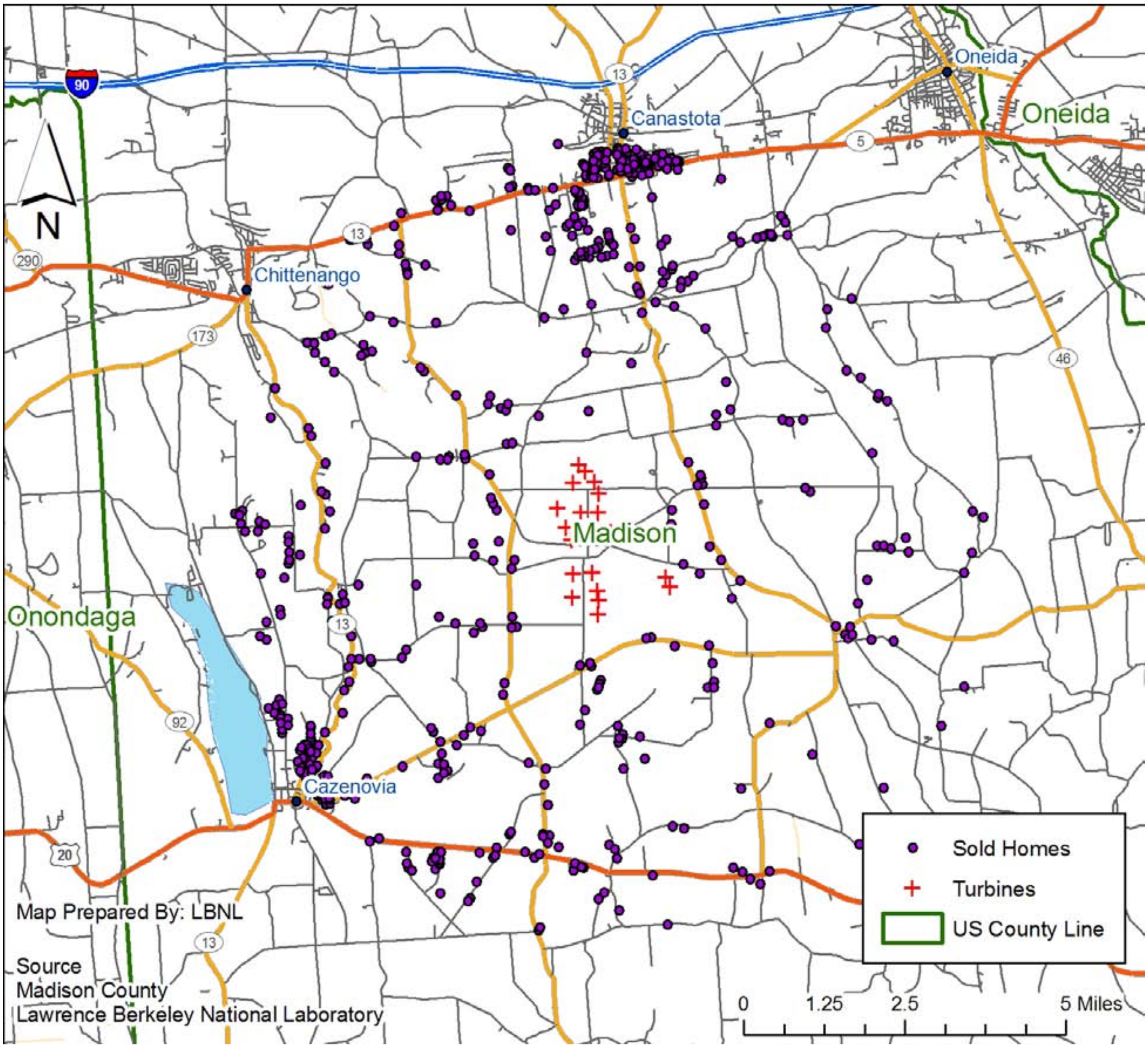
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Madison	Town	304	-2.9%	605	38.1	$ 36,348	$ 94,734	n/a
Hamilton	Town	3,781	7.9%	1,608	20.8	$ 48,798	$ 144,872	n/a
Orinkany Fal	Town	1,413	-2.9%	1,703	40.8	$ 47,689	$ 105,934	n/a
Waterville	Town	1,735	-3.2%	1,308	37.8	$ 46,692	$ 104,816	n/a
Sangerfield	Town	2,626	-1.4%	85	37.6	$ 47,563	$ 106,213	n/a
Madison	County	69,829	0.6%	106	36.1	$ 53,600	$ 109,000	39%
Oneida	County	232,304	-1.3%	192	38.2	$ 44,636	$ 102,300	40%
New York	State	19,297,729	1.7%	408	35.9	$ 53,514	$ 311,000	109%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.10 NYMC Study Area: Madison County (New York)

Figure A - 11: Map of NYMC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area surrounds the 20 turbine (30 MW, 218 ft hub height) Fenner wind facility in Madison County, New York, roughly 20 miles East of Syracuse and 40 miles West of Utica in the middle of New York. The study area is dominated by two roughly parallel ridges. One, on which the Fenner facility is located, runs Southeast to Northwest and falls away towards the town of Canastota. The second ridge runs roughly North from Cazenovia, and falls away just South of the town of Chittenango. Surrounding these ridges is an undulating landscape with many water features, including the Chittenango Falls and Lake Cazenovia. A number of high-priced homes are situated along the ridge to the North of Cazenovia, some of which are afforded views of the lake and areas to the West, others with views to the East over the wind facility, and a few having significant panoramic views. The west side of the study area has a number of drivers to its real estate economy: it serves as a bedroom community for Syracuse, is the home to Cazenovia College, and enjoys a thriving summer recreational population. Canastota to the North, and Oneida to the East, are older industrial towns, both of which now serve as feeder communities for Syracuse because of easy access to Highway 90. Between the towns of Cazenovia and Canastota are many rural residential properties, some of which have been recently developed, but most of which are homes at least a half century old.

Data Collection and Summary

Data were obtained from the Madison County Real Property Tax Services department directed by Carol Brophy. As the first study area that was investigated, IT and mapping specialists Kevin Orr and Mike Ellis were subjected to a large number of questions from the study team and were enormously helpful in helping shape what became the blueprint for other study areas. Additionally, real estate brokers Nancy Proctor of Prudential, Joel Arsenault of Century 21, Don Kinsley of Kingsley Real Estate, and Steve Harris of Cazenovia Real Estate were extremely helpful in understanding the local market.

Data on 693 valid sales transactions of single family residential structures that occurred between 1996 and 2006 were obtained, most of which were within five miles of the wind facility. These sales ranged in price from $26,000 to $575,000, with a mean of $124,575. Roughly 68% of these sales (n = 469) occurred after construction commenced on the wind facility, 13 of which were inside of one mile, and 74 of which had views of the turbines. Of that latter group, 24 have more dramatic than MINOR views of the turbines.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/31/1996	9/29/2006	693	$109,900	$124,575	$26,000	$575,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Fenner Wind Power Project	30	20	Dec-98	Mar-01	Nov-01	Enron	66

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Madison, NY (NYMC)	59	165	74	70	325	693

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Madison, NY (NYMC)	224	395	50	16	8	0	693

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Madison, NY (NYMC)	224	2	11	80	374	2	693

Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Cazenovia	Town	2,835	8.6%	1,801	32.3	$ 58,172	$ 159,553	n/a
Chittenango	Town	4,883	-0.5%	2,000	36.0	$ 58,358	$ 104,845	n/a
Canastota	Town	4,339	-1.7%	1,306	37.3	$ 45,559	$ 93,349	n/a
Oneida	City	10,791	-1.7%	490	36.9	$ 47,173	$ 99,305	n/a
Morrisville	Town	2,155	0.6%	1,869	20.4	$ 45,852	$ 102,352	n/a
Madison	County	69,829	0.6%	106	36.1	$ 53,600	$ 109,000	39%
New York	State	19,297,729	1.7%	408	35.9	$ 53,514	$ 311,000	109%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

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Appendix B: Methodology for Calculating Distances with GIS

For each of the homes in the dataset, accurate measurements of the distance to the nearest wind turbine at the time of sale were needed, and therefore the exact locations of both the turbines and the homes was required. Neither of these locations was available from a single source, but through a combination of techniques, turbine and home locations were derived. This section describes the data and techniques used to establish accurate turbine and home locations, and the process for then calculating distances between the two.

There were a number of possible starting points for mapping accurate wind turbine locations. First, the Energy Velocity data, which covered all study areas, provided a point estimate for project location, but did not provide individual turbine locations. The Federal Aviation Administration (FAA), because of permitting and aviation maps, maintains data on turbine locations, but at the time of this study, that data source did not cover all locations, contained data on structures that no longer exist, and was difficult to use.[110] Finally, in some cases, the counties had mapped the wind turbines into GIS.

In the end, because no single dataset was readily available to serve all study areas, instead the variety of data sources described above was used to map and/or confirm the location of every turbine in the 10 study areas. The process began with high-resolution geocoded satellite and aerial ortho imagery that the United States Department of Agriculture (USDA) collects and maintains under its National Agriculture Imagery Program (NAIP), and which covers virtually all of the areas in this investigation. Where needed, older ortho imagery from the USDA was used. Combining these data with the Energy Velocity data, and discussions with local officials, and maps provided by the county or the developer, locating and mapping all of the turbines in each study area was possible.

Home locations were provided directly by some counties; in other cases, a parcel centroid was created as a proxy.[111] In some situations, the centroid did not correspond to the actual house location, and therefore required further refinement. This refinement was only required and conducted if the parcel was near the wind turbines, where the difference of a few hundred feet, for example, could alter its distance rating in a meaningful fashion, or when the parcel included a considerable amount of acreage, where inaccuracy in home location could be considerable. Therefore, parcels inside of 1.5 miles of the nearest wind turbine and of any size, and parcels outside of 1.5 miles and larger than 5 acres, were both examined using the USDA NAIP imagery to determine the exact home location. In cases where the parcel centroid was not centered over the home, the location was adjusted, using the ortho image as a guide, to the actual house location.

With both turbine and home locations identified, the next step was to determine distances between the two. To do so, the date when each transaction in the sample occurred was taken into

[110] A newer FAA database is now available that clears up many of these earlier concerns.

[111] A “parcel centroid” is the mathematical center point of a polygon, and was determined by XTools Pro (www.xtoolspro.com).

account, combined with the determination of which turbines were in existence at what time.[112] This required breaking the transactions in the sample into three categories: 1) those occurring before any wind facility was announced in the study area, 2) those occurring after the first wind facility was announced in the area but before all development was complete in the area, and 3) those occurring after all wind development in the area was complete. Any sale that occurred before wind development was announced in the study area was coded with a distance to the nearest turbine derived from the actual turbine locations after all wind development had occurred.[113] Homes that sold after all wind development had occurred were treated similarly, with distances derived from the set of turbines in place after all development had taken place. The final set of homes - those that sold after announcement of the first facility, but before the construction of the last - had to be treated, essentially, on a case by case basis. Some homes were located within five miles of one wind facility but more than five miles from another wind facility in the same study area (e.g., many homes in PASC). In this case the distance to that closer facility could be applied in a similar fashion as would be the case if only one facility was erected (e.g., NYMC or PAWC). Another group of homes, those that sold during the development of the first facility in the study area, were given the distance to that facility, regardless of distance to the other facilities in the study area. The final and most complicated group of homes consisted of those that were within five miles of multiple wind facilities, and that sold after the first facility had been erected. In those cases, the exact configuration of turbines was determined for each stage of the development process. In study areas with multiple facilities that were developed over multiple periods, there might be as many as six possible configurations (e.g., IABV). In this final scenario, the distance to the closest turbine was used, assuming it had been "announced" at the time of sale.

Once the above process was complete, the mechanics of calculating distances from the turbines to the homes was straightforward. After establishing the location of a set of turbines, for instance those constructed in the first development in the area, a euclidian distance raster was derived that encompassed every home in the study area. [114] The calculations were made using a 50-foot resolution state-plane projection and North American Datum from 1983 (NAD83). As discussed above, similar rasters were created for each period in the development cycle for each study area, depending on the turbine configuration at that time. Ultimately, a home's sale date was matched to the appropriate raster, and the underlying distance was extracted. Taking everything into account discussed above, it is expected that these measurements are accurate to

[112] It is recognized that the formal date of sale will follow the date at which pricing decisions were made. It is also recognized, as mentioned in Section 3, that wind facility announcement and construction dates are likely to be preceded by "under the radar" discussions in the community. Taken together, these two factors might have the effect, in the model, of creating some apparent lag in when effects are shown, compared to the earlier period in which effects may begin to occur. For this to bias the results, however, effects would have to disappear or dramatically lesson with time (e.g., less than one year after construction) such that the effects would not be uncovered with the models in later periods. Based on evidence from other potentially analogous infrastructure (e.g., HVTL), any fading of effects would likely occur over many years, so it is assumed that any bias is likely minimal.

[113] These distances were used to compare homes sold, for instance, within 1 mile of where the turbines were eventually erected with similar homes sold after the turbines were erected (see, for example, the Temporal Aspects Model).

[114] A "Raster" is a grid of, in this case, 50 feet by 50 feet squares, each of which contains a number representing the number of feet from the center of the square to the nearest turbine.

within roughly 150 feet inside of 1.5 miles and within a maximum of roughly 1150 feet outside of 1.5 miles.[115]

[115] The resolution of the raster is 50 feet, so the hypotenuse is 70 feet. If the home is situated in the top left of a raster cell and the turbine is situated in the bottom right of a diagonally adjacent cell, they could be separated by as much as 140 feet, yet the raster distance would only be 50 feet, a difference of 90 feet. Moreover, the resolution of the Ortho image is 40 feet so that location could additionally be off by another 55 feet along the diagonal. These two uncertainties total to roughly 150 feet for homes inside of 1.5 miles. Outside of 1.5 miles the variation between centroid and house location for parcels smaller than 5 acres could be larger still. If a 4.9 acre parcel had a highly irregular rectangular shape of 102 by 2100 feet, for instance, the centroid could be as much as 1050 feet from the property line. If the home was situated 50 feet from the property line then the actual house location could be off by as much as 1000 feet. Adding this to the 150 feet from above leads to a total discrepancy of 1150 feet (0.22 miles) for homes outside of 1.5 miles on parcels smaller than 5 acres. Of course, these extreme scenarios are highly unlikely to be prevalent.

Appendix C: Field Data Collection Instrument

Figure A - 12: Field Data Collection Instrument

House # (Control/ Key #)			County		
House Address					
Home Characteristics			**House Photo Number(s)**		
Cul-De-Sac?	No(0) / Yes(1)		Waterfront?		No(0) / Yes(1)
Scenic Vista Characteristics			**Vista Photo Numbers**		
Overall Quality of Scenic Vista: Poor (1), Below Average (2), Average (3), Above Average (4), Premium (5)					
View of Turbines Characteristics			**View Photo Numbers**		
Total # of Turbines visible			Orientation of Home to View: See Below		
# of Turbines- blade tips only visible			Side (S), Front (F), Back (B), Angled (A)		
# of Turbines- nacelle/hub visible					
# of Turbines- tower visible			View Scope: Narrow(1), Medium(2), Wide(3)		
The Degree to which the View of Turbines Dominate the Site? Non-Existent (0), Minor (1), Moderate (2), Substantial (3), Extreme (4)					
Degree to which the Turbines Overlap the Prominent Scenic Vista? Not at all (0), Barely (1), Somewhat (2), Strongly (3), Entirely (4)					
Notes:					

Figure A - 13: Field Data Collection Instrument - Instructions - Page 1

Home Characteristics

Cul-De-Sac? No(0)/Yes(1)	Is the home situated on a cul-de-sac?
Waterfront? No(0)/Yes(1)	Is the home situated on the waterfront?

"Vista" Characteristics

Overall Quality of Scenic Vista: Poor (1)	This rating is reserved for vistas of unmistakably poor quality. These vistas are often dominated by visually discordant man-made alterations (not considering turbines), or are uncomfortable spaces for people, lack interest, or have virtually no recreational potential.
Overall Quality of Scenic Vista: Below Average (2)	The home's vista is of the below average quality. These vistas contain visually discordant man-made alterations (not considering turbines) but are not dominated by them. They are not inviting spaces for people, but are not uncomfortable. They have little interest, mystery and have minor recreational potential.
Overall Quality of Scenic Vista: Average (3)	The home's vista is of the average quality. These vistas include interesting views which can be enjoyed often only a narrow scope. These vistas may contain some visually discordant man-made alterations (not considering turbines), are moderately comfortable spaces for people, have some interest, and have minor recreational potential.
Overall Quality of Scenic Vista: Above Average (4)	The vista from the home is of above average quality. These vistas include interesting views which often can be enjoyed in a medium to wide scope. They might contain some man made alterations (not considering turbines), yet still possess significant interest and mystery, are moderately balanced and have some potential for recreation.
Overall Quality of Scenic Vista: Premium (5)	This rating is reserved for vistas of unmistakably premium quality. These vistas would include "picture post card" views which can be enjoyed in a wide scope. They are often free or largely free of any discordant man made alterations (not considering turbines), possess significant interest, memorable qualities, mystery and are well balanced and likely have a high potential for recreation.
Degree Turbines Overlap Prominent Vista? Not at all (0))	The vista does not contain any view of the turbines.
Degree Turbines Overlap Prominent Vista? Barely (1)	A small portion (~ 0 - 20%) of the vista is overlapped by the view of turbines therefore the vista might contain a view of a few turbines, only a few of which can be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Somewhat (2)	A moderate portion (~20-50%) of the vista contains turbines, and likely contains a view of more than one turbine, some of which are likely to be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Strongly (3)	A large portion (~50-80%) of the vista contains a view of turbines, many of which likely can be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Entirely (4)	This rating is reserved for situations where the turbines overlap virtually the entire (~80-100%) vista from the home. The vista likely contains a view of many turbines, virtually all of which can be seen entirely (from below the sweep of the blades to the top of their tips).

Figure A - 14: Field Data Collection Instrument - Instructions - Page 2

View of Turbines Characterist	
House Orientation to View of Turbines: Side (S)	Orientation of home to the view of the turbines is from the side.
House Orientation to View of Turbines: Front (F)	Orientation of home to the view of the turbines is from the front.
House Orientation to Vista of Turbines: Back (B)	Orientation of home to the view of the turbines is from the back.
House Orientation to Vista of Turbines: Angled (A)	Orientation of home to the view of the turbines is from an angle.
View of Turbines Scope: Narrow(1)	The view of the turbines is largely blocked by trees, large shrubs or man made features in the foreground (0-300 feet) allowing 0 - 30 degrees of view of the wind facility
View of Turbines Scope: Medium(2)	The view of turbines is partially blocked by trees, large shrubs or man made features in the foreground (0-300 feet) allowing only 30-90 degrees of view of the wind facility.
View of Turbines Scope: Wide(3)	The view of the turbines is free or almost free from blockages by trees, large shrubs or man made features in the foreground (0-300 feet) allowing at least 90 degrees of view of the wind facility.
Degree to which View of Turbines Dominates the Site? None (0)	The turbines are not visible at all frrom this home.
Degree to which View of Turbines Dominates the Site? Minor (1)	The turbines are visible but either the scope is narrow, there are many obstructions, or the distance between the home and the facility is large.
Degree to which View of Turbines Dominates the Site? Moderate (2)	The turbines are visible but the scope is either narrow or medium, there might be some obstructions, and the distance between the home and the facility is most likely a few miles.
Degree to which View of Turbines Dominates the Site? Substantial (3)	The turbines are dramatically visible from the home. The turbines are likely visible in a wide scope, and most likely the distance between the home and the facility is short.
Degree to which View of Turbines Dominates the Site? Extreme (4)	This rating is reserved for sites that are unmistakably dominated by the presence of the windfarm. The turbines are dramatically visible from the home and there is a looming quality to their placement. The turbines are often visible in a wide scope, or the distance to the facility is very small.

Appendix D: Vista Ratings with Photos

POOR VISTA

BELOW AVERAGE VISTA

AVERAGE VISTA

ABOVE AVERAGE VISTA

PREMIUM VISTA

Appendix E: View Ratings with Photos

<u>MINOR VIEW</u>

3 turbines visible from front orientation, nearest 1.4 miles (TXHC)

5 turbines visible from front orientation, nearest 0.9 miles (NYMC)

<u>MODERATE VIEW</u>

18 turbines visible from back orientation, nearest 1.6 miles (ILLC)

6 turbines visible from back orientation, nearest 0.8 miles (PASC)

<u>SUBSTANTIAL VIEW</u>

90 turbines visible from all orientations, nearest 0.6 miles (IABV)

27 turbines visible from multiple orientations, nearest 0.6 miles (TXHC)

EXTREME VIEW

6 turbines visible from multiple orientations, nearest 0.2 miles (WIKCDC)

212 turbines visible from all orientations, nearest 0.4 miles (IABV)

Appendix F: Selecting the Primary ("Base") Hedonic Model

Equation (1) as described in Section 4.2 is presented in this report as the primary (or "Base") model to which all other models are compared. As noted earlier, in the Base Hedonic Model and in all subsequent models presented in Section 5 all variables of interest, spatial adjustments, and home and site characteristics are pooled, and therefore their estimates represent the average across all study areas. Ideally, one would have enough data to estimate a model at the study area level - a fully unrestricted model - rather than pooled across all areas. In this appendix, alternative model forms are presented that unrestrict these variables at the level of study areas. As shown here, these investigations ultimately encouraged the selection of the somewhat simpler pooled Base Model as the primary model, and to continue to use restricted or pooled models in the alternative hedonic analyses.

F.1 Discussion of Fully Unrestricted Model Form

The Base Model described by equation (1) has variables that are pooled, and the coefficients for these variables therefore represent the average across all study areas (after accounting for study area fixed effects). An alternative (and arguably superior) approach would be to estimate coefficients at the level of each study area, thereby allowing coefficient values to vary among study areas.[116] This fully interacted – or unrestricted – model would take the following form:

$$\ln(\mathrm{P}) = \beta_0 + \sum_{s}\beta_1(\mathrm{N}\cdot\mathrm{S}) + \sum_{c}\beta_2(\mathrm{Y}) + \sum_{k}\beta_3(\mathrm{X}\cdot\mathrm{S}) + \sum_{v}\beta_4(\mathrm{VIEW}\cdot\mathrm{S}) + \sum_{d}\beta_5(\mathrm{DISTANCE}\cdot\mathrm{S}) + \varepsilon \qquad \text{(F13)}$$

where

P represents the inflation-adjusted sale price,
N is the spatially weighted neighbors' predicted sale price,
S is a vector of *s* study areas (e.g., WAOR, OKCC, etc.),
Y is a vector of *c* study area locational characteristics (e.g., census tract, school district, etc.),
X is a vector of k home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
VIEW is a vector of v categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),
DISTANCE is a vector of d categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a vector of *s* parameter estimates for the spatially weighted neighbor's predicted sale price for S study areas,
β_2 is a vector of *c* parameter estimates for the study area locational fixed effect variables,
β_3 is a vector of *k* parameter estimates for the home and site characteristics for S study areas,
β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines for S study areas,

[116] For instance, the marginal contribution of Acres (the number of acres) to the selling price would be estimated for each study area (i.e., Acres_WAOR, Acres_TXHC etc.), as would the variables of interest: VIEW and DISTANCE.

β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles for S study areas, and
ε is a random disturbance term.

To refresh, the fully restricted equation (1) takes the following form:

$$\ln\left(\mathrm{P}\right) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{v}\beta_4\mathrm{VIEW} + \sum_{d}\beta_5\mathrm{DISTANCE} + \varepsilon \qquad (1)$$

where
P represents the inflation-adjusted sale price,
N is the spatially weighted neighbors' predicted sale price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
VIEW is a vector of *v* categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),
DISTANCE is a vector of *d* categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a parameter estimate for the spatially weighted neighbor's predicted sale price,
β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to homes sold in the Washington/Oregon (WAOR) study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles, and
ε is a random disturbance term.

The significant change between equations (1) and (F13) is that each of the primary groups of variables in equation (F13) is interacted with the study areas (S) so that parameters can be estimated at the study area level. For example, whereas ACRES is estimated in equation (1) across all study areas, in equation (F13) it is estimated for each study area (i.e., Acres_WAOR, Acres_TXHC, etc).[117] Similarly, when considering the possible impact of wind facilities on residential sales prices, equation (1) seeks average effects that exist over the entire sample, while equation (F13) instead looks for differential effects in each individual study area. Additionally, in equation (F13), instead of estimating fixed effects using inter-study area parameters alone (e.g., WAOR, TXHC), a set of intra-study area effects (Y) - school district and census tract delineations - are added.[118] These latter coefficients represent not only effects that are presumed

[117] This change is made because, theoretically, the contribution to sales prices of home or site characteristics may differ between study areas – for instance Central_AC in Texas vs. New York – and therefore estimating them at the study area level may increase the explanatory power of the model.
[118] In the evaluation and selection of the best model to use as the "Base Model" a set of census tract and school district delineations were used instead of the study area fixed effects. These more-granular fixed effects were extracted from GIS using house locations and census tract and school district polygons. Often, the school district and census tract delineations were not mutually exclusive. For example, in Wisconsin the WIKCDC study area contains four school districts and six census tracts, none of which completely overlap. Alternatively, in some study

to exist over each entire study area (inter-study area effects), but also intra-study area effects such as differences in home valuation due to school districts, distances to amenities, and other locationally bound influences. As with the inter-study area coefficients, because of the myriad influences captured by these variables, interpretation of any single coefficient can be difficult. However, it is expected that such coefficients would be influential, indicating significant differences in value between homes in each study area and across study areas due to school district quality and factors that differ between census tracts (e.g., crime rates).

Although the fully unrestricted model described by equation (F13) is arguably superior to the fully restricted model described in equation (1) because of its ability to resolve differences between and within study areas that are not captured by the Base Model, there are three potential drawbacks:

- Model parsimony and performance;
- Standard error magnitudes; and
- Parameter estimate stability.

Each of these potential drawbacks is discussed in turn below:

Model parsimony and performance: In general, econometricians prefer a simpler, more parsimonious statistical model. In this instance, variables should be added to a model only if their addition is strongly supported by theory and if the performance of the model is substantially improved by their inclusion. As such, if a model with a relatively small number of parameters performs well, it should be preferred to a model with more parameters unless the simple model can be "proven to be inadequate" (Newman, 1956). To prove the inadequacy of a simpler model requires a significant increase in performance to be exhibited from the more complex model. In this case, as presented later, performance is measured using the combination of Adjusted R^2, Modified R^2, and the Schwarz information criterion (see footnote 119 on page 127).

Standard error magnitudes: The magnitude of the standard errors for the variables of interest, as well as the other controlling variables, are likely to increase in the unrestricted model form because the number of cases for each variable will decrease when they are estimated at the study area level. Within each study area, there are a limited number of home transactions that meet the criteria for inclusion in the model, but even more limiting is the number of home transactions within each study area that have the characteristics of interest. For example, in Lee County, IL (ILLC), there are 205 post-construction home sales, while in Wayne County, PA (PAWC) there are 222. More importantly, in those areas, the data include a total of one and eleven sales inside of one mile, respectively, and a total of one and two homes with either EXTREME or SUBSTANTIAL rated views of turbines. With so few observations, there is increased likelihood that a single or small group of observations will strongly influence the sample mean of an independent variable. Since the standard error is derived from the variance of the parameter estimate, which in turn is derived from the summed deviation of each observation's actual level relative to its sample mean, this standard error is more likely to be larger than if a larger sample were considered. If the presence of wind facilities does have a detrimental effect on property

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areas the school district and census tracts perfectly overlapped, and in those cases either both were omitted as the reference category or one was included and the other withdrawn from the model to prevent perfect collinearity.

values, that effect seems likely to be relatively small, at least outside of the immediate vicinity of the wind turbines. The smaller sample sizes for the independent variables that come with the unrestricted model, which may decrease statistical precision by producing larger standard errors, would likely decrease the ability to accurately identify these possible effects statistically. To explore the magnitude of this concern, the difference in standard errors of the variables of interest is investigated among the restricted and unrestricted models.

Parameter estimate stability: In an unrestricted model, parameter estimates are more likely to be unstable because the sample of home transactions with any particular characteristic may be small and thus not representative of the population as a whole. As mentioned above, there are a limited number of transactions within each study area that have the characteristics of interest. Restricting the sample size by using an unrestricted model increases the likelihood that a limited number of observations, which in the population as a whole represent a very small segment, will drive the results in one direction or another, thereby leading to erroneous conclusions. The difference in parameter estimates is investigated by comparing the coefficients for the unrestricted variables of interest to those for the restricted variables of interest. Additionally, the sign of any significant variables will be investigated for the unrestricted models, which might help uncover potentially spurious results.

F.2 Analysis of Alterative Model Forms

Here the spectrum of alternative models is explored, from the fully restricted equation (1) to the fully unrestricted equation (F13). To do so, not only are these two ends of the spectrum estimated, but also 14 intermediate models are estimated that consist of every combination of restriction of the four variable groups (i.e., variables of interest, spatial adjustments, study area delineations, and home and site characteristics). This produces a total of 16 models over which to assess model parsimony and performance, standard error size, and coefficient stability. This process allows for an understanding of model performance but, more importantly, to ultimately define a “Base Model” that is parsimonious (i.e., has the fewest parameters), robust (i.e., high adjusted R^2), and best fits the purpose of investigating wind facility impacts on home sales prices.

Table A - 2 presents the performance statistics for each of the 16 models defined above, moving from the fully restricted model equation (1) (“Model 1”) to the fully unrestricted model equation (F13) (“Model 16”). In columns 2 – 5 of the table, the “R” represents a restriction for this variable group (i.e., not crossed with the study areas) and the “U” represents the case when the variable group is unrestricted (i.e., crossed with the study areas). Also shown are summary model statistics (i.e., Adjusted R^2, Modified R^2, and Schwarz information criterion - “SIC”), as well as the number of estimated parameters (*k*). [119] All models were run using the post-construction data subset of the sample of home sales transactions (n = 4,937).

[119] Goldberger (1991), as cited by Gujarati (2003), suggests using a Modified $R^2 = (1 – k/n) * R^2$ to adjust for added parameters. For example, Models 1 and 14 have Modified R^2 of 0.76, yet Adjusted R^2 of 0.77 and 0.78 respectively. Therefore the Modified R^2 penalizes their measure of explanatory power more than the Adjusted R^2 when taking into account the degrees of freedom. Similarly, the Schwarz information criterion penalizes the models for increased numbers of parameters (Schwarz, 1978). More importantly, practitioners often rely on the Schwarz criterion – over the Modified or Adjusted R^2 statistics - to rank models with the same dependent variable by their relative parsimony (Gujarati, 2003). Therefore it will be used for that purpose here.

Model Parsimony and Performance

Overall, the fully restricted model (1) performs well with only 37 independent variables, producing an Adjusted R^2 of 0.77. Despite the limited number of explanatory variables, the model explains ~77% of the variation in home prices in the sample. When the fully unrestricted model 16 (equation F13) is estimated, which lies at the other end of the spectrum, it performs only slightly better, with an Adjusted R^2 of 0.81, but with an additional 285 explanatory variables. It is therefore not surprising that the Modified R^2 is 0.76 for Model 1 and is only 0.77 for Model 16. Similarly, the Schwarz information criterion (SIC) increases from 0.088 to 0.110 when moving from model 1 to model 16 indicating relatively less parsimony. Combined, these metrics show that the improvement in the explanatory power of model 16 over model 1 is not enough to overcome the lack of parsimony. Turning to the 14 models that lie between Models 1 and 16, in general, little improvement in performance is found over Model 1, and considerably less parsimony, providing little initial justification to pursue a more complex specification than equation (1).

Table A - 2: Summarized Results of Restricted and Unrestricted Model Forms

Model [1]	Study Area [2]	Spatial Adjustment	Home and Site Characteristics	Variables of Interest	Adj R^2	Modified R^2	SIC	*k* †
1	R	R	R	R	0.77	0.76	0.088	37
2	U	R	R	R	0.74	0.73	0.110	111
3	R	U	R	R	0.77	0.76	0.088	46
4	R	R	U	R	0.80	0.78	0.095	188
5	R	R	R	U	0.77	0.76	0.093	88
6	U	U	R	R	0.78	0.76	0.094	120
7	R	U	U	R	0.80	0.77	0.096	197
8	R	R	U	U	0.80	0.77	0.101	239
9	U	R	U	R	0.80	0.77	0.107	262
10	U	R	R	U	0.76	0.75	0.107	162
11	R	U	R	U	0.77	0.76	0.094	97
12	U	U	U	R	0.81	0.77	0.103	271
13	R	U	U	U	0.80	0.77	0.103	248
14	U	U	R	U	0.78	0.76	0.100	171
15	U	R	U	U	0.80	0.76	0.113	313
16	U	U	U	U	0.81	0.77	0.110	322

"R" indicates parameters are pooled ("restricted") across the study areas.
"U" indicates parameters are not pooled ("unrestricted"), and are instead estimated at the study area level.
1 - *Model numbers do not correspond to equation numbers listed in the report; equation (1) is Model 1, and equation (F1) is Model 16.*
2 - *In its restricted form "Study Area" includes only inter-study area delineations, while unrestricted "Study Area" includes intra-study area delineations of school district and census tract.*
† - *Numbers of parameters do not include intercept or omitted variables.*

The individual contributions to model performance from unrestricting each of the variable groups in turn (as shown in Models 2-5) further emphasizes the small performance gains that are earned despite the sizable increases in the number of parameters. As a single group, the unrestricted Home and Site Characteristics model (Model 4) makes the largest impact on model performance, at least with respect to the Adjusted R^2 (0.80), but this comes with the addition of 151 estimated parameters a slight improvement in the Modified R^2 (0.78) and a worsening SIC (0.095). Adding unrestricted Study Area delineations (Model 2), on the other hand, adversely affects performance (Adj. R^2 = 0.74, Modified R^2 = 0.73) and adds 74 estimated parameters (SIC = 0.110). Similarly, unrestricting the Spatial Adjustments (Model 3) offers little improvement in performance (Adj. R^2 = 0.77, Modified R^2 = 0.76) despite adding nine additional variables (SIC = 0.088). Finally, unrestricting the Variables of Interest (Model 5) does not increase model performance (Adj. R^2 = 0.77, Modified R^2 = 0.76) and adds 51 variables to the model (SIC = 0.093). This pattern of little model improvement yet considerable increases in the number of estimated parameters (i.e., less parsimony) continues when pairs or trios of variable groups are unrestricted. With an Adjusted R^2 of 0.77, the fully restricted equation (1) performs more than adequately, and is, by far, the most parsimonious.

Standard Error Magnitudes

Table A - 3 summarizes the standard errors for the variables of interest for all of the 16 models, grouped into restricted and unrestricted model categories. The table specifically compares the medians, minimums, and maximums of the standard errors for the models with restricted variables of interest (1, 2, 3, 4, 6, 7, 9 and 12) to those with unrestricted variables of interest (5, 8, 10, 11, 13, 14, 15 and 16).[120] The table demonstrates that the unrestricted standard errors for the variables of interest are significantly larger than the restricted standard errors. In fact, the minimum standard errors in the unrestricted models are often higher than the maximum standard errors produced in the restricted models. For example, the maximum standard error for an EXTREME VIEW in the restricted models is 0.09, yet the minimum in the unrestricted models is 0.12, with a maximum of 0.34. To put this result in a different light, a median standard error for the unrestricted EXTREME VIEW variable of 0.25 would require an effect on house prices larger than 50% to be considered statistically significant at the 90% level. Clearly, the statistical power of the unrestricted models is weak.[121] Based on other disamenities, as discussed in Section 2.1, an effect of this magnitude is very unlikely. Therefore, based on these standard errors, there is no apparent reason to unrestrict the variables of interest.

[120] For the restricted models, the medians, minimums, and maximums are derived across all eight models for each variable of interest. For the unrestricted models, they are derived across all study areas and all eight models for each variable of interest.

[121] At 90% confidence a standard error of 0.25 would produce a confidence interval of roughly +/- 0.42 (0.25 * 1.67). An effect of this magnitude represents a 52% change in sales prices because sales price is in a natural log form (*e* ^ 0.42-1 = 0.52).

Table A - 3: Summary of VOI Standard Errors for Restricted and Unrestricted Models

Standard Errors	Restricted Models Standard Errors			Unrestricted Models Standard Errors		
	Median	Min	Max	Median	Min	Max
Minor View	0.01	0.01	0.02	0.05	0.03	0.07
Moderate View	0.03	0.03	0.03	0.10	0.06	0.18
Substantial View	0.05	0.05	0.06	0.19	0.10	0.29
Extreme View	0.08	0.08	0.09	0.25	0.12	0.34
Inside 3000 Feet	0.05	0.05	0.06	0.21	0.09	0.33
Between 3000 Feet and 1 Mile	0.04	0.04	0.05	0.13	0.08	0.40
Between 1 and 3 Miles	0.02	0.02	0.02	0.05	0.02	0.11
Between 3 and 5 Miles	0.01	0.01	0.02	0.05	0.02	0.10

Parameter Estimate Stability

Table A - 4 summarizes the coefficient estimates for the variables of interest for all of the 16 models. The table specifically compares the medians, minimums, and maximums of the coefficients for the models with restricted variables of interest (1, 2, 3, 4, 6, 7, 9 and 12) to those with unrestricted variables of interest (5, 8, 10, 11, 13, 14, 15 and 16). As shown, the coefficients in the unrestricted models diverge significantly from those in the restricted models. For example, in the restricted models, the median coefficient for homes inside of 3000 feet is -0.03, with a minimum of -0.06 and a maximum of -0.01, yet in the unrestricted models the median coefficient is 0.06, with a minimum of -0.38 and a maximum of 0.32. Similarly, a MODERATE VIEW in the restricted models has a median of 0.00, with a minimum of -0.01 and a maximum of 0.03, whereas the unrestricted models produce coefficients with a median of -0.05 and with a minimum of -0.25 and a maximum of 0.35.

Table A - 4: Summary of VOI Coefficients for Restricted and Unrestricted Models

Parameters	Restricted Models Coefficients			Unrestricted Models Coefficients		
	Median	Min	Max	Median	Min	Max
Minor View	-0.02	-0.03	0.00	-0.02	-0.16	0.24
Moderate View	0.00	-0.01	0.03	-0.05	-0.25	0.35
Substantial View	-0.01	-0.04	0.02	-0.08	-0.31	0.13
Extreme View	0.03	0.02	0.05	-0.03	-0.23	0.09
Inside 3000 Feet	-0.03	-0.06	-0.01	0.06	-0.38	0.32
Between 3000 Feet and 1 Mile	-0.04	-0.06	-0.01	-0.10	-0.44	0.52
Between 1 and 3 Miles	-0.01	-0.03	0.02	0.00	-0.23	0.40
Between 3 and 5 Miles	0.02	0.01	0.04	0.05	-0.05	0.32

Turning from the levels of the coefficients to the stability of their statistical significance and sign across models more reasons for concern are found. Table A - 5 summarizes the results of the unrestricted models, and presents the number of statistically significant variables of interest as a percent of the total estimated. The table also breaks these results down into two groups, those with coefficients above zero and those with coefficients below zero.[122] It should be emphasized here that it is the *a priori* expectation that, if effects exist, all of these coefficients would be less than zero, indicating an adverse effect on home prices from proximity to and views of wind turbines. Despite that expectation, when the variables of interest are unrestricted it is found that they are as likely to be above zero as they are below.[123] In effect, the small numbers of cases available for analysis at the study area level produce unstable results, likely because the estimates are being unduly influenced by either study area specific effects that are not captured by the model or by a limited number of observations that represents a larger fraction of the overall sample in that model.[124]

Table A - 5: Summary of Significant VOI Above and Below Zero in Unrestricted Models

Significant Variables	Unrestricted Models		
	Total	Below Zero	Above Zero
Minor View	32%	14%	18%
Moderate View	23%	11%	13%
Substantial View	4%	4%	0%
Extreme View	0%	0%	0%
Inside 3000 Feet	23%	15%	8%
Between 3000 Feet and 1 Mile	30%	14%	16%
Between 1 and 3 Miles	56%	32%	24%
Between 3 and 5 Miles	45%	3%	43%

F.3 Selecting a Base Model

To conclude, it was found that all three concerns related to the estimation and use of an unrestricted model form are borne out in practice. Despite experimenting with 16 different combinations of interactions, little overall improvement in performance is discovered. Where performance gains are found they are at the expense of parsimony as reflected in the lack of increase in the Modified R^2 and the relatively higher Schwartz information criterion. Further, divergent and spurious coefficients of interest and large standard errors are associated with those coefficients. Therefore the fully restricted model, equation (1), is used in this report as the "Base Model".

[122] The "Total" percentage of significant coefficients is calculated by counting the total number of significant coefficients across all 8 unrestricted models for each variable of interest, and dividing this total by the total number of coefficients. Therefore, a study area that did not have any homes in a group (for example, homes with EXTREME VIEWS) was not counted in the "total number of coefficients" sum. Any differences between the sum of "above" and "below" zero groups from the total are due to rounding errors.

[123] The relatively larger number of significant variables for the MINOR rated view, MODERATE rated view, Mile 1 to 3, and Mile 3 to 5 parameters are likely related to the smaller standard errors for those categories, which result from larger numbers of cases.

[124] Another possible explanation for spurious results in general is measurement error, when parameters do not appropriately represent what one is testing for. In this case though, the VIEW variables have been adequately "ground truthed" during the development of the measurement scale, and are similar to the VISTA variables, which were found to be very stable across study areas. DISTANCE, or for that matter, distance to any disamenity, has been repeatedly found to be an appropriate proxy for the size of effects. As a result, it is not believed that measurement error is a likely explanation for the results presented here.

Appendix G: OLS Assumptions, and Tests for the Base Model

A number of criteria must be met to ensure that the Base Model and Alternative Hedonic Models produce unbiased coefficient estimates and standard errors: 1) appropriate controls for outliers and influencers; 2) homoskedasticity; 3) absence of serial or spatial autocorrelation; and 4) reasonably limited multicollinearity. Each of these criteria, and how they are addressed, is discussed below.

Outliers and Influencers: Home sale prices that are well away from the mean, also called outliers and influencers, can cause undue influence on parameter estimates. A number of formal tests are available to identify these cases, the most common being Mahalanobis' Distance ("M Distance") (Mahalanobis, 1936) and standardized residual screening. M Distance measures the degree to which individual observations influence the mean of the residuals. If any single observation has a strong influence on the residuals, it should be inspected and potentially removed. An auxiliary, but more informal, test for identifying these potentially influential observations is to see when the standardized absolute value of the residual exceeds some threshold. Both the Base Model and the All Sales Model were run using the original dataset of 7,464 transactions and the 4,940 transactions which occurred post-construction respectively. For both models the standardized residuals and the M Distance statistics were saved.[125] The histograms of these two sets of statistics from the two regressions are shown in Figure A - 15 through Figure A - 18.

[125] For the M Distance statistics all variables of interest were removed from the model. If they were left in the M-Distance statistics could be influenced by the small numbers of cases in the variables of interest. If these parameters were strongly influenced by a certain case, it could drive the results upward. Inspecting the controlling variables in the model, and how well they predicted the sale prices of the transactions in the sample, was of paramount importance therefore the variables of interest were not included.

Figure A - 15: Histogram of Standardized Residuals for Base Model

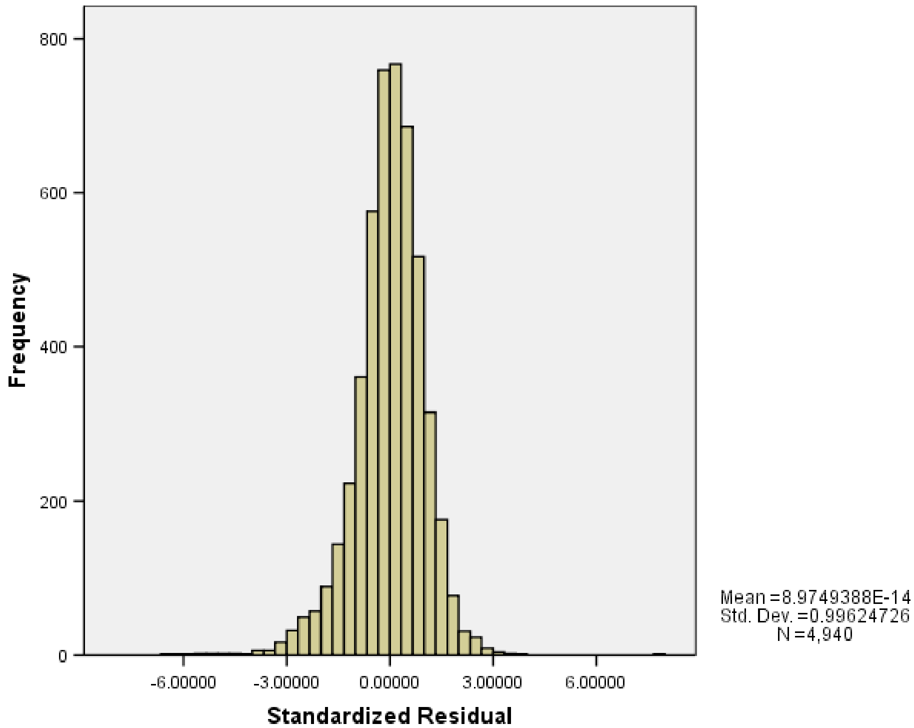


Figure A - 16: Histogram of Mahalanobis Distance Statistics for Base Model

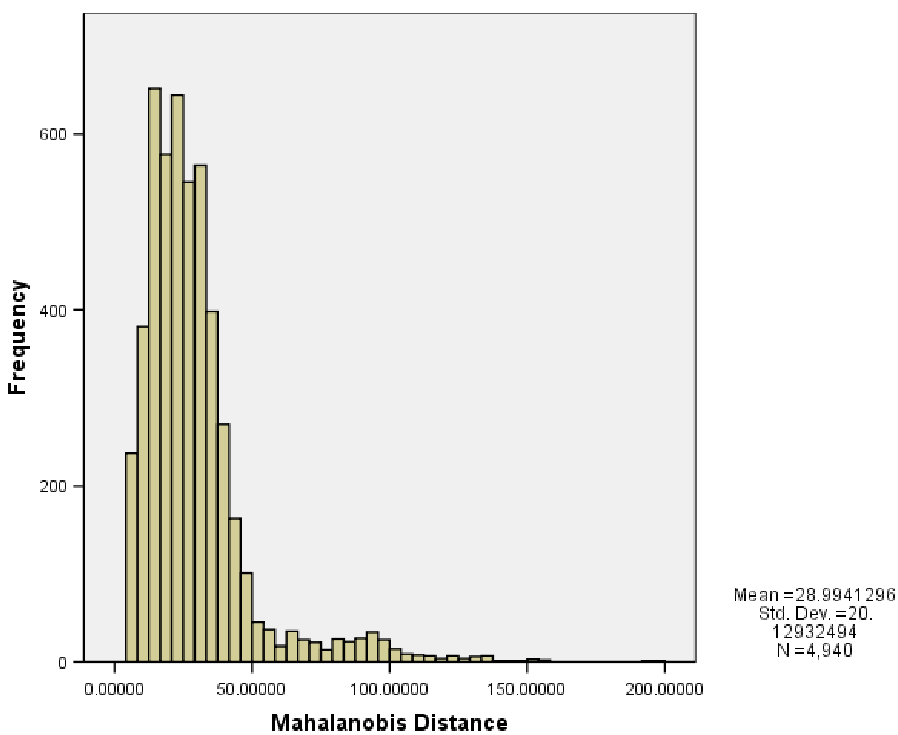


Figure A - 17: Histogram of Standardized Residuals for All Sales Model

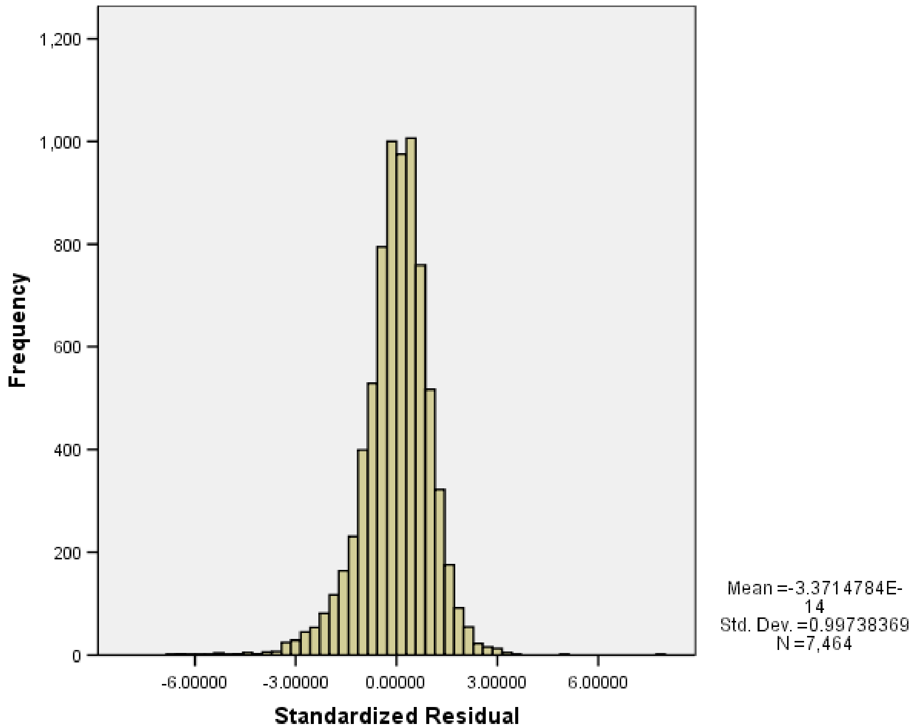
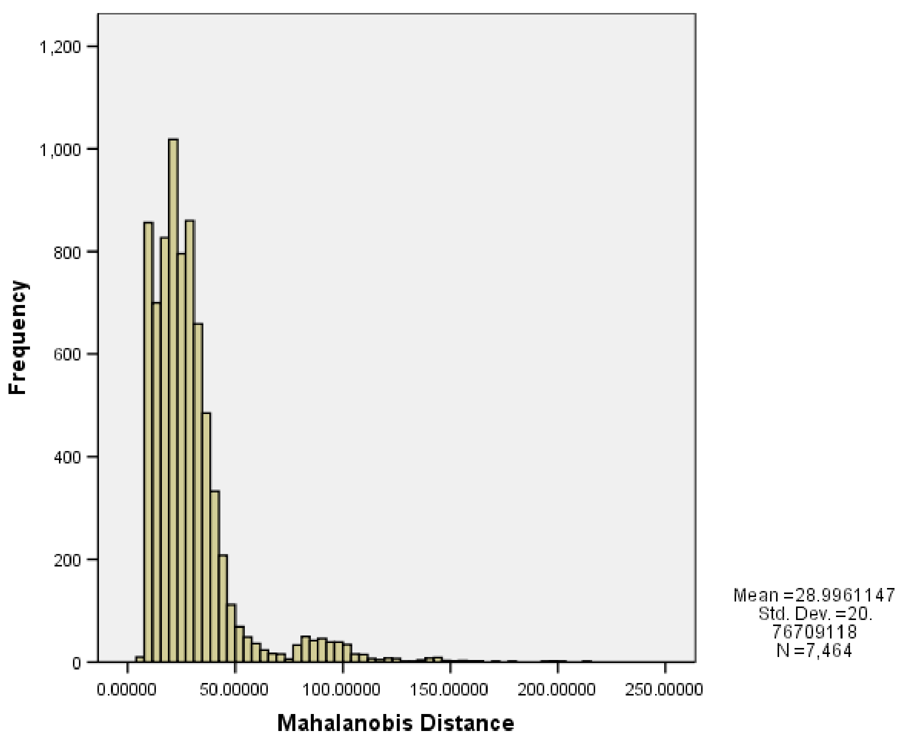


Figure A - 18: Histogram of Mahalanobis Distance Statistics for All Sales Model



The M Distance histograms suggested that a cutoff of 150 may be appropriate, which would exclude 15 cases from the All Sales Model and seven cases from the Base Model (all of the latter of which were among the 15 outliers in the All Sales Model). The Standardized Residual histograms suggested a cutoff of 4, 5, or 6, which would exclude 13, 8, and 3 cases from the Base Model, and 22, 12, and 5 cases from the All Sales Model. A case-by-case investigation of each of these sales transactions was then conducted by comparing their home characteristics (e.g., square feet, baths, age, etc.) against their study area and panel model cohorts to ensure that none had been inappropriately coded. None of the M Distance flagged cases seemed to be inappropriately coded, and none of those cases were removed from the final dataset as a result. Five cases that were flagged from the All Sales Model (which corresponded to three cases in the Base Model) with a Standardized Residual greater than six, however, were clearly outliers. One had a sale price that was more than $200,000 more than any other transaction in the model, and the other four had exceptionally low prices, yet high numbers of corresponding characteristics that would suggest higher home sales prices (such as over 2000 square feet – all four cases – or more than two bathrooms – three cases).

As a result of these investigations, these five cases were removed from the model. One of the five cases occurred prior to announcement, one occurred after announcement and before construction, and the other three occurred after construction began. None were within three miles of the nearest wind turbine except one, which was 0.6 miles from the nearest turbine and had a MINOR view of the wind facility. The other two had no views of the turbines. Although there was hesitancy in removing any cases from the model, these transactions were considered appropriately influential and keeping them in the model would bias the results inappropriately. Further, the one home that was situated inside of one mile was surrounded by five other transactions in the same study area that also occurred after construction began and were a similar distance from the turbines, but that were not flagged by the outliers screen. Therefore, its removal was considered appropriate given that other homes in the sample would likely experience similar effects.

After removing these five cases, the sensitivity of the model results were tested to the inclusion or exclusion of the “greater than five” and “greater than four” Standardized Residuals observations and the cases flagged by the M Distance screen, finding that parameter estimates for the variables of interest moved slightly with these cases removed but not enough to change the results significantly. Because they did not show a unique grouping across the variables of interest, nor any unusual potentially inappropriate coding, and, more importantly, did not substantially influence the results, no substantive reason was found to remove any additional transactions from the sample. Therefore, the final dataset included a total of 7,459 cases, of which 4,937 occurred post-construction.

Homoskedasticity: A standard formal test for the presence of homoskedastic error terms is the White's statistic (White, 1980). However, the requirements to perform this test were overly burdensome for the computing power available. Instead, an informal test was applied, which plots the regression errors against predicted values and various independent variables to observe whether a "heteroskedastic pattern" is in evidence (Gujarati, 2003). Although no evidence of heteroskedasticity was found using this method, to be conservative, nonetheless all models were run with White's heteroskedasticity correction to the parameter estimates' standard errors (which will not adversely influence the errors if they are homoskedastic).

Serial Autocorrelation: A standard formal test for the presence of serial autocorrelation in the error term is the Durbin-Watson statistic (Durbin and Watson, 1951). Applying this test as proposed by Durbin and Watson to the full panel dataset was problematic because the test looks at the error structure based on the order that observations are included in the statistical regression model. Any ordering choice over the entire panel data set invariably involves mixing home transactions from various study areas. Ideally, one would segment the data by study area for purposes of calculating this test, but that method was not easily implemented with the statistical software package used for this analysis (i.e., SAS). Instead, study area specific regression models were run with the data chronologically ordered in each to produce twelve different Durbin-Watson statistics, one for each study area specific model. The Durbin-Watson test statistics ranged from 1.98–2.16, which are all within the acceptable range.[126] Given that serial autocorrelation was not found to be a significant concern for each study area specific model, it is assumed that the same holds for the full dataset used in the analysis presented in this report.

Spatial Autocorrelation: It is well known that the sales price of a home can be systematically influenced by the sales prices of those homes that have sold nearby (Dubin, 1998; LeSage, 1999). Both the seller and the buyer use information from comparable surrounding sales to inform them of the appropriate transaction price, and nearby homes often experience similar amenities and disamenities. Therefore, the price for any single home is likely to be weakly dependent of the prices of homes in close temporal and spatial proximity. This lack of independence of home sale prices could bias the hedonic results (Dubin, 1998; LeSage, 1999), if not adequately addressed. A number of techniques are available to address this concern (Case et al., 2004; Espey et al., 2007), but because of the large sample and computing limits, a variation of the Spatial Auto Regressive Model (SAR) was chosen (Espey et al., 2007).

Specifically, an independent variable is included in the models: the predicted values of the weighted nearest neighbor's natural log of sales price in 1996 dollars.[127] To construct this vector of predicted prices, an auxiliary regression is developed using the spatially weighted average natural log of sales price in 1996 dollars as the independent variable and the spatially weighted average set of home characteristics as the dependent variables. This regression was used to produce the <u>predicted</u> weighted nearest neighbor's natural log of sales price in 1996 dollars that is then included in the Base and Alternative Models. This process required the following steps:
1) Selecting the neighbors for inclusion in the calculation;
2) Calculating a weighted sales price from these neighbors' transactions;
3) Selecting and calculating the weighted neighbors home characteristics; and
4) Forecasting the weighted average neighbor's sales price.

- **Selecting the neighbors**: To select the neighbors whose home transactions would most likely have affected the sales price of the subject home under review, all of the homes that

[126] The critical values for the models were between 1.89 and 2.53, assuming 5% significance, greater than 20 variables, and more than 200 cases (Gujarati, 2003).
[127] The predicted value was used, instead of the actual value, to help correct for simultaneity or endogeneity problems that might otherwise exist.

sold within the preceding six months of a subject home's sale date in the same study area are identified and, from those, the five nearest neighbors based on Euclidian distance are selected. The inverse of each selected nearest neighbors' distance (in quarter miles) to the subject home was then calculated. Each of these values was then divided by the sum of the five nearest neighbor's inverse distance values to create a neighbor's distance weight (NDW) for each of the five nearest neighbors.[128]

- **Creating the weighted sales price**: Each of the neighbor's natural log of sales price in 1996 dollars (LN_Saleprice96) is multiplied by its distance weight (NDW). Then, each weighted neighbor's LN_Saleprice96 is summed to create a weighted nearest neighbor LN_Saleprice96 (Nbr_LN_Saleprice96).

- **Selecting and calculating the weighted neighbors home characteristics**: Nine independent variables are used from each of the neighbor's homes: square feet, age of the home at the time of sale, age of the home at the time of sale squared, acres, number of full baths, and condition (1-5, with Poor = 1, Below Average = 2, etc.). A weighted average is created of each of the characteristics by multiplying each of the neighbor's individual characteristics by their NDW, and then summing those values across the five neighbors to create the weighted average nearest neighbors' home characteristic.[129] Then each of the independent variables is interacted with the study area to allow each one to be independently estimated for each study area.

- **Forecasting the weighted average neighbors sales price**: To create the final predicted neighbor's price, the weighted nearest neighbor LN_Saleprice96 is regressed on the weighted average nearest neighbors' home characteristics to produce a predicted weighted nearest neighbor LN_Saleprice96 (Nbr_LN_SalePrice96_hat). These predicted values are then included in the Base and Alternative Models as independent variables to account for the spatial and temporal influence of the neighbors' home transactions.

In all models, the coefficient for this spatial adjustment parameter meets the expectations for sign and magnitude and is significant well above the 99% level, indicating both the presence of spatial autocorrelation and the appropriateness of the control for it.

Multicollinearity: There are several standard formal tests for detecting multicollinearity within the independent variables of a regression model. The Variance-Inflation Factor and Condition Index is applied to test for this violation of OLS assumptions. Specifically, a Variance-Inflation Factor (VIF) greater than 4 and/or a Condition Index of greater than 30 (Kleinbaum et al., 1988) are strong indicators that multicollinearity may exist. Multicollinearity is found in the model using both tests. Such a result is not uncommon in hedonic models because a number of characteristics, such as square feet or age of a home, are often correlated with other characteristics, such as the number of acres, bathrooms, and fireplaces. Not surprisingly, age of the home at the time of sale (AgeofHome) and the age of the home squared (AgeatHome_Sqrd)

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[128] Put differently, the weight is the contribution of that home's inverse distance to the total sum of the five nearest neighbors' inverse distances.

[129] Condition requires rounding to the nearest integer and then creating a dummy from the 1-5 integers.

exhibited some multicollinearity (VIF equaled 11.8 and 10.6, respectively). Additionally, the home condition shows a fairly high Condition Index with square feet, indicating collinearity. More importantly, though, are the collinearity statistics for the variables of interest. The VIF for the VIEW variables range from 1.17 to 1.18 and for the DISTANCE variables they range from 1.2 to 3.6, indicating little collinearity with the other variables in the model. To test for this in another way, a number of models are compared with various identified highly collinear variables removed (e.g., AgeatSale, Sqft) and found that the removal of these variables had little influence on the variables of interest. Therefore, despite the presence of multicollinearity in the model, it is not believed that the variables of interest are inappropriately influenced. Further, any corrections for these issues might cause more harm to the model's estimating efficiency than taking no further action (Gujarati, 2003); as such, no specific adjustments to address the presence of multicollinearity are pursued further.

Appendix H: Alternative Models: Full Hedonic Regression Results

Table A - 6: Full Results for the Distance Stability Model

	Coef.	SE	p Value	*n*
Intercept	7.61	0.18	0.00	
Nbr_LN_SalePrice96_hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale_Sqrd	0.00002	0.000003	0.00	4,937
Sqft_1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls_Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul_De_Sac	0.10	0.01	0.00	992
Water_Front	0.33	0.04	0.00	87
Cnd_Low	-0.45	0.05	0.00	69
Cnd_BAvg	-0.24	0.02	0.00	350
Cnd_Avg	Omitted	Omitted	Omitted	2,727
Cnd_AAvg	0.13	0.01	0.00	1,445
Cnd_High	0.23	0.02	0.00	337
Vista_Poor	-0.21	0.02	0.00	310
Vista_BAvg	-0.08	0.01	0.00	2,857
Vista_Avg	Omitted	Omitted	Omitted	1,247
Vista_AAvg	0.10	0.02	0.00	448
Vista_Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.08	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.30	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Mile_Less_0_57	-0.04	0.04	0.29	67
Mile_0_57to1	-0.06	0.05	0.27	58
Mile_1to3	-0.01	0.02	0.71	2,019
Mile_3to5	0.01	0.01	0.26	1,923
Mile_Gtr5	Omitted	Omitted	Omitted	870

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**2**
Model Name	**Distance Stability**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**33**
F Statistic	**496.7**
Adjusted R Squared	**0.77**

Table A - 7: Full Results for the View Stability Model

	Coef.	SE	Sig	*n*
Intercept	7.64	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.34	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.02	0.00	1,071
OKCC	-0.45	0.02	0.00	476
IABV	-0.25	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.08	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Post Con NoView	Omitted	Omitted	Omitted	4,207
View Minor	-0.02	0.01	0.25	561
View Mod	0.00	0.03	0.90	106
View Sub	-0.04	0.06	0.56	35
View Extrm	-0.03	0.06	0.61	28

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**3**
Model Name	**View Stability**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**33**
F Statistic	**495.9**
Adjusted R Squared	**0.77**

Table A - 8: Full Results for the Continuous Distance Model

	Coef.	SE	p Value	*n*
Intercept	7.64	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.34	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.02	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.25	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.33	561
Moderate View	0.01	0.03	0.77	106
Substantial View	-0.02	0.07	0.72	35
Extreme View	0.01	0.10	0.88	28
InvDISTANCE	-0.01	0.02	0.46	4,937

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**5**
Model Name	**Continuous Distance Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**34**
F Statistic	**481.3**
Adjusted R Squared	**0.77**

Table A - 9: Full Results for the All Sales Model

	Coef.	SE	p Value	*n*
Intercept	9.08	0.14	0.00	
Nbr LN SP96 hat All OI	0.16	0.01	0.00	7,459
AgeatSale	-0.007	0.0003	0.00	7,459
AgeatSale Sqrd	0.00003	0.000002	0.00	7,459
Sqft 1000	0.28	0.01	0.00	7,459
Acres	0.02	0.00	0.00	7,459
Baths	0.08	0.01	0.00	7,459
ExtWalls Stone	0.21	0.01	0.00	2,287
CentralAC	0.12	0.01	0.00	3,785
Fireplace	0.11	0.01	0.00	2,708
FinBsmt	0.09	0.01	0.00	990
Cul De Sac	0.09	0.01	0.00	1,472
Water Front	0.35	0.03	0.00	107
Cnd Low	-0.43	0.04	0.00	101
Cnd BAvg	-0.21	0.02	0.00	519
Cnd Avg	Omitted	Omitted	Omitted	4,357
Cnd AAvg	0.13	0.01	0.00	2,042
Cnd High	0.22	0.02	0.00	440
Vista Poor	-0.25	0.02	0.00	470
Vista BAvg	-0.09	0.01	0.00	4,301
Vista Avg	Omitted	Omitted	Omitted	1,912
Vista AAvg	0.10	0.01	0.00	659
Vista Prem	0.09	0.03	0.00	117
WAOR	Omitted	Omitted	Omitted	790
TXHC	-0.82	0.02	0.00	1,311
OKCC	-0.53	0.02	0.00	1,113
IABV	-0.31	0.02	0.00	822
ILLC	-0.05	0.02	0.02	412
WIKCDC	-0.17	0.01	0.00	810
PASC	-0.37	0.03	0.00	494
PAWC	-0.15	0.02	0.00	551
NYMCOC	-0.25	0.02	0.00	463
NYMC	-0.15	0.02	0.00	693
Pre-Construction Sales	Omitted	Omitted	Omitted	2,522
No View	0.02	0.01	0.06	4,207
Minor View	0.00	0.02	0.76	561
Moderate View	0.03	0.03	0.38	106
Substantial View	0.03	0.07	0.63	35
Extreme View	0.06	0.08	0.43	28
Inside 3000 Feet	-0.06	0.05	0.23	80
Between 3000 Feet and 1 Mile	-0.08	0.05	0.08	65
Between 1 and 3 Miles	0.00	0.01	0.79	2,359
Between 3 and 5 Miles	0.01	0.01	0.58	2,200
Outside 5 Miles	0.00	0.02	0.76	1,000
Pre-Announcement Sales	Omitted	Omitted	Omitted	1,755

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**6**
Model Name	**All Sales Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**7459**
Number of Predictors (k)	**39**
F Statistic	**579.9**
Adjusted R Squared	**0.75**

Table A - 10: Full Results for the Temporal Aspects Model

	Coef.	SE	p Value	*n*
Intercept	9.11	0.14	0.00	
Nbr LN SP96 hat All OI	0.16	0.01	0.00	7,459
AgeatSale	-0.007	0.0003	0.00	7,459
AgeatSale Sqrd	0.00003	0.000002	0.00	7,459
Sqft 1000	0.28	0.01	0.00	7,459
Acres	0.02	0.00	0.00	7,459
Baths	0.08	0.01	0.00	7,459
ExtWalls Stone	0.21	0.01	0.00	2,287
CentralAC	0.12	0.01	0.00	3,785
Fireplace	0.12	0.01	0.00	2,708
FinBsmt	0.09	0.01	0.00	990
Cul De Sac	0.09	0.01	0.00	1,472
Water Front	0.35	0.03	0.00	107
Cnd Low	-0.43	0.04	0.00	101
Cnd BAvg	-0.21	0.02	0.00	519
Cnd Avg	Omitted	Omitted	Omitted	4,357
Cnd AAvg	0.13	0.01	0.00	2,042
Cnd High	0.22	0.02	0.00	440
Vista Poor	-0.25	0.02	0.00	470
Vista BAvg	-0.09	0.01	0.00	4,301
Vista Avg	Omitted	Omitted	Omitted	1,912
Vista AAvg	0.10	0.01	0.00	659
Vista Prem	0.09	0.03	0.00	117
WAOR	Omitted	Omitted	Omitted	790
TXHC	-0.82	0.02	0.00	1,311
OKCC	-0.52	0.02	0.00	1,113
IABV	-0.30	0.02	0.00	822
ILLC	-0.04	0.02	0.05	412
WIKCDC	-0.17	0.02	0.00	810
PASC	-0.37	0.03	0.00	494
PAWC	-0.14	0.02	0.00	551
NYMCOC	-0.25	0.02	0.00	463
NYMC	-0.15	0.02	0.00	693

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Note: Results for variables of interest shown on following page

	Coef.	SE	p Value	*n*
No View	Omitted	Omitted	Omitted	6,729
Minor View	-0.02	0.01	0.20	561
Moderate View	0.00	0.03	0.97	106
Substantial View	0.01	0.07	0.87	35
Extreme View	0.04	0.07	0.59	28
Pre_Anc_Gtr2Yr_Lt1Mile	-0.13	0.06	0.02	38
Pre_Anc_2Yr_Lt1Mile	-0.10	0.05	0.06	40
Post_Anc_Pre_Con_Lt1Mile	-0.14	0.06	0.02	21
Post_Con_2Yr_Lt1Mile	-0.09	0.07	0.15	39
Post_Con_2_4Yr_Lt1Mile	-0.01	0.06	0.86	44
Post_Con_Gtr5Yr_Lt1Mile	-0.07	0.08	0.37	42
Pre_Anc_Gtr2Yr_1_3Mile	-0.04	0.03	0.19	283
Pre_Anc_2Yr_1_3Mile	0.00	0.03	0.91	592
Post_Anc_Pre_Con_1_3Mile	-0.02	0.03	0.53	342
Post_Con_2Yr_1_3Mile	0.00	0.03	0.90	807
Post_Con_2_4Yr_1_3Mile	0.01	0.03	0.78	503
Post_Con_Gtr5Yr_1_3Mile	0.00	0.03	0.93	710
Pre_Anc_Gtr2Yr_3_5Mile	0.00	0.04	0.93	157
Pre_Anc_2Yr_3_5Mile	0.00	0.03	0.98	380
Post_Anc_Pre_Con_3_5Mile	0.00	0.03	0.93	299
Post_Con_2Yr_3_5Mile	0.02	0.03	0.56	574
Post_Con_2_4Yr_3_5Mile	0.01	0.03	0.66	594
Post_Con_Gtr5Yr_3_5Mile	0.01	0.03	0.68	758
Pre_Anc_Gtr2Yr_Gtr5Mile	Omitted	Omitted	Omitted	132
Pre_Anc_2Yr_Gtr5Mile	-0.03	0.04	0.39	133
Post_Anc_Pre_Con_Gtr5Mile	-0.03	0.03	0.36	105
Post_Con_2Yr_Gtr5Mile	-0.03	0.03	0.44	215
Post_Con_2_4Yr_Gtr5Mile	0.03	0.03	0.42	227
Post_Con_Gtr5Yr_Gtr5Mile	0.01	0.03	0.72	424

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**7**
Model Name	**Temporal Aspects Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**7459**
Number of Predictors (k)	**56**
F Statistic	**404.5**
Adjusted R2	**0.75**

Table A - 11: Full Results for the Orientation Model

	Coef.	SE	p Value	*n*
Intercept	7.62	0.18	0.00	
Nbr_LN_SalePrice96_hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale_Sqrd	0.00002	0.000003	0.00	4,937
Sqft_1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls_Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul_De_Sac	0.10	0.01	0.00	992
Water_Front	0.33	0.04	0.00	87
Cnd_Low	-0.44	0.05	0.00	69
Cnd_BAvg	-0.24	0.02	0.00	350
Cnd_Avg	Omitted	Omitted	Omitted	2,727
Cnd_AAvg	0.13	0.01	0.00	1,445
Cnd_High	0.24	0.02	0.00	337
Vista_Poor	-0.21	0.02	0.00	310
Vista_BAvg	-0.08	0.01	0.00	2,857
Vista_Avg	Omitted	Omitted	Omitted	1,247
Vista_AAvg	0.10	0.02	0.00	448
Vista_Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.08	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.06	0.92	561
Moderate View	0.00	0.06	0.97	106
Substantial View	-0.01	0.09	0.87	35
Extreme View	0.02	0.17	0.89	28
Inside 3000 Feet	-0.04	0.07	0.55	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.37	58
Between 1 and 3 Miles	0.00	0.02	0.83	2,019
Between 3 and 5 Miles	0.02	0.01	0.22	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870
Front Orientation	-0.01	0.06	0.82	294
Back Orientation	0.03	0.06	0.55	280
Side Orientation	-0.03	0.06	0.55	253

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**8**
Model Name	**Orientation Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**40**
F Statistic	**410.0**
Adjusted R Squared	**0.77**

Table A - 12: Full Results for the Overlap Model

	Coef.	SE	p Value	*n*
Intercept	7.61	0.18	0.00	
Nbr_LN_SalePrice96_hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale_Sqrd	0.00002	0.000003	0.00	4,937
Sqft_1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls_Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul_De_Sac	0.10	0.01	0.00	992
Water_Front	0.34	0.04	0.00	87
Cnd_Low	-0.45	0.05	0.00	69
Cnd_BAvg	-0.24	0.02	0.00	350
Cnd_Avg	Omitted	Omitted	Omitted	2,727
Cnd_AAvg	0.13	0.01	0.00	1,445
Cnd_High	0.24	0.02	0.00	337
Vista_Poor	-0.21	0.02	0.00	310
Vista_BAvg	-0.08	0.01	0.00	2,857
Vista_Avg	Omitted	Omitted	Omitted	1,247
Vista_AAvg	0.10	0.02	0.00	448
Vista_Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.03	0.02	0.10	561
Moderate View	-0.02	0.04	0.67	106
Substantial View	-0.05	0.09	0.57	35
Extreme View	-0.03	0.10	0.77	28
Inside 3000 Feet	-0.05	0.06	0.41	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.38	58
Between 1 and 3 Miles	0.00	0.02	0.82	2,019
Between 3 and 5 Miles	0.02	0.01	0.22	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870
View Does Not Overlap Vista	Omitted	Omitted	Omitted	320
View Barely Overlaps Vista	0.05	0.03	0.09	150
View Somewhat Overlaps Vista	0.01	0.03	0.67	132
View Strongly Overlaps Vista	0.05	0.05	0.31	128

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**9**
Model Name	**Overlap Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**40**
F Statistic	**409.7**
Adjusted R Squared	**0.77**

LBNL-6362E

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A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States

Ben Hoen, Jason P. Brown, Thomas Jackson, Ryan Wiser, Mark Thayer and Peter Cappers

Environmental Energy Technologies Division

August 2013

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Disclaimer

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Wind and Water Power Technologies Office
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Abstract

Previous research on the effects of wind energy facilities on surrounding home values has been limited by small samples of relevant home-sale data and the inability to account adequately for confounding home-value factors and spatial dependence in the data. This study helps fill those gaps. We collected data from more than 50,000 home sales among 27 counties in nine states. These homes were within 10 miles of 67 different wind facilities, and 1,198 sales were within 1 mile of a turbine—many more than previous studies have collected. The data span the periods well before announcement of the wind facilities to well after their construction. We use OLS and spatial-process difference-in-difference hedonic models to estimate the home-value impacts of the wind facilities; these models control for value factors existing before the wind facilities' announcements, the spatial dependence of unobserved factors effecting home values, and value changes over time. A set of robustness models adds confidence to our results. Regardless of model specification, we find no statistical evidence that home values near turbines were affected in the post-construction or post-announcement/pre-construction periods. Previous research on potentially analogous disamenities (e.g., high-voltage transmission lines, roads) suggests that the property-value effect of wind turbines is likely to be small, on average, if it is present at all, potentially helping to explain why no evidence of an effect was found in the present research.

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1. Introduction

In 2012, approximately 13 gigawatts (GW) of wind turbines were installed in the United States, bringing total U.S. installed wind capacity to approximately 60 GW from more than 45,000 turbines (AWEA, 2013). Despite uncertainty about future extensions of the federal production tax credit, U.S. wind capacity is expected by some to continue growing by approximately 5–6 GW annually owing to state renewable energy standards and areas where wind can compete with natural gas on economics alone (Bloomberg, 2013); this translates into approximately 2,750 turbines per year.[1] Much of that development is expected to occur in relatively populated areas (e.g., New York, New England, the Mid-Atlantic and upper Midwest) (Bloomberg, 2013).

In part because of the expected wind development in more-populous areas, empirical investigations into related community concerns are required. One concern is that the values of properties near wind developments may be reduced; after all, it has been demonstrated that in some situations market perceptions about an area's disamenities (and amenities)[2] are capitalized into home prices (e.g., Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006). The published research about wind energy and property values has largely coalesced around a finding that homes sold after nearby wind turbines have been constructed do not experience statistically significant property value impacts. Additional research is required, however, especially for homes located within about a half mile of turbines, where impacts would be expected to be the largest. Data and studies are limited for these proximate homes in part because setback requirements generally result in wind facilities being sited in areas with relatively few houses, limiting available sales transactions that might be analyzed.

This study helps fill the research gap by collecting and analyzing data from 27 counties across nine U.S. states, related to 67 different wind facilities. Specifically, using the collected data, the study constructs a pooled model that investigates average effects near the turbines across the sample while controlling for the local effects of many potentially correlated independent variables. Property-value effect estimates are derived from two types of models: (1) an ordinary

[1] Assuming 2-MW turbines, the 2012 U.S. average (AWEA, 2013), and 5.5 GW of annual capacity growth.
[2] Disamenities and amenities are defined respectively as disadvantages (e.g., a nearby noxious industrial site) and advantages (e.g., a nearby park) of a location.

least squares (OLS) model, which is standard for this type of disamenity research (see, e.g., discussion in Jackson, 2003; Sirmans et al., 2005), and (2) a spatial-process model, which accounts for spatial dependence. Each type of model is used to construct a difference-in-difference (DD) specification—which simultaneously controls for preexisting amenities or disamenities in areas where turbines were sited and changes in the community after the wind facilities' construction was announced—to estimate effects near wind facilities after the turbines were announced and, later, after the turbines were constructed.[3]

The remainder of the report is structured as follows. Section 2 reviews the current literature. Section 3 details our methodology. Section 4 describes the study data. Section 5 presents the results, and Section 6 provides a discussion and concluding remarks.

2. Previous Literature

Although the topic is relatively new, the peer-reviewed literature investigating impacts to home values near wind facilities is growing. To date, results largely have coalesced around a common set of non-significant findings generated from home sales after the turbines became operational. Previous Lawrence Berkeley National Laboratory (LBNL) work in this area (Hoen et al., 2009, 2011) found no statistical evidence of adverse property-value effects due to views of and proximity to wind turbines after the turbines were constructed (i.e., post-construction or PC). Other peer-reviewed and/or academic studies also found no evidence of PC effects despite using a variety of techniques and residential transaction datasets. These include homes surrounding wind facilities in Cornwall, United Kingdom (Sims and Dent, 2007; Sims et al., 2008); multiple wind facilities in McLean County, Illinois (Hinman, 2010); near the Maple Ridge Wind Facility in New York (Heintzelman and Tuttle, 2011); and, near multiple facilities in Lee County, Illinois (Carter, 2011). Analogously, a 2012 Canadian case found a lack of evidence near a wind facility in Ontario to warrant the lowering of surrounding assessments (Kenney v MPAC, 2012). In contrast, one recent study did find impacts to land prices near a facility in North Rhine-Westphalia, Germany (Sunak and Madlener, 2012). Taken together, these results imply that the

[3] Throughout this report, the terms "announced/announcement" and "constructed/construction" represent the dates on which the proposed wind facility (or facilities) entered the public domain and the dates on which facility construction began, respectively. Home transactions can either be pre-announcement (PA), post-announcement/pre-construction (PAPC), or post-construction (PC).

PC effects of wind turbines on surrounding home values, if they exist, are often too small for detection or sporadic (i.e., a small percentage overall), or appearing in some communities for some types of properties but not others.

In the post-announcement, pre-construction period (i.e., PAPC), however, recent analysis has found more evidence of potential property value effects: by theorizing the possible existence of, but not finding, an effect (Laposa and Mueller, 2010; Sunak and Madlener, 2012); potentially finding an effect (Heintzelman and Tuttle, 2011)[4]; and, consistently finding what the author terms an "anticipation stigma" effect (Hinman, 2010). The studies that found PAPC property-value effects appear to align with earlier studies that suggested lower community support for proposed wind facilities before construction—potentially indicating a risk-averse (i.e., fear of the unknown) stance by community members—but increased support after facilities began operation (Gipe, 1995; Palmer, 1997; Devine-Wright, 2005; Wolsink, 2007; Bond, 2008, 2010). Similarly, researchers have found that survey respondents who live closer to turbines support the turbines more than respondents who live farther away (Braunholtz and MORI Scotland, 2003; Baxter et al., 2013), which could also indicate more risk-adverse / fear of the unknown effects (these among those who live farther away). Analogously, a recent case in Canada, although dismissed, highlighted the fears that nearby residents have for a planned facility (Wiggins v. WPD Canada Corporation, 2013)

Some studies have examined property-value conditions existing before wind facilities were announced (i.e., pre-announcement or PA). This is important for exploring correlations between wind facility siting and pre-existing home values from an environmental justice perspective and also for measuring PAPC and PC effects more accurately. Hoen et al. (2009, 2011) and Sims and Dent (2007) found evidence of depressed values for homes that sold before a wind facility's announcement and were located near the facility's eventual location, but they did not adjust their PC estimates for this finding. Hinman (2010) went further, finding value reductions of 12%–20% for homes near turbines in Illinois, which sold prior to the facilities' announcements; then using these findings to deflate their PC home-value-effect estimates.

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[4] Heintzelman and Tuttle do not appear convinced that the effect they found is related to the PAPC period, yet the two counties in which they found an effect (Clinton and Franklin Counties, NY) had transaction data produced almost entirely in the PAPC period.

Some research has linked wind-related property-value effects with the effects of better-studied disamenities (Hoen et al., 2009). The broader disamenity literature (e.g., Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006) suggests that, although property-value effects might occur near wind facilities as they have near other disamenities, those effects (if they do exist) are likely to be relatively small, are unlikely to persist some distance from a facility, and might fade over time as home buyers who are more accepting of the condition move into the area (Tiebout, 1956).

For example, a review of the literature investigating effects near high-voltage transmission lines (a largely visual disturbance, as turbines may be for many surrounding homes) found the following: property-value reductions of 0%–15%; effects that fade with distance, often only affecting properties crossed by or immediately adjacent to a line or tower; effects that can increase property values when the right-of-way is considered an amenity; and effects that fade with time as the condition becomes more accepted (Kroll and Priestley, 1992). While potentially much more objectionable to residential communities than turbines, a review of the literature on landfills (which present odor, traffic, and groundwater-contamination issues) indicates effects that vary by landfill size (Ready, 2010). Large-volume operations (accepting more than 500 tons per day) reduce adjacent property values by 13.7% on average, fading to 5.9% one mile from the landfill. Lower-volume operations reduce adjacent property values by 2.7% on average, fading to 1.3% one mile away, with 20%–26% of lower-volume landfills not having any statistically significant impact. A study of 1,600 toxic industrial plant openings found adverse impacts of 1.5% within a half mile, which disappeared if the plants closed (Currie et al., 2012). Finally, a review of the literature on road noise (which might be analogous to turbine noise) shows property-value reductions of 0% –11% (median 4%) for houses adjacent to a busy road that experience a 10-dBA noise increase, compared with houses on a quiet street (Bateman et al., 2001).

It is not clear where wind turbines might fit into these ranges of impacts, but it seems unlikely that they would be considered as severe a disamenity as a large-volume landfill, which present odor, traffic, and groundwater-contamination issues. Low-volume landfills, with an effect near 3%, might be a better comparison, because they have an industrial (i.e., non-natural) quality, similar to turbines, but are less likely to have clear health effects. If sound is the primary concern, a 4% effect (corresponding to road noise) could be applied to turbines, which might correspond to a 10-dBA increase for houses within a half mile of a turbine (see e.g., Hubbard and Shepherd, 1991). Finally, as with transmission lines, if houses are in sight but not within sound distance of turbines, there may be no property-value effects unless those homes are immediately adjacent to the turbines. In summary, assuming these potentially analogous disamenity effects can be entirely transferred, turbine impacts might be 0%–14%, but more likely might coalesce closer to 3%–4%.

Of course, wind turbines have certain positive qualities that landfills, transmission lines, and roads do not always have, such as mitigating greenhouse gas emissions. no air or water pollution, no use of water during the generation of energy, and no generation of solid or hazardous waste that requires permanent storage/disposal (IPCC, 2011). Moreover, wind facilities can, and often do, provide economic benefits to local communities (Lantz and Tegen, 2009; Slattery et al., 2011; Brown et al., 2012; Loomis et al., 2012), which might not be the case for all other disamenities. Similarly, wind facilities can have direct positive effects on local government budgets through property tax or other similar payments (Loomis and Aldeman, 2011), which might, for example, improve school quality and thus increase nearby home values (e.g., Haurin and Brasington, 1996; Kane et al., 2006). These potential positive qualities might mitigate potential negative wind effects somewhat or even entirely. Therefore for the purposes of this research we will assume 3-4% is a maximum possible effect.

The potentially small average property-value effect of wind turbines, possibly reduced further by wind's positive traits, might help explain why effects have not been discovered consistently in previous research. To discover effects with small margins of error, large amounts of data are needed. However, previous datasets of homes very near turbines have been small. Hoen et al. (2009, 2011) used 125 PC transactions within a mile of the turbines, while others used far fewer PC transactions within a mile: Heintzelman and Tuttle (2012) ($n \sim 35$); Hinman (2010) ($n \sim 11$), Carter (2011) ($n \sim 41$), and Sunak and Madlener (2012) ($n \sim 51$). Although these numbers of observations are adequate to examine large impacts (e.g., over 10%), they are less likely to reveal small effects with any reasonable degree of statistical significance. Using results from Hoen et al. (2009) and the confidence intervals for the various fixed-effect variables in that study, estimates for the numbers of transactions needed to find effects of various sizes were obtained.

Approximately 50 cases are needed to find an effect of 10% and larger, 100 cases for 7.5%, 200 cases for 5%, 350 cases for 4%, 700 cases for 3%, and approximately 1,000 cases for a 2.5% effect.[5] Therefore, in order to detect an effect in the range of 3%–4%, a dataset of approximately 350–700 cases within a mile of the turbines will be required to detect it statistically, a number that to-date has not been amassed by any of the previous studies.

As discussed above, in addition to being relatively small on average, impacts are likely to decay with distance. As such, an appropriate empirical approach must be able to reveal spatially diminishing effects. Some researchers have used continuous variables to capture these effects, such as linear distance (Hoen et al., 2009; Sims et al., 2008) and inverse distance (Heintzelman and Tuttle, 2012; Sunak and Madlener, 2012), but doing so forces the model to estimate effects at the mean distance. In some cases, those means can be far from the area of expected impact. For example, Heintzelman and Tuttle (2012) estimated an inverse distance effect using a mean distance of more than 10 miles from the turbines, while Sunak and Madlener (2012) used a mean distance of approximately 1.9 miles. Using this approach weakens the ability of the model to quantify real effects near the turbines, where they are likely to be stronger. More importantly, this method encourages researchers to extrapolate their findings to the ends of the distance curve, near the turbines, despite having few data at those distances to support these extrapolations. This was the case for Heintzelman and Tuttle (2012), who had fewer than 10 cases within a half mile in the two counties where effects were found and only a handful that sold in those counties after the turbines were built, yet they extrapolated their findings to a quarter mile and even a tenth of a mile, where they had very few (if any) cases. Similarly, Sunak and Madlener (2012) had only six PC sales within a half mile and 51 within 1 mile, yet they extrapolated their findings to these distance bands.

One way to avoid using a single continuous function to estimate effects at all distances is to use a spline model, which breaks the distances into continuous groups (Hoen et al., 2011), but this method still imposes structure on the data by forcing the ends of each spline to tie together. A second and more transparent method is to use fixed-effect variables for discrete distances, which imposes little structure on the data (Hoen et al., 2009; Hinman, 2010; Carter, 2011; Hoen et al.,

[5] This analysis is available upon request from the authors.

2011). Although this latter method has been used in a number of studies, because of a paucity of data, the resulting models are often ineffective at detecting what might be relatively small effects very close to the turbines. As such, when using this method (or any other, in fact) it is important that the underlying dataset is large enough to estimate the anticipated magnitude of the effect sizes.

Finally, one rarely investigated aspect of potential wind-turbine effects is the possibly idiosyncratic nature of spatially averaged transaction data used in the hedonic analyses. Sunak and Madlener (2012) used a geographically weighted regression (GWR), which estimates different regressions for small clusters of data and then allows the investigation of the distribution of effects across all of the clusters. Although GWR can be effective for understanding the range of impacts across the study area, it is not as effective for determining an average effect or for testing the statistical significance of the range of estimates. Results from studies that use GWR methods are also sometimes counter-intuitive.[6] As is discussed in more detail in the methodology section, a potentially better approach is to estimate a spatial-process model that is flexible enough to simultaneously control for spatial heterogeneity and spatial dependence, while also estimating an average effect across fixed discrete effects.

In summary, building on the existing literature, further research is needed on property-value effects in particularly close proximity to wind turbines. Specifically, research is needed that uses a large set of data near the turbines, accounts for home values before the announcement of the facility (as well as after announcement but before construction), accounts for potential spatial dependence in unobserved factors effecting home values, and uses a fixed-effect distance model that is able to accurately estimate effects near turbines.

3. Methodology

The present study seeks to respond to the identified research needs noted above, with this section describing our methodological framework for estimating the effects of wind turbines on the value of nearby homes in the United States.

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[6] For example, Sunak and Madlener (2012) find larger effects related to the turbines in a city that is farther from the turbines than they find in a town which is closer. Additionally, they find stronger effects in the center of a third town than they do on the outskirts of that town, which do not seem related to the location of the turbines.

3.1. Basic Approach and Models

Our methods are designed to help answer the following questions:

1. Did homes that sold prior to the wind facilities' announcement (PA)—and located within a short distance (e.g., within a half mile) from where the turbines were eventually located—sell at lower prices than homes located farther away?
2. Did homes that sold after the wind facilities' announcement but before construction (PAPC)—and located within a short distance (e.g., within a half mile)—sell at lower prices than homes located farther away?
3. Did homes that sold after the wind facilities' construction (PC)—and located within a short distance (e.g., within a half mile)—sell at lower prices than homes located farther away?
4. For question 3 above, if no statistically identifiable effects are found, what is the likely maximum effect possible given the margins of error around the estimates?

To answer these questions, the hedonic pricing model (Rosen, 1974; Freeman, 1979) is used in this paper, as it has been in other disamenity research (Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006). The value of this approach is that is allows one to disentangle and control for the potentially competing influences of home, site, neighborhood, and market characteristics on property values, and to uniquely determine how home values near announced or operating facilities are affected.[7] To test for these effects, two pairs of "base" models are estimated, which are then coupled with a set of "robustness" models to test and bound the estimated effects. One pair is estimated using a standard OLS model, and the other is estimated using a spatial-process model. The models in each pair are different in that one focuses on all homes within 1 mile of an existing turbine (*one-mile* models), which allows the maximum number of data for the fixed effect to be used, while the other focuses on homes within a half mile (*half-mile* models), where effects are more likely to appear but fewer data are available. We assume that, if effects exist near turbines, they are larger for the *half-mile* models than the *one-mile* models.

[7] See Jackson (2003) for a further discussion of the Hedonic Pricing Model and other analysis methods.

As is common in the literature (Malpezzi, 2003; Sirmans et al., 2005), a semi-log functional form of the hedonic pricing model is used for all models, where the dependent variable is the natural log of sales price. The OLS *half-mile* model form is as follows:

$$\ln(SP_i) = \alpha + \sum_a \beta_1 (T_i \bullet S_i) + \beta_2 (W_i) + \sum_b \beta_3 (X_i \bullet C_i) + \beta_4 (D_i \bullet P_i) + \varepsilon_i \quad (1)$$

where

SP_i represents the sale price for transaction *i*,

α is the constant (intercept) across the full sample,

T_i is a vector of time-period dummy variables (e.g., sale year and if the sale occurred in winter) in which transaction *i* occurred,

S_i is the state in which transaction *i* occurred,

W_i is the census tract in which transaction *i* occurred,

X_i is a vector of home, site, and neighborhood characteristics for transaction *i* (e.g., square feet, age, acres, bathrooms, condition, percent of block group vacant and owned, median age of block group),[8]

C_i is the county in which transaction *i* occurred,

D_i is a vector of four fixed-effect variables indicating the distance (to the nearest turbine) bin (i.e., group) in which transaction *i* is located (e.g., within a half mile, between a half and 1 mile, between 1 and 3 miles, and between 3 and 10 miles),

P_i is a vector of three fixed-effect variables indicating the wind project development period in which transaction *i* occurred (e.g., PA, PAPC, PC),

$B_{1\text{-}3}$ is a vector of estimates for the controlling variables,

B_4 is a vector of 12 parameter estimates of the distance-development period interacted variables of interest,

ε_i is a random disturbance term for transaction *i.*

This pooled construction uses all property transactions in the entire dataset. In so doing, it takes advantage of the large dataset in order to estimate an average set of turbine-related effects across all study areas, while simultaneously allowing for the estimation of controlling characteristics at

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[8] A "block group" is a US Census Bureau geographic delineation that contains a population between 600 to 3000 persons.

the local level, where they are likely to vary substantially across the study areas.[9] Specifically, the interaction of county-level fixed effects (C_i) with the vector of home, site, and neighborhood characteristics (X_i) allows different slopes for each of these independent variables to be estimated for each county. Similarly, interacting the state fixed-effect variables (S_i) with the sale year and sale winter fixed effects variables (T_i) (i.e., if the sale occurred in either Q1 or Q4) allows the estimation of the respective inflation/deflation and seasonal adjustments for each state in the dataset.[10] Finally, to control for the potentially unique collection of neighborhood characteristics that exist at the micro-level, census tract fixed effects are estimated.[11] Because a pooled model is used that relies upon the full dataset, smaller effect sizes for wind turbines will be detectable. At the same time, however, this approach does not allow one to distinguish possible wind turbine effects that may be larger in some communities than in others.

As discussed earlier, effects might predate the announcement of the wind facility and thus must be controlled for. Additionally, the area surrounding the wind facility might have changed over time simultaneously with the arrival of the turbines, which could affect home values. For example, if a nearby factory closed at the same time a wind facility was constructed, the influence of that factor on all homes in the general area would ideally be controlled for when estimating wind turbine effect sizes.

To control for both of these issues simultaneously, we use a difference-in-difference (*DD)* specification (see e.g., Hinman, 2010; Zabel and Guignet, 2012) derived from the interaction of

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[9] The dataset does not include "participating" landowners, those that have turbines situated on their land, but does include "neighboring" landowners, those adjacent to or nearby the turbines. One reviewer notes that the estimated average effects also include any effects from payments "neighboring" landowners might receive that might transfer with the home. Based on previous conversations with developers (see Hoen et al, 2009), we expect that the frequency of these arrangements is low, as is the right to transfer the payments to the new homeowner. Nonetheless, our results should be interpreted as "net" of any influence whatever "neighboring" landowner arrangements might have.

[10] Unlike the vector of home, site, and neighborhood characteristics, sale price inflation/deflation and seasonal changes were not expected tovary substantially across various counties in the same states in our sample and therefore the interaction was made at the state level. This assumption was tested as part of the robustness tests though, where they are interacted at the county level and found to not affect the results.

[11] In part because of the rural nature of many of the study areas included in the research sample, these census tracts are large enough to contain sales that are located close to the turbines as well as those farther away, thereby ensuring that they do not unduly absorb effects that might be related to the turbines. Moreover each tract contains sales from throughout the study periods, both before and after the wind facilities' announcement and construction, further ensuring they are not biasing the variables of interest.

the spatial (D_i) and temporal (P_i) terms. These terms produce a vector of 11 parameter estimates (β_4) as shown in Table 1 for the *half-mile* models and in Table 2 for the *one-mile* models. The omitted (or reference) group in both models is the set of homes that sold prior to the wind facilities' announcement and which were located more than 3 miles away from where the turbines were eventually located (A3). It is assumed that this reference category is likely not affected by the imminent arrival of the turbines, although this assumption is tested in the robustness tests.

Using the *half-mile* models, to test whether the homes located near the turbines that sold in the PA period were uniquely affected (*research question 1*), we examine A0, from which the null hypothesis is A0=0. To test if the homes located near the turbines that sold in the PAPC period were uniquely affected (*research question 2*), we first determine the difference in their values as compared to those farther away (B0-B3), while also accounting for any pre-announcement (i.e., pre-existing) difference (A0-A3) and any change in the local market over the development period (B3-A3). Because all covariates are determined in relation to the omitted category (A3), the null hypothesis collapses B0-A0-B3=0. Finally, in order to determine if homes near the turbines that sold in the PC period were uniquely affected (*research question 3*), we test if C0-A0-C3=0. Each of these *DD* tests are estimated using a linear combination of variables that produces the "net effect" and a measure of the standard error and corresponding confidence intervals of the effect, which enables the estimation of the maximum (and minimum) likely impacts for each research question. We use 90% confidence intervals both to determine significance and to estimate maximum likely effects (*research question 4*).

Following the same logic as above, the corresponding hypothesis tests for the *one-mile* models are as follows: *PA*, A1=0; *PAPC*, B1-A1-B3=0; and, *PC,* C1-A1-C3=0.

Table 1: Interactions between Wind Facility Development Periods and Distances – ½ Mile

Wind Facility Development Periods	Distances to Nearest Turbine: Within 1/2 Mile	Between 1/2 and 1 Mile	Between 1 and 3 Miles	Outside of 3 Miles
Prior to Announcement	A0	A1	A2	A3 (Omitted)
After Announcement but Prior to Construction	B0	B1	B2	B3
Post Construction	C0	C1	C2	C3

Table 2: Interactions between Wind Facility Development Periods and Distances - 1 Mile

Wind Facility Development Periods	Distances to Nearest Turbine: Within 1 Mile	Between 1 and 3 Miles	Outside of 3 Miles
Prior to Announcement	A1	A2	A3 (Omitted)
After Announcement but Prior to Construction	B1	B2	B3
Post Construction	C1	C2	C3

3.2. Spatial Dependence

As discussed briefly above, a common feature of the data used in hedonic models is the spatially dense nature of the real estate transactions. While this spatial density can provide unique insights into local real estate markets, one concern that is often raised is the impact of potentially omitted variables given that this is impossible to measure all of the local characteristics that affect housing prices. As a result, spatial dependence in a hedonic model is likely because houses located closer to each other typically have similar unobservable attributes. Any correlation between these unobserved factors and the explanatory variables used in the model (e.g., distance to turbines) is a source of omitted-variable bias in the OLS models. A common approach used in the hedonic literature to correct this potential bias is to include local fixed effects (Hoen et al., 2009, 2011; Zabel and Guignet, 2012), which is our approach as described in formula (1).

In addition to including local fixed effects, spatial econometric methods can be used to help further mitigate the potential impact of spatially omitted variables by modeling spatial dependence directly. When spatial dependence is present and appropriately modeled, more accurate (i.e., less biased) estimates of the factors influencing housing values can be obtained. These methods have been used in a number of previous hedonic price studies; examples include the price impacts of wildfire risk (Donovan et al., 2007), residential community associations (Rogers, 2006), air quality (Anselin and Lozano-Gracia, 2009), and spatial fragmentation of land use (Kuethe, 2012). To this point, however, these methods have not been applied to studies of the impact of wind turbines on property values.

Moran's I is the standard statistic used to test for spatial dependence in OLS residuals of the hedonic equation. If the Moran's I is statistically significant (as it is in our models – see Section 5.1.2), the assumption of spatial independence is rejected. To account for this, in spatial-process models, spatial dependence is routinely modeled as an additional covariate in the form of a spatially lagged dependent variable *Wy*, or in the error structure $\mu = \lambda W\mu + \varepsilon$, where ε is an identically and independently distributed disturbance term (Anselin, 1988). Neighboring criterion determines the structure of the spatial weights matrix *W*, which is frequently based on contiguity, distance criterion, or *k*-nearest neighbors (Anselin, 2002). The weights in the spatial-weights matrix are typically row standardized so that the elements of each row sum to one.

The spatial-process model, known as the SARAR model (Kelejian and Prucha, 1998)[12], allows for both forms of spatial dependence, both as an autoregressive process in the lag-dependent and in the error structure, as shown by:

$$\begin{aligned} y &= \rho W y + X\beta + \mu, \\ \mu &= \lambda W \mu + \varepsilon. \end{aligned} \tag{2}$$

[12] SARAR refers to a "spatial-autoregressive model with spatial autoregressive residuals".

Equation (2) is often estimated by a multi-step procedure using generalized moments and instrumental variables (Arraiz et al., 2009), which is our approach. The model allows for the innovation term ε in the disturbance process to be heteroskedastic of an unknown form (Kelejian and Prucha, 2010). If either λ or ρ are not significant, the model reduces to the respective spatial lag or spatial error model (SEM). In our case, as is discussed later, the spatial process model reduces to the SEM, therefore both *half-mile* and *one-mile* SEMs are estimated, and, as with the OLS models discussed above, a similar set of *DD* "net effects" are estimated for the PA, PAPC, and PC periods. One requirement of the spatial model is that the x/y coordinates be unique across the dataset. However, the full set of data (as described below) contains, in some cases, multiple sales for the same property, which consequently would have non-unique x/y coordinates.[13] Therefore, for the spatial models, only the most recent sale is used. An OLS model using this limited dataset is also estimated as a robustness test.

In total, four "base" models are estimated: an OLS *one-mile* model, a SEM *one-mile* model, an OLS *half-mile* model, and a SEM *half-mile* model. In addition, a series of robustness models are estimated as described next.

3.3. Robustness Tests

To test the stability of and potentially bound the results from the four base models, a series of robustness tests are conducted that explore: the effect that outliers and influential cases have on the results; a micro-inflation/deflation adjustment by interacting the sale-year fixed effects with the county fixed effects rather than state fixed effects; the use of only the most recent sale of homes in the dataset to compare results to the SEM models that use the same dataset; the application of a more conservative reference category by using transactions between 5 and 10 miles (as opposed to between 3 and 10 miles) as the reference; and a more conservative

[13] The most recent sale weights the transactions to those occurring after announcement and construction, that are more recent in time. One reviewer wondered if the frequency of sales was affected near the turbines, which is also outside the scope of the study, though this "sales volume" was investigated in Hoen et al. (2009), where no evidence of such an effect was discovered. Another correctly noted that the most recent assessment is less accurate for older sales, because it might overestimate some characteristics of the home (e.g., sfla, baths) that might have changed (i.e., increased) over time. This would tend to bias those characteristics' coefficients downward. Regardless, it is assumed that this occurrence is not correlated with proximity to turbines and therefore would not bias the variables of interest.

reference category by using transactions more than 2 years PA (as opposed to simply PA) as the reference category. Each of these tests is discussed in detail below.

3.3.1. Outliers and Influential Cases

Most datasets contain a subset of observations with particularly high or low values for the dependent variables, which might bias estimates in unpredictable ways. In our robustness test, we assume that observations with sales prices above or below the 99% and 1% percentile are potentially problematic outliers. Similarly, individual sales transactions and the values of the corresponding independent variables might exhibit undue influence on the regression coefficients. In our analysis, we therefore estimate a set of Cook's Distance statistics (Cook, 1977; Cook and Weisberg, 1982) on the base OLS *half-mile* model and assume any cases with an absolute value of this statistic greater than one to be potentially problematic influential cases. To examine the influence of these cases on our results, we estimate a model with both the outlying sales prices and Cook's influential cases removed.

3.3.2. Interacting Sale Year at the County Level

It is conceivable that housing inflation and deflation varied dramatically in different parts of the same state. In the base models, we interact sale year with the state to account for inflation and deflation of sales prices, but a potentially more-accurate adjustment might be warranted. To explore this, a model with the interaction of sale year and county, instead of state, is estimated.

3.3.3. Using Only the Most Recent Sales

The dataset for the base OLS models includes not only the most recent sale of particular homes, but also, if available, the sale prior to that. Some of these earlier sales occurred many years prior to the most recent sale. The home and site characteristics (square feet, acres, condition, etc.) used in the models are populated via assessment data for the home. For some of these data, only the most recent assessment information is available (rather than the assessment from the time of sale), and therefore older sales might be more prone to error as their characteristics might have changed since the sale.[14] Additionally, the SEMs require that all x/y coordinates entered into the model are unique; therefore, for those models only the most recent sale is used. Excluding older sales therefore potentially reduces measurement error, and also enables a more-direct comparison of effects between the base OLS model and SEM results.

3.3.4. Using Homes between 5 and 10 Miles as Reference Category

The base models use the collection of homes between 3 and 10 miles from the wind facility (that sold before the announcement of the facility) as the reference category in which wind facility effects are not expected. However, it is conceivable that wind turbine effects extend farther than 3 miles. If homes outside of 3 miles are affected by the presence of the turbines, then effects estimated for the target group (e.g., those inside of 1 mile) will be biased downward (i.e., smaller) in the base models. To test this possibility and ensure that the results are not biased, the group of homes located between 5 and 10 miles is used as a reference category as a robustness test.

3.3.5. Using Transactions Occurring More than 2 Years before Announcement as Reference Category

The base models use the collection of homes that sold before the wind facilities were announced (and were between 3 and 10 miles from the facilities) as the reference category, but, as discussed in Hoen et al. (2009, 2011), the announcement date of a facility, when news about a facility enters the <u>public domain</u>, might be after that project was known <u>in private</u>. For example, wind facility developers may begin talking to landowners some time before a facility is announced, and these landowners could share that news with neighbors. In addition, the developer might erect an anemometer to collect wind-speed data well before the facility is formally "announced," which might provide concrete evidence that a facility may soon to be announced. In either case, this news might enter the local real estate market and affect home prices before the formal facility announcement date. To explore this possibility, and to ensure that the reference category

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[14] As discussed in more detail in the Section 4, approximately 60% of all the data obtained for this study (that obtained from CoreLogic) used the most recent assessment to populate the home and site characteristics for all transactions of a given property.

is unbiased, a model is estimated that uses transactions occurring more than 2 years before the wind facilities were announced (and between 3 and 10 miles) as the reference category.

Combined, this diverse set of robustness tests allows many assumptions used for the base models to be tested, potentially allowing greater confidence in the final results.

4. Data

The data used for the analysis are comprised of four types: wind turbine location data, real estate transaction data, home and site characteristic data, and census data. From those, two additional sets of data are calculated: distance to turbine and wind facility development period. Each data type is discussed below. Where appropriate, variable names are shown in *italics*.

4.1. Wind Turbine Locations

Location data (i.e., x/y coordinates) for installed wind turbines were obtained via an iterative process starting with Federal Aviation Administration obstacle data, which were then linked to specific wind facilities by Ventyx[15] and matched with facility-level data maintained by LBNL. Ultimately, data were collected on the location of almost all wind turbines installed in the U.S. through 2011 ($n \sim 40{,}000$), with information about each facility's announcement, construction, and operation dates as well as turbine nameplate capacity, hub height, rotor diameter, and facility size.

4.2. Real Estate Transactions

Real estate transaction data were collected through two sources, each of which supplied the home's sale price (*sp*), sale date (*sd*), x/y coordinates, and address including zip code. From those, the following variables were calculated: natural log of sale price (*lsp*), sale year (*sy*), if the sale occurred in winter (*swinter*) (i.e., in Q1 or Q4).

The first source of real estate transaction data was CoreLogic's extensive dataset of U.S. residential real estate information.[16] Using the x/y coordinates of wind turbines, CoreLogic

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[15] See the EV Energy Map, which is part of the Velocity Suite of products at www.ventyx.com.
[16] See www.corelogic.com.

selected all arms-length single-family residential transactions between 1996 and 2011 within 10 miles of a turbine in any U.S. counties where they maintained data (not including New York – see below) on parcels smaller than 15 acres.[17] The full set of counties for which data were collected were then winnowed to 26 by requiring at least 250 transactions in each county, to ensure a reasonably robust estimation of the controlling characteristics (which, as discussed above, are interacted with county-level fixed effects), and by requiring at least one PC transaction within a half mile of a turbine in each county (because this study's focus is on homes that are located in close proximity to turbines).

The second source of data was the New York Office of Real Property Tax Service (NYORPTS),[18] which supplied a set of arms-length single-family residential transactions between 2001 and 2012 within 10 miles of existing turbines in any New York county in which wind development had occurred prior to 2012. As before, only parcels smaller than 15 acres were included, as were a minimum of 250 transactions and at least one PC transaction within a half mile of a turbine for each New York county. Both CoreLogic and NYORPTS provided the most recent home sale and, if available, the prior sale.

4.3. Home and Site Characteristics

A set of home and site characteristic data was also collected from both data suppliers: 1000s of square feet of living area (*sfla1000*), number of acres of the parcel (*acres*), year the home was built (or last renovated, whichever is more recent) (*yrbuilt*), and the number of full and half bathrooms (*baths*).[19] Additional variables were calculated from the other variables as well: log of 1,000s of square feet (*lsfla1000*),[20] the number of acres less than 1 (*lt1acre)*,[21] age at the time of sale (*age*), and age squared (*agesqr*).[22]

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[17] The 15 acre screen was used because of a desire to exclude from the sample any transaction of property that might be hosting a wind turbine, and therefore directly benefitting from the turbine's presence (which might then increase property values). To help ensure that the screen was effective, all parcels within a mile of a turbine were also visually inspected using satellite and ortho imagery via a geographic information system.

[18] See www.orps.state.ny.us

[19] *Baths* was calculated in the following manner: full bathrooms + (half bathrooms x 0.5). Some counties did not have *baths* data available, so for them *baths* was not used as an independent variable.

[20] The distribution of *sfla1000* is skewed, which could bias OLS estimates, thus *lsfla1000* is used instead, which is more normally distributed. Regression results, though, were robust when *sfla1000* was used instead.

Regardless of when the sale occurred, CoreLogic supplied the related home and site characteristics as of the most recent assessment, while NYORPTS supplied the assessment data as of the year of sale.[23]

4.4. Census Information

Each of the homes in the data was matched (based on the x/y coordinates) to the underlying census block group and tract via ArcGIS. Using the year 2000 block group census data, each transaction was appended with neighborhood characteristics including the median age of the residents (*medage*), the total number of housing units (*units*), the number vacant (*vacant*) homes, and the number of owned (*owned*) homes. From these, the percentages of the total number of housing units in the block group that were vacant and owned were calculated, i.e., *pctvacant* and *pctowned*.

4.5. Distances to Turbine

Using the x/y coordinates of both the homes and the turbines, a Euclidian distance (in miles) was calculated for each home to the nearest wind turbine (*tdis*), regardless of when the sale occurred (e.g., even if a transaction occurred prior to the wind facility's installation).[24] These were then broken into four mutually exclusive distance bins (i.e., groups) for the base *half-mile* models: inside a half mile, between a half and 1 mile, between 1 and 3 miles, and between 3 and 10 miles. They were broken into three mutually exclusive bins for the base *one-mile* models: inside 1 mile, between 1 and 3 miles, and between 3 and 10 miles.

4.6. Wind Facility Development Periods

After identifying the nearest wind turbine for each home, a match could be made to Ventyx' dataset of facility-development announcement and construction dates. These facility-development dates in combination with the dates of each sale of the homes determined in which

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[21] This variable allows the separate estimations of the 1st acre and any additional acres over the 1st.

[22] *Age* and *agesqr* together account for the fact that, as homes age, their values usually decrease, but further increases in age might bestow countervailing positive "antique" effects.

[23] See footnote 13.

[24] Before the distances were calculated, each home inside of 1 mile was visually inspected using satellite and ortho imagery, with x/y coordinates corrected, if necessary, so that those coordinates were on the roof of the home.

of the three facility-development periods (*fdp*) the transaction occurred: *pre-announcement* (PA), *post-announcement-pre-construction* (PAPC), or *post-construction* (PC).

4.7. Data Summary

After cleaning to remove missing or erroneous data, a final dataset of 51,276 transactions was prepared for analysis.[25] As shown in the map of the study area (Figure 1), the data are arrayed across nine states and 27 counties (see Table 4), and surround 67 different wind facilities.

Table 3 contains a summary of those data. The average unadjusted sales price for the sample is $122,475. Other average house characteristics include the following: 1,600 square feet of living space; house age of 48 years[26]; land parcel size of 0.90 acres; 1.6 bathrooms; in a block group in which 74% of housing units are owned, 9% are vacant, and the median resident age is 38 years; located 4.96 miles from the nearest turbine; and sold at the tail end of the PA period.

The data are arrayed across the temporal and distance bins as would be expected, with smaller numbers of sales nearer the turbines, as shown in Table 5. Of the full set of sales, 1,198 occurred within 1 mile of a then-current or future turbine location, and 376 of these occurred post construction; 331 sales occurred within a half mile, 104 of which were post construction. Given these totals, the models should be able to discern a post construction effect larger than ~3.5% within a mile and larger than ~7.5% within a half mile (see discussion in Section 2). These effects are at the top end of the expected range of effects based on other disamenities (high-voltage power lines, roads, landfills, etc.).

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[25] Cleaning involved the removal of all data that did not have certain core characteristics (sale date, sale price, *sfla, yrbuilt, acres, median age*, etc.) fully populated as well as the removal of any sales that had seemingly miscoded data (e.g., having a *sfla* that was greater than *acres,* having a *yrbuilt* more than 1 year after the sale, having less than one *bath*) or that did not conform to the rest of the data (e.g., had *acres* or *sfla* that were either larger or smaller, respectively, than 99% or 1% of the data). OLS models were rerun with those "nonconforming" data included with no substantive change in the results in comparison to the screened data presented in the report.

[26] Age could be as low as -1(for a new home) for homes that were sold before construction was completed.

Figure 1: Map of Transactions, States, and Counties

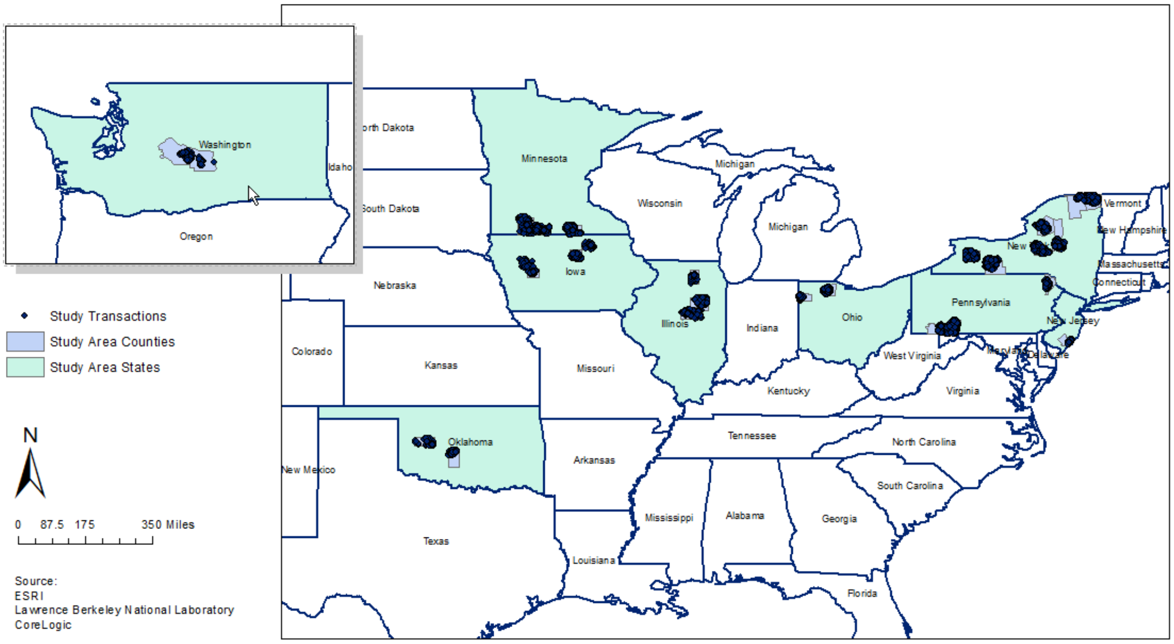

Table 3: Summary Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
sp	sale price in dollars	$ 122,475	$ 80,367	$ 9,750	$ 690,000
lsp	natural log of sale price	11.52	0.65	9.19	13.44
sd	sale date	1/18/2005	1,403 days	1/1/1996	9/30/2011
sy	sale year	2005	3.84	1996	2011
sfla1000	living area in 1000s of square feet	1.60	0.57	0.60	4.50
lsfla1000	natural log of sfla1000	0.41	0.34	-0.50	1.50
acres	number of acres in parcel	0.90	1.79	0.03	14.95
acreslt1*	acres less than 1	-0.58	0.34	-0.97	0.00
age	age of home at time of sale	48	37	-1	297
agesq	age squared	3689	4925	0	88209
baths**	number of bathrooms	1.60	0.64	1.00	5.50
pctowner	fraction of house units in block group that are owned (as of 2000)	0.74	0.17	0.63	0.98
pctvacant	fraction of house units in block group that are vacant (as of 2000)	0.09	0.10	0.00	0.38
med_age	median age of residents in block group (as of 2000)	38	6	20	63
tdis	distance to nearest turbine (as of December 2011) in miles	4.96	2.19	0.09	10.00
fdp***	facility development period of nearest turbine at time of sale	1.94	0.87	1.00	3.00

Note: The number of cases for the full dataset is 51,276

** acreslt1 is calculated as follows: acres (if less than 1) * - 1*

*** Some counties did not have bathrooms populated; for those, these variables are entered into the regression as 0.*

**** fdp periods are: 1, pre-announcement,; 2, post-announcement-pre-construction; and, 3, post-construction.*

Table 4: Summary of Transactions by County

County	State	<1/2 mile	1/2-1 mile	1-3 miles	3-10 miles	Total
Carroll	IA	12	56	331	666	1,065
Floyd	IA	3	2	402	119	526
Franklin	IA	8	1	9	322	340
Sac	IA	6	77	78	485	646
DeKalb	IL	4	8	44	605	661
Livingston	IL	16	6	237	1,883	2,142
McLean	IL	18	88	380	4,359	4,845
Cottonwood	MN	3	10	126	1,012	1,151
Freeborn	MN	17	16	117	2,521	2,671
Jackson	MN	19	28	36	149	232
Martin	MN	7	25	332	2,480	2,844
Atlantic	NJ	34	96	1,532	6,211	7,873
Paulding	OH	15	58	115	309	497
Wood	OH	5	31	563	4,844	5,443
Custer	OK	45	24	1,834	349	2,252
Grady	OK	1	6	97	874	978
Fayette	PA	1	2	10	284	297
Somerset	PA	23	100	1,037	2,144	3,304
Wayne	PA	4	29	378	739	1,150
Kittitas	WA	2	6	61	349	418
Clinton	NY	4	6	49	1,419	1,478
Franklin	NY	16	41	75	149	281
Herkimer	NY	3	17	354	1,874	2,248
Lewis	NY	5	6	93	732	836
Madison	NY	5	26	239	3,053	3,323
Steuben	NY	5	52	140	1,932	2,129
Wyoming	NY	50	50	250	1,296	1,646
Total		331	867	8,919	41,159	51,276

Table 5: Frequency Crosstab of Wind Turbine Distance and Development Period Bins

	<1/2 mile	1/2-1 mile	1-3 miles	3-10 miles	total
PA	143	383	3,892	16,615	21,033
PAPC	84	212	1,845	9,995	12,136
PC	104	272	3,182	14,549	18,107
total	331	867	8,919	41,159	51,276

As shown in Table 6, the home sales occurred around wind facilities that range from a single-turbine project to projects of 150 turbines, with turbines of 290–476 feet (averaging almost 400 feet) in total height from base to tip of blade and with an average nameplate capacity of 1,637 kW. The average facility was announced in 2004 and constructed in 2007, but some were announced as early as 1998 and others were constructed as late as 2011.

Table 6: Wind Facility Summary

	mean	min	25th percentile	median	75th percentile	max
turbine rotor diameter (feet)	262	154	253	253	269	328
turbine hub height (feet)	256	197	256	262	262	328
turbine total height (feet)	388	290	387	389	397	476
turbine capacity (kW)	1637	660	1500	1500	1800	2500
facility announcement year	2004	1998	2002	2003	2005	2010
facility construction year	2007	2000	2004	2006	2010	2011
number of turbines in facility	48	1	5	35	84	150
nameplate capacity of facility (MW)	79	1.5	7.5	53	137	300

Note: The data correspond to 67 wind facilities located in the study areas. Mean values are rounded to integers

4.8. Comparison of Means

To provide additional context for the analysis discussed in the next section, we further summarize the data here using four key variables across the sets of development period (*fdp*) and distance bins (*tdis*) used in the *one-mile* models.[27] The variables are the dependent variable log of sale price *(lsp)* and three independent variables: *lsfla100, acres*, and *age*. These summaries are provided in Table 7; each sub-table gives the mean values of the variables across the three *fdp* bins and three *tdis* bins, and the corresponding figures plot those values.

The top set of results are focused on the log of the sales price, and show that, based purely on price and not controlling for differences in homes, homes located within 1 mile of turbines had lower sale prices than homes farther away; this is true across all of the three development periods. Moreover, the results also show that, over the three periods, the closer homes appreciated to a somewhat lesser degree than homes located farther from the turbines. As a result, focusing only on the post-construction period, these results might suggest that home prices near turbines are

[27] Summaries for the *half-mile* models reveal a similar relationship, so only the *one-mile* model summaries are shown here.

adversely impacted by the turbines. After all, the logarithmic values for the homes within a mile of the turbines (11.39) and those outside of a three miles (11.72) translate into an approximately 40% difference, in comparison to an 21% difference before the wind facilities were announced (11.16 vs. 11.35).[28] Focusing on the change in average values between the pre-announcement and post-construction periods might also suggest an adverse effect due to the turbines, because homes inside of 1 mile appreciated more slowly (11.16 to 11.39, or 25%) than those outside of 3 miles (11.35 to 11.72, or 45%). Both conclusions of adverse turbine effects, however, disregard other important differences between the homes, which vary over the periods and distances. Similarly, comparing the values of the PA inside 1 mile homes (11.16) and the PC outside of 3 miles homes (11.72), which translates into a difference of 75%, and which is the basis for comparison in the regressions discussed below, but also ignores any differences in the underlying characteristics.

The remainder of Table 7, for example, indicates that, although the homes that sold within 1 mile are lower in value, they are also generally (in all but the PA period) smaller, on larger parcels of land, and older. These differences in home size and age across the periods and distances might explain the differences in price, while the differences in the size of the parcel, which add value, further amplifying the differences in price. Without controlling for these possible impacts, one cannot reliably estimate the impact of wind turbines on sales prices.

In summary, focusing solely on trends in home price (or price per square foot) alone, and for only the PC period, as might be done in a simpler analysis, might incorrectly suggest that wind turbines are affecting price when other aspects of the markets, and other home and sites characteristic differences, could be driving the observed price differences. This is precisely why researchers generally prefer the hedonic model approach to control for such effects, and the results from our hedonic OLS and spatial modeling detailed in the next section account for these and many other possible influencing factors.

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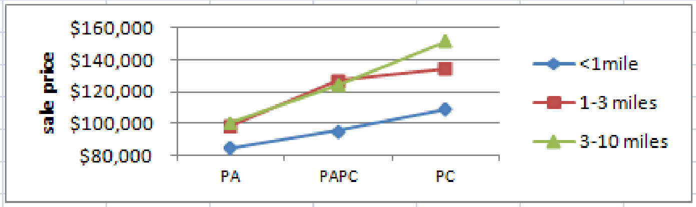
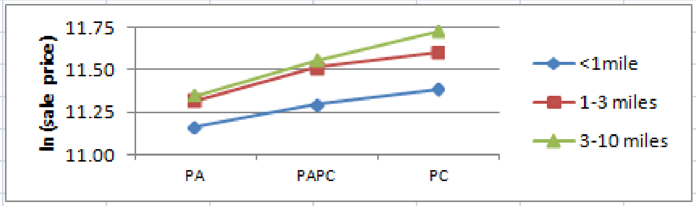
[28] Percentage differences are calculated as follows: exp(11.72-11.39)-1=0.40 and exp(11.35-11.16)-1=0.21.

Table 7: Dependent and Independent Variable Means

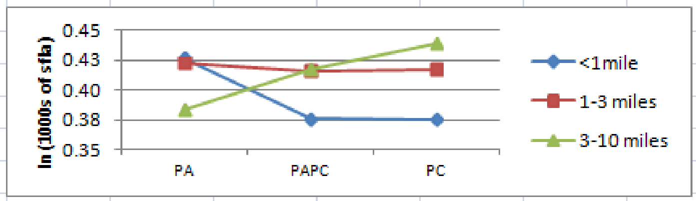
Sale Price	<1mile	1-3 miles	3-10 miles
PA	$ 84,830	$ 98,676	$100,485
PAPC	$ 95,223	$127,054	$124,532
PC	$109,133	$134,647	$151,559



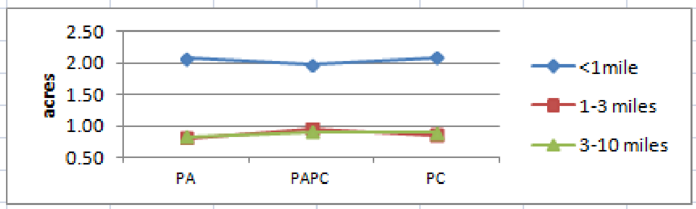
Log of Sale Price	<1mile	1-3 miles	3-10 miles
PA	11.16	11.32	11.35
PAPC	11.30	11.52	11.56
PC	11.39	11.61	11.72



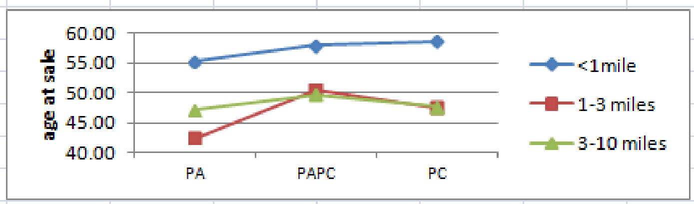
Log of Square Feet (in 1000s)	<1mile	1-3 miles	3-10 miles
PA	0.43	0.42	0.38
PAPC	0.38	0.42	0.42
PC	0.38	0.42	0.44



Number of Acres	<1mile	1-3 miles	3-10 miles
PA	2.08	0.80	0.83
PAPC	1.98	0.94	0.90
PC	2.09	0.84	0.89



Age at the Time of Sale	<1mile	1-3 miles	3-10 miles
PA	55.32	42.34	47.19
PAPC	58.01	50.34	49.73
PC	58.63	47.39	47.73



5. Results

This section contains analysis results and discussion for the four base models, as well as the results from the robustness models.

5.1. Estimation Results for Base Models

Estimation results for the "base" models are shown in Table 8 and Table 9.[29] In general, given the diverse nature of the data, the models perform adequately, with adjusted R^2 values ranging from 0.63 to 0.67 (bottom of Table 9).

5.1.1. Control Variables

The controlling home, site, and block group variables, which are interacted at the county level, are summarized in Table 8. Table 8 focuses on only one of the base models, the *one-mile* OLS model, but full results from all models are shown in the Appendix.[30] To concisely summarize results for all of the 27 counties, the table contains the percentage of all 27 counties for which each controlling variable has statistically significant (at or below the 10% level) coefficients for the *one-mile* OLS model. For those controlling variables that are found to be statistically significant, the table further contains mean values, standard deviations, and minimum and maximum levels.

Many of the county-interacted controlling variables (e.g., *lsfla1000, lt1acre, age, agesqr, baths,* and *swinter*) are consistently (in more than two thirds of the counties) statistically significant (with a p-value < 0.10) and have appropriately sized mean values. The seemingly spurious minimum and maximum values among some of the county-level controlling variables (e.g., *lt1acre* minimum of -0.069) likely arise when these variables in particular counties are highly correlated with other variables, such as square feet (*lsfla1000*), and also when sample size is limited.[31] The other variables (*acres* and the three block group level census variables: *pctvacant, pctowner,* and *med_age*) are statistically significant in 33-59% of the counties. Only one variable's mean value—the percent of housing units vacant in the block group as of the 2000 census (*pctvacant*)—was counterintuitive. In that instance, a positive coefficient was estimated, when in fact, one would expect that increasing the percent of vacant housing would lower prices;

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[29] The OLS models are estimated using the areg procedure in Stata with robust (White's corrected) standard errors (White, 1980). The spatial error models are estimated using the *gstslshet* routine in the sphet package in R, which also allows for robust standard errors to be estimated. See: http://cran.r-project.org/web/packages/sphet/sphet.pdf

[30] The controlling variables' coefficients were similar across the base models, so only the *one-mile* results are summarized here.

[31] The possible adverse effects of these collinearities were fully explored both via the removal of the variables and by examining VIF statistics. The VOI results are robust to controlling variable removal and have relatively low (< 5) VIF statistics.

this counter-intuitive effect may be due to collinearity with one or more of the other variables, or possible measurement errors.[32]

The sale year variables, which are interacted with the state, are also summarized in Table 8, with the percentages indicating the number of states in which the coefficients are statistically significant. The inclusion of these sale year variables in the regressions control for inflation and deflation across the various states over the study period. The coefficients represent a comparison to the omitted year, which is 2011. All sale year state-level coefficients are statistically significant in at least 50% of the states in all years except 2010, and they are significant in two thirds of the states in all except 3 years. The mean values of all years are appropriately signed, showing a monotonically ordered peak in values in 2007, with lower values in the prior and following years. The minimum and maximum values are similarly signed (negative) through 2003 and from 2007 through 2010 (positive), and are both positive and negative in years 2003 through 2006, indicating the differences in inflation/deflation in those years across the various states. This reinforces the appropriateness of interacting the sale years at the state level. Finally, although not shown, the model also contains 250 fixed effects for the census tract delineations, of which approximately 50% were statistically significant.

[32] The removal of this, as well as the other block group census variables, however, did not substantively influence the results of the VOI.

Table 8: Levels and Significance for County- and State-Interacted Controlling Variables[33]

Variable	% of Counties/States Having Significant (p-value <0.10) Coefficients	Statistics for Significant Variables: Mean	St Dev	Min	Max
lsfla1000	100%	0.604	0.153	0.332	0.979
acres	48%	0.025	0.035	-0.032	0.091
lt1acre	85%	0.280	0.170	-0.069	0.667
age	81%	-0.006	0.008	-0.021	0.010
agesqr	74%	-0.006	0.063	-0.113	0.108
*baths**	85%	0.156	0.088	0.083	0.366
pctvacant	48%	1.295	3.120	-2.485	9.018
pctowner	33%	0.605	0.811	-0.091	2.676
med_age	59%	-0.016	0.132	-0.508	0.066
swinter	78%	-0.034	0.012	-0.053	-0.020
sy1996	100%	-0.481	0.187	-0.820	-0.267
sy1997	100%	-0.448	0.213	-0.791	-0.242
sy1998	100%	-0.404	0.172	-0.723	-0.156
sy1999	100%	-0.359	0.169	-0.679	-0.156
sy2000	88%	-0.298	0.189	-0.565	-0.088
sy2001	88%	-0.286	0.141	-0.438	-0.080
sy2002	67%	-0.261	0.074	-0.330	-0.128
sy2003	67%	-0.218	0.069	-0.326	-0.119
sy2004	75%	-0.084	0.133	-0.208	0.087
sy2005	67%	0.082	0.148	-0.111	0.278
sy2006	67%	0.128	0.158	-0.066	0.340
sy2007	67%	0.196	0.057	0.143	0.297
sy2008	56%	0.160	0.051	0.084	0.218
sy2009	50%	0.138	0.065	0.071	0.219
sy2010	33%	0.172	0.063	0.105	0.231

** % of counties significant is reported only for counties that had the baths variable populated (17 out of 27 counties)*

5.1.2. Variables of Interest

The variables of interest, the interactions between the *fdp* and *tdis* bins, are shown in Table 9 for the four base models. The reference (i.e., omitted) case for these variables are homes that sold prior to the wind facilities' announcement (PA) and are located between 3 and 10 miles from the

[33] Controlling variable statistics are provided for only the *one-mile* OLS model but did not differ substantially for other models. All variables are interacted with counties, except for sale year (sy), which is interacted with the state.

wind turbines' eventual locations. In relation to that group of transactions, three of the eight interactions in the *one-mile* models and four of the 11 interactions in the *half-mile* models produce coefficients that are statistically significant (at the 10% level).

Across all four base models none of the PA coefficients show statistically significant differences between the reference category (outside of 3 miles) and the group of transactions within a mile for the *one-mile* models (OLS: -1.7%, *p*-value 0.48; SEM: -0.02%, *p*-value 0.94)[34] or within a half- or between one-half and one-mile for the *half-mile* models (OLS inside a half mile: 0.01%, *p*-value 0.97; between a half and 1 mile: -2.3%, *p*-value 0.38; SEM inside a half mile: 5.3%, *p*-value 0.24; between a half and 1 mile: -1.8%, *p*-value 0.60). Further, none of the coefficients are significant, and all are relatively small (which partially explains their non-significance). Given these results, we find an absence of evidence of a PA effect for homes close to the turbines (*research question 1*). These results can be contrasted with the differences in prices between within-1-mile homes and outside-of-3-miles homes as summarized in Section 4.8 when no differences in the homes, the local market, the neighborhood, etc. are accounted for. The approximately 75% difference in price (alone) in the pre-announcement period 1-mile homes, as compared to the PC 3-mile homes, discussed in Section 4.8, is largely explained by differences in the controlling characteristics, which is why the pre-announcement distance coefficients shown here are not statistically significant.

Turning to the PAPC and PC periods, the results also indicate statistically insignificant differences in average home values, all else being equal, between the reference group of transactions (sold in the PA period) and those similarly located more than 3 miles from the turbines but sold in the PAPC or PC periods. Those differences are estimated to be between -0.8% and -0.5%.

The results presented above, and in Table 8, include both OLS and spatial models. Prior to estimating the spatial models, the Moran's I was calculated using the residuals of an OLS model that uses the same explanatory variables as the spatial models and the same dataset (only the most recent transactions). The Moran's I statistic (0.133) was highly significant (*p*-value 0.00),

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[34] p-values are not shown in the table can but can be derived from the standard errors, which are shown.

which allows us to reject the hypothesis that the residuals are spatially independent. Therefore, there was justification in estimating the spatial models. However, after estimation, we determined that only the spatial error process was significant. As a result, we estimated spatial error models (SEMs) for the final specification. The spatial autoregressive coefficient, lambda (bottom of Table 9), which is an indication of spatial autocorrelation in the residuals, is sizable and statistically significant in both SEMs (0.26, *p*-value 0.00). The SEM models' variable-of-interest coefficients are quite similar to those of the OLS models. In most cases, the coefficients are the same sign, approximately the same level, and often similarly insignificant, indicating that although spatial dependence is present it does not substantively bias the variables of interest. The one material difference is the coefficient size and significance for homes outside of 3 miles in the PAPC and PC periods, 3.3% (*p*-value 0.000) and 3.1% (*p*-value 0.008), indicating there are important changes to home values over the periods that must be accounted for in the later DD models in order to isolate the potential impacts that occur due to the presence of wind turbines.

Table 9: Results of Interacted Variables of Interest: *fdp* and *tdis*

		one-mile	*one-mile*	*half-mile*	*half-mile*
		OLS	SEM	OLS	SEM
fdp	tdis	β (se)	β (se)	β (se)	β (se)
PA	< 1 mile	-0.017	0.002		
		(0.024)	*(0.031)*		
PA	1-2 miles	-0.015	0.008		
		(0.011)	*(0.016)*		
PA	> 3 miles	Omitted	Omitted		
		n/a	*n/a*		
PAPC	< 1 mile	-0.035	-0.038		
		(0.029)	*(0.033)*		
PAPC	1-2 miles	-0.001	-0.033.		
		(0.014)	*(0.018)*		
PAPC	> 3 miles	-0.006	-0.033***		
		(0.008)	*(0.01)*		
PC	< 1 mile	0.019	-0.022		
		(0.026)	*(0.032)*		
PC	1-2 miles	0.044***	-0.001		
		(0.014)	*(0.019)*		
PC	> 3 miles	-0.005	-0.031**		
		(0.010)	*(0.012)*		
PA	< 1/2 mile			0.001	0.053
				(0.039)	*(0.045)*
PA	1/2 - 1 mile			-0.023	-0.018
				(0.027)	*(0.035)*
PA	1-2 miles			-0.015	0.008
				(0.011)	*(0.016)*
PA	> 3 miles			Omitted	Omitted
				n/a	*n/a*
PAPC	< 1/2 mile			-0.028	-0.065
				(0.049)	*(0.056)*
PAPC	1/2 - 1 mile			-0.038	-0.027
				(0.033)	*(0.036)*
PAPC	1-2 miles			-0.001	-0.034.
				(0.014)	*(0.017)*
PAPC	> 3 miles			-0.006	-0.033***
				(0.008)	*(0.009)*
PC	< 1/2 mile			-0.016	-0.036
				(0.041)	*(0.046)*
PC	1/2 - 1 mile			0.032	-0.016
				(0.031)	*(0.035)*
PC	1-2 miles			0.044***	-0.001
				(0.014)	*(0.018)*
PC	> 3 miles			-0.005	-0.031**
				(0.010)	*(0.012)*
lambda			0.247 ***		0.247 ***
			(0.008)		*(0.008)*
*Note: p-values: < 0.1 *, < 0.05 **, <0.01 ***.*					
n		51,276	38,407	51,276	38,407
adj R-sqr		0.67	0.64	0.67	0.64

5.1.3. Impact of Wind Turbines

As discussed above, there are important differences in property values between development periods for the reference group of homes (those located outside of 3 miles) that must be accounted for. Further, although they are not significant, differences between the reference category and those transactions inside of 1 mile in the PA period still must be accounted for if accurate measurements of PAPC or PC wind turbine effects are to be estimated. The DD specification accounts for both of these critical effects.

Table 10 shows the results of the DD tests across the four models, based on the results for the variables of interest presented in Table 9.[35] For example, to determine the net difference for homes that sold inside of a half mile (drawing from the *half-mile* OLS model) in the PAPC period, we use the following formula: PAPC half-mile coefficient (-0.028) less the PAPC 3-mile coefficient (-0.006) less the PA half-mile coefficient (0.001), which equals -0.024 (without rounding), which equates to 2.3% difference,[36] and is not statistically significant.

None of the DD effects in either the OLS or SEM specifications are statistically significant in the PAPC or PC periods, indicating that we do not observe a statistically significant impact of wind turbines on property values. Some small differences are apparent in the calculated coefficients, with those for PAPC being generally more negative/less positive than their PC counterparts, perhaps suggestive of a small announcement effect that declines once a facility is constructed. Further, the inside-a-half-mile coefficients are more negative/less positive than their between-a-half-and-1-mile counterparts, perhaps suggestive of a small property value impact very close to turbines.[37] However, in all cases, the sizes of these differences are smaller than the margins of error in the model (i.e., 90% confidence interval) and thus are not statistically significant. Therefore, based on these results, we do not find evidence supporting either of our two core hypotheses (*research questions 2 and 3*). In other words, there is no statistical evidence that homes in either the PAPC or PC periods that sold near turbines (i.e., within a mile or even a half

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[35] All DD estimates for the OLS models were calculated using the post-estimation “lincom” test in Stata, which uses the stored results’ variance/covariance matrix to test if a linear combination of coefficients is different from 0. For the SEM models, a similar test was performed in R.

[36] All differences in coefficients are converted to percentages in the table as follows: exp(coef)-1.

[37] Although not discussed in the text, this trend continues with homes between 1 and 2 miles being less negative/more positive than homes closer to the turbines (e.g., those within 1 mile).

mile) did so for less than similar homes that sold between 3 and 10 away miles in the same period.

Further, using the standard errors from the DD models we can estimate the maximum size an average effect would have to be in our sample for the model to detect it (*research question 4*). For an average effect in the PC period to be found for homes within 1 mile of the existing turbines (therefore using the *one-mile* model results), an effect greater than 4.9%, either positive or negative, would have to be present to be detected by the model.[38] In other words, it is highly unlikely that the true average effect for homes that sold in our sample area within 1 mile of an existing turbine is larger than +/-4.9%. Similarly, it is highly unlikely that the true average effect for homes that sold in our sample area within a half mile of an existing turbine is larger than +/-9.0%.[39] Regardless of these maximum effects, however, as well as the very weak suggestion of a possible small announcement effect and a possible small effect on homes that are very close to turbines, the core results of these models show effect sizes that are not statistically significant from zero, and are considerably smaller than these maximums.[40]

[38] Using the 90% confidence interval (i.e., 10% level of significance) and assuming more than 300 cases, the critical t-value is 1.65. Therefore, using the standard error of 0.030, the 90% confidence intervals for the test will be +/-0.049.

[39] Using the critical t-value of 1.66 for the 100 PC cases within a half mile in our sample and the standard error of 0.054.

[40] It is of note that these maximum effects are slightly larger than those we expected to find, as discussed earlier. This likely indicates that there was more variation in this sample, causing relatively higher standard errors for the same number of cases, than in the sample used for the 2009 study (Hoen et al., 2009, 2011).

Table 10: "Net" Difference-in-Difference Impacts of Turbines

		< 1 Mile	< 1 Mile	< 1/2 Mile	< 1/2 Mile
		OLS	SEM	OLS	SEM
fdp	tdis	b/se	b/se	b/se	b/se
PAPC	< 1 mile	-1.2% NS	-0.7% NS		
		(0.033)	(0.037)		
PC	< 1 mile	4.2% NS	0.7% NS		
		(0.030)	(0.035)		
PAPC	< 1/2 mile			-2.3% NS	-8.1% NS
				(0.060)	(0.065)
PAPC	1/2 - 1 mile			-0.8% NS	2.5% NS
				(0.039)	(0.043)
PC	< 1/2 mile			-1.2% NS	-5.6% NS
				(0.054)	(0.057)
PC	1/2 - 1 mile			6.3% NS	3.4% NS
				(0.036)	(0.042)

*Note: p-values: > 10% NS, < 10% *, < 5% **, <1 % ****

5.2. Robustness Tests

Table 11 summarizes the results from the robustness tests. For simplicity, only the DD coefficients are shown and only for the *half-mile* OLS models.[41] The first two columns show the base OLS and SEM *half-mile* DD results (also presented earlier, in Table 9), and the remaining columns show the results from the robustness models as follows: exclusion of outliers and influential cases from the dataset (*outlier*); using sale year/county interactions instead of sale year/state (*sycounty*); using only the most recent sales instead of the most recent and prior sales (*recent*); using homes between 5 and 10 miles as the reference category, instead of homes between 3 and 10 miles (*outside5*); and using transactions occurring more than 2 years before announcement as the reference category instead of using transactions simply *before* announcement (*prior*).

[41] Results were also estimated for the *one-mile* OLS models for each of the robustness tests and are available upon request: the results do not substantively differ from what is presented here for the *half-mile* models. Because of the similarities in the results between the OLS and SEM "base" models, robustness tests on the SEM models were not prepared as we assumed that differences between the two models for the robustness tests would be minimal as well.

The robustness results have patterns similar to the base model results: none of the coefficients are statistically different from zero; all coefficients (albeit non-significant) are lower in the PAPC period than the PC period; and, all coefficients (albeit non-significant) are lower (i.e., less negative/more positive) within a half mile than outside a half mile.[42] In sum, regardless of dataset or specification, there is no change in the basic conclusions drawn from the base model results: there is no evidence that homes near operating or announced wind turbines are impacted in a statistically significant fashion. Therefore, if effects do exist, either the average impacts are relatively small (within the margin of error in the models) and/or sporadic (impacting only a small subset of homes). Moreover, these results seem to corroborate what might be predicted given the other, potentially analogous disamenity literature that was reviewed earlier, which might be read to suggest that any property value effect of wind turbines might coalesce at a maximum of 3%–4%, on average. Of course, we cannot offer that corroboration directly because, although the size of the coefficients in the models presented here are reasonably consistent with effects of that magnitude, none of our models offer results that are statistically different from zero.

[42] This trend also continues outside of 1 mile, with those coefficients being less negative/more positive than those within 1 mile.

Table 11: Robustness Half-Mile Model Results

				Robustness OLS Models				
		Base OLS	Base SEM	outlier	sycounty	recent	outside5	prior
fdp	tdis	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)
PAPC	< 1/2 mile	-2.3% NS	-8.1% NS	-4.7% NS	-4.2% NS	-5.6% NS	-1.7% NS	0.1% NS
		(0.060)	*(0.065)*	*(0.056)*	*(0.060)*	*(0.066)*	*(0.060)*	*(0.062)*
PAPC	1/2 - 1 mile	-0.8% NS	2.5% NS	-1.7% NS	-2.5% NS	2.3% NS	-0.2% NS	0.4% NS
		(0.039)	*(0.043)*	*(0.036)*	*(0.039)*	*(0.043)*	*(0.039)*	*(0.044)*
PC	< 1/2 mile	-1.2% NS	-5.6% NS	-0.5% NS	-1.8% NS	-4.3% NS	-0.3% NS	1.3% NS
		(0.054)	*(0.057)*	*(0.047)*	*(0.054)*	*(0.056)*	*(0.054)*	*(0.056)*
PC	1/2 - 1 mile	6.3% NS	3.4% NS	6.2% NS	3.8% NS	4.1% NS	7.1% NS	7.5% NS
		(0.036)	*(0.041)*	*(0.033)*	*(0.036)*	*(0.042)*	*(0.036)*	*(0.041)*
*Note: p-values: > 0.1 NS, < 0.1 *, <0.5 **, <0.01 ****								
	n	51,276	38,407	50,106	51,276	38,407	51,276	51,276
	adj R-sqr	0.67	0.64	0.66	0.67	0.66	0.67	0.67

6. Conclusion

Wind energy facilities are expected to continue to be developed in the United States. Some of this growth is expected to occur in more-populated regions, raising concerns about the effects of wind development on home values in surrounding communities.

Previous published and academic research on this topic has tended to indicate that wind facilities, after they have been constructed, produce little or no effect on home values. At the same time, some evidence has emerged indicating potential home-value effects occurring after a wind facility has been announced but before construction. These previous studies, however, have been limited by their relatively small sample sizes, particularly in relation to the important population of homes located very close to wind turbines, and have sometimes treated the variable for distance to wind turbines in a problematic fashion. Analogous studies of other disamenities—including high-voltage transmission lines, landfills, and noisy roads—suggest that if reductions in property values near turbines were to occur, they would likely be no more than 3%–4%, on average, but to discover such small effects near turbines, much larger amounts of data are needed than have been used in previous studies. Moreover, previous studies have not accounted adequately for potentially confounding home-value factors, such as those affecting home values before wind facilities were announced, nor have they adequately controlled for spatial dependence in the data, i.e., how the values and characteristics of homes located near one another influence the value of those homes (independent of the presence of wind turbines).

This study helps fill those gaps by collecting a very large data sample and analyzing it with methods that account for confounding factors and spatial dependence. We collected data from more than 50,000 home sales among 27 counties in nine states. These homes were within 10 miles of 67 different then-current or existing wind facilities, with 1,198 sales that were within 1 mile of a turbine (331 of which were within a half mile)—many more than were collected by previous research efforts. The data span the periods well before announcement of the wind facilities to well after their construction. We use OLS and spatial-process difference-in-difference hedonic models to estimate the home-value impacts of the wind facilities; these models control for value factors existing prior to the wind facilities' announcements, the spatial dependence of home values, and value changes over time. We also employ a series of robustness models, which provide greater confidence in our results by testing the effects of data outliers and influential cases, heterogeneous inflation/deflation across regions, older sales data for multi-sale homes, the distance from turbines for homes in our reference case, and the amount of time before wind-facility announcement for homes in our reference case.

Across all model specifications, we find no statistical evidence that home prices near wind turbines were affected in either the post-construction or post-announcement/pre-construction periods. Therefore, if effects do exist, either the average impacts are relatively small (within the margin of error in the models) and/or sporadic (impacting only a small subset of homes). Related, our sample size and analytical methods enabled us to bracket the size of effects that would be detected, if those effects were present at all. Based on our results, we find that it is *highly unlikely* that the actual average effect for homes that sold in our sample area within 1 mile of an existing turbine is larger than +/-4.9%. In other words, the average value of these homes could be as much as 4.9% higher than it would have been without the presence of wind turbines, as much as 4.9% lower, the same (i.e., zero effect), or anywhere in between. Similarly, it is highly unlikely that the average actual effect for homes that sold in our sample area within a half mile of an existing turbine is larger than +/-9.0%. In other words, the average value of these homes could be as much as 9% higher than it would have been without the presence of wind turbines, as much as 9% lower, the same (i.e., zero effect), or anywhere in between.

Regardless of these potential maximum effects, the core results of our analysis consistently show no sizable statistically significant impact of wind turbines on nearby property values. The maximum impact suggested by potentially analogous disamenities (high-voltage transmission lines, landfills, roads etc.) of 3%-4% is at the far end of what the models presented in this study would have been able to discern, potentially helping to explain why no statistically significant effect was found. If effects of this size are to be discovered in future research, even larger samples of data may be required. For those interested in estimating such effects on a more micro (or local) scale, such as appraisers, these possible data requirements may be especially daunting, though it is also true that the inclusion of additional market, neighborhood, and individual property characteristics in these more-local assessments may sometimes improve model fidelity.

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8. Appendix – Full Results

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
Intercept	11.332***	(0.058)	11.330***	(0.058)	11.292***	(0.090)	11.292***	(0.090)
fdp3tdis3_11	-0.017	(0.024)			0.002	(0.031)		
fdp3tdis3_12	-0.015	(0.011)			0.008	(0.016)		
fdp3tdis3_21	-0.035	(0.029)			-0.038	(0.033)		
fdp3tdis3_22	-0.001	(0.014)			-0.033*	(0.017)		
fdp3tdis3_23	-0.006	(0.008)			-0.033***	(0.009)		
fdp3tdis3_31	0.019	(0.026)			-0.022	(0.031)		
fdp3tdis3_32	0.044***	(0.014)			-0.001	(0.018)		
fdp3tdis3_33	-0.005	(0.010)			-0.031***	(0.012)		
fdp3tdis4_10			0.001	(0.039)			0.053	(0.045)
fdp3tdis4_11			-0.023	(0.027)			-0.018	(0.035)
fdp3tdis4_12			-0.015	(0.011)			0.008	(0.016)
fdp3tdis4_20			-0.028	(0.049)			-0.065	(0.056)
fdp3tdis4_21			-0.038	(0.033)			-0.027	(0.036)
fdp3tdis4_22			-0.001	(0.014)			-0.034*	(0.017)
fdp3tdis4_23			-0.006	(0.008)			-0.033***	(0.009)
fdp3tdis4_30			-0.016	(0.041)			-0.036	(0.046)
fdp3tdis4_31			0.032	(0.031)			-0.016	(0.035)
fdp3tdis4_32			0.044***	(0.014)			-0.001	(0.018)
fdp3tdis4_33			-0.005	(0.010)			-0.031***	(0.012)
lsfla1000_ia_car	0.750***	(0.042)	0.749***	(0.042)	0.723***	(0.045)	0.722***	(0.045)
lsfla1000_ia_flo	0.899***	(0.054)	0.900***	(0.054)	0.879***	(0.060)	0.88***	(0.060)
lsfla1000_ia_fra	0.980***	(0.077)	0.980***	(0.077)	0.932***	(0.083)	0.934***	(0.083)
lsfla1000_ia_sac	0.683***	(0.061)	0.683***	(0.061)	0.633***	(0.065)	0.633***	(0.064)
lsfla1000_il_dek	0.442***	(0.037)	0.441***	(0.037)	0.382***	(0.040)	0.38***	(0.040)
lsfla1000_il_liv	0.641***	(0.030)	0.641***	(0.030)	0.643***	(0.046)	0.643***	(0.046)
lsfla1000_il_mcl	0.512***	(0.019)	0.512***	(0.019)	0.428***	(0.029)	0.428***	(0.029)
lsfla1000_mn_cot	0.800***	(0.052)	0.800***	(0.052)	0.787***	(0.077)	0.787***	(0.077)
lsfla1000_mn_fre	0.594***	(0.028)	0.595***	(0.028)	0.539***	(0.031)	0.539***	(0.031)
lsfla1000_mn_jac	0.587***	(0.101)	0.587***	(0.101)	0.551***	(0.102)	0.55***	(0.102)
lsfla1000_mn_mar	0.643***	(0.025)	0.643***	(0.025)	0.603***	(0.029)	0.603***	(0.029)
lsfla1000_nj_atl	0.421***	(0.012)	0.421***	(0.012)	0.389***	(0.014)	0.389***	(0.014)
lsfla1000_ny_cli	0.635***	(0.044)	0.635***	(0.044)	0.606***	(0.045)	0.606***	(0.045)
lsfla1000_ny_fra	0.373***	(0.092)	0.375***	(0.092)	0.433***	(0.094)	0.436***	(0.094)
lsfla1000_ny_her	0.520***	(0.034)	0.520***	(0.034)	0.559***	(0.035)	0.559***	(0.035)
lsfla1000_ny_lew	0.556***	(0.054)	0.556***	(0.054)	0.518***	(0.057)	0.518***	(0.057)
lsfla1000_ny_mad	0.503***	(0.025)	0.503***	(0.025)	0.502***	(0.025)	0.502***	(0.025)
lsfla1000_ny_ste	0.564***	(0.032)	0.564***	(0.032)	0.534***	(0.034)	0.534***	(0.034)
lsfla1000_ny_wyo	0.589***	(0.034)	0.589***	(0.034)	0.566***	(0.034)	0.566***	(0.034)
lsfla1000_oh_pau	0.625***	(0.080)	0.624***	(0.080)	0.567***	(0.090)	0.565***	(0.090)
lsfla1000_oh_woo	0.529***	(0.030)	0.529***	(0.030)	0.487***	(0.035)	0.487***	(0.035)
lsfla1000_ok_cus	0.838***	(0.037)	0.838***	(0.037)	0.794***	(0.046)	0.793***	(0.046)
lsfla1000_ok_gra	0.750***	(0.063)	0.750***	(0.063)	0.706***	(0.072)	0.706***	(0.072)
lsfla1000_pa_fay	0.332***	(0.111)	0.332***	(0.111)	0.335***	(0.118)	0.334***	(0.118)
lsfla1000_pa_som	0.564***	(0.025)	0.564***	(0.025)	0.548***	(0.031)	0.548***	(0.031)
lsfla1000_pa_way	0.486***	(0.056)	0.486***	(0.056)	0.44***	(0.063)	0.44***	(0.063)
lsfla1000_wa_kit	0.540***	(0.073)	0.540***	(0.073)	0.494***	(0.078)	0.494***	(0.078)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
acres_ia_car	0.033	(0.030)	0.033	(0.030)	0.013	(0.032)	0.013	(0.032)
acres_ia_flo	0.050***	(0.014)	0.050***	(0.014)	0.044***	(0.014)	0.044***	(0.014)
acres_ia_fra	-0.008	(0.022)	-0.008	(0.022)	-0.009	(0.022)	-0.009	(0.022)
acres_ia_sac	0.064***	(0.014)	0.064***	(0.014)	0.054***	(0.015)	0.054***	(0.015)
acres_il_dek	0.068**	(0.027)	0.064**	(0.027)	0.055*	(0.029)	0.048*	(0.029)
acres_il_liv	0.023	(0.014)	0.023	(0.014)	0.014	(0.018)	0.014	(0.018)
acres_il_mcl	0.091***	(0.010)	0.091***	(0.010)	0.092***	(0.011)	0.092***	(0.011)
acres_mn_cot	-0.030***	(0.011)	-0.030***	(0.011)	-0.024*	(0.013)	-0.024*	(0.013)
acres_mn_fre	-0.002	(0.007)	-0.002	(0.007)	0.002	(0.008)	0.002	(0.008)
acres_mn_jac	0.019	(0.016)	0.020	(0.016)	0.03*	(0.016)	0.03*	(0.016)
acres_mn_mar	0.020**	(0.008)	0.020**	(0.008)	0.017*	(0.009)	0.017*	(0.009)
acres_nj_atl	-0.041	(0.031)	-0.041	(0.031)	-0.013	(0.026)	-0.013	(0.026)
acres_ny_cli	0.019***	(0.007)	0.019***	(0.007)	0.022***	(0.007)	0.022***	(0.007)
acres_ny_fra	0.009	(0.010)	0.009	(0.010)	0.014	(0.011)	0.014	(0.011)
acres_ny_her	-0.004	(0.008)	-0.004	(0.008)	0.012	(0.008)	0.012	(0.008)
acres_ny_lew	0.014*	(0.008)	0.014*	(0.008)	0.014	(0.009)	0.014	(0.009)
acres_ny_mad	0.021***	(0.003)	0.021***	(0.003)	0.021***	(0.004)	0.021***	(0.004)
acres_ny_ste	0.009*	(0.005)	0.009*	(0.005)	0.007	(0.005)	0.007	(0.005)
acres_ny_wyo	0.016***	(0.004)	0.016***	(0.004)	0.019***	(0.004)	0.019***	(0.004)
acres_oh_pau	-0.010	(0.020)	-0.010	(0.020)	0.01	(0.024)	0.009	(0.024)
acres_oh_woo	-0.007	(0.010)	-0.007	(0.010)	0.002	(0.010)	0.002	(0.010)
acres_ok_cus	-0.037*	(0.019)	-0.037*	(0.019)	-0.034	(0.022)	-0.034	(0.022)
acres_ok_gra	0.014	(0.010)	0.014	(0.010)	0.019*	(0.011)	0.019*	(0.011)
acres_pa_fay	-0.006	(0.023)	-0.006	(0.023)	0.01	(0.023)	0.01	(0.023)
acres_pa_som	0.003	(0.009)	0.004	(0.009)	0.009	(0.010)	0.009	(0.010)
acres_pa_way	0.017**	(0.007)	0.017**	(0.007)	0.024***	(0.007)	0.024***	(0.007)
acres_wa_kit	0.009	(0.010)	0.009	(0.010)	0.014	(0.011)	0.014	(0.011)
acreslt1_ia_car	0.446***	(0.136)	0.448***	(0.136)	0.559***	(0.144)	0.56***	(0.143)
acreslt1_ia_flo	0.436***	(0.112)	0.435***	(0.112)	0.384***	(0.118)	0.383***	(0.118)
acreslt1_ia_fra	0.670***	(0.124)	0.668***	(0.124)	0.684***	(0.139)	0.68***	(0.139)
acreslt1_ia_sac	0.159	(0.115)	0.160	(0.115)	0.222*	(0.123)	0.221*	(0.123)
acreslt1_il_dek	0.278***	(0.066)	0.285***	(0.066)	0.282***	(0.073)	0.294***	(0.073)
acreslt1_il_liv	0.278***	(0.063)	0.276***	(0.063)	0.383***	(0.088)	0.38***	(0.088)
acreslt1_il_mcl	-0.069***	(0.021)	-0.070***	(0.021)	-0.007	(0.032)	-0.007	(0.032)
acreslt1_mn_cot	0.529***	(0.093)	0.529***	(0.093)	0.466***	(0.120)	0.465***	(0.120)
acreslt1_mn_fre	0.314***	(0.053)	0.314***	(0.053)	0.294***	(0.061)	0.293***	(0.061)
acreslt1_mn_jac	0.250*	(0.144)	0.247*	(0.145)	0.169	(0.146)	0.162	(0.146)
acreslt1_mn_mar	0.452***	(0.062)	0.452***	(0.062)	0.461***	(0.069)	0.462***	(0.069)
acreslt1_nj_atl	0.135***	(0.048)	0.135***	(0.048)	0.044	(0.047)	0.043	(0.047)
acreslt1_ny_cli	0.115***	(0.044)	0.115***	(0.044)	0.108**	(0.047)	0.108**	(0.047)
acreslt1_ny_fra	0.118	(0.100)	0.118	(0.100)	0.113	(0.115)	0.113	(0.115)
acreslt1_ny_her	0.364***	(0.047)	0.364***	(0.047)	0.331***	(0.050)	0.332***	(0.050)
acreslt1_ny_lew	0.119*	(0.061)	0.120**	(0.061)	0.117*	(0.067)	0.117*	(0.067)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
acreslt1_ny_mad	0.017	(0.031)	0.018	(0.031)	0.043	(0.032)	0.043	(0.032)
acreslt1_ny_ste	0.100**	(0.042)	0.100**	(0.042)	0.18***	(0.047)	0.18***	(0.047)
acreslt1_ny_wyo	0.144***	(0.035)	0.144***	(0.035)	0.137***	(0.039)	0.137***	(0.039)
acreslt1_oh_pau	0.426***	(0.087)	0.425***	(0.087)	0.507***	(0.120)	0.507***	(0.120)
acreslt1_oh_woo	0.124***	(0.034)	0.124***	(0.034)	0.114***	(0.041)	0.114***	(0.041)
acreslt1_ok_cus	0.103	(0.070)	0.104	(0.070)	0.091	(0.092)	0.093	(0.092)
acreslt1_ok_gra	-0.038	(0.054)	-0.038	(0.054)	-0.065	(0.066)	-0.065	(0.066)
acreslt1_pa_fay	0.403***	(0.153)	0.403***	(0.153)	0.42**	(0.165)	0.42**	(0.164)
acreslt1_pa_som	0.243***	(0.039)	0.243***	(0.039)	0.223***	(0.047)	0.223***	(0.047)
acreslt1_pa_way	0.138**	(0.062)	0.138**	(0.062)	0.108	(0.077)	0.109	(0.077)
acreslt1_wa_kit	0.335**	(0.134)	0.335**	(0.134)	0.342**	(0.164)	0.342**	(0.164)
age_ia_car	-0.013***	(0.001)	-0.013***	(0.001)	-0.011***	(0.001)	-0.011***	(0.001)
age_ia_flo	-0.013***	(0.002)	-0.013***	(0.002)	-0.013***	(0.002)	-0.013***	(0.002)
age_ia_fra	-0.012***	(0.003)	-0.012***	(0.003)	-0.011***	(0.003)	-0.011***	(0.003)
age_ia_sac	-0.013***	(0.003)	-0.013***	(0.003)	-0.011***	(0.003)	-0.011***	(0.003)
age_il_dek	-0.004***	(0.001)	-0.004***	(0.001)	-0.004***	(0.001)	-0.004***	(0.001)
age_il_liv	-0.001	(0.001)	-0.002	(0.001)	-0.003	(0.002)	-0.003	(0.002)
age_il_mcl	-0.004***	(0.001)	-0.004***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_mn_cot	-0.021***	(0.003)	-0.021***	(0.003)	-0.013***	(0.005)	-0.013***	(0.005)
age_mn_fre	-0.013***	(0.001)	-0.013***	(0.001)	-0.012***	(0.002)	-0.012***	(0.002)
age_mn_jac	-0.018***	(0.005)	-0.018***	(0.005)	-0.018***	(0.005)	-0.018***	(0.005)
age_mn_mar	-0.010***	(0.001)	-0.010***	(0.001)	-0.009***	(0.002)	-0.009***	(0.002)
age_nj_atl	-0.004***	(0.000)	-0.004***	(0.000)	-0.003***	(0.001)	-0.003***	(0.001)
age_ny_cli	-0.005***	(0.001)	-0.005***	(0.001)	-0.005***	(0.001)	-0.005***	(0.001)
age_ny_fra	-0.004	(0.003)	-0.005	(0.003)	-0.005*	(0.003)	-0.005*	(0.003)
age_ny_her	-0.008***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)
age_ny_lew	-0.008***	(0.001)	-0.008***	(0.001)	-0.009***	(0.001)	-0.009***	(0.001)
age_ny_mad	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_ny_ste	-0.006***	(0.001)	-0.006***	(0.001)	-0.007***	(0.001)	-0.007***	(0.001)
age_ny_wyo	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_oh_pau	0.003	(0.003)	0.003	(0.003)	0.003	(0.004)	0.003	(0.004)
age_oh_woo	0.008***	(0.001)	0.008***	(0.001)	0.01***	(0.001)	0.01***	(0.001)
age_ok_cus	-0.000	(0.002)	-0.000	(0.002)	0.002	(0.003)	0.002	(0.003)
age_ok_gra	-0.000	(0.002)	-0.000	(0.002)	0.001	(0.002)	0.001	(0.002)
age_pa_fay	0.010**	(0.004)	0.010**	(0.004)	0.01**	(0.005)	0.01**	(0.005)
age_pa_som	-0.006***	(0.001)	-0.006***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)
age_pa_way	0.006***	(0.002)	0.006***	(0.002)	0.007***	(0.002)	0.007***	(0.002)
age_wa_kit	0.010***	(0.003)	0.010***	(0.003)	0.014***	(0.003)	0.014***	(0.003)
agesq_ia_car	0.034***	(0.011)	0.034***	(0.000)	0.022*	(0.012)	0.022*	(0.012)
agesq_ia_flo	0.040***	(0.016)	0.040**	(0.016)	0.044***	(0.016)	0.044***	(0.016)
agesq_ia_fra	0.025	(0.022)	0.025	(0.022)	0.02	(0.023)	0.021	(0.023)
agesq_ia_sac	0.032	(0.022)	0.032	(0.022)	0.025	(0.023)	0.025	(0.023)
agesq_il_dek	0.008	(0.010)	0.008	(0.010)	0.013	(0.012)	0.013	(0.011)
agesq_il_liv	-0.023**	(0.009)	-0.023**	(0.009)	-0.011	(0.014)	-0.011	(0.014)
agesq_il_mcl	0.005	(0.007)	0.005	(0.007)	0.021*	(0.011)	0.021*	(0.011)
agesq_mn_cot	0.109**	(0.043)	0.109**	(0.043)	0.032	(0.069)	0.033	(0.069)
agesq_mn_fre	0.046***	(0.010)	0.045***	(0.010)	0.044***	(0.012)	0.044***	(0.012)
agesq_mn_jac	0.103***	(0.035)	0.104***	(0.035)	0.1***	(0.034)	0.101***	(0.034)
agesq_mn_mar	0.012	(0.012)	0.012	(0.012)	0.006	(0.014)	0.006	(0.014)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
agesq_nj_atl	0.010***	(0.003)	0.010***	(0.003)	0.003	(0.005)	0.003	(0.005)
agesq_ny_cli	0.011*	(0.006)	0.011*	(0.006)	0.011*	(0.006)	0.011*	(0.006)
agesq_ny_fra	-0.011	(0.022)	-0.011	(0.022)	-0.002	(0.020)	-0.002	(0.020)
agesq_ny_her	0.022***	(0.005)	0.022***	(0.005)	0.022***	(0.006)	0.022***	(0.006)
agesq_ny_lew	0.031***	(0.006)	0.031***	(0.006)	0.032***	(0.007)	0.032***	(0.007)
agesq_ny_mad	0.017***	(0.003)	0.017***	(0.003)	0.023***	(0.003)	0.023***	(0.003)
agesq_ny_ste	0.013**	(0.005)	0.013**	(0.005)	0.018***	(0.005)	0.018***	(0.005)
agesq_ny_wyo	0.016***	(0.005)	0.016***	(0.005)	0.017***	(0.005)	0.017***	(0.005)
agesq_oh_pau	-0.044**	(0.022)	-0.045**	(0.022)	-0.043	(0.028)	-0.043	(0.028)
agesq_oh_woo	-0.074***	(0.007)	-0.074***	(0.007)	-0.091***	(0.009)	-0.091***	(0.009)
agesq_ok_cus	-0.091***	(0.019)	-0.091***	(0.019)	-0.113***	(0.026)	-0.113***	(0.026)
agesq_ok_gra	-0.081***	(0.023)	-0.081***	(0.023)	-0.097***	(0.029)	-0.097***	(0.029)
agesq_pa_fay	-0.112***	(0.032)	-0.112***	(0.032)	-0.105***	(0.034)	-0.106***	(0.034)
agesq_pa_som	0.000	(0.008)	0.002	(0.008)	0.016*	(0.009)	0.016*	(0.009)
agesq_pa_way	-0.000***	(0.012)	-0.052***	(0.012)	-0.053***	(0.014)	-0.053***	(0.014)
agesq_wa_kit	-0.000***	(0.027)	-0.097***	(0.027)	-0.132***	(0.031)	-0.132***	(0.031)
bathsim_ia_sac	-0.050	(0.073)	-0.050	(0.073)	-0.082	(0.077)	-0.081	(0.077)
bathsim_il_dek	-0.005	(0.015)	-0.005	(0.015)	0.001	(0.018)	0.001	(0.018)
bathsim_ny_cli	0.090***	(0.025)	0.090***	(0.025)	0.087***	(0.024)	0.087***	(0.024)
bathsim_ny_fra	0.246***	(0.062)	0.245***	(0.062)	0.213***	(0.064)	0.212***	(0.064)
bathsim_ny_her	0.099***	(0.022)	0.099***	(0.022)	0.079***	(0.022)	0.079***	(0.022)
bathsim_ny_lew	0.168***	(0.030)	0.167***	(0.030)	0.142***	(0.031)	0.142***	(0.031)
bathsim_ny_mad	0.180***	(0.014)	0.180***	(0.014)	0.157***	(0.013)	0.157***	(0.013)
bathsim_ny_ste	0.189***	(0.019)	0.189***	(0.019)	0.166***	(0.020)	0.166***	(0.020)
bathsim_ny_wyo	0.107***	(0.021)	0.107***	(0.021)	0.1***	(0.021)	0.1***	(0.021)
bathsim_oh_pau	0.095*	(0.051)	0.095*	(0.051)	0.149***	(0.057)	0.149***	(0.057)
bathsim_oh_woo	0.094***	(0.017)	0.094***	(0.017)	0.092***	(0.019)	0.092***	(0.019)
bathsim_pa_fay	0.367***	(0.077)	0.367***	(0.077)	0.301***	(0.082)	0.302***	(0.082)
bathsim_pa_way	0.082**	(0.036)	0.082**	(0.036)	0.081**	(0.041)	0.081**	(0.041)
pctvacant_ia_car	-2.515*	(1.467)	-2.521*	(1.468)	-2.011	(1.936)	-2.019	(1.937)
pctvacant_ia_flo	0.903	(1.152)	0.921	(1.152)	1.358	(1.409)	1.339	(1.410)
pctvacant_ia_fra	8.887**	(3.521)	8.928**	(3.518)	-2.596	(1.703)	-2.6	(1.703)
pctvacant_ia_sac	0.672	(0.527)	0.673	(0.527)	1.267***	(0.377)	1.266***	(0.377)
pctvacant_il_dek	0.052	(0.639)	0.062	(0.638)	0.037	(0.964)	0.069	(0.961)
pctvacant_il_liv	-0.475	(0.474)	-0.476	(0.474)	-0.699	(0.872)	-0.701	(0.872)
pctvacant_il_mcl	-0.365	(0.397)	-0.366	(0.397)	0.445	(0.670)	0.442	(0.670)
pctvacant_mn_cot	1.072*	(0.592)	1.072*	(0.592)	0.272	(1.039)	0.273	(1.039)
pctvacant_mn_fre	-1.782**	(0.703)	-1.787**	(0.703)	-1.372	(0.965)	-1.384	(0.965)
pctvacant_mn_jac	-1.345	(0.883)	-1.318	(0.884)	-1.285	(1.084)	-1.313	(1.084)
pctvacant_mn_mar	2.178***	(0.502)	2.175***	(0.502)	1.53**	(0.622)	1.528**	(0.622)
pctvacant_nj_atl	-0.054	(0.062)	-0.054	(0.062)	0.096	(0.085)	0.095	(0.085)
pctvacant_ny_cli	0.709***	(0.224)	0.709***	(0.224)	0.842***	(0.251)	0.841***	(0.251)
pctvacant_ny_fra	6.173***	(2.110)	6.104***	(2.113)	0.519	(0.710)	0.499	(0.709)
pctvacant_ny_her	-1.226***	(0.247)	-1.226***	(0.247)	-1.347***	(0.288)	-1.347***	(0.288)
pctvacant_ny_lew	-0.125	(0.127)	-0.125	(0.127)	-0.266*	(0.159)	-0.266*	(0.159)
pctvacant_ny_mad	0.750***	(0.196)	0.752***	(0.196)	0.767***	(0.246)	0.765***	(0.246)
pctvacant_ny_ste	0.280	(0.190)	0.281	(0.190)	0.039	(0.242)	0.04	(0.242)
pctvacant_ny_wyo	0.179*	(0.101)	0.178*	(0.101)	0.225*	(0.119)	0.224*	(0.119)
pctvacant_oh_pau	-1.473	(1.498)	-1.473	(1.499)	-1.341	(1.951)	-1.256	(1.952)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
pctvacant_oh_woo	-0.565	(0.400)	-0.565	(0.400)	-0.304	(0.563)	-0.306	(0.563)
pctvacant_ok_cus	-0.127	(0.358)	-0.140	(0.359)	-0.167	(0.521)	-0.189	(0.521)
pctvacant_ok_gra	1.413*	(0.777)	1.414*	(0.777)	0.537	(1.045)	0.536	(1.045)
pctvacant_pa_fay	0.227	(0.596)	0.229	(0.596)	0.232	(0.807)	0.235	(0.807)
pctvacant_pa_som	0.517***	(0.098)	0.516***	(0.098)	0.562***	(0.138)	0.562***	(0.138)
pctvacant_pa_way	0.445***	(0.156)	0.444***	(0.156)	0.446**	(0.175)	0.446**	(0.175)
pctvacant_wa_kit	-0.076	(0.546)	-0.075	(0.546)	-0.377	(0.282)	-0.377	(0.281)
pctowner_ia_car	-0.225	(0.244)	-0.225	(0.244)	-0.156	(0.324)	-0.156	(0.324)
pctowner_ia_flo	0.579**	(0.238)	0.578**	(0.238)	0.75***	(0.290)	0.75***	(0.290)
pctowner_ia_fra	0.207	(0.310)	0.206	(0.310)	0.172	(0.393)	0.169	(0.393)
pctowner_ia_sac	0.274	(0.585)	0.261	(0.586)	-0.34	(0.545)	-0.345	(0.545)
pctowner_il_dek	0.075	(0.088)	0.073	(0.087)	0.032	(0.123)	0.028	(0.123)
pctowner_il_liv	0.176	(0.140)	0.176	(0.140)	0.265	(0.200)	0.264	(0.200)
pctowner_il_mcl	0.389***	(0.051)	0.388***	(0.051)	0.331***	(0.101)	0.331***	(0.101)
pctowner_mn_cot	0.375***	(0.138)	0.375***	(0.138)	0.609**	(0.254)	0.609**	(0.254)
pctowner_mn_fre	-0.119	(0.090)	-0.120	(0.090)	-0.072	(0.124)	-0.073	(0.124)
pctowner_mn_jac	-0.206	(0.474)	-0.205	(0.474)	-0.175	(0.569)	-0.185	(0.570)
pctowner_mn_mar	0.262***	(0.076)	0.262***	(0.076)	0.151	(0.103)	0.151	(0.103)
pctowner_nj_atl	-0.087**	(0.037)	-0.087**	(0.037)	-0.036	(0.052)	-0.037	(0.052)
pctowner_ny_cli	-0.229	(0.171)	-0.229	(0.171)	-0.305	(0.199)	-0.303	(0.199)
pctowner_ny_fra	2.743*	(1.500)	2.693*	(1.505)	-0.315	(1.447)	-0.398	(1.442)
pctowner_ny_her	0.246***	(0.095)	0.246***	(0.095)	0.213*	(0.109)	0.213*	(0.109)
pctowner_ny_lew	-0.034	(0.185)	-0.034	(0.185)	-0.126	(0.219)	-0.126	(0.219)
pctowner_ny_mad	0.750***	(0.075)	0.750***	(0.075)	0.723***	(0.084)	0.723***	(0.084)
pctowner_ny_ste	0.192	(0.128)	0.191	(0.128)	-0.083	(0.162)	-0.084	(0.162)
pctowner_ny_wyo	-0.089	(0.111)	-0.089	(0.111)	-0.109	(0.138)	-0.108	(0.138)
pctowner_oh_pau	-0.187	(0.347)	-0.185	(0.348)	-1.245***	(0.473)	-1.249***	(0.474)
pctowner_oh_woo	0.263***	(0.092)	0.264***	(0.092)	0.274**	(0.136)	0.274**	(0.136)
pctowner_ok_cus	0.068	(0.104)	0.068	(0.104)	-0.041	(0.146)	-0.043	(0.146)
pctowner_ok_gra	0.271*	(0.159)	0.271*	(0.159)	0.253	(0.217)	0.253	(0.217)
pctowner_pa_fay	-0.413	(1.736)	-0.420	(1.736)	-0.15	(2.037)	-0.165	(2.037)
pctowner_pa_som	0.171	(0.114)	0.170	(0.114)	0.098	(0.173)	0.098	(0.173)
pctowner_pa_way	-0.351	(0.441)	-0.348	(0.441)	-0.251	(0.345)	-0.252	(0.345)
pctowner_wa_kit	0.257	(2.139)	0.259	(2.139)	-0.358	(1.889)	-0.361	(1.890)
med_age_ia_car	0.002	(0.002)	0.002	(0.002)	0.003	(0.003)	0.003	(0.003)
med_age_ia_flo	0.003	(0.002)	0.003	(0.002)	0.004	(0.003)	0.004	(0.003)
med_age_ia_fra	0.066***	(0.015)	0.066***	(0.015)	0.014**	(0.006)	0.014**	(0.006)
med_age_ia_sac	0.028**	(0.014)	0.028**	(0.014)	0.012	(0.010)	0.012	(0.010)
med_age_il_dek	-0.001	(0.002)	-0.001	(0.002)	-0.001	(0.003)	-0.001	(0.003)
med_age_il_liv	-0.004	(0.004)	-0.004	(0.004)	-0.005	(0.005)	-0.005	(0.005)
med_age_il_mcl	-0.006***	(0.002)	-0.006***	(0.002)	-0.006**	(0.003)	-0.006**	(0.003)
med_age_mn_cot	0.017***	(0.005)	0.017***	(0.005)	0.018**	(0.008)	0.018**	(0.008)
med_age_mn_fre	0.012***	(0.002)	0.012***	(0.002)	0.013***	(0.002)	0.013***	(0.002)
med_age_mn_jac	0.013	(0.008)	0.013	(0.008)	0.012	(0.010)	0.012	(0.010)
med_age_mn_mar	0.013***	(0.003)	0.013***	(0.003)	0.012***	(0.003)	0.012***	(0.003)
med_age_nj_atl	0.010***	(0.001)	0.010***	(0.001)	0.016***	(0.002)	0.016***	(0.002)
med_age_ny_cli	0.020***	(0.004)	0.020***	(0.004)	0.02***	(0.004)	0.02***	(0.004)
med_age_ny_fra	-0.517***	(0.198)	-0.511***	(0.198)	0.008	(0.040)	0.01	(0.039)
med_age_ny_her	0.007*	(0.003)	0.007*	(0.003)	0.005	(0.003)	0.005	(0.003)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
med_age_ny_lew	0.013***	(0.005)	0.013***	(0.005)	0.008	(0.005)	0.008	(0.005)
med_age_ny_mad	0.004**	(0.002)	0.004**	(0.002)	0.004*	(0.002)	0.004*	(0.002)
med_age_ny_ste	0.012***	(0.003)	0.012***	(0.003)	0.001	(0.004)	0.001	(0.004)
med_age_ny_wyo	0.008	(0.005)	0.007	(0.005)	0.008	(0.006)	0.008	(0.006)
med_age_oh_pau	0.034***	(0.013)	0.034***	(0.013)	0.019	(0.012)	0.019	(0.012)
med_age_oh_woo	-0.004	(0.003)	-0.004	(0.003)	-0.004	(0.004)	-0.004	(0.004)
med_age_ok_cus	0.004	(0.002)	0.004	(0.002)	0.008**	(0.004)	0.008**	(0.004)
med_age_ok_gra	0.011	(0.009)	0.011	(0.009)	0	(0.006)	0	(0.006)
med_age_pa_fay	0.049	(0.073)	0.049	(0.073)	0.052	(0.095)	0.052	(0.095)
med_age_pa_som	0.008***	(0.002)	0.008***	(0.002)	0.012***	(0.004)	0.012***	(0.004)
med_age_pa_way	-0.005	(0.012)	-0.005	(0.012)	0.002	(0.007)	0.002	(0.007)
med_age_wa_kit	-0.015	(0.095)	-0.015	(0.095)	0.025	(0.034)	0.025	(0.034)
swinter_ia	-0.034**	(0.015)	-0.034**	(0.015)	-0.039***	(0.015)	-0.039***	(0.015)
swinter_il	-0.020**	(0.008)	-0.020**	(0.008)	-0.013	(0.012)	-0.013	(0.012)
swinter_mn	-0.053***	(0.009)	-0.053***	(0.009)	-0.057***	(0.011)	-0.057***	(0.011)
swinter_nj	-0.007	(0.006)	-0.007	(0.006)	-0.008	(0.007)	-0.008	(0.007)
swinter_ny	-0.030***	(0.007)	-0.030***	(0.007)	-0.026***	(0.007)	-0.026***	(0.007)
swinter_oh	-0.048***	(0.012)	-0.048***	(0.012)	-0.055***	(0.014)	-0.055***	(0.014)
swinter_ok	-0.039**	(0.015)	-0.039**	(0.015)	-0.024	(0.018)	-0.024	(0.018)
swinter_pa	-0.025*	(0.015)	-0.025*	(0.015)	-0.02	(0.017)	-0.02	(0.017)
swinter_wa	-0.004	(0.046)	-0.004	(0.046)	0.014	(0.051)	0.013	(0.051)
sy_1996_ia	-0.436***	(0.137)	-0.433***	(0.137)	-0.493***	(0.157)	-0.489***	(0.157)
sy_1996_il	-0.267***	(0.037)	-0.267***	(0.037)	-0.344***	(0.061)	-0.344***	(0.061)
sy_1996_mn	-0.521***	(0.058)	-0.521***	(0.059)	-0.585***	(0.065)	-0.585***	(0.065)
sy_1996_nj	-0.820***	(0.022)	-0.820***	(0.022)	-0.717***	(0.038)	-0.717***	(0.038)
sy_1996_oh	-0.298***	(0.042)	-0.298***	(0.042)	-0.43***	(0.053)	-0.43***	(0.053)
sy_1996_ok	-0.444***	(0.073)	-0.444***	(0.073)	-0.846***	(0.079)	-0.846***	(0.079)
sy_1996_pa	-0.584***	(0.060)	-0.584***	(0.060)	-0.604***	(0.067)	-0.604***	(0.067)
sy_1997_il	-0.242***	(0.036)	-0.242***	(0.036)	-0.234***	(0.052)	-0.232***	(0.052)
sy_1997_mn	-0.445***	(0.055)	-0.445***	(0.055)	-0.535***	(0.060)	-0.535***	(0.060)
sy_1997_nj	-0.791***	(0.021)	-0.791***	(0.021)	-0.686***	(0.038)	-0.686***	(0.038)
sy_1997_oh	-0.302***	(0.043)	-0.302***	(0.043)	-0.39***	(0.053)	-0.39***	(0.053)
sy_1997_pa	-0.458***	(0.057)	-0.458***	(0.057)	-0.51***	(0.066)	-0.51***	(0.066)
sy_1998_ia	-0.442***	(0.078)	-0.441***	(0.078)	-0.633***	(0.099)	-0.634***	(0.099)
sy_1998_il	-0.156***	(0.031)	-0.156***	(0.031)	-0.175***	(0.048)	-0.175***	(0.048)
sy_1998_mn	-0.391***	(0.054)	-0.391***	(0.054)	-0.484***	(0.059)	-0.484***	(0.059)
sy_1998_nj	-0.723***	(0.020)	-0.723***	(0.021)	-0.633***	(0.037)	-0.633***	(0.037)
sy_1998_oh	-0.217***	(0.040)	-0.217***	(0.040)	-0.302***	(0.047)	-0.302***	(0.047)
sy_1998_ok	-0.394***	(0.048)	-0.395***	(0.048)	-0.816***	(0.059)	-0.818***	(0.059)
sy_1998_pa	-0.481***	(0.059)	-0.480***	(0.059)	-0.554***	(0.068)	-0.552***	(0.067)
sy_1998_wa	-0.433***	(0.115)	-0.433***	(0.115)	-0.356**	(0.161)	-0.356**	(0.161)
sy_1999_ia	-0.347***	(0.085)	-0.345***	(0.086)	-0.568***	(0.117)	-0.565***	(0.117)
sy_1999_il	-0.155***	(0.031)	-0.156***	(0.031)	-0.215***	(0.046)	-0.214***	(0.046)
sy_1999_mn	-0.302***	(0.055)	-0.303***	(0.055)	-0.367***	(0.059)	-0.368***	(0.059)
sy_1999_nj	-0.679***	(0.020)	-0.679***	(0.020)	-0.583***	(0.036)	-0.583***	(0.036)
sy_1999_oh	-0.161***	(0.040)	-0.161***	(0.040)	-0.243***	(0.047)	-0.243***	(0.047)
sy_1999_ok	-0.347***	(0.044)	-0.348***	(0.044)	-0.743***	(0.050)	-0.743***	(0.050)
sy_1999_pa	-0.452***	(0.058)	-0.452***	(0.058)	-0.515***	(0.066)	-0.515***	(0.066)
sy_1999_wa	-0.432***	(0.114)	-0.432***	(0.114)	-0.454***	(0.166)	-0.453***	(0.165)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
sy_2000_ia	-0.165	(0.145)	-0.164	(0.146)	-0.246	(0.183)	-0.246	(0.183)
sy_2000_il	-0.088***	(0.031)	-0.088***	(0.031)	-0.172***	(0.045)	-0.171***	(0.045)
sy_2000_mn	-0.148***	(0.051)	-0.149***	(0.051)	-0.224***	(0.053)	-0.224***	(0.053)
sy_2000_nj	-0.565***	(0.020)	-0.565***	(0.020)	-0.461***	(0.036)	-0.462***	(0.036)
sy_2000_oh	-0.098**	(0.041)	-0.098**	(0.041)	-0.161***	(0.047)	-0.16***	(0.047)
sy_2000_ok	-0.330***	(0.050)	-0.331***	(0.050)	-0.748***	(0.059)	-0.749***	(0.059)
sy_2000_pa	-0.394***	(0.057)	-0.395***	(0.057)	-0.478***	(0.067)	-0.478***	(0.067)
sy_2000_wa	-0.463***	(0.115)	-0.463***	(0.115)	-0.403**	(0.160)	-0.402**	(0.160)
sy_2001_ia	-0.334***	(0.065)	-0.332***	(0.065)	-0.435***	(0.066)	-0.433***	(0.066)
sy_2001_il	-0.080**	(0.031)	-0.080***	(0.031)	-0.101**	(0.048)	-0.101**	(0.048)
sy_2001_mn	-0.119**	(0.050)	-0.119**	(0.050)	-0.204***	(0.051)	-0.204***	(0.052)
sy_2001_nj	-0.438***	(0.018)	-0.438***	(0.018)	-0.333***	(0.034)	-0.333***	(0.034)
sy_2001_oh	-0.033	(0.036)	-0.033	(0.036)	-0.078**	(0.040)	-0.078**	(0.040)
sy_2001_ok	-0.250***	(0.041)	-0.251***	(0.041)	-0.648***	(0.044)	-0.648***	(0.044)
sy_2001_pa	-0.402***	(0.055)	-0.402***	(0.055)	-0.446***	(0.063)	-0.447***	(0.063)
sy_2001_wa	-0.378***	(0.122)	-0.378***	(0.122)	-0.275*	(0.163)	-0.275*	(0.163)
sy_2002_ia	-0.130**	(0.059)	-0.128**	(0.059)	-0.264***	(0.064)	-0.261***	(0.064)
sy_2002_il	0.008	(0.030)	0.007	(0.030)	-0.013	(0.043)	-0.013	(0.043)
sy_2002_mn	-0.072	(0.050)	-0.072	(0.050)	-0.138***	(0.051)	-0.139***	(0.051)
sy_2002_nj	-0.330***	(0.019)	-0.330***	(0.019)	-0.195***	(0.035)	-0.195***	(0.035)
sy_2002_ny	-0.307***	(0.020)	-0.307***	(0.020)	-0.342***	(0.020)	-0.342***	(0.020)
sy_2002_oh	-0.022	(0.038)	-0.022	(0.038)	-0.053	(0.042)	-0.053	(0.042)
sy_2002_ok	-0.249***	(0.045)	-0.249***	(0.045)	-0.649***	(0.052)	-0.649***	(0.052)
sy_2002_pa	-0.313***	(0.053)	-0.313***	(0.053)	-0.355***	(0.059)	-0.354***	(0.059)
sy_2002_wa	-0.241**	(0.123)	-0.241**	(0.123)	-0.216	(0.166)	-0.216	(0.166)
sy_2003_ia	-0.195**	(0.081)	-0.194**	(0.081)	-0.311***	(0.085)	-0.314***	(0.084)
sy_2003_il	0.034	(0.030)	0.034	(0.030)	0.021	(0.040)	0.021	(0.040)
sy_2003_mn	0.034	(0.049)	0.034	(0.049)	-0.026	(0.049)	-0.026	(0.049)
sy_2003_nj	-0.119***	(0.017)	-0.119***	(0.017)	0.023	(0.033)	0.023	(0.033)
sy_2003_ny	-0.247***	(0.020)	-0.247***	(0.020)	-0.276***	(0.020)	-0.276***	(0.020)
sy_2003_oh	0.005	(0.036)	0.005	(0.036)	-0.019	(0.039)	-0.019	(0.039)
sy_2003_ok	-0.229***	(0.046)	-0.229***	(0.046)	-0.632***	(0.053)	-0.632***	(0.053)
sy_2003_pa	-0.191***	(0.052)	-0.191***	(0.052)	-0.213***	(0.054)	-0.213***	(0.054)
sy_2003_wa	-0.326***	(0.114)	-0.326***	(0.114)	-0.335**	(0.159)	-0.337**	(0.159)
sy_2004_ia	-0.209***	(0.076)	-0.208***	(0.076)	-0.307***	(0.087)	-0.308***	(0.087)
sy_2004_il	0.087***	(0.029)	0.087***	(0.029)	0.105***	(0.034)	0.105***	(0.034)
sy_2004_mn	0.082*	(0.049)	0.081*	(0.049)	0.036	(0.049)	0.036	(0.049)
sy_2004_ny	-0.179***	(0.019)	-0.179***	(0.019)	-0.2***	(0.020)	-0.2***	(0.020)
sy_2004_oh	0.059	(0.037)	0.059	(0.037)	0.067*	(0.039)	0.067*	(0.039)
sy_2004_ok	-0.143***	(0.041)	-0.143***	(0.041)	-0.511***	(0.044)	-0.511***	(0.044)
sy_2004_pa	-0.146***	(0.052)	-0.146***	(0.052)	-0.145***	(0.053)	-0.145***	(0.053)
sy_2004_wa	-0.144	(0.113)	-0.144	(0.113)	-0.082	(0.152)	-0.081	(0.152)
sy_2005_ia	-0.074**	(0.037)	-0.075**	(0.037)	-0.151***	(0.040)	-0.151***	(0.040)
sy_2005_il	0.125***	(0.027)	0.125***	(0.027)	0.139***	(0.032)	0.138***	(0.032)
sy_2005_mn	0.163***	(0.048)	0.162***	(0.048)	0.12**	(0.048)	0.119**	(0.048)
sy_2005_nj	0.278***	(0.018)	0.278***	(0.018)	0.453***	(0.034)	0.453***	(0.034)
sy_2005_ny	-0.110***	(0.019)	-0.111***	(0.019)	-0.122***	(0.019)	-0.122***	(0.019)
sy_2005_oh	0.112***	(0.036)	0.112***	(0.036)	0.099***	(0.037)	0.098***	(0.037)
sy_2005_ok	-0.018	(0.038)	-0.018	(0.038)	-0.354***	(0.038)	-0.354***	(0.038)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
sy_2005_pa	-0.060	(0.051)	-0.060	(0.051)	-0.058	(0.053)	-0.058	(0.053)
sy_2005_wa	-0.070	(0.111)	-0.070	(0.111)	0.025	(0.153)	0.025	(0.153)
sy_2006_ia	-0.050*	(0.028)	-0.051*	(0.028)	-0.106***	(0.028)	-0.106***	(0.028)
sy_2006_il	0.192***	(0.026)	0.192***	(0.026)	0.215***	(0.030)	0.215***	(0.030)
sy_2006_mn	0.206***	(0.049)	0.206***	(0.049)	0.164***	(0.049)	0.164***	(0.049)
sy_2006_nj	0.340***	(0.017)	0.340***	(0.017)	0.514***	(0.032)	0.514***	(0.032)
sy_2006_ny	-0.066***	(0.019)	-0.066***	(0.019)	-0.073***	(0.019)	-0.073***	(0.019)
sy_2006_oh	0.147***	(0.034)	0.147***	(0.034)	0.144***	(0.035)	0.144***	(0.035)
sy_2006_ok	0.025	(0.039)	0.026	(0.039)	-0.3***	(0.037)	-0.3***	(0.037)
sy_2006_pa	0.008	(0.051)	0.008	(0.051)	-0.001	(0.052)	-0.001	(0.052)
sy_2006_wa	-0.066	(0.131)	-0.066	(0.131)	0.02	(0.160)	0.021	(0.160)
sy_2007_ia	0.013	(0.028)	0.012	(0.028)	-0.019	(0.028)	-0.019	(0.028)
sy_2007_il	0.218***	(0.025)	0.218***	(0.025)	0.251***	(0.028)	0.251***	(0.028)
sy_2007_mn	0.177***	(0.049)	0.177***	(0.049)	0.145***	(0.048)	0.144***	(0.048)
sy_2007_nj	0.297***	(0.017)	0.297***	(0.017)	0.459***	(0.031)	0.459***	(0.031)
sy_2007_ny	-0.020	(0.019)	-0.020	(0.019)	-0.022	(0.019)	-0.022	(0.019)
sy_2007_oh	0.144***	(0.035)	0.143***	(0.035)	0.138***	(0.036)	0.138***	(0.036)
sy_2007_ok	0.149***	(0.037)	0.150***	(0.037)	-0.154***	(0.034)	-0.154***	(0.034)
sy_2007_pa	0.030	(0.051)	0.030	(0.051)	0.067	(0.052)	0.067	(0.052)
sy_2007_wa	0.189*	(0.110)	0.189*	(0.110)	0.209	(0.147)	0.209	(0.147)
sy_2008_ia	0.011	(0.029)	0.010	(0.029)	-0.029	(0.029)	-0.029	(0.029)
sy_2008_il	0.219***	(0.026)	0.218***	(0.026)	0.217***	(0.029)	0.217***	(0.029)
sy_2008_mn	0.149***	(0.050)	0.149***	(0.050)	0.108**	(0.049)	0.108**	(0.049)
sy_2008_nj	0.195***	(0.018)	0.195***	(0.018)	0.35***	(0.032)	0.35***	(0.032)
sy_2008_ny	-0.000	(0.019)	-0.000	(0.019)	-0.008	(0.019)	-0.008	(0.019)
sy_2008_oh	0.084**	(0.036)	0.084**	(0.036)	0.061*	(0.037)	0.061*	(0.037)
sy_2008_ok	0.154***	(0.039)	0.153***	(0.039)	-0.145***	(0.035)	-0.145***	(0.035)
sy_2008_pa	0.044	(0.053)	0.044	(0.053)	0.055	(0.053)	0.056	(0.053)
sy_2008_wa	0.178	(0.117)	0.179	(0.117)	0.326**	(0.148)	0.325**	(0.148)
sy_2009_ia	-0.056	(0.036)	-0.057	(0.036)	-0.102***	(0.036)	-0.102***	(0.036)
sy_2009_il	0.158***	(0.026)	0.158***	(0.026)	0.176***	(0.028)	0.176***	(0.028)
sy_2009_mn	0.104**	(0.051)	0.104**	(0.051)	0.089*	(0.050)	0.089*	(0.050)
sy_2009_nj	0.071***	(0.019)	0.071***	(0.019)	0.238***	(0.032)	0.238***	(0.032)
sy_2009_ny	-0.005	(0.019)	-0.005	(0.019)	-0.013	(0.019)	-0.013	(0.019)
sy_2009_oh	0.036	(0.035)	0.036	(0.035)	0.028	(0.036)	0.028	(0.036)
sy_2009_ok	0.219***	(0.038)	0.219***	(0.038)	-0.102***	(0.034)	-0.101***	(0.034)
sy_2009_pa	0.009	(0.053)	0.010	(0.053)	0.0003	(0.054)	0.0004	(0.054)
sy_2010_ia	0.018	(0.029)	0.017	(0.029)	-0.004	(0.028)	-0.004	(0.028)
sy_2010_il	0.105***	(0.028)	0.105***	(0.028)	0.104***	(0.029)	0.104***	(0.029)
sy_2010_mn	0.181***	(0.050)	0.180***	(0.050)	0.137***	(0.049)	0.137***	(0.049)
sy_2010_nj	0.010	(0.019)	0.010	(0.019)	0.177***	(0.032)	0.178***	(0.032)
sy_2010_ny	0.003	(0.021)	0.003	(0.021)	-0.006	(0.020)	-0.006	(0.020)
sy_2010_oh	-0.017	(0.036)	-0.017	(0.036)	-0.024	(0.036)	-0.024	(0.036)
sy_2010_ok	0.231***	(0.038)	0.231***	(0.038)	-0.074**	(0.033)	-0.074**	(0.033)
sy_2010_pa	0.013	(0.057)	0.013	(0.057)	0.013	(0.057)	0.013	(0.057)
sy_2010_wa	0.207	(0.127)	0.207	(0.127)	0.305*	(0.165)	0.305*	(0.165)
note: *** p<0.01, ** p<0.05, * p<0.1								
N	51,276		51,276		38,407		38,407	
Adjusted R^2	0.66		0.66		0.64		0.64	

DNV·GL

DAKOTA RANGE WIND PROJECT

Decommissioning Cost Analysis

Apex Clean Energy Management, LLC

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Task and objective:
Wind power project decommissioning cost analysis

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List of abbreviations

Abbreviation	**Meaning**
BOP	Balance of Plant
COD	Commercial Operation Date
DNV GL	Garrad Hassan America, Inc.
GRP	Glass Reinforced Plastic
O&M	Operations and Maintenance
WTG	Wind Turbine Generator

EXECUTIVE SUMMARY

At the request of Apex Clean Energy Management, LLC ("Apex" or the "Sponsor"), Garrad Hassan America, Inc. ("DNV GL") performed a decommissioning analysis of the Dakota Range Wind Project (the "Project") located in Grant and Codington Counties, South Dakota. The study estimates the costs associated with the dismantling, removal, and salvage or disposal of the Project equipment; all costs in this study are given in U.S. dollars.

The Dakota Range Wind Project is intended to consist of 72 Vestas V136-4.2 MW wind turbine generators (WTG), with an aggregate rated output of 302.4 MW, and associated infrastructure, and will be located in Grant and Codington Counties, South Dakota. The turbines will be mounted on 82 m tubular steel towers. The Project is anticipated to commence commercial operations in 2019. Per the Sponsor's request, it is assumed that decommissioning of the Project will take place 30 years after the start of commercial operations [1].

DNV GL assumes that there are strong parallels between wind power project construction and decommissioning programs and consequently bases the estimates for decommissioning costs on its broad experience of wind power project construction programs and the associated costs of labor, plant, and materials. The complete decommissioning cost is calculated as the sum of the cost of disassembly, removal, and disposal of the turbines and balance of plant (BOP), as may be offset by gains from salvage or resale of materials and components. It is noted that crane costs are the most dominant cost item in disassembly while transportation of the large turbine components dominates the costs of removal.

Assessments of salvage opportunities are based on the bill of quantities identified in this report. The average material weights and ratios for turbine components are derived from previous DNV GL studies, Sponsor documentation [2], and/or turbine supplier technical specification sheets. Although DNV GL assumes certain commodity prices and disposal service rates based on present day estimates, it does not forecast such future values. The salvage value is calculated as the difference between the sum of parts resale and scrap revenue, less the landfill cost of the remaining material. Two salvage/disposal scenarios are presented: Scenario 1 considers that all equipment is sold as scrap, while Scenario 2 assumes partial resale of some of the Project's major components.

The net decommissioning value is determined from the difference of 1) the sum of the disassembly and removal cost and 2) the sum of the salvage value and resale. The estimated net decommissioning gain or cost for the Project assuming no resale (Scenario 1), and with partial resale of the Project's major components (Scenario 2), are presented in the table below. Note, values in parenthesis are negative values representing positive returns to the Project.

	Scenario 1 No Resale	Scenario 2 Partial Resale
Total per WTG	$40,360	($26,160)
Total for Project (72 WTGs)	$2,906,000	($1,883,500)

As it is considered to be the more likely option, a detailed breakdown of Scenario 2 is shown below.

Project net decommissioning cost with partial resale (Scenario 2)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage/Resale (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(16,009,500)	$(4,647,500)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
High voltage substation	$157,000	$72,000	$9,000	$238,000	$(1,787,000)	$(1,549,000)
Transmission Line	$220,000	$17,000	$0	$237,000	$(82,000)	$155,000
Access roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,475,000	$0	$0	$2,475,000	$0	$2,475,000
Project Totals	$10,637,000	$5,419,000	$1,009,400	$17,065,400	$(19,389,900)	$(2,324,500)
Total per WTG						**$ (32,280)**
Total Project (72 WTGs)						**$ (2,324,500)**

Note: negative values, those in parenthesis, are positive returns to the Project.

It is stressed that this report is based on broad assumptions regarding the Project, including the approach to the decommissioning task and the market conditions for contracting costs, scrap value, and resale options. It is recommended that the net costs of decommissioning be reviewed closer to the end of the operating period (e.g., 2 to 4 years prior to the end of operations). At that time it would also be prudent to take into consideration: 1) a scenario in which Project profitability and turbine conditions justify continued operation beyond the initially assumed Project operating life; and 2) a "re-powering" scenario, in which case the existing turbines would be removed in the interest of constructing a more valuable project with larger, more efficient turbines. In the first scenario, decommissioning costs could be paid for by allocations of Project revenues in future Project years, while in the latter scenario any decommissioning costs could be transferred to the capital budget of the new project.

1 INTRODUCTION

Apex Clean Energy Management, LLC ("Apex" or the "Sponsor") retained Garrad Hassan America, Inc. ("DNV GL") to perform a decommissioning analysis of the Dakota Range Wind Project (the "Project") to be located in Grant and Codington Counties, South Dakota. The Dakota Range Wind Project is intended to consist of 72 Vestas V136-4.2 MW wind turbine generators (WTG), with an aggregate rated output of 302.4 MW, and associated infrastructure.

The Sponsor has advised DNV GL that the required decommissioning tasks will include the removal of all towers, WTGs, substation, underground collection lines, ancillary equipment and other physical material owned by and pertaining exclusively to the Project, and restoration of the property, including the Project roads.

While no specific ordinance specifies how decommissioning of wind power projects should be performed in either of the above mentioned counties as of the writing of this report, the following assumptions have been applied:

- Decommissioning will start soon after the end of the Project's operating life (assumed to be 30 years for purposes of this study), and all decommissioning work is performed in generally conducive weather conditions;
- Decommissioning includes removal of WTGs, electrical cabling, electrical components, roads, and any other associated facilities down to 3 feet (ft) below grade in accordance with industry best practice. Additionally:
  - The WTG foundations will have only the pedestals and concrete transformer pads removed and the remainder of the spread footing is abandoned in place.
  - One Project substation with two main transformers is assumed, a 1.4-mile, 345 kV transmission line will be completely decommissioned, as will the approximately 53 miles of underground collection system cabling.
  - Approximately 19.1 miles of Project roads will be decommissioned. DNV GL considers this a conservative assumption as many land owners may find such roads a benefit to their land and request to keep them.
- Crane pads are assumed to have been remediated during initial construction.
- No decommissioning of the operations and maintenance (O&M) building has been estimated as per Sponsor request.

This report does not consider the time value of money; the results should therefore be adjusted to represent the inflated costs at the time of decommissioning (e.g., annual escalation). It should also be noted that commodity values are volatile and difficult to predict over the study horizon.

This report also does not consider the decommissioning scenarios from a legal, regulatory, or commercial perspective, which should be assessed by the Sponsor.

2 STUDY ASSUMPTIONS

DNV GL's decommissioning study methodology assumes there are strong parallels between wind power project construction and decommissioning programs. DNV GL has used an internal bottom-up decommissioning model developed from its experience in the wind industry to formulate these study results.

All costs are quoted in 2017 US dollars, and it should be noted that no specific quotes were obtained in relation to this study, although the Project's location has been considered in the modeling. The study is broken down into three sections: disassembly, removal, and salvage/disposal. Due to the uncertainty associated with the majority of cost categories assumed and modeled, DNV GL has rounded costs to the nearest $1,000, unless otherwise noted.

2.1 General assumptions

DNV GL has assumed that, on average, one main crane will dismantle one turbine every day (including time for crane movements from turbine to turbine, crane teardowns where necessary, and some minor weather delays). A base crane for lower tower sections, as well as to aid in loading the components onto transport trucks, will also be required. The number of main cranes used determines the approximate time to complete the job. The Project layout was also analyzed for crane walking impediments to estimate crane teardown requirements. While a detailed analysis in this regard was not performed, the Project was assumed to require the number of cranes and teardowns presented in Table 2-1.

2.2 Initiation and mobilization

Before executing any decommissioning works, it is necessary to plan the work carefully, secure the appropriate permits and insurance, and manage the program of work and associated health and safety risks in order to ensure successful completion of the work. It is assumed that mobilization and soft costs are overhead. Soft costs, for the purposes of this study, include costs not specifically accounted for in the derivations presented later in this Report, including environmental studies, obtaining permits, environmental protection plans, hazardous material disposal, onsite administrative infrastructure and staff, utilities, off-site project management and insurance/legal services. DNV GL assumed 5% of the total disassembly and removal cost will be required for soft costs.

In addition to soft costs, DNV GL assumed that an additional 1% of the total disassembly and removal costs will be needed for contractor mobilization. DNV GL separately accounted for a lay-down yard of 10,000 m^2 to house the office trailers, staff parking and facilities for mobilization and demobilization. Table 2-1 summarizes the crane, mobilization, and soft cost assumptions used in this report, as well as the total cost estimate for such activities.

Table 2-1 Mobilization and soft cost assumptions

Item	Quantity
Number of main cranes needed	3
Number of main crane tear-downs needed	6
Number of base cranes needed	6
Number of base crane tear-downs needed	0
Decommissioning contractor's lay-down yard size [m^2]	10,000
Additional mobilization as percent of total hard costs (1)	1%
Decommissioning soft costs as percent of total hard costs (2)	5%
Total Mobilization and Soft Costs	**$2,475,000**

(1) Represents the costs of contractor’s mob./demob.
(2) For soft costs, it is assumed that decommissioning would be completed for the entire Project at once.

2.3 Schedule

It is assumed that the decommissioning program would be 7 to 12 weeks in length. This timeline is based on the assumption that the dismantling rate of the WTGs is approximately one turbine per workday per main crane, and that 7 to 10 workdays of mobilization and demobilization are allowed before and after turbine dismantling. During construction of wind power projects, it is typical that the time for erection across the entire project schedule averages about one turbine per day per main crane on a simple site. While disassembly could in theory be done with slightly less care than during assembly (damage to turbines not as much of a concern), safety and resale considerations will likely dictate that disassembly be accomplished in much the same fashion as erection, although in reverse order.

It is also assumed that other works across the site such as foundation removal, underground collection systems disassembly, substation disassembly and reclaiming of roads will be done simultaneously and/or in concert with the turbine dismantling and crane progress.

3 DISASSEMBLY

The disassembly of the Project pertains to all work prior to physical transportation of the infrastructure from the site. In the case of the WTGs, it includes the dismantling and loading of the tower sections, nacelle, and blade scraps onto trucks for transport. In the case of concrete foundations and roads, it pertains to the tear down, aggregate stripping, excavation and backfilling, and all reclaiming as necessary. Reseeding of removed roads and turbine areas is included in these costs.

Although certain activities must be sequenced appropriately, based on DNV GL's knowledge of wind project construction considerations, it is assumed that many activities (e.g., turbine, collection system, and substation disassembly) may be undertaken in parallel, facilitating an efficient decommissioning process.

3.1 Turbines

Once the site is mobilized, it is assumed that the decommissioning of turbines would start immediately and sequentially. This typically entails the individual removal of the rotor assembly followed by the nacelle enclosure. The tower internals are stripped of lifts, cables, cabinets, lighting and other miscellanea and are then dismantled, section by section, down to the foundation surface.

For the Project, 72 turbines are to be removed, consisting of 4.2 MW nacelles, with three-section, 82-m steel towers, and 66.7-m blades. It is assumed that the scope of the disassembly works includes the cost of labor, machinery, and tools required to perform the tasks and the loading of the dismantled material onto transport vehicles for removal from site. The main cranes would be required on site for approximately 6 to 8 weeks during the turbine dismantlement activities. The base cranes may be required a slightly longer period in order to assist with transport loading activities and substation dismantling.

It is also assumed that aside from the possible removal of the drive train to aid lifting, the nacelle and its contents will remain fully intact for purposes of transport. All cooling, heating, and lubrication fluids will be drained, stored, and appropriately disposed of before the nacelle is removed from site. Blades, however, will be cut into sections for easier transport to a recycling or incineration plant.

The costs presented below include the cost of a main crane to handle the hub/rotor, nacelle and top tower section (or top sections, depending on base crane hired). They also include the cost of a base crane for lower tower sections, as well as to aid in loading the components onto transport trucks. The costs take into consideration the rental of special tools needed from the manufacturer.

In accordance with industry best practice it is assumed that the site will be remediated to 3 ft below grade. This assumes that the concrete structures are to be cut and crushed down to 3.5 ft below grade (to allow some margin). It is assumed that approximately 31 m^3 of crushed concrete will result from removing each turbine's foundation pedestal and pad-mount transformer foundation (essentially in their entirety) to achieve these criteria. Table 3-1 summarizes the turbine disassembly costs for Project.

Table 3-1 Summary of turbine disassembly costs

Cost item	Costs per WTG
Dismantle hub and blades (3 blades per turbine)	$26,000
Dismantle nacelle (drive train, generator and transformer included)	$26,000
Dismantle tower sections, internals included	$27,000
Remove turbine foundation (1)	$8,000
Total per WTG	**$87,000**
Total for Project (72 WTGs)	**$6,264,000**

(1) 1 m below grade. Does NOT consider concrete tower sections

DNV GL notes that the disassembly costs of WTGs are highly dependent on crane costs (which include crane plus crane crew): over 60% of the total per-WTG cost is associated with crane-related costs. DNV GL estimated this cost based on experience from various projects in North America. It is noted that crane availability may greatly influence crane costs, and that it is not possible to accurately predict crane costs given the long study horizon.

3.2 Collection system

The decommissioning of the collection system has been considered, as requested by the Sponsor. DNV GL notes that in many decommissioning study requests, the underground portion of the collection system does not need to be removed, since it is often below the required grade clearance. That said, due to the relatively high value of conductors, removal and resale of the underground cables may yield a positive return to the Project. If the Sponsor determines the removal and resale may not yield a positive return, the cabling will be left in place because it will be buried at 4 feet, which is below the required grade clearance of 3 feet.

3.2.1 Underground Collection System

According to the Sponsor [1], the Project collection system will be composed of 53 miles of three-phase buried lines along with bare copper grounding cable. Underground collection system disassembly includes trenching, winding triplex with ground wire, and reclaiming. The conductors would subsequently need to be re-reeled for transport.

It is assumed that the scope of the disassembly includes the cost of labor and the loading of the dismantled material onto transport vehicles for removal from site. It is assumed that the disconnection work at the terminals would be performed as part of turbine removal or substation removal. The results are reported in Table 3-3 below.

3.2.2 Overhead Collection System

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider any overhead lines in this decommissioning analysis.

3.3 High-voltage substation

The Sponsor has advised that the Project will be equipped with two 345/34.5 kV, 167 MVA transformers at one substation location. The remaining portions of the Project's high-voltage (HV) substation is assumed to include typical equipment seen in North American for wind projects of this size, including grounding transformers, bus bars, relay switches, circuit breakers, air disconnect switches, capacitor banks, reactor banks and a control building. It is assumed that a dead-end structure will also be present.

An interconnection switchyard for the Project has not been considered in this decommissioning analysis.

It is assumed that the scope of the disassembly work includes the cost of labor and machinery required to perform the disassembly tasks, including disconnection work at the terminals, and the loading of the dismantled material onto transport vehicles for removal from site. The following table summarizes the costs to disassemble the Project's HV substation.

Table 3-2 Costs to disassemble Project substation

Item	Cost
Preparation	$7,000
Dismantle HV equipment	$29,000
Dismantle and prep. main transformers for shipment	$38,000
Remove control building	$5,000
Remove foundations	$36,000
Large machinery hire	$15,000
Small machinery hire	$13,000
Reclaim and reseed	$14,000
Total for Project (one substation)	**$157,000**

3.4 Transmission line

According to the Sponsor, the Project will use a 1.4-mile 345 kV overhead transmission line. Transmission line disassembly includes pole teardown and reclaiming. The conductors would subsequently need to be re-reeled for transport.

It is assumed that the scope of the disassembly includes the cost of labor and the loading of the dismantled material onto transport vehicles for removal from site. The results are reported in Table 3-3 below.

3.5 Site access roads

In practice, it is probable that most of the roads could remain after the completion of the Project, with the exception of the dead-end access roads that lead to the turbines. However, for purposes of the study, DNV GL has assumed that the entirety of the approximately 19.1 miles of roads will be remediated. Based on Sponsor information, DNV GL has additionally assumed that 72 crane pads will be reseeded during decommissioning, but that removal of concrete would have occurred during initial construction activities. The lay-down yard reclamation is accounted for in the mobilization/demobilization costs. Decommissioning of the site access roads will typically include stripping back the road surface and replacing it with topsoil in keeping with the surrounding environment. In the case of the Project, this activity also includes stripping and piling geotextile material used in the road base. The costs include reseeding with native grasses. A secondary reseeding may be required if the initial work proves inadequate.

The results are reported in Table 3-3 below. Note the cost of aggregate transport off site is captured in removal costs.

3.6 Meteorological masts

A total of three permanent 82-m meteorological masts are to be installed on the Project site. It is assumed that these met masts will be disassembled at an appropriate time during the decommissioning activities so as not to interfere with the other ongoing work. This typically involves the use of a base crane to dismantle the masts, section by section, down to the foundation surface. The instrumentation and booms would be either removed before the sections are laid down, or removed from the sections once on the ground.

It is assumed that the scope of the disassembly works includes the cost of labor, machinery and tools to perform the dismantling tasks, including foundation removal to appropriate below grade level, and the loading of the dismantled material onto transport vehicles for removal from site. It is also assumed that only one crane is needed for removal. The results are reported in Table 3-3 below.

3.7 Disassembly conclusion

The total estimated cost for the disassembly of the Project is summarized in Table 3-3.

Table 3-3 Summary of Project disassembly costs

Cost item	Cost
WTG	$6,264,000
Collection system	$845,000
HV substation	$157,000
Transmission line	$220,000
Access roads	$642,000
Met Masts	$34,000
Mobilization & soft costs	$2,475,000
Total Project Disassembly Cost	**$10,637,000**

4 REMOVAL FROM SITE

Removal of the Project in this study refers strictly to the transporting of the equipment from the site to the appropriate landfill, aggregate rework facility, or scrap yard. Various distances and truck sizes are applied in DNV GL's decommissioning model, depending on which Project component is being considered. Removal costs also include the costs of unloading the material once it reaches its destination. DNV GL notes that appropriate landfills and scrap yards appear to be located in the general region of the Project.

4.1 Turbines

It is assumed that the scope of the removal of the WTGs includes the cost of labor and vehicles required to transport the dismantled material to an appropriate disposal, salvage or rework facility. It is assumed that the transport distances for general waste would be within a radius of 80 miles, whereas the more complex and valuable material is assumed to be transported within a radius of 300 to 450 miles (300 miles for the tower internals and 450 miles for the main turbine and substation components). These assumptions may be somewhat conservative considering there are a number of recycling or salvage facilities near the Project site. DNV GL additionally notes the presence of rail transport in the relative vicinity which could decrease costs for removal of turbine components. While most of the main turbine components are modeled to be removed much as they were initially transported to the site during construction, the turbine blades will be sectioned to limit oversize transport.

Table 4-1 summarizes the costs for the removal of each of the turbine components from the site.

Table 4-1 Turbine removal costs

Turbine component	Cost per WTG
Blades (cut up prior to loading)	$5,000
Hub (one per truck)	$10,000
Nacelle	$10,000
Tower sections	$30,000
Internals	$1,000
Transformer	$1,000
Crushed foundation (31 m^3)	$800
Total per WTG	**$57,800**
Total for Project (72 WTGs)	**$4,162,000**

4.2 Collection system

4.2.1 Underground collection system

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material to an appropriate salvage facility. The material will mainly include the wound reels and/or cut cables removed by trucks. The results are reported in Table 4-3 below.

4.2.2 Overhead collection system

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider the remove of overhead lines in this decommissioning analysis.

4.3 High-voltage substation

It is assumed that the transport distances for substation foundation rubble and general waste would be within a radius of 80 miles, whereas the more complex and valuable substation material is assumed to be transported within a radius of 300 to 450 miles. It is assumed that local dump truck loads are 10 yd^3 in capacity.

The following table summarizes removal costs for the Project substation. As previously mentioned, an interconnection switchyard has not been considered in the present study.

Table 4-2 Project substation removal costs

Substation component	Cost
HV equipment	$10,000
Main transformers	$20,000
Control building	$4,000
Dead-end structures	$10,000
Crushed foundations (local transport)	$22,000
Yard gravel (local transport)	$6,000
Total removal costs for HV substation(s)	**$72,000**

4.4 Transmission line

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material to an appropriate salvage or rework facility. The material will include the wound reels and/or cut cables as well as the dismantled poles (9 steel poles assumed). The results are reported in Table 4-3 below.

4.5 Site access roads

For the purpose of removal calculations and at the Sponsor's request, the Project's 19.1 miles of roads to be removed were assumed to be 16 ft wide and approximately 1 ft deep and underlain by geotextile in line with Project drawings. While this width attempts to capture any shoulder material as well, the assumption that all roads to be removed are 16 ft wide is likely conservative with respect to the Project design and is expected to therefore cover the cost of decompaction and reclamation of any additional width required due to crane walking. Dump truck capacity is assumed to be 10 yd^3 and all load trips are assumed to be local. The results are reported in Table 4-3.

4.6 Meteorological masts

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material from the two meteorological masts to an appropriate disposal, salvage or rework facility. The results are reported in Table 4-3 below.

4.7 Removal conclusions

Table 4-3 summarizes the total anticipated costs for removing the turbines, electrical collection system, substation, roadways, and met masts from the Project site.

Table 4-3 Project removal conclusions

Item	Cost
WTG	$4,162,000
Collection system	$284,000
HV substations	$72,000
Transmission line	$17,000
Access roads	$853,000
Met Masts	$31,000
Total Project removal cost	**$5,419,000**

5 SALVAGE – DISPOSAL

While it is impossible to predict the exact evolution of an industry 30 years into the future, it is not unreasonable to assume that there may exist by that time consolidated centers that will fully recycle a wind turbine given that many project "decommissionings" or "repowerings" will have been undertaken prior to that time. For example, DNV GL notes that significant attention is being placed by industry and academia alike into possible uses or methods for recycling wind turbine blades.

DNV GL notes that in this section only, gains are shown as positive and costs to the Project are shown in parentheses

While it may become easier to recycle wind turbines in the future, DNV GL performed this study assuming only the application of present day means. Following the disassembly and removal of all materials from the Project site, four potential destinations for the remediated material are typically envisaged by DNV GL when performing decommissioning studies. These scenarios may add extra cost to the decommissioning budget or offer an opportunity to reclaim some value from the project components to offset the cost of decommissioning.

1. Low-grade material such as contaminated aggregate, concrete rubble, wood, non-recyclable materials and other mixed general waste will in all likelihood be sent to landfill or incineration at cost to the Project. DNV GL notes that there is a relatively large volume of waste associated with the glass reinforced plastic (GRP) which composes most turbine blades today. It is possible that in 30 years recycling blade GRP into cement fill, roofing shingles or other useful industrial raw materials may be a net positive for the Project, or at least an offset to the cost, but no such projections have been made in the present study. Thus, blade GRP has been considered waste.
2. Medium-grade materials such as small- and medium-gauge cabling, small motors, cabinets of mixed electronics, and lighting may be sent to salvage centers to be stripped for parts and sold for re-use or re-processing. This may be done at a nominal, neutral, or negative cost (positive return) to the Project. However, this material may also be sent to landfill if an appropriate third party cannot be found. DNV GL notes that it is difficult to predict future returns of salvage for such materials due to the unpredictability of commodity prices.
3. High-grade materials such as large steel components (tower sections, bedplates, hub castings, gearboxes, and steel cables), large-gauge copper and aluminum cabling, aluminum flooring and ladders will be sent to reprocessing centers at a net neutral cost or positive return to the Project. DNV GL notes that it is difficult to predict future returns of reprocessing for such materials due to the unpredictability of commodity prices.
4. Reusable components that are deemed to be undamaged, functional and have not fulfilled their design life could be sold back to the manufacturer or its supply chain for a modest second-hand price for refurbishment. Some electrical infrastructure equipment as well as recently replaced turbine components could fall into this category.

Applying a conservative approach, DNV GL only considered items 1, 3, and 4 in this study. No resale gains were assumed for item 2, only scrap/disposal value. Furthermore, item 4 was limited only to certain main components within a conservative age range.

5.1 Pricing assumptions

The following salvage assessment is based on DNV GL's decommissioning model which estimates bill of quantities, typical material weights, and ratios for turbine components derived from the manufacturer's technical specifications or from DNV GL experience. The DNV GL model uses commodity prices and disposal service rates as inputs.

For the Project's decommissioning study, the following scrap commodity prices are assumed:

- Steel and cast iron: $300/ton
- Copper: $5,000/ton
- Aluminum: $1,400/ton

Weights are in metric tons. It should be noted that the commodity price of metals is volatile and thus, assuming present day values will hold true is highly uncertain. The assumed prices are based on DNV GL's analysis of USGS historical scrap metal cost statistics [3]. .

Because landfill costs are expected to keep rising, DNV GL used a different cost variable for the incineration, recycling or disposal of GRP. Although it is possible that in 30 years technology will be available to extract the fibers from the epoxy laminate for high-grade industrial reuse at a net benefit, DNV GL assumed a net cost to incinerate or low-grade recycle the GRP as a separate cost to landfill. The following landfill costs are assumed:

- GRP disposal (incineration or recycling): \$100/m^3
- Class 2 landfill, Industrial/toxic waste: \$75/m^3
- Class 3 landfill, General waste: \$35/m^3

5.2 Turbines

5.2.1 Salvage and disposal

There should be considerable opportunity to reclaim scrap value from the turbines from the copper in the low voltage cabling, transformer and generator; steel from the tower, hub, drive train and bedplate; and aluminum from the tower internals. The blades and nacelle housing are made from GRP and would have to be disposed of.

The following table summarizes the salvage and disposal costs per each turbine. Component weights have been estimated by DNV GL, and/or obtained directly from manufacturer's documentation.

Table 5-1 Turbine salvage values

Component	Net Scrap Value
Blades	$(8,000)
Hub + blade steel	$9,500
Nacelle/hub GRP	$(3,500)
Nacelle bedplate	$19,000
Main shaft	$3,000
Gearbox	$9,000
Generator	$16,500
Tower steel sections	$81,000
Internals	$21,500
Transformer	$6,500
Crushed foundation	$(1,000)
Total per WTG	**$154,000**
Total for Project (72 WTGs)	**$11,088,000**

Note: Negative values (those in parenthesis) are costs to the Project.

5.2.2 Partial resale of major components

DNV GL considers that at the end of the Project's assumed 30-year operating life, many of the components of the turbines will still be serviceable and have positive value in the secondary parts market. DNV GL considers that the towers and nacelle shells would still be sold as scrap as well as the rest of the major components that were not resold.

While wind turbines are structurally designed to meet a fatigue life of 20 years plus some margin, DNV GL expects a significant number of failures during the Project's operating life involving the major components such as gearboxes and generators. DNV GL continually tracks and models the various failure rates for each of the main components across all major wind turbine model types and has, for purposes of this study, modeled failure rate assumptions for the Project for the assumed 30-year life. DNV GL considers that a number of other considerations apply to the actual potential for the turbines to economically operate past their 20-year design life, but notes that such discussion is outside the scope of this report.

It is assumed that other North American wind power projects with Vestas wind turbines (either owned by the Sponsor or not) will be arriving or will have arrived at their 20-year design life at the time of decommissioning of the Project, and some will have chosen to operate beyond it. Therefore, a secondary parts market may be assumed to exist that would demand some of the major components being decommissioned from the Project. Using a conservative approach and with the exception of the transformer, major components that are five years or younger (i.e., replaced or refurbished during operational years 25 through 30) are considered candidates for resale. Only the gearbox, generator, blades, pitch system, main yaw system, hydraulic unit, power converter, main bearing, and transformer are considered. The transformer is assumed to have a higher design life and so, half of the Project's 72 are considered candidates for resale.

Table 5-2 summarizes the turbine partial resale valuations estimated for the Project. The calculations account for the lost scrap opportunities.

Table 5-2 WTG component resale valuations

Component	New Part Cost [$]	Estimated qty. Aged ≤ 5 years (1)	Qty. to Resale (2)	Value at 25% of New	Scrap Loss [$] (3)
Gearbox	$350,000	18	18	$1,575,000	$162,000
Generator	$190,000	19	19	$903,000	$313,500
Blades	$330,000	4	4	$330,000	$(32,000)
Pitch system	$10,000	11	11	$28,000	$0
Main Yaw	$85,000	0	0	$0	$0
Hydraulic unit	$10,000	0	0	$0	$0
Power converter	$34,000	27	27	$230,000	$0
Main Bearing	$175,000	11	11	$481,000	$0
Transformer	$75,000	4	36	$675,000	$234,000
Gross Resale Total				**$4,222,000**	
Minus Loss of Scrap					**$(677,500)**
Net Resale Total					**$3,544,500**

(1) Component replaced within the last 5 years of operation according to DNV GL model.
(2) Component assumed to be resold based on DNV GL engineering judgment.
(3) Partial resale of turbine components means scrap opportunities need to be subtracted from previous calculations; this is taken into account in this column, and therefore the net resale value of turbine components includes this loss of scrap.

5.3 Collection system

5.3.1 Underground collection system

The underground three-phase conductor and ground cabling reels from the Project will likely be sold for scrap. Based on Project information, DNV GL has estimated at total of approximately 159 miles of conductor (3 phases) along with 53 miles of bare copper ground wire. The salvage – disposal results are reported in Table 5-3 below.

5.3.2 Overhead collection system

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider the salvage value of overhead lines in this decommissioning analysis.

5.4 High-voltage substation

There should be opportunity to reclaim metal scrap value from substation electrical equipment. Equipment such as bus work, circuit breakers, grounding transformers, and main transformers contain a significant amount of conductive material such as copper and aluminum. Dead-end and other steel structures contain a significant amount of steel. The substation yards also contain aggregate fill that could be sold. Rubble from the foundation demolition and all other materials would be sent to landfill at cost. The scrap value of the substation is presented in Table 5-3 below.

DNV GL considers that there is a resale market for substation transformers. Therefore, the transformer could be sold as operational second-hand equipment instead of being scrapped. This scenario has been taken into account in Section 6.

5.5 Transmission line

The three-phase conductor cable can be sold for scrap and the steel poles from the overhead line could potentially be resold to an electric utility as second hand parts. Based on Project drawings and specifications, DNV GL has estimated at total of 9 steel transmission poles and approximately 4.1 miles of total conductor (3 phases). The salvage – disposal results are presented in Table 5-3 below.

5.6 Site access roads

For the purpose of removal and salvage calculations and at the Sponsor's request, the Project's 19.1 miles of roads to be removed were assumed to be 16 ft wide and 0.3 m (~1 ft) deep and underlain by geotextile, in line with Project drawings.

The salvage – disposal results are presented in Table 5-3 below.

5.7 Meteorological masts

Although it is possible that the met masts could be dismantled, resold and reused at a different location, a 30-year old mast may have limited reinstallation value (although it could very well be a candidate to remain installed onsite in a repowering scenario). For the purpose of conservatism in this study, DNV GL assumes a dismantling and removal scenario with the intent of scrapping the met towers.

The salvage – disposal results are presented in Table 5-3 below.

5.8 Salvage – disposal conclusions

The following table summarizes the opportunities from the salvage / disposal analysis. Please note that this table does not incorporate the turbine major component resale scenario presented in Table 5-2.

Table 5-3 Salvage/disposal value (without resale of turbine components)

Item	Disposal	Salvage
WTG	$(936,000)	$12,024,000
Collection System	$(26,000)	$1,083,000
HV Substation	$(9,000)	$542,000
Transmission Line	$0	$82,000
Access Roads	$(38,000)	$423,000
Met Masts	$(400)	$5,400
Total Project Salvage Return	**$(1,009,400)**	**$14,159,400**

Note: The value presented does not include the resale returns of turbine components; negative values, those in parenthesis, are costs to the Project.

6 NET DECOMMISSIONING COST

The estimated net decommissioning cost for the Project is calculated by subtracting the total salvage value from the total of the disassembly and removal costs. This report presents two net decommissioning cost breakdowns: Scenario 1 assumes no resale of Project components, and Scenario 2 assumes the partial resale of major turbine components noted in Section 5.2.2 and the substation's main power transformers.

6.1 Net decommissioning cost – no resale

Table 6-1 summarizes the Project's net decommissioning costs assuming no resale of any Project components other than for scrap value (Scenario 1).

Table 6-1 Project Net decommissioning cost – no resale (Scenario 1)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(12,024,000)	$(662,000)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
HV Substation	$157,000	$72,000	$9,000	$238,000	$(542,000)	$(304,000)
Transmission Line	$220,000	$17,000	$0	$237,000	$(82,000)	$155,000
Access Roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,475,000	$0	$0	$2,475,000	$0	$2,475,000
Project Totals	$10,637,000	$5,419,000	$1,009,400	$17,065,400	$(14,159,400)	$2,906,000
Total per WTG						**$40,360**
Total for Project (72 WTGs)						**$2,906,000**

Note: negative values, those in parenthesis, are positive returns to the Project.

6.2 Net Decommissioning Cost – Partial Resale of Selected Components

Table 6-2 summarizes the Project's net decommissioning costs for Scenario 2, which includes some plausible and conservative parts resale assumptions.

Table 6-2 Project Net decommissioning cost – partial resale of selected components (Scenario 2)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage/Resale (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(15,568,500)	$(4,206,500)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
HV substation	$157,000	$72,000	$9,000	$238,000	$(1,787,000)	$(1,549,000)
Transmission Line	$220,000	$17,000	$0	$237,000	$(82,000)	$155,000
Access roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,475,000	$0	$0	$2,475,000	$0	$2,475,000
Project Totals	$10,637,000	$5,419,000	$1,009,400	$17,065,400	$(18,948,900)	$(1,883,500)
Total per WTG						**$ (26,160)**
Total Project (72 WTGs)						**$ (1,883,500)**

Note: negative values, those in parenthesis, are positive returns to the Project.

6.3 Future recommendations

It is stressed that this report is based on broad assumptions regarding the Project including the approach to the decommissioning task, the market conditions for contracting costs, and scrap value and resale options. DNV GL recommends that the net costs of decommissioning be reviewed closer to the end of the operating period (e.g., 2 to 4 years prior to the end of operations) when better visibility on these factors would be possible. Also at this time, the value of decommissioning could be reviewed against potential extended operational revenue. At the same time it would also be prudent to consider a "re-powering" scenario, in which case the existing turbines would be removed in the interest of constructing a more valuable project with larger, more efficient turbines. Any cost to remove the old turbines would be incurred as construction costs of the new wind power project.

7 REFERENCES

[1] Email from N. Pedder, Apex Clean Energy to K. Kallevig-Childers, DNV GL providing Project assumptions, 8 November 2017.

[2] Emails from N. Pedder, Apex Clean Energy to D. Pardo, DNV GL providing infrastructure assumptions, 21 and 22 November 2017.

[3] USGS web site: http://minerals.usgs.gov/minerals/pubs/commodity/

APPENDIX A – CUSTOMER PROVIDED INPUTS

1000	**Special requirements**	
1001	Decommissioning requirements applicable to the Project	n/a
1100	**Project Basics**	
1101	Wind Power Plant Name	Dakota Range
1102	Construction Status	County Permitting
1103	General Location	45.1227823, -97.0504154
1104	No. Wind Turbines in Grant County	72
1105	Make and Model of Wind Turbine	Vestas V136 4.2 MW
1106	Hub Height [m]	82
1107	Project Capacity [MW]	302.4 MW
1108	Project Design Life (civil, turbine, electrical and financial) [yr]	30
1109	Decommissioning to Occur After Which Project Year	2048
1110	No. of Substations to Remove	1
1111	No. of main project transformers	2
1112	No. of O&M buildings to Remove	0
1113	Length of Underground Collection System to Remove	280,184 lf
1114	Length of Overhead Collection System to Remove	0 lf
1115	Length of Transmission Line to Remove	7,218 lf
1116	Length of Project Access Roads to Reclaim [km]	101,050 lf
1117	No. of Meteorological Towers to Remove	3
1118	Average Height of Met Towers [m]	82
1119	Met tower type	Self-support
1200	**Additional Information**	
1201	COD date	2019
1202	Warranty term [yr]	Not provided
1203	Estimated Annual P50 Production Capacity Factor	Not provided
1204	Main step-up transformer voltage [kV/kV]	345/34.5
1205	Main step-up transformer rating [MVA]	167
1206	No. of Transmission Line Steel Poles	9
1207	No. of Transmission Line Wood Poles	0
1208	Project Layout file name	DKR_XCEL_LAY_20171108.KMZ
1209	Number of tower sections per Wind Turbine	3
1210	Site plan (incl. Electrical layout)	DKR_XCEL_LAY_20171108.KMZ
1211	Construction schedule	Not provided
1212	As built or issued for construction (IFC) drawings (civil & electrical)	Not provided
1213	Contracts in place or existing quotes/price	Not provided

ABOUT DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, we empower our customers' decisions and actions with trust and confidence. We continuously invest in research and collaborative innovation to provide customers and society with operational and technological foresight. Operating in more than 100 countries, our professionals are dedicated to helping customers make the world safer, smarter and greener.