APPENDIX B
Shadow Flicker Assessment: Odell Wind Project

SHADOW FLICKER ASSESSMENT

ODELL WIND PROJECT

COTTONWOOD, JACKSON, MARTIN, AND WATONWAN COUNTIES, MINNESOTA

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Odell Wind Farm, LLC ('Odell') is developing the Odell Wind Farm ('Project') in southwestern Minnesota with a nameplate capacity of approximately 200 megawatts. Currently, the Project is proposed to consist of between 100 and 133 turbines depending on the final model selected. To support the permitting of the Project at the Minnesota Public Utilities Commission, Geronimo Wind Energy, LLC d/b/a Geronimo Energy, LLC ('Geronimo') completed, on behalf of Odell, a shadow flicker analysis to estimate levels of flicker potentially associated with the operation of the Project.

1.2 DESCRIPTION OF SHADOW FLICKER AND MODELING

Rotating wind turbine blades may cast shadows during periods when the sun is shining and the turbine is operating. Such shadows may occasionally fall upon homes or other occupied structures (known as receptors) in and near the wind farm area. Expected shadow flicker impacts of the Project have been evaluated by the WindPRO software package, which incorporates the proposed turbine layout, 178 receptors identified by review of aerial imagery, and site-specific meteorological data.

1.3 SUMMARY OF FINDINGS

The WindPRO model predicted that shadow flicker exposure will not exceed 30 hours per year in the "expected case" at any of the 178 receptors. It is notable that the expected case is itself fairly conservative, so anticipated impacts of shadow flicker during the operation of the Odell Wind Farm will likely be lower than predicted.

2. SHADOW FLICKER – DEFINITION AND CHARACTERISTICS

Like any tall structure, wind turbines will cast a shadow when the sun is visible. As wind turbines rotate, a flickering or flashing effect may occur when the shadows of the rotating blades cause rapid changes in light intensity at stationary locations such as homes (referred to as receptors). This change in light intensity is known as shadow flicker. Shadow flicker at a receptor may occur only when the following four conditions are met:

- The sun is shining with no cloud cover present;
- The turbine is operating;
- The turbine blades are positioned on a line between the sun and the receptor; and
- The receptor is close enough to the turbine to distinguish the shadow created by the blades.

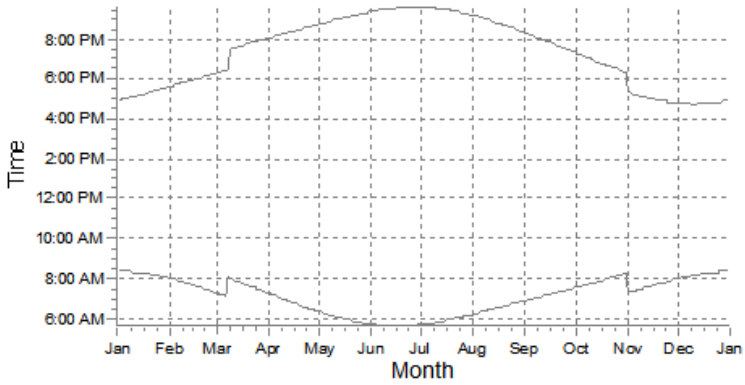
Shadow flicker intensity and frequency of occurrence at a given receptor are determined by several factors:

- **Cloud Cover and Visibility:** If the sun is obscured by clouds, the solar disk is not prominent enough to perceive shadow flicker. Similarly, atmospheric phenomena such as haze, fog, or smoke which would limit visibility also reduce the intensity of shadow flicker because it diffuses the light from the sun.
- **Local Topography:** Elevation differences between the receptor and the turbine location can either increase or decrease frequency of shadow flicker, compared to flat terrain. For example, a receptor may be shielded from the turbine by a prominent hill, wind break, or by other nearby buildings.
- **Wind Speed:** Shadow flicker will only occur if the turbine is operating, as discussed previously. Turbines are designed to operate above a specific wind speed (cut-in speed, generally 3 – 4 m/s for modern wind turbines) and below another specific wind speed (cut-out speed, generally 20 – 25 m/s for modern wind turbines).
- **Wind Direction:** Upwind wind turbines like those proposed at the Project seek to maximize energy production by orienting themselves with blades facing into the wind. The area affected by shadow flicker depends on the orientation of the plane of blade rotation relative to a line between the receptor and the sun. If the other conditions are such that shadow flicker is possible and the plane is close to parallel to the receptor-sun

line, the generation of flicker is negligible at the receptor. Alternatively, if the plane is close to perpendicular the generation of flicker at the receptor may be noticeable.

- **Maintenance:** It is occasionally necessary to shut down wind turbines for maintenance, during which time the turbine will not produce shadow flicker.

- **Sun Angle and Path:** On a given day, shadows cast by the sun are longest during the periods around sunrise and sunset and shortest during mid-day hours. Shadows are also longer in the summer than the winter, with the longest shadows occurring on the summer solstice and shortest shadows occurring on the winter solstice, as seen in the image below:



- **Position of Turbines Relative to Receptors:** The frequency of shadow flicker at a receptor decreases as the distance between the receptor and a wind turbine increases. The frequency is also affected by the location of a wind turbine relative to the receptor. For example, a wind turbine will never cast a shadow on a receptor located directly to its south, since it is never possible for the turbine to lie between the receptor and the sun. A receptor located to the west of the turbine, however, may experience shadow flicker during the early morning hours when the sun is in the eastern sky and low to the ground provided other conditions are met.

- **Distance from Turbines to Receptors:** It is generally accepted that shadow flicker from wind turbines is not perceptible beyond distances of 1500 meters (4921 feet), because the shadow is sufficiently diffuse that the shadow is not seen as a solid obstruction.

Currently, shadow flicker impacts are not regulated by state and federal law; however, a general threshold of 30 hours of shadow flicker exposure is often used as a reference within the wind industry based on a standard goal which has been derived from a German court case in which it was determined that 30 hours of actual observed shadow flicker at a neighbor's property was tolerable [1].

3. SHADOW FLICKER MODELING

Computer models are frequently employed to predict the expected amount of shadow flicker at locations within or around a wind farm. One such model is built into EMD WindPRO 2.7.490, an industry standard software package for the design, assessment, and optimization of wind farms. The WindPRO SHADOW module is able to incorporate the sun's position, topography of the wind farm site, locations of receptors, wind turbine specifications, and the observed wind direction distribution to calculate shadow positions and orientations at one-minute intervals for a calendar year.

3.1 MODEL INPUTS

The model used three separate layouts, specific to each turbine model. Figures 1 – 4 display the proposed turbine positions within the wind farm area as well as the receptor locations. Each turbine was modeled at the highest possible hub height for that unit as follows:

Table 1 - Hub heights used in WindPRO shadow flicker modeling

Turbine	Hub Height (m)
GE 1.6-87	96
Vestas V110	95
Gamesa G97	90
Goldwind GW87	100

Possible receptor locations were identified from 2011 aerial imagery provided by the Farm Service Agency's (FSA) National Agricultural Imagery Program (NAIP). The locations were further refined by field visits to determine if the buildings were still occupiable and to identify any new buildings since the 2011 photo was taken. A total of 178 receptors were identified within 1500 meters (4921 feet) of the proposed wind turbines, as seen in Figure 1. Beyond a distance of 1500 meters, it is assumed that a viewer does not perceive the oscillation in sunlight as the size of the blade relative to the solar disk is too small.

Historical sunshine frequencies (in terms of mean sunlight hours per day) for each calendar month were provided by the WindPRO station database. The nearest site in the database to the Odell Project is at the National Weather Service (NWS) weather station at Sioux Falls, SD. Table 1 lists the average daily sunshine hours per month that were used in the flicker modeling.

Table 2 - Average daily sunshine hours per month at Sioux Falls, SD

Average Sunshine Hours Per Day											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.35	6.33	7.15	8.16	9.53	10.6	11.21	10.21	8.53	6.56	4.82	4.4

Wind direction data collected by an on-site meteorological tower was used in the analysis. The wind direction observations were binned into twelve 30-degree sectors to determine the relative frequency of wind direction at the site. Table 2 below shows the hourly distribution for the 12 sectors and their number of corresponding hours per direction on an annual basis that was used by the shadow flicker model.

Table 3 - Wind turbine operating hours by direction, Odell Wind Farm

Operating Hours by Direction													
Sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Frequency (%)	7.6	4.5	4.3	4.2	5.7	10.1	13.7	9.2	7.0	7.9	9.3	16.4	100
Hrs/Year	666	395	377	368	500	886	1,201	806	616	693	815	1,437	8760.0

Finally it was assumed that no shadows would be cast if the sun angle was less than 3 degrees above the horizon, since the depth of the atmospheric column at these angles substantially increases scattering of solar radiation and renders shadows, like those analyzed in this report, incoherent.

Geronimo assessed the wind turbine/receptor interaction using two methods – an expected case and a conservative case – each using the following assumptions:

- Receptors assumed to be transparent in all directions (known as ‘greenhouse’ mode);
- Flat terrain without obstacles which would reduce shadow flicker occurrences; and
- Turbines were assumed to always operate regardless of wind speed conditions

In the ‘conservative case’ model, further conservative assumptions were made beyond those listed above:

- Turbines were assumed to be always oriented perpendicular to the receptors; and
- Skies were assumed to be clear at all times regardless of observed sunshine frequency.

3.2 MODEL RESULTS

Summary statistics for each of the four turbine layouts and both of the model configurations are as follows, for participating and non-participating landowners:

Table 4 - WindPRO shadow flicker results for participating receptors

Hours / Year, Participant	Gamesa G97	Goldwind GW87	GE 1.6-87	Vestas V110
Max - Conservative Case	81.7	76.8	76.8	101.2
Average - Conservative Case	25.1	28.1	27.3	32.6
Max - Expected Case	29.4	25.2	30.0	30.0
Average - Expected Case	8.2	8.9	8.6	10.4

Table 5 - WindPRO shadow flicker results for non-participating receptors

Hours / Year, Non-Participant	Gamesa G97	Goldwind GW87	GE 1.6-87	Vestas V110
Max - Conservative Case	76.7	111.3	109.8	96.6
Average - Conservative Case	5.2	7.9	7.4	6.7
Max - Expected Case	21.9	28.5	28.0	27.7
Average - Expected Case	1.6	2.5	2.4	2.1

Calculated flicker impacts for each receptor under each model configuration are provided in Appendix A.

4. MITIGATION

Due to the conservative nature of the shadow flicker modeling, it is not expected that any of the receptors in the study area will experience significant impacts during operations. In the event that Odell receives complaints about flicker from the Project, impacts can be re-evaluated and mitigation measures will be taken if necessary. Such mitigation measures include but are not limited to planting of additional vegetation near receptors and installation of curtains or blinds in the windows of affected receptors.

Odell plans to address any post-construction shadow flicker concerns on a case-by-case basis. If shadow flicker concerns are reported to Odell, project representatives will implement the following procedure:

- Log the contact in Odell's complaint database to track resolution efforts;
- Prepare site-specific assessment of shadow flicker impacts, noting the time of day, season, and expected duration of future flicker impacts;
- Meet with landowner to discuss site-specific assessment, educate landowners on landowner driven mitigation strategies (e.g. modification of interior lighting) and discuss concerns;
- Assess the residence to determine if on-site mitigation measures, including but not limited to, installation of exterior or interior screening, are appropriate for the level of impact and effectively address the concern;
- Work with landowner to develop a mitigation plan; and
- Implement the mitigation plan.

Odell's goal is to resolve all flicker related complaints the project may receive satisfactorily. Odell has preference for the least intrusive methodology for mitigating any effects first by engaging with the landowner through education, and will go to more intrusive measures in the event that education is not sufficient in resolving the matter with the landowner.

5. CONCLUSION

An analysis of potential shadow flicker impacts from the Odell Wind Farm on nearby receptors indicates that the effects are expected to be minor and well within tolerances that do not present concerns for nuisance. Of the 178 receptors identified in and near the wind farm, none were predicted to exceed a target of 30 hours per year. Odell will take steps to mitigate flicker impacts if needed during project operations.

6. REFERENCES

1. WindPower. 2003. Danish Wind Industry Association. Shadow Casting From Wind Turbines. http://guidedtour.windpower.org/en/tour/env/shadow/index.html. Accessed 20 June 2013.

APPENDIX A – SHADOW FLICKER MODEL CALCULATIONS

Table 6 - WindPRO shadow flicker calculation results, GE 1.6-87

Receptor ID	Participating Status	Hours Per Year (Conservative Case)	Hours Per Year (Expected Case)
A	Not Participating	0.0	0.0
AA	Not Participating	82.2	28.0
AB	Participating	0.0	0.0
AC	Not Participating	11.6	3.7
AD	Not Participating	28.1	12.1
AE	Not Participating	0.0	0.0
AF	Not Participating	0.0	0.0
AG	Not Participating	0.0	0.0
AH	Not Participating	0.0	0.0
AI	Not Participating	0.0	0.0
AJ	Not Participating	0.0	0.0
AK	Not Participating	0.0	0.0
AL	Not Participating	0.0	0.0
AM	Not Participating	0.0	0.0
AN	Not Participating	0.0	0.0
AO	Not Participating	0.0	0.0
AP	Not Participating	0.0	0.0
AQ	Not Participating	0.0	0.0
AR	Not Participating	0.0	0.0
AS	Not Participating	23.2	10.0
AT	Participating	9.6	2.7
AU	Participating	44.8	12.5
AV	Participating	44.8	12.5
AW	Participating	0.0	0.0
AX	Not Participating	79.6	27.7
AY	Participating	39.4	14.1
AZ	Participating	53.6	16.0
B	Not Participating	0.0	0.0
BA	Participating	65.0	17.0
BB	Not Participating	14.3	4.7
BC	Not Participating	18.6	4.2
BD	Not Participating	9.0	1.8

BE	Participating	0.5	0.1
BF	Not Participating	0.0	0.0
BG	Not Participating	0.0	0.0
BH	Not Participating	0.0	0.0
BI	Not Participating	0.0	0.0
BJ	Not Participating	0.0	0.0
BK	Not Participating	0.0	0.0
BL	Not Participating	0.0	0.0
BM	Not Participating	0.0	0.0
BN	Not Participating	21.7	6.2
BO	Participating	4.9	1.5
BP	Not Participating	0.0	0.0
BQ	Participating	62.2	24.4
BR	Not Participating	3.5	1.2
BS	Not Participating	6.4	2.2
BT	Not Participating	0.0	0.0
BU	Not Participating	0.0	0.0
BV	Participating	0.0	0.0
BW	Not Participating	33.9	10.7
BX	Not Participating	0.0	0.0
BY	Participating	23.8	7.4
BZ	Participating	4.6	1.2
C	Not Participating	0.0	0.0
CA	Not Participating	0.0	0.0
CB	Participating	13.9	2.9
CC	Not Participating	16.4	4.0
CD	Not Participating	0.0	0.0
CE	Not Participating	0.0	0.0
CF	Not Participating	0.0	0.0
CG	Participating	44.2	14.0
CH	Participating	65.6	25.3
CI	Not Participating	70.5	24.1
CJ	Participating	61.0	19.9
CK	Participating	74.2	23.9
CL	Participating	0.0	0.0
CM	Participating	5.8	1.1
CN	Not Participating	21.7	7.4
CO	Not Participating	76.0	24.0
CP	Participating	0.6	0.1

CQ	Participating	7.5	2.1
CR	Participating	59.1	20.2
CS	Participating	73.0	22.3
CT	Participating	36.6	12.3
CU	Participating	74.6	22.8
CV	Participating	48.4	15.4
CW	Not Participating	0.0	0.0
CX	Not Participating	0.0	0.0
CY	Not Participating	0.0	0.0
CZ	Participating	4.1	1.3
D	Not Participating	0.0	0.0
DA	Not Participating	16.8	5.7
DB	Not Participating	109.9	28.0
DC	Not Participating	4.9	1.3
DD	Not Participating	14.3	5.4
DE	Not Participating	23.7	7.9
DF	Participating	11.5	2.8
DG	Participating	9.3	3.3
DH	Participating	7.0	2.4
DI	Participating	7.9	3.4
DJ	Not Participating	0.0	0.0
DK	Not Participating	11.0	2.3
DL	Not Participating	0.0	0.0
DM	Not Participating	0.0	0.0
DN	Not Participating	0.0	0.0
DO	Participating	0.0	0.0
DP	Not Participating	0.0	0.0
DQ	Not Participating	0.0	0.0
DR	Not Participating	0.0	0.0
DS	Not Participating	0.0	0.0
DT	Not Participating	0.0	0.0
DU	Not Participating	0.0	0.0
DV	Not Participating	0.0	0.0
DW	Not Participating	0.0	0.0
DX	Not Participating	0.0	0.0
DY	Not Participating	0.0	0.0
DZ	Not Participating	0.0	0.0
E	Not Participating	0.0	0.0
EA	Not Participating	0.0	0.0

EB	Not Participating	0.0	0.0
EC	Not Participating	0.0	0.0
ED	Not Participating	0.0	0.0
EE	Not Participating	0.0	0.0
EF	Not Participating	0.0	0.0
EG	Not Participating	0.0	0.0
EH	Not Participating	13.2	3.2
EI	Not Participating	21.1	5.2
EJ	Not Participating	36.1	14.1
EK	Not Participating	28.6	9.7
EL	Not Participating	16.8	5.8
EM	Not Participating	14.3	5.0
EN	Not Participating	20.3	7.0
EO	Participating	0.0	0.0
EP	Not Participating	20.3	6.9
EQ	Not Participating	0.0	0.0
ER	Not Participating	0.0	0.0
ES	Participating	0.0	0.0
ET	Not Participating	0.0	0.0
EU	Participating	22.5	7.4
EV	Participating	76.8	22.7
EW	Not Participating	0.0	0.0
EX	Not Participating	0.0	0.0
EY	Not Participating	0.0	0.0
EZ	Not Participating	0.0	0.0
F	Not Participating	0.0	0.0
FA	Not Participating	0.0	0.0
FB	Not Participating	0.0	0.0
FC	Not Participating	0.0	0.0
FD	Not Participating	65.4	19.5
FE	Not Participating	0.0	0.0
FF	Not Participating	0.0	0.0
FG	Not Participating	0.0	0.0
FH	Participating	7.0	1.8
FI	Not Participating	0.0	0.0
FJ	Not Participating	0.0	0.0
FK	Not Participating	0.0	0.0
FL	Not Participating	0.0	0.0
FM	Not Participating	0.0	0.0

FN	Not Participating	0.0	0.0
FO	Not Participating	0.0	0.0
FP	Not Participating	0.0	0.0
FQ	Not Participating	0.0	0.0
FR	Not Participating	0.0	0.0
FS	Not Participating	0.0	0.0
FT	Not Participating	0.0	0.0
FU	Not Participating	0.0	0.0
FV	Not Participating	0.0	0.0
G	Not Participating	0.0	0.0
H	Not Participating	0.0	0.0
I	Not Participating	0.0	0.0
J	Not Participating	0.0	0.0
K	Not Participating	0.0	0.0
L	Not Participating	0.0	0.0
M	Not Participating	9.0	2.4
N	Not Participating	0.0	0.0
O	Not Participating	0.0	0.0
P	Not Participating	0.0	0.0
Q	Not Participating	0.0	0.0
R	Not Participating	0.0	0.0
S	Not Participating	4.3	1.1
T	Not Participating	0.0	0.0
U	Not Participating	0.0	0.0
V	Not Participating	27.4	8.3
W	Not Participating	8.7	2.9
X	Participating	27.7	7.3
Y	Not Participating	25.6	7.4
Z	Not Participating	16.1	7.0

Table 7 - WindPRO shadow flicker calculation results, Vestas V110

Receptor ID	Participating Status	Hours Per Year (Conservative Case)	Hours Per Year (Expected Case)
A	Not Participating	0.0	0.0
AA	Not Participating	77.5	25.0
AB	Participating	7.7	3.4
AC	Not Participating	12.4	3.8
AD	Not Participating	26.5	11.3
AE	Not Participating	0.0	0.0
AF	Not Participating	0.0	0.0
AG	Not Participating	0.0	0.0
AH	Not Participating	0.0	0.0
AI	Not Participating	0.0	0.0
AJ	Not Participating	0.0	0.0
AK	Not Participating	0.0	0.0
AL	Not Participating	0.0	0.0
AM	Not Participating	0.0	0.0
AN	Not Participating	0.0	0.0
AO	Not Participating	0.0	0.0
AP	Not Participating	0.0	0.0
AQ	Not Participating	0.0	0.0
AR	Not Participating	0.0	0.0
AS	Not Participating	0.0	0.0
AT	Participating	6.9	1.6
AU	Participating	0.0	0.0
AV	Participating	0.0	0.0
AW	Participating	6.5	2.9
AX	Not Participating	56.5	20.2
AY	Participating	31.1	10.7
AZ	Participating	79.6	23.1
B	Not Participating	0.0	0.0
BA	Participating	95.1	24.9
BB	Not Participating	18.6	6.1
BC	Not Participating	19.4	4.2
BD	Not Participating	16.4	3.3
BE	Participating	5.3	1.0
BF	Not Participating	0.0	0.0
BG	Not Participating	0.0	0.0
BH	Not Participating	0.0	0.0

BI	Not Participating	0.0	0.0
BJ	Not Participating	0.0	0.0
BK	Not Participating	0.0	0.0
BL	Not Participating	0.0	0.0
BM	Not Participating	0.0	0.0
BN	Not Participating	28.3	8.1
BO	Participating	6.5	2.0
BP	Not Participating	0.0	0.0
BQ	Participating	60.0	22.1
BR	Not Participating	5.0	1.7
BS	Not Participating	0.0	0.0
BT	Not Participating	0.0	0.0
BU	Not Participating	0.0	0.0
BV	Participating	0.0	0.0
BW	Not Participating	22.9	7.3
BX	Not Participating	0.0	0.0
BY	Participating	40.4	12.1
BZ	Participating	19.0	5.4
C	Not Participating	0.0	0.0
CA	Not Participating	0.0	0.0
CB	Participating	6.2	1.2
CC	Not Participating	36.6	10.2
CD	Not Participating	0.0	0.0
CE	Not Participating	0.0	0.0
CF	Not Participating	0.0	0.0
CG	Participating	77.8	24.0
CH	Participating	75.5	27.6
CI	Not Participating	62.0	20.6
CJ	Participating	64.8	21.4
CK	Participating	49.5	16.5
CL	Participating	2.9	0.5
CM	Participating	10.5	2.3
CN	Not Participating	10.8	3.6
CO	Not Participating	62.8	21.7
CP	Participating	0.0	0.0
CQ	Participating	10.3	2.9
CR	Participating	76.4	25.6
CS	Participating	79.4	24.4
CT	Participating	32.3	11.3

CU	Participating	96.5	30.0
CV	Participating	78.7	24.5
CW	Not Participating	0.0	0.0
CX	Not Participating	0.0	0.0
CY	Not Participating	0.0	0.0
CZ	Participating	13.0	4.3
D	Not Participating	0.0	0.0
DA	Not Participating	31.1	10.6
DB	Not Participating	62.0	17.9
DC	Not Participating	33.4	8.9
DD	Not Participating	0.0	0.0
DE	Not Participating	96.6	27.7
DF	Participating	0.9	0.3
DG	Participating	7.3	2.5
DH	Participating	11.6	4.0
DI	Participating	18.1	7.7
DJ	Not Participating	0.0	0.0
DK	Not Participating	12.9	2.7
DL	Not Participating	12.0	2.6
DM	Not Participating	0.0	0.0
DN	Not Participating	11.0	3.8
DO	Participating	54.9	20.2
DP	Not Participating	0.0	0.0
DQ	Not Participating	0.0	0.0
DR	Not Participating	0.0	0.0
DS	Not Participating	0.0	0.0
DT	Not Participating	0.0	0.0
DU	Not Participating	0.0	0.0
DV	Not Participating	0.0	0.0
DW	Not Participating	0.0	0.0
DX	Not Participating	0.0	0.0
DY	Not Participating	0.0	0.0
DZ	Not Participating	0.0	0.0
E	Not Participating	0.0	0.0
EA	Not Participating	0.0	0.0
EB	Not Participating	0.0	0.0
EC	Not Participating	0.0	0.0
ED	Not Participating	0.0	0.0
EE	Not Participating	0.0	0.0

EF	Not Participating	0.0	0.0
EG	Not Participating	0.0	0.0
EH	Not Participating	10.9	2.7
EI	Not Participating	21.1	4.8
EJ	Not Participating	28.6	12.6
EK	Not Participating	17.1	5.9
EL	Not Participating	7.5	2.5
EM	Not Participating	0.3	0.1
EN	Not Participating	5.6	1.9
EO	Participating	0.0	0.0
EP	Not Participating	42.5	14.9
EQ	Not Participating	0.0	0.0
ER	Not Participating	0.0	0.0
ES	Participating	5.1	1.7
ET	Not Participating	0.0	0.0
EU	Participating	42.2	14.2
EV	Participating	101.2	30.0
EW	Not Participating	0.0	0.0
EX	Not Participating	0.0	0.0
EY	Not Participating	0.0	0.0
EZ	Not Participating	0.0	0.0
F	Not Participating	0.0	0.0
FA	Not Participating	0.0	0.0
FB	Not Participating	0.0	0.0
FC	Not Participating	0.0	0.0
FD	Not Participating	51.0	15.2
FE	Not Participating	0.0	0.0
FF	Not Participating	0.0	0.0
FG	Not Participating	0.0	0.0
FH	Participating	0.0	0.0
FI	Not Participating	0.0	0.0
FJ	Not Participating	0.0	0.0
FK	Not Participating	0.0	0.0
FL	Not Participating	0.0	0.0
FM	Not Participating	0.0	0.0
FN	Not Participating	0.0	0.0
FO	Not Participating	0.0	0.0
FP	Not Participating	0.0	0.0
FQ	Not Participating	0.0	0.0

FR	Not Participating	0.0	0.0
FS	Not Participating	0.0	0.0
FT	Not Participating	0.0	0.0
FU	Not Participating	0.0	0.0
FV	Not Participating	0.0	0.0
G	Not Participating	0.0	0.0
H	Not Participating	0.0	0.0
I	Not Participating	0.0	0.0
J	Not Participating	0.0	0.0
K	Not Participating	0.0	0.0
L	Not Participating	0.0	0.0
M	Not Participating	0.0	0.0
N	Not Participating	0.0	0.0
O	Not Participating	0.0	0.0
P	Not Participating	0.0	0.0
Q	Not Participating	0.0	0.0
R	Not Participating	0.0	0.0
S	Not Participating	0.0	0.0
T	Not Participating	0.0	0.0
U	Not Participating	0.0	0.0
V	Not Participating	0.0	0.0
W	Not Participating	0.0	0.0
X	Participating	6.6	2.1
Y	Not Participating	25.2	7.4
Z	Not Participating	0.0	0.0

Table 8 - WindPRO shadow flicker model results, Gamesa G97

Receptor ID	Participating Status	Hours Per Year (Conservative Case)	Hours Per Year (Expected Case)
A	Not Participating	0.0	0.0
AA	Not Participating	61.7	19.8
AB	Participating	6.5	2.9
AC	Not Participating	9.7	2.9
AD	Not Participating	17.7	7.5
AE	Not Participating	0.0	0.0
AF	Not Participating	0.0	0.0
AG	Not Participating	0.0	0.0
AH	Not Participating	0.0	0.0
AI	Not Participating	0.0	0.0
AJ	Not Participating	0.0	0.0
AK	Not Participating	0.0	0.0
AL	Not Participating	0.0	0.0
AM	Not Participating	0.0	0.0
AN	Not Participating	0.0	0.0
AO	Not Participating	0.0	0.0
AP	Not Participating	0.0	0.0
AQ	Not Participating	0.0	0.0
AR	Not Participating	0.0	0.0
AS	Not Participating	0.0	0.0
AT	Participating	5.1	1.2
AU	Participating	0.0	0.0
AV	Participating	0.0	0.0
AW	Participating	5.3	2.4
AX	Not Participating	45.0	16.1
AY	Participating	22.8	7.8
AZ	Participating	64.8	18.8
B	Not Participating	0.0	0.0
BA	Participating	76.7	20.0
BB	Not Participating	14.3	4.7
BC	Not Participating	15.6	3.3
BD	Not Participating	9.0	1.7
BE	Participating	0.0	0.0
BF	Not Participating	0.0	0.0
BG	Not Participating	0.0	0.0

BH	Not Participating	0.0	0.0
BI	Not Participating	0.0	0.0
BJ	Not Participating	0.0	0.0
BK	Not Participating	0.0	0.0
BL	Not Participating	0.0	0.0
BM	Not Participating	0.0	0.0
BN	Not Participating	23.5	6.7
BO	Participating	4.9	1.5
BP	Not Participating	0.0	0.0
BQ	Participating	47.7	17.6
BR	Not Participating	3.9	1.3
BS	Not Participating	0.0	0.0
BT	Not Participating	0.0	0.0
BU	Not Participating	0.0	0.0
BV	Participating	0.0	0.0
BW	Not Participating	17.9	5.7
BX	Not Participating	0.0	0.0
BY	Participating	31.1	9.2
BZ	Participating	10.9	3.2
C	Not Participating	0.0	0.0
CA	Not Participating	0.0	0.0
CB	Participating	2.2	0.4
CC	Not Participating	28.8	8.0
CD	Not Participating	0.0	0.0
CE	Not Participating	0.0	0.0
CF	Not Participating	0.0	0.0
CG	Participating	55.0	17.5
CH	Participating	58.3	21.2
CI	Not Participating	48.2	15.9
CJ	Participating	52.9	17.5
CK	Participating	38.2	12.7
CL	Participating	0.0	0.0
CM	Participating	8.1	1.8
CN	Not Participating	7.9	2.7
CO	Not Participating	50.2	17.3
CP	Participating	0.0	0.0
CQ	Participating	8.1	2.2
CR	Participating	61.1	20.4
CS	Participating	60.7	18.6

CT	Participating	25.1	8.8
CU	Participating	73.2	22.5
CV	Participating	63.5	19.7
CW	Not Participating	0.0	0.0
CX	Not Participating	0.0	0.0
CY	Not Participating	0.0	0.0
CZ	Participating	9.9	3.3
D	Not Participating	0.0	0.0
DA	Not Participating	24.6	8.4
DB	Not Participating	49.4	14.3
DC	Not Participating	25.9	6.9
DD	Not Participating	0.0	0.0
DE	Not Participating	76.7	21.9
DF	Participating	0.4	0.2
DG	Participating	5.4	1.8
DH	Participating	7.8	2.7
DI	Participating	13.0	5.5
DJ	Not Participating	0.0	0.0
DK	Not Participating	10.0	2.1
DL	Not Participating	9.5	2.0
DM	Not Participating	0.0	0.0
DN	Not Participating	9.5	3.3
DO	Participating	42.4	15.7
DP	Not Participating	0.0	0.0
DQ	Not Participating	0.0	0.0
DR	Not Participating	0.0	0.0
DS	Not Participating	0.0	0.0
DT	Not Participating	0.0	0.0
DU	Not Participating	0.0	0.0
DV	Not Participating	0.0	0.0
DW	Not Participating	0.0	0.0
DX	Not Participating	0.0	0.0
DY	Not Participating	0.0	0.0
DZ	Not Participating	0.0	0.0
E	Not Participating	0.0	0.0
EA	Not Participating	0.0	0.0
EB	Not Participating	0.0	0.0
EC	Not Participating	0.0	0.0
ED	Not Participating	0.0	0.0

EE	Not Participating	0.0	0.0
EF	Not Participating	0.0	0.0
EG	Not Participating	0.0	0.0
EH	Not Participating	8.1	2.0
EI	Not Participating	15.7	3.6
EJ	Not Participating	24.0	10.6
EK	Not Participating	12.4	4.2
EL	Not Participating	5.9	2.0
EM	Not Participating	0.0	0.0
EN	Not Participating	4.5	1.6
EO	Participating	0.0	0.0
EP	Not Participating	32.5	11.4
EQ	Not Participating	0.0	0.0
ER	Not Participating	0.0	0.0
ES	Participating	3.8	1.2
ET	Not Participating	0.0	0.0
EU	Participating	33.0	11.0
EV	Participating	81.7	29.4
EW	Not Participating	0.0	0.0
EX	Not Participating	0.0	0.0
EY	Not Participating	0.0	0.0
EZ	Not Participating	0.0	0.0
F	Not Participating	0.0	0.0
FA	Not Participating	0.0	0.0
FB	Not Participating	0.0	0.0
FC	Not Participating	0.0	0.0
FD	Not Participating	40.5	12.0
FE	Not Participating	0.0	0.0
FF	Not Participating	0.0	0.0
FG	Not Participating	0.0	0.0
FH	Participating	0.0	0.0
FI	Not Participating	0.0	0.0
FJ	Not Participating	0.0	0.0
FK	Not Participating	0.0	0.0
FL	Not Participating	0.0	0.0
FM	Not Participating	0.0	0.0
FN	Not Participating	0.0	0.0
FO	Not Participating	0.0	0.0
FP	Not Participating	0.0	0.0

FQ	Not Participating	0.0	0.0
FR	Not Participating	0.0	0.0
FS	Not Participating	0.0	0.0
FT	Not Participating	0.0	0.0
FU	Not Participating	0.0	0.0
FV	Not Participating	0.0	0.0
G	Not Participating	0.0	0.0
H	Not Participating	0.0	0.0
I	Not Participating	0.0	0.0
J	Not Participating	0.0	0.0
K	Not Participating	0.0	0.0
L	Not Participating	0.0	0.0
M	Not Participating	0.0	0.0
N	Not Participating	0.0	0.0
O	Not Participating	0.0	0.0
P	Not Participating	0.0	0.0
Q	Not Participating	0.0	0.0
R	Not Participating	0.0	0.0
S	Not Participating	0.0	0.0
T	Not Participating	0.0	0.0
U	Not Participating	0.0	0.0
V	Not Participating	0.0	0.0
W	Not Participating	0.0	0.0
X	Participating	5.1	1.6
Y	Not Participating	14.8	4.5
Z	Not Participating	0.0	0.0

Table 9 - WindPRO shadow flicker model results, Goldwind GW87

Receptor ID	Participating Status	Hours Per Year (Conservative Case)	Hours Per Year (Expected Case)
A	Not Participating	0.0	0.0
AA	Not Participating	82.2	28.0
AB	Participating	0.0	0.0
AC	Not Participating	11.6	3.7
AD	Not Participating	28.1	12.1
AE	Not Participating	0.0	0.0
AF	Not Participating	0.0	0.0
AG	Not Participating	0.0	0.0
AH	Not Participating	0.0	0.0
AI	Not Participating	0.0	0.0
AJ	Not Participating	0.0	0.0
AK	Not Participating	0.0	0.0
AL	Not Participating	0.0	0.0
AM	Not Participating	0.0	0.0
AN	Not Participating	0.0	0.0
AO	Not Participating	0.0	0.0
AP	Not Participating	0.0	0.0
AQ	Not Participating	0.0	0.0
AR	Not Participating	0.0	0.0
AS	Not Participating	23.2	10.0
AT	Participating	9.6	2.7
AU	Participating	44.8	12.5
AV	Participating	44.8	12.5
AW	Participating	0.0	0.0
AX	Not Participating	79.6	27.7
AY	Participating	39.4	14.1
AZ	Participating	53.6	16.0
B	Not Participating	0.0	0.0
BA	Participating	65.0	17.0
BB	Not Participating	14.3	4.7
BC	Not Participating	18.6	4.2
BD	Not Participating	9.0	1.8

BE	Participating	0.5	0.1
BF	Not Participating	0.0	0.0
BG	Not Participating	0.0	0.0
BH	Not Participating	0.0	0.0
BI	Not Participating	0.0	0.0
BJ	Not Participating	0.0	0.0
BK	Not Participating	0.0	0.0
BL	Not Participating	0.0	0.0
BM	Not Participating	0.0	0.0
BN	Not Participating	21.7	6.2
BO	Participating	4.9	1.5
BP	Not Participating	0.0	0.0
BQ	Participating	62.2	24.4
BR	Not Participating	3.5	1.2
BS	Not Participating	6.4	2.2
BT	Not Participating	0.0	0.0
BU	Not Participating	0.0	0.0
BV	Participating	0.0	0.0
BW	Not Participating	33.9	10.7
BX	Not Participating	0.0	0.0
BY	Participating	24.2	7.6
BZ	Participating	20.2	5.7
C	Not Participating	0.0	0.0
CA	Not Participating	0.0	0.0
CB	Participating	9.7	1.9
CC	Not Participating	26.0	7.1
CD	Not Participating	0.0	0.0
CE	Not Participating	0.0	0.0
CF	Not Participating	0.0	0.0
CG	Participating	44.2	14.0
CH	Participating	65.6	25.3
CI	Not Participating	70.5	24.1
CJ	Participating	61.1	19.9
CK	Participating	74.2	23.9
CL	Participating	0.0	0.0
CM	Participating	7.6	1.6
CN	Not Participating	21.7	7.4
CO	Not Participating	70.5	23.5
CP	Participating	2.3	0.4

CQ	Participating	7.5	2.1
CR	Participating	59.1	20.2
CS	Participating	73.0	22.3
CT	Participating	36.6	12.3
CU	Participating	74.6	22.8
CV	Participating	48.4	15.4
CW	Not Participating	0.0	0.0
CX	Not Participating	0.0	0.0
CY	Not Participating	0.0	0.0
CZ	Participating	4.1	1.3
D	Not Participating	0.0	0.0
DA	Not Participating	17.1	5.8
DB	Not Participating	111.3	28.5
DC	Not Participating	9.9	3.1
DD	Not Participating	11.4	4.1
DE	Not Participating	49.3	14.5
DF	Participating	11.5	2.8
DG	Participating	9.3	3.3
DH	Participating	7.0	2.4
DI	Participating	7.9	3.4
DJ	Not Participating	0.0	0.0
DK	Not Participating	11.0	2.3
DL	Not Participating	15.8	3.4
DM	Not Participating	0.0	0.0
DN	Not Participating	0.0	0.0
DO	Participating	2.3	1.0
DP	Not Participating	0.0	0.0
DQ	Not Participating	0.0	0.0
DR	Not Participating	0.0	0.0
DS	Not Participating	0.0	0.0
DT	Not Participating	0.0	0.0
DU	Not Participating	0.0	0.0
DV	Not Participating	0.0	0.0
DW	Not Participating	0.0	0.0
DX	Not Participating	0.0	0.0
DY	Not Participating	0.0	0.0
DZ	Not Participating	0.0	0.0
E	Not Participating	0.0	0.0
EA	Not Participating	0.0	0.0

EB	Not Participating	0.0	0.0
EC	Not Participating	0.0	0.0
ED	Not Participating	0.0	0.0
EE	Not Participating	0.0	0.0
EF	Not Participating	0.0	0.0
EG	Not Participating	0.0	0.0
EH	Not Participating	13.2	3.2
EI	Not Participating	21.1	5.2
EJ	Not Participating	60.3	19.9
EK	Not Participating	28.6	9.7
EL	Not Participating	16.9	5.9
EM	Not Participating	18.4	6.4
EN	Not Participating	20.0	6.9
EO	Participating	0.0	0.0
EP	Not Participating	20.3	6.9
EQ	Not Participating	0.0	0.0
ER	Not Participating	0.0	0.0
ES	Participating	0.0	0.0
ET	Not Participating	0.0	0.0
EU	Participating	35.6	13.1
EV	Participating	76.8	22.7
EW	Not Participating	0.0	0.0
EX	Not Participating	0.0	0.0
EY	Not Participating	0.0	0.0
EZ	Not Participating	0.0	0.0
F	Not Participating	0.0	0.0
FA	Not Participating	0.0	0.0
FB	Not Participating	0.0	0.0
FC	Not Participating	0.0	0.0
FD	Not Participating	65.4	19.5
FE	Not Participating	0.0	0.0
FF	Not Participating	0.0	0.0
FG	Not Participating	0.0	0.0
FH	Participating	7.0	1.8
FI	Not Participating	0.0	0.0
FJ	Not Participating	0.0	0.0
FK	Not Participating	0.0	0.0
FL	Not Participating	0.0	0.0
FM	Not Participating	0.0	0.0

FN	Not Participating	0.0	0.0
FO	Not Participating	0.0	0.0
FP	Not Participating	0.0	0.0
FQ	Not Participating	0.0	0.0
FR	Not Participating	0.0	0.0
FS	Not Participating	0.0	0.0
FT	Not Participating	0.0	0.0
FU	Not Participating	0.0	0.0
FV	Not Participating	0.0	0.0
G	Not Participating	0.0	0.0
H	Not Participating	0.0	0.0
I	Not Participating	0.0	0.0
J	Not Participating	0.0	0.0
K	Not Participating	0.0	0.0
L	Not Participating	0.0	0.0
M	Not Participating	9.0	2.4
N	Not Participating	0.0	0.0
O	Not Participating	0.0	0.0
P	Not Participating	0.0	0.0
Q	Not Participating	0.0	0.0
R	Not Participating	0.0	0.0
S	Not Participating	4.3	1.1
T	Not Participating	0.0	0.0
U	Not Participating	0.0	0.0
V	Not Participating	27.4	8.3
W	Not Participating	8.7	2.9
X	Participating	27.7	7.3
Y	Not Participating	25.6	7.4
Z	Not Participating	16.1	7.0

APPENDIX B – FIGURES

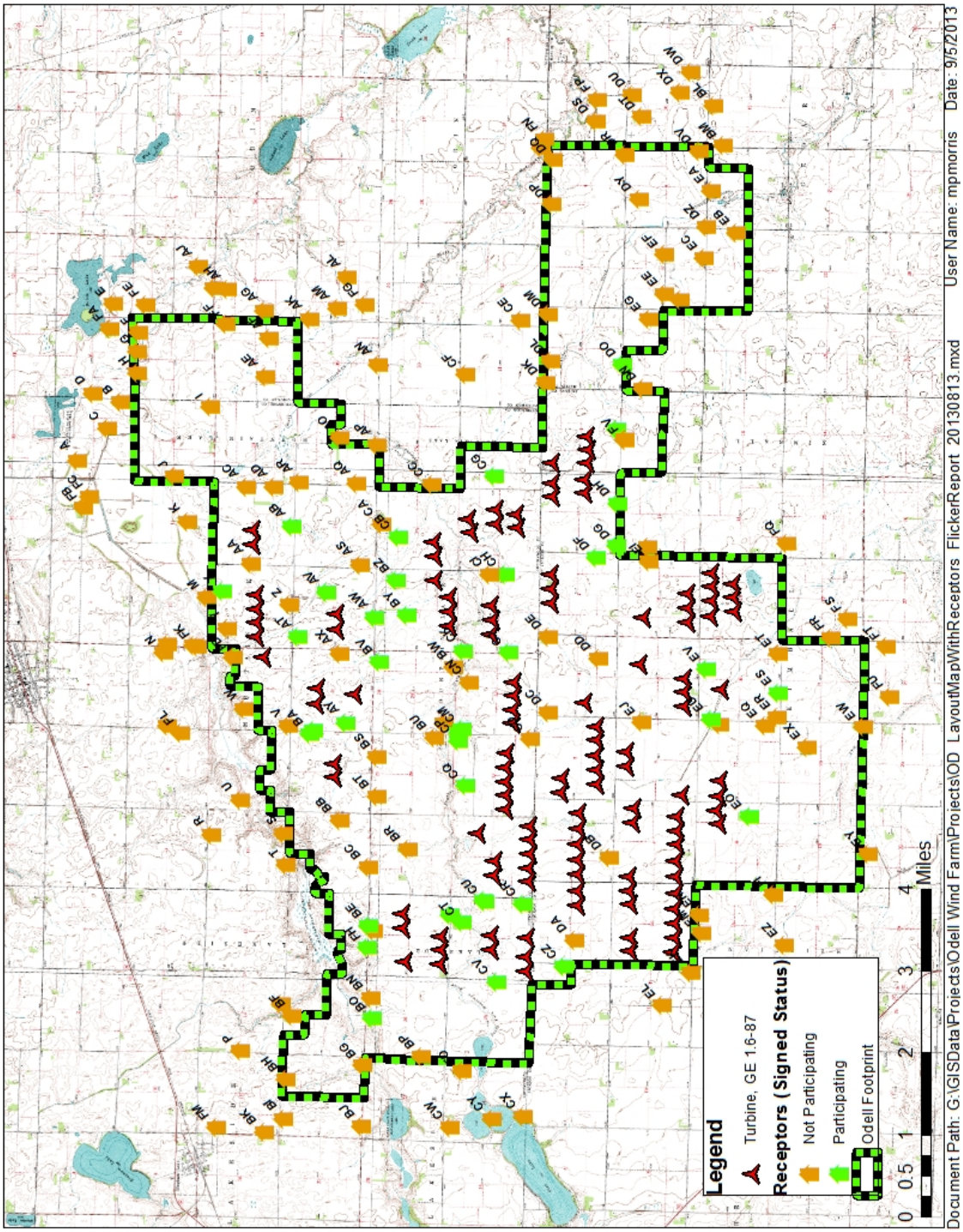


Figure 1 - Odell Wind Farm GE 1.6-87 layout with shadow flicker receptors

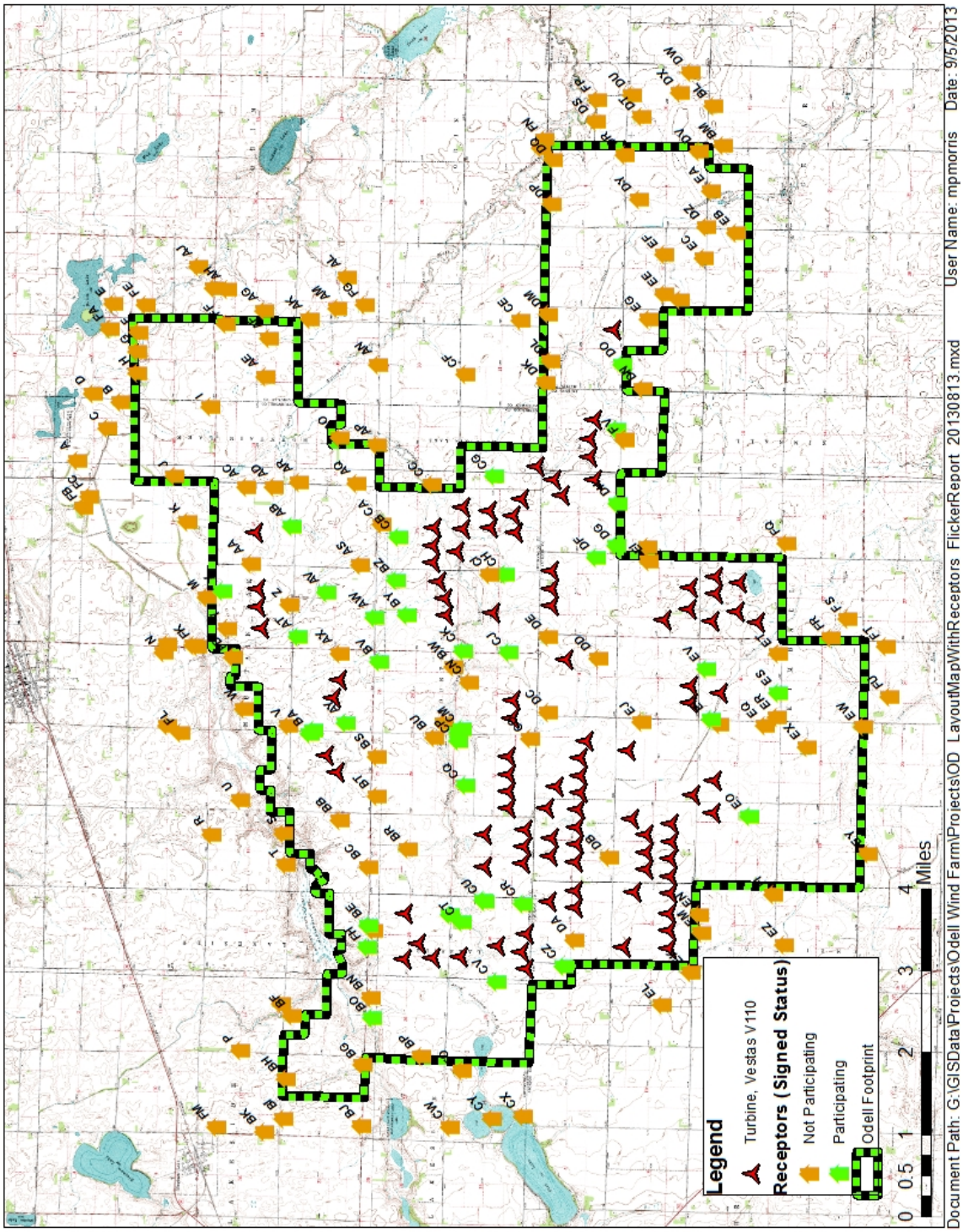


Figure 2 - Odell Wind Farm Vestas V110 turbine layout with shadow flicker receptors

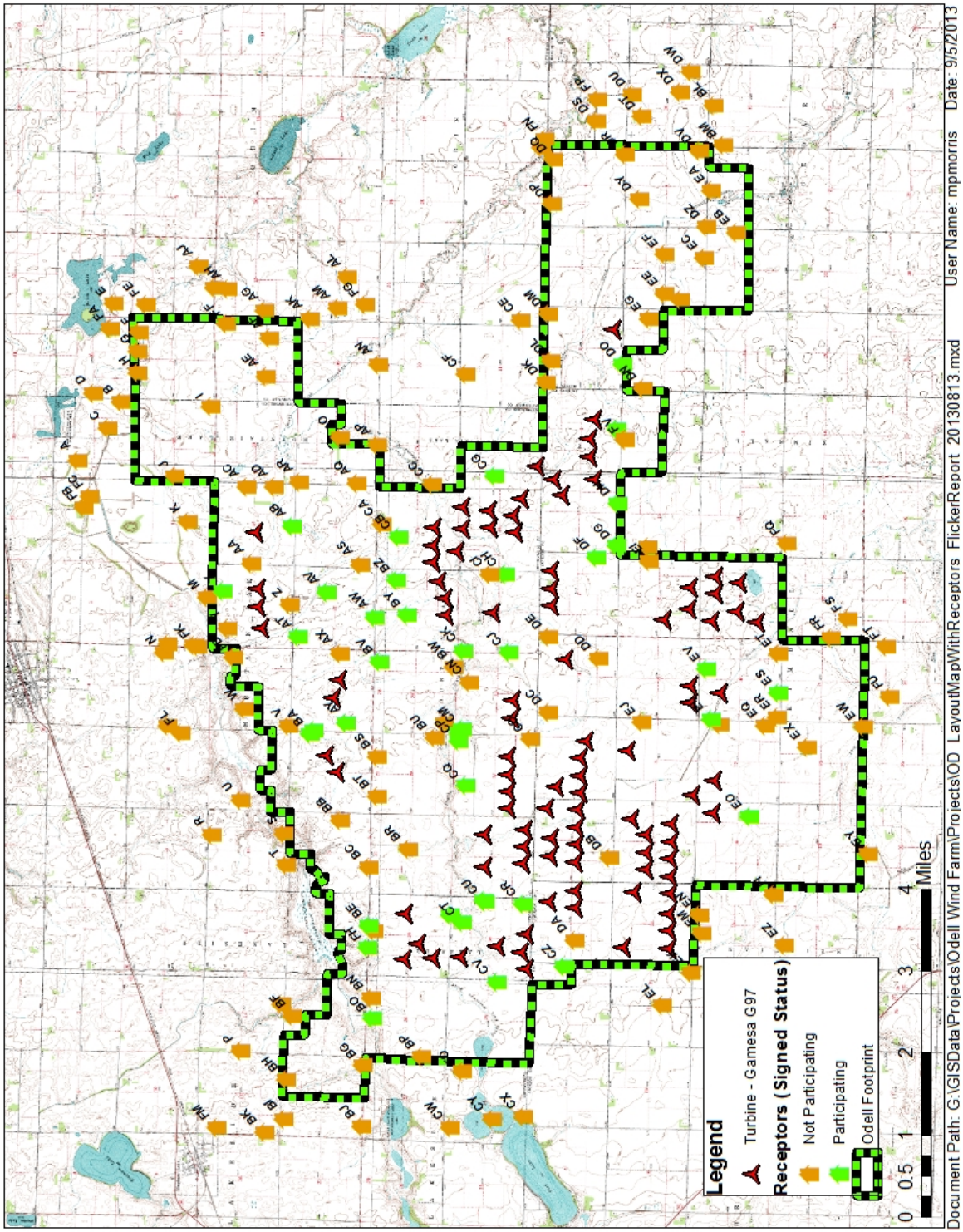


Figure 3 - Odell Wind Farm Gamesa G97 turbine layout with shadow flicker receptors

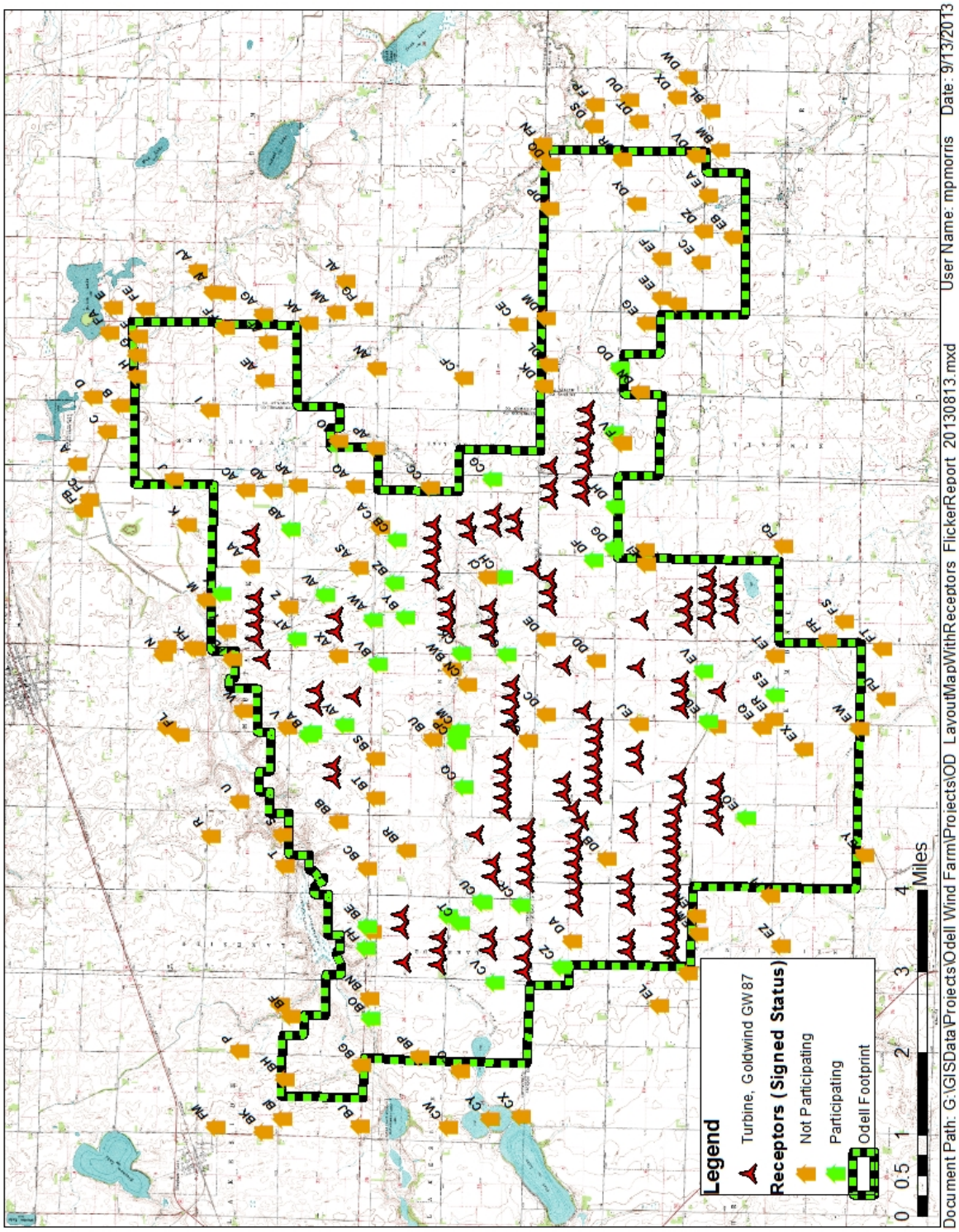


Figure 4 - Odell Wind Farm Goldwind GW87 turbine layout with shadow flicker receptors

APPENDIX C
Archaeological and Architectural Technical Memorandum

BLONDO CONSULTING LLC.
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June 29, 2013

Regarding Phase Ia Archaeological Assessment for Geronimo Wind's Proposed Odell Wind Farm Project, Cottonwood, Watonwan, Jackson, and Martin Counties, Minnesota

Project Overview

Blondo Consulting, LLC was retained to assess archaeological potential for the proposed Odell Wind Farm Project located in Cottonwood, Watonwan, Jackson, and Martin Counties, Minnesota. The proposed project includes construction of a 200 mw wind farm and approximately seven-mile 115 kV transmission line. The purpose of the assessment is to learn whether previously identified archaeological resources (including deposits or subsurface features) exist within the APE as part of environmental review.

Background Research

On June 12, 2013, a records search was completed by Steven Blondo at the Minnesota SHPO to identify previously recorded and reported archaeological and architectural sites within a half-mile of the project area. For a historic property (including archaeological sites) to be considered important within a cultural resource management they must meet a level of significance and retain historic integrity for *National Register of Historic Places* listing. No previously recorded archaeological and two architectural sites have been identified within the project area. Neither site has been evaluated for *National Register* eligibility. Within one-mile of the exterior project boundaries, six archaeological and five historic structures have been identified (Tables 1 and 2). One of these archaeological sites (21CO0001) is listed on the *National Register.* The remaining sites have not been evaluated for *National Register* eligibility. Many properties in the state have not been identified (due to lack of survey), and so an absence of properties in this report does not preclude their existence.

Table 1. Previously Identified Archaeological Sites					
Number	**Name**	**Description**	**Location**	**Relativity to Project Area**	***National Register* Eligibility**
21CO0001	Mountain Lake Site	Multicomponent Prehistoric Village Site	T105N R34W Section 2	outside project area	**LISTED on the *National Register***
21CO0002	Franz Site	Archaic Cache Site	T105N R34W Section 10	outside project area	unevaluated
21CO0050	T. Thompson Site	Fox Lake and Lake Benton Woodland Artifact Scatter	T105N R35W Section 34 Cottonwood County	outside project area	unevaluated
21JK0033		Woodland and Plains Village Artifact Scatter	T104N R34W Section 30 Jackson County	outside project area	unevaluated
21JK0035		Prehistoric Lithic Scatter	T104N R34W Section 30 Jackson County	outside project area	unevaluated
21JK0036		Prehistoric Artifact Scatter	T104N R34W Section 30 Jackson County	outside project area	unevaluated

Table 2. Previously Identified Standing Structures					
Number	**Name**	**Description**	**Location**	**Relativity to Project Area**	***National Register* Eligibility**
CO-MLT-002	Mountain Lake Mountain	"first settlement around Mt. Lake"	T105N R34W Section 10 Cottonwood County	outside project area	unevaluated
JK-CRS-8	Christiana Town Hall	stucco covered school house	T104N R35W Section 23 Jackson County	outside project area	unevaluated
JK-CRS-9	Bergen Store	rural general store	T104N R35W Section 25 Jackson County	outside project area	unevaluated
JK-CRS-10	House	"Bergen's most intact house of this age"	T104N R35W Section 25 Jackson County	outside project area	unevaluated
JK-KIM-1	Kimball Town Hall	school	T104N R34W Section 15 Jackson County	**within project area**	unevaluated
JK-KIM-2 to JK-KIM-6	Calvin Fett Farmstead	historic farm consisting of house, barn, granary, garage, and chicken shed	T104N R34W Section 20 Jackson County	**within project area**	unevaluated
MR-CED-2	Church	church	T104N R33W Section 20 Martin County	outside project area	unevaluated

Field Results

On June 13, 2013, Blondo Consulting conducted a preliminary windshield survey of the project area. Current field conditions were assessed. Most farmsteads in the area appear to be typical family farms, occasional buildings aged 50-years or older are present. Tilled agricultural fields are currently cultivated in corn and other commodity crops. Due to this year's wet and cool spring weather conditions, crop growth is experiencing a delayed start.

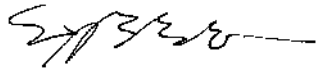
Predictive Modeling

The Project Area is located within the Prairie Lake archeological region (Anfinson 1990). In two articles Archaeological Regions of Minnesota" and "Archaeological Regions in Minnesota and the Woodland Period", Scott Anfinson defines archaeological regions within the state and models site locations within these regions. Within the Prairie Lake region, Anfinson states that "base camps should be located near woods, which were limited to water surrounded areas on major lakes or in major river valleys in much of the region" (1990:155). He goes on to describes site types within a variety of landforms and environments: (1) larger river valleys may be preferred winter locations; (2) temporary camps on lakes and streams; (3) resource procurement sites within upland settings; and (4) The Minnesota River was the main east-west transportation route in early historic times. There are few Middle Prehistoric sites within the region, with the majority of sites belonging to the Late Prehistoric period. A history of survey resulting in the identification of unrecorded sites evidences moderate to high potential for cultural resources within many parts of the project area.

Results and Recommendations

It is the recommendation of Blondo Consulting that a Phase I Cultural Resource Reconnaissance Survey be undertaken to identify previously unrecorded properties within the project area. This survey should follow Minnesota State Historic Preservation Office's guidelines for cultural resource survey and should include an assessment of both archaeological and historic architectural sites. Should properties be identified, evaluation should take place to determine if they are eligible for the *National Register of Historic Places*. Recommendations should be formulated in regards to eligible properties and project design to insure protection of significant cultural resources and completion of project.

Sincerely,



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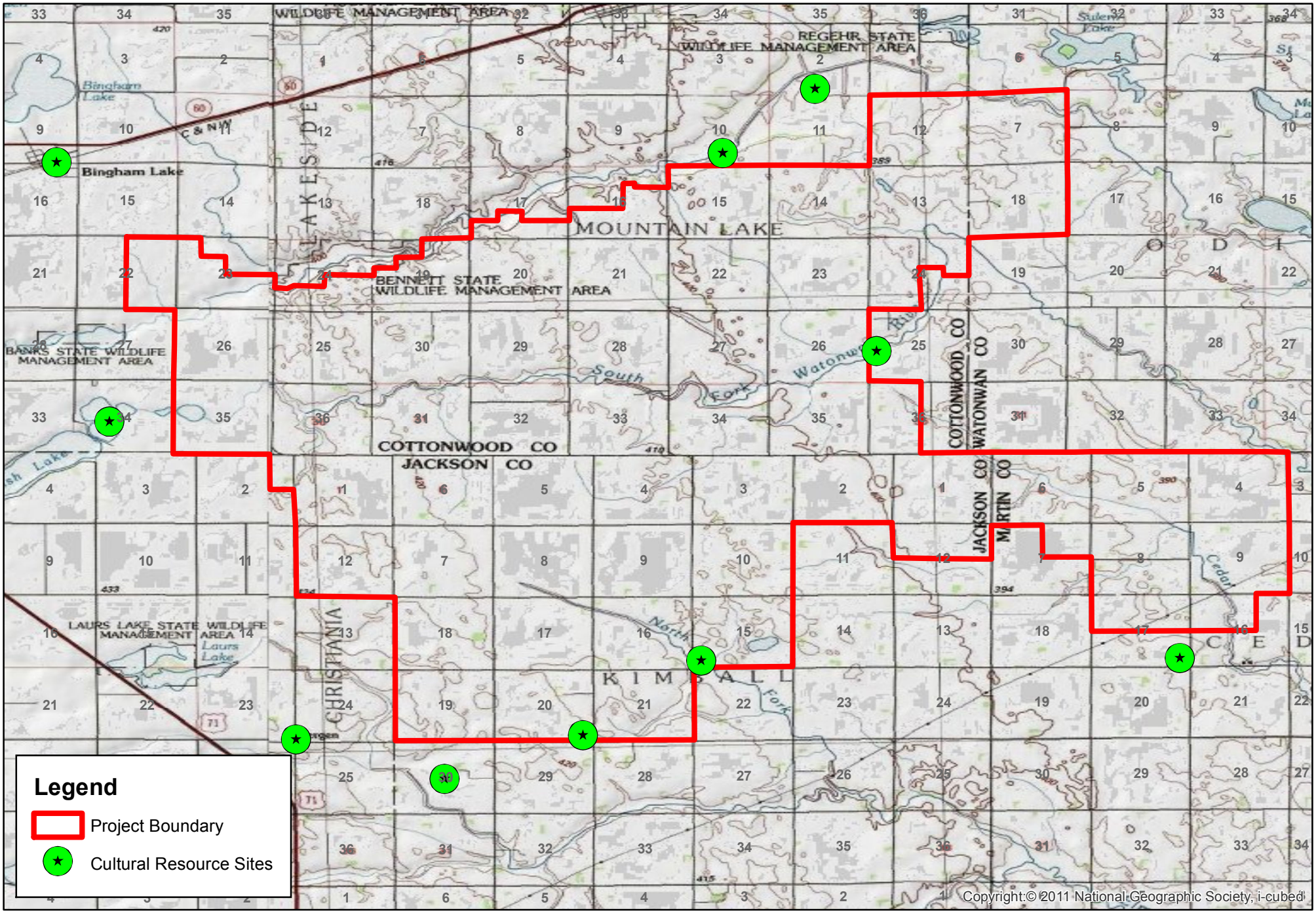

Odell Site - Archaeological Potential