REPORT

Wild Rose 2 Wind Power Project

Shadow Flicker Assessment

Submitted to:

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Distribution List

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1.0 INTRODUCTION

Wild Rose 2 Wind Inc. (Wild Rose 2) are owners of the approved but not yet constructed Wild Rose 2 Wind Power Project (the Approved Project), which will be located in Cypress County, Alberta, approximately 30 km southeast of Medicine Hat. The Alberta Utilities Commission decision on the Approved Project was issued in July 2024 (AUC 2024a). The Approved Project consists of 36 Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbines, each with a power rating of 5.2 megawatts (MW), a collector system, and an electrical substation consisting of one step-up transformer with a nominal power rating of 275 megavolt-amperes (MVA).

Wild Rose 2 is proposing to permit two new wind turbines. The two wind turbines will hereafter be referred to as the Project. The Project will make use of Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbines, identical to the units used in the Approved Project.

Power generating facilities in Alberta are regulated by the AUC through Rule 007 (AUC 2024b). Rule 007 requires preparation of a shadow flicker assessment for the Project. According to Rule 007, the shadow flicker assessment must: *"…predict the extent of shadow flicker at receptors [occupied dwellings] within 1.5 kilometres from the centre point of each turbine where the potential for shadow flicker is possible"* (AUC 2024b).

Wild Rose 2 retained WSP Canada Inc. (WSP) to prepare a shadow flicker assessment for the Project, in accordance with Rule 007. The results of WSP's shadow flicker assessment are presented in this report. This report is structured as follows:

- Section 1 provides a brief introduction.
- Section 2 presents a description of the wind turbines associated with the Approved Project and the Project.
- Section 3 outlines the assessment approach, including a description of:
  - assessment cases
  - shadow flicker receptors
  - assessment criteria
  - shadow flicker modelling methods
- Section 4 provides results for each assessment case.
- Section 5 summarizes and discusses the results of the shadow flicker assessment.

2.0 PROJECT DESCRIPTION

The Approved Project will consist of 36 Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbines, along with a collector system and substation. The Project will consist of two Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbines, identical to the wind turbines associated with the Approved Project. The Approved Project wind turbines and Project wind turbines will consist of three-blade rotors and tubular towers. All wind turbines will have a hub height of 95.5 m and a rotor diameter of 145 m.

Table 1 presents the locations of the Approved Project wind turbines. Table 2 presents the locations of the Project wind turbines. A map showing the locations of the Approved Project and Project wind turbines is presented in Section 3.2 of this report (see Figure 1).

Table 1: Location of Approved Project Wind Turbines

Turbine Identification Code[(a)]	Description	Universal Transverse Mercator Coordinates[(b)] (Zone 12)	
		Easting (m)	Northing (m)
A05	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536429	5511941
A07	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536041	5516840
A09	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	533831	5518370
T01	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	527899	5519590
T02	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	528000	5519087
T03	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	527991	5518649
T04	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	531182	5520833
T05	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	531474	5520144
T06	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	532168	5519290
T07	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	532315	5518843
T12	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	532098	5516799
T13	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	532453	5516414
T15	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	533583	5517116
T16	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	533808	5516737
T17	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	534395	5516405
T18	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	534896	5516156
T19	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	535510	5515878
T20	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	534494	5517964
T21	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	534913	5517550
T22	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	535503	5517270
T23	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	530508	5513883
T24	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536398	5515188
T25	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536468	5514686
T26	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536598	5513725
T27	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536614	5513253
T28	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	537273	5513183
T29	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	535551	5513016
T30	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536197	5512433
T31	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	537348	5512184
T32	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	535463	5512398
T33	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	535409	5511832
T34	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	530743	5513437
T35	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	537076	5511169
T36	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	537358	5510726
T37	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	536875	5510002
T38	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	537171	5509679

(a) Turbine identification codes are consistent with supplemental shadow flicker study filed with the AUC as part of the regulatory process for the Approved Project (WSP 2023).

(b) Turbine locations taken from supplemental shadow flicker study filed with the AUC as part of the regulatory process for the Approved Project (WSP 2023).

Table 2: Location of Project Wind Turbines

Turbine Identification Code	Description	Universal Transverse Mercator Coordinates (Zone 12)	
		Easting (m)	Northing (m)
T10	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	531156	5516351
T11	Siemens Gamesa Renewable Energy SGRE 5.2-145 wind turbine	531510	5515837

3.0 ASSESSMENT APPROACH

3.1 Assessment Cases

Shadow flicker occurs when the turning rotor of a wind turbine is located between the sun and a receptor point (e.g., an occupied dwelling). As the turbine blades alternately block sunlight and allow sunlight to shine through, the shadow at the receptor point may be observed to flicker under certain environmental conditions. For shadow flicker to occur, the sun must be shining, the sun must be low enough in the sky that the shadow of the wind turbine falls across the receptor point, the wind turbine must be active (i.e., the rotor must be turning), and the turbine rotor must be oriented such that the blades are not parallel to the line joining the sun and receptor point. The shadow flicker assessment for the Project considered two assessment cases, representing two different sets of environmental conditions.

Assessment Case A assumes the sun is always shining during daylight hours (i.e., there are no cloudy periods), all Approved Project and Project wind turbines are always active (i.e., rotors turning), and all Approved Project and Project wind turbines are always oriented with their rotors perpendicular to the line joining the sun and all receptor points. Assessment Case A is highly conservative (i.e., likely to overestimate potential shadow flicker effects) because the sun is not always shining, and wind turbines are not always active. In addition, the orientation of the Approved Project and Project wind turbines will change continuously based on wind direction, so turbine rotors are not always oriented perpendicular to the line joining the sun and receptor points.

Assessment Case B makes use of statistical weather data to reduce some of the conservatism inherent in Assessment Case A. In particular, Assessment Case B uses statistical weather data to estimate the probability of sunshine for each month of the year. In addition, Assessment Case B uses statistical weather data to estimate the probability of different wind directions, and hence turbine orientations. Even with the use of statistical weather data, Assessment Case B is still a conservative evaluation of potential shadow flicker effects because it assumes the Approved Project and Project wind turbines are always active (i.e., turbine rotors are always turning), which is not the case.

3.2 Receptors

Rule 007 requires that shadow flicker be predicted and assessed at receptors corresponding to occupied dwellings located within 1.5 km of the Project wind turbines (AUC 2024b). WSP established a Study Area for the shadow flicker assessment as a 1.5 km buffer on the Project wind turbines. All occupied dwellings within this study area were treated as shadow flicker receptors for the Project.

Potential receptors within the Study Area were identified using information presented in the Approved Project shadow flicker assessment (WSP Golder 2022), information presented in a supplemental shadow flicker study for the Approved Project (WSP 2023), and information gathered by Wild Rose 2 as part of their stakeholder consultation efforts. Two occupied dwellings were identified within 1.5 km of Project wind turbines and treated as receptors in the Project shadow flicker assessment. Based on direction from Wild Rose 2, the Little Plume Church was also treated as a receptor in the shadow flicker assessment. Please note the church is not a shadow flicker receptor based on the definition provided in Rule 007 (AUC 2024b). However, the Little Plume Church is located within 1.5 km of the Project and the potential for impacts to the church was one of the key topics discussed during the AUC hearing for the Approved Project (AUC 2024a).

When assessing potential shadow flicker effects, each receptor was assumed to be sensitive to shadow flicker in any direction. In other words, each receptor was assumed to have windows facing in all directions. This approach is often called greenhouse mode modelling. Greenhouse mode modelling is conservative since receptors may not actually have windows facing in all directions. In addition, trees, outbuildings, and other local structures can screen shadow flicker effects. These local shadow flicker screens were not considered when modelling receptors, which adds further conservatism to the shadow flicker assessment.

Table 3 presents locations for the three receptors considered in the Project shadow flicker assessment. For each receptor, Table 3 also identifies and provides the distance to the closest Project wind turbine. Figure 1 presents a map showing the locations of the Approved Project wind turbines, Project wind turbines, and shadow flicker receptors.

Table 3: Shadow Flicker Receptors

Receptor Identification Code[(a),(b)]	Receptor Description	Universal Transverse Mercator Coordinates (Zone 12)		Closest Project Wind Turbine	Distance to Closest Project Wind Turbine (m)
		Easting (m)	Northing (m)		
R26	occupied dwelling	532750	5515539	T11	1,275
R27	occupied dwelling	532807	5515430	T11	1,359
Church	Little Plume Church[(c)]	531077	5514769	T11	1,152

(a) Receptor identification codes are consistent with the Approved Project shadow flicker assessment (WSP Golder 2022) and the supplemental shadow flicker study for the Approved Project (WSP 2023).

(b) The Approved Project shadow flicker assessment included an additional receptor, R23, located within the Study Area for the Project shadow flicker assessment. WSP understands this structure has been purchased by Wild Rose 2 and will be used as an office once the Approved Project and Project commence operations. Therefore, R23 no longer qualifies as a shadow flicker receptor.

(c) The Little Plume Church is not an occupied dwelling and does not qualify as a shadow flicker receptor based on the definition provided in Rule 007 (AUC 2024b). Nevertheless, the Little Plume Church has been treated as a shadow flicker receptor based on direction from Wild Rose 2.

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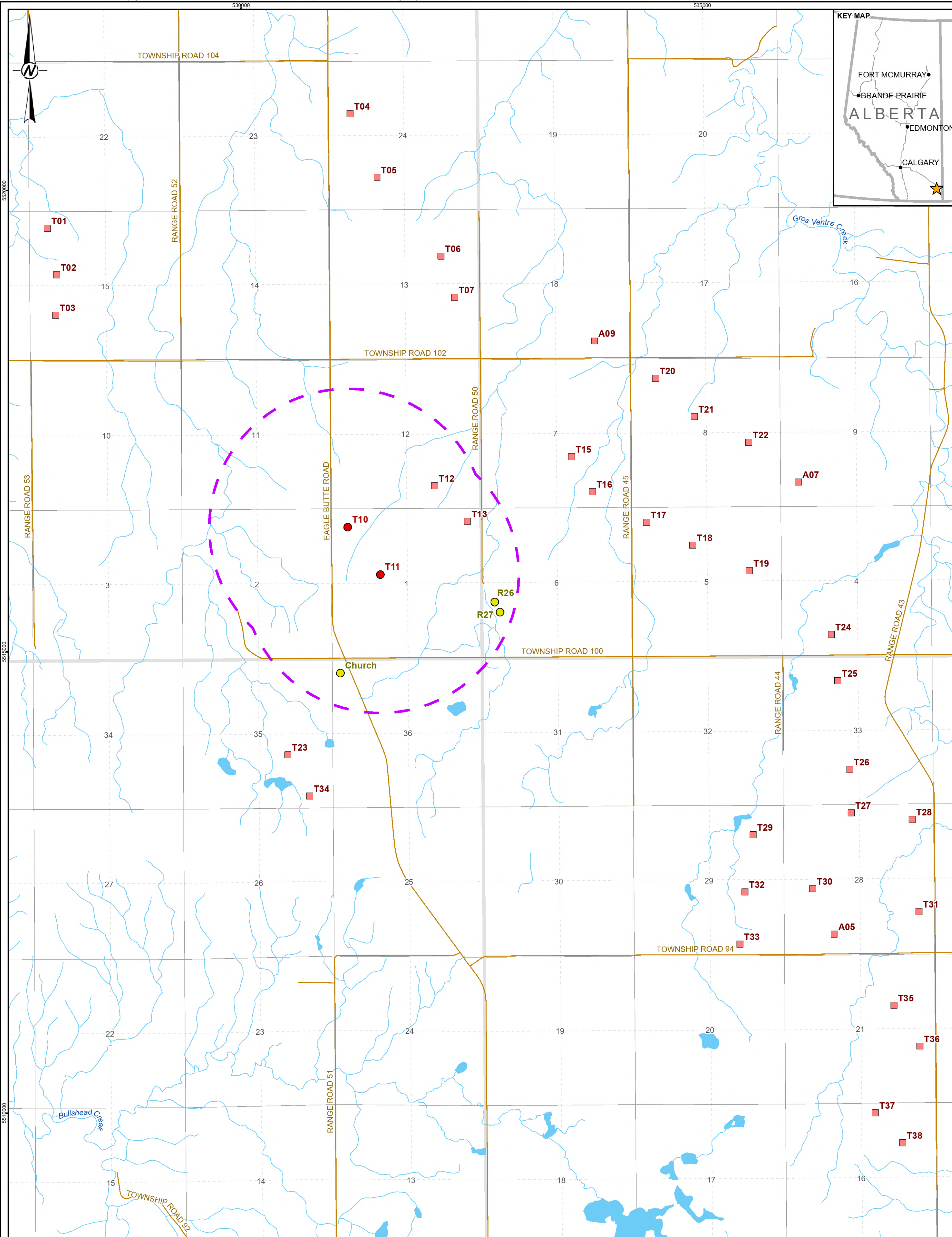

LEGEND

- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- APPROVED PROJECT WIND TURBINE
- PROJECT WIND TURBINE
- SHADOW FLICKER RECEPTOR
- STUDY AREA

0 1 2

1:40,000 KILOMETRES

REFERENCE(S)

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PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 12N

CLIENT

WILD ROSE 2 WIND INC.

PROJECT

WILD ROSE 2 WIND POWER PROJECT

TITLE

STUDY AREA

CONSULTANT

wsp

YYYY-MM-DD	2024-10-02
DESIGNED	VY
PREPARED	BS
REVIEWED	VY
APPROVED	AF

PROJECT NO.	CONTROL	REV.	FIGURE
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25mm

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3.3 Assessment Criteria

There are no federal or provincial guidelines or regulations that specify limits or criteria for assessing shadow flicker effects for wind power facilities in Alberta. In the absence of federal or provincial guidance, the shadow flicker assessment for the Project compared predicted shadow flicker to guidelines from Nova Scotia, which recommend that exposure to shadow flicker be limited to a maximum of 30 hours per year and a maximum of 30 minutes per day (Nova Scotia 2021).

3.4 Modelling Methods

Potential shadow flicker effects from the Approved Project and the Project were modelled using WindPro® v2.7, a commercial software tool developed and distributed by EMD International A/S. Separate shadow flicker models were developed for Assessment Case A and Assessment Case B.

Inputs to the WindPro® models for both assessment cases included the location, hub height, and rotor diameter for the Approved Project and Project wind turbines, location of shadow flicker receptors, and terrain elevation contours at 5 m intervals. Additional inputs to the WindPro® model for Assessment Case B included statistical data about monthly sunshine and annual wind direction in the Study Area.

Table 4 presents statistical sunshine data used in the WindPro® model for Assessment Case B. This statistical sunshine data was obtained from a meteorological station located in Suffield, Alberta. Table 5 presents statistical wind direction data used in the WindPro® model for Assessment Case B. This statistical wind direction data was obtained from Project meteorological towers.

Table 4: Statistical Sunshine Data Used to Model Assessment Case B

Month	Average Daily Sunshine (hours)
January	3.34
February	4.39
March	5.56
April	7.26
May	8.85
June	9.92
July	10.59
August	9.78
September	6.62
October	5.84
November	4.03
December	2.92

Table 5: Statistical Wind Direction Data Used to Model Assessment Case B

Wind Direction	Hours Per Year
north	379
north-northeast	313
east-northeast	377
east	377
east-southeast	287
south-southeast	636
south	1,065
south-southwest	1,313
west-southwest	1,571
west	1,150
west-northwest	720
north-northwest	572
Total	***8,760***

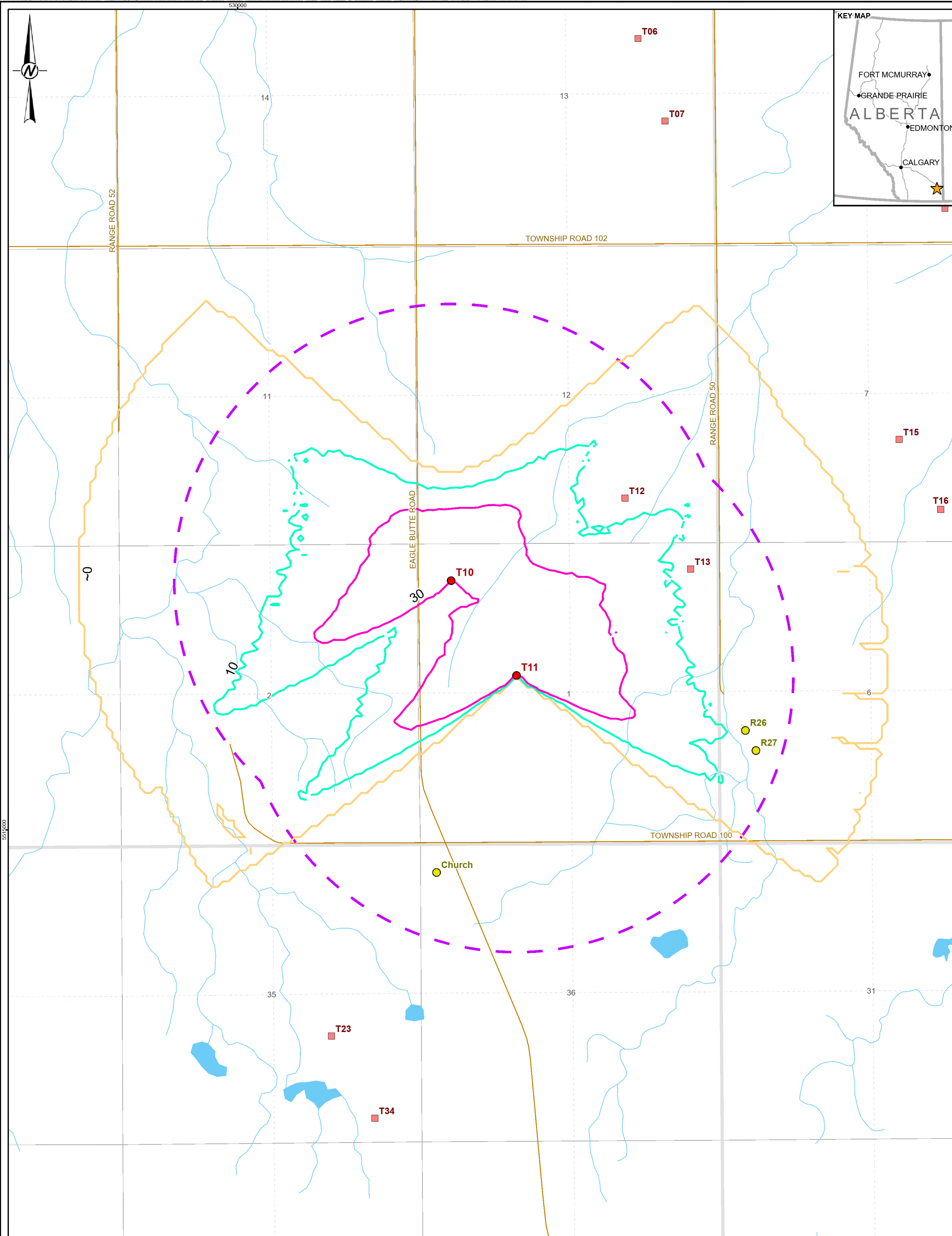
The WindPro® models predicted shadow flicker effects at each of the receptors listed in Table 3 based on the daily and yearly path of the sun through the sky at the Project latitude. In Assessment Case A, the WindPro® model assumed that the sun was always shining, the wind turbines were always active, and the turbine rotors were always oriented perpendicular to the line joining the sun and each receptor. In Assessment Case B, the WindPro® model adjusted the predictions to account for statistical monthly sunshine data and to account for turbine orientation based on statistical wind direction data. In both Assessment Case A and Assessment Case B, each receptor was modelled in greenhouse mode (i.e., sensitive to shadow flicker in every direction). Modelling for both Assessment Case A and Assessment Case B considered screening by terrain features (e.g., hills and valleys), but neither assessment case considered screening effects from trees, outbuildings, or other local structures.

4.0 RESULTS

Table 6 presents shadow flicker modelling results for the Approved Project and the Project, as well as combined results for both the Approved Project and Project. Shadow flicker results are presented for each of the receptors identified in Table 3. For Assessment Case A, results are presented in the form of total hours of shadow flicker per year, number of days per year with shadow flicker, and maximum minutes of shadow flicker on a single day. For Assessment Case B, results are presented in the form of total hours of shadow flicker per year. Note that daily results are not available for Assessment Case B because the modelling algorithm is based on monthly sunshine statistics and annual wind direction data. Figure 2 presents a contour map of modelling results in the form of total hours of shadow flicker per year for Assessment Case B. Please note that Figure 2 is focused on the Project in isolation from other sources of shadow flicker.

Table 6: Shadow Flicker Modelling Results

Receptor Identification Code	Approved Project Wind Turbines				Project Wind Turbines				Combined Approved Project and Project Wind Turbines			
	Case A			Case B	Case A			Case B	Case A			Case B
	Total Hours of Shadow Flicker Per Year	Number of Days Per Year with Shadow Flicker	Maximum Minutes of Shadow Flicker on a Single Day	Total Hours of Shadow Flicker Per Year	Total Hours of Shadow Flicker Per Year	Number of Days Per Year with Shadow Flicker	Maximum Minutes of Shadow Flicker on a Single Day	Total Hours of Shadow Flicker Per Year	Total Hours of Shadow Flicker Per Year	Number of Days Per Year with Shadow Flicker	Maximum Minutes of Shadow Flicker on a Single Day	Total Hours of Shadow Flicker Per Year
R26	3.18	28	10	1.32	19.85	81	27	7.13	23.03	81	27	8.47
R27	7.18	56	10	3.03	20.33	93	25	7.43	27.52	107	25	10.47
Church	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0	0	0.00



LEGEND

- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- PROJECT WIND TURBINE
- STUDY AREA

PREDICTED PROJECT SHADOW FLICKER [HOURS\YEAR]

- ~0
- 10
- 30

0 0.5 1

1:20,000 KILOMETRES

REFERENCE(S)
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PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 12N

CLIENT
WILD ROSE 2 WIND INC.

PROJECT
WILD ROSE 2 WIND POWER PROJECT

TITLE
PROJECT SHADOW FLICKER; STATISTICAL SUNSHINE AND WIND DIRECTION

CONSULTANT

wsp

YYYY-MM-DD	2024-10-02
DESIGNED	VY
PREPARED	BS
REVIEWED	VY
APPROVED	AF

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The results presented in Table 6 indicate that receptor R26 and R27 may experience some shadow flicker from the Approved Project and the Project. In contrast, the Little Plume Church is not expected to receive any shadow flicker from either the Approved Project or the Project.

In Assessment Case A, which assumes the sun is always shining and turbines are always operating with rotors perpendicular to the line joining the sun and receptor points, none of the receptors considered in the Project assessment is predicted to receive more than 30 hours of shadow flicker per year or more than 30 minutes of shadow flicker on a single day. The modelling assumptions used in Assessment Case A are unrealistic and highly conservative (i.e., tending to overestimate potential shadow flicker effects).

Assessment Case B predicts potential shadow flicker effects under more realistic, but still conservative, environmental conditions. Assessment Case B makes use of statistical sunshine data (rather than assuming the sun is always shining) and statistical wind direction data (rather than assuming turbine rotors are always perpendicular to the line joining the sun and receptor points). Assessment Case B is still a conservative treatment of potential shadow flicker effects since it assumes the Approved Project and Project wind turbines are always active (i.e., rotor always turning), assumes that receptors are sensitive to shadow flicker in every direction (i.e., greenhouse mode), and does not account for screening by trees, outbuildings, or other local structures. As indicated in Table 6, modelling for Assessment Case B predicts that no receptor will experience more than 30 hours of shadow flicker per year from the Approved Project and/or Project.

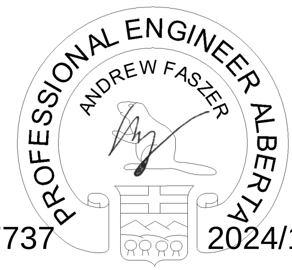
5.0 SUMMARY AND DISCUSSION

A shadow flicker assessment was completed for the Project. The shadow flicker assessment evaluated two conservative modelling scenarios: Assessment Case A and Assessment Case B. In accordance with Rule 007, the shadow flicker assessment considered potential effects at two occupied dwellings located within 1.5 km of the Project wind turbines. Based on direction from Wild Rose 2, the Little Plume Church was also treated as a receptor in the shadow flicker assessment.

Computer modelling predicts that none of the receptors considered in the Project assessment will receive more than 30 hours of shadow flicker per year or more than 30 minutes of shadow flicker on a single day, as recommended in Nova Scotia guidance (Nova Scotia 2021). Therefore, the present assessment demonstrates there is minimal potential for shadow flicker effects from the Project.

Signature Page

WSP Canada Inc.



67737 2024/10/02

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WSP CANADA INC.

RM SIGNATURE:

RM APEGA ID #: 67737

DATE: 2024/10/02

PERMIT NUMBER: P007641

The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

6.0 REFERENCES

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