



REPORT

Windy Ridge Wind Power Project
Shadow Flicker Assessment

Submitted to:

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Submitted by:

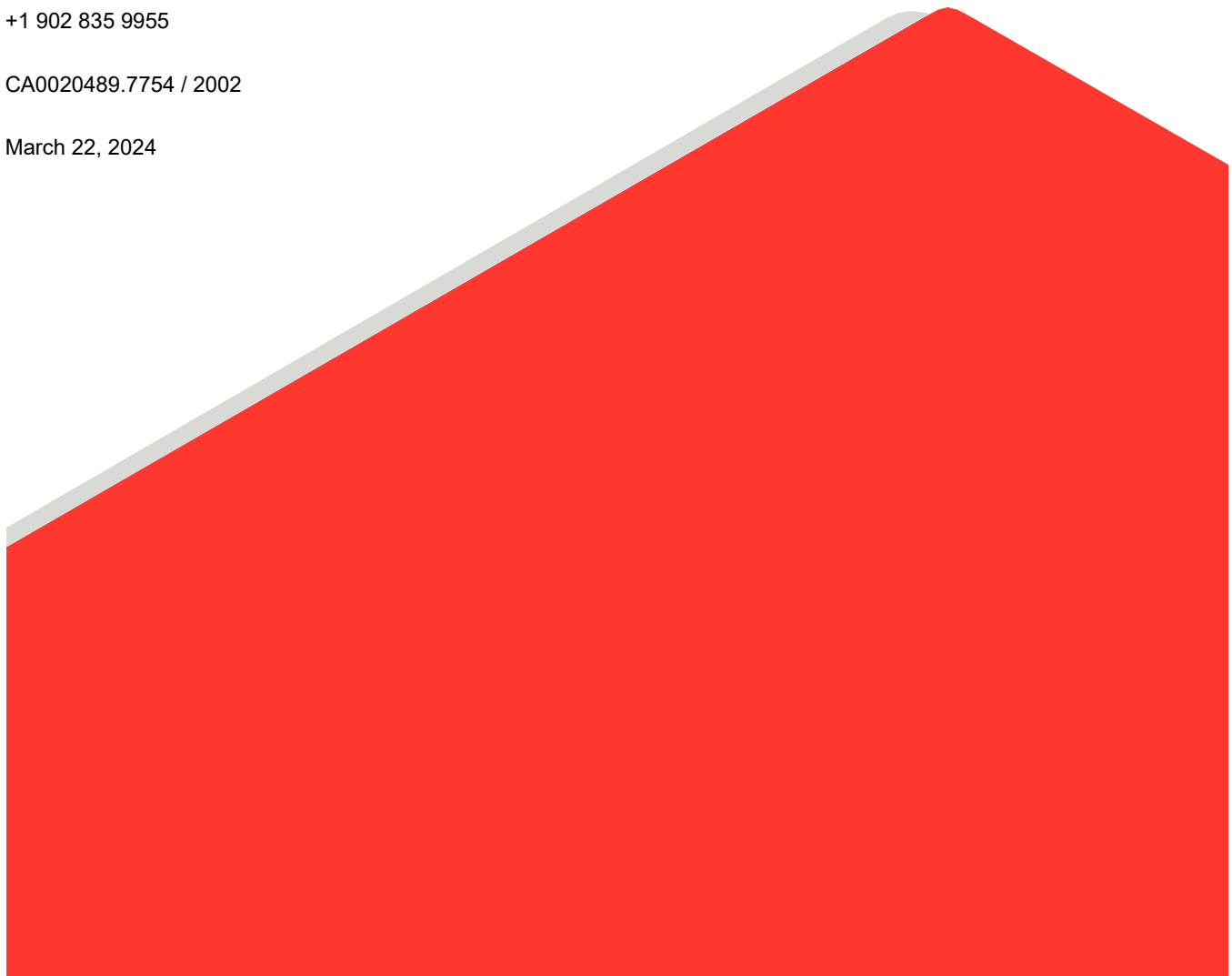
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1.0 INTRODUCTION

Windy Ridge Wind (Windy Ridge) is proposing development of the Windy Ridge Wind Power Project (the Project) in the Municipality of the County of Colchester (Colchester County). The Project will be located approximately 20 kilometres (km) northwest of the Town of Truro, Nova Scotia.

Provincial guidance for assessing potential environmental effects from wind power facilities in Nova Scotia is provided in the *Guide to Preparing an EA Registration Document for Wind Power Projects in Nova Scotia* (Nova Scotia 2021), which will hereafter be referred to as the EA Guide. The EA Guide requires preparation of a shadow flicker assessment, which must “...demonstrate through modelling that no receptor will receive 30 minutes or more per day and/or 30 hours or more per year of shadow flicker” (Nova Scotia 2021).

EverWind Fuels LLC, majority owner of Windy Ridge, retained WSP Canada Inc. (WSP) to prepare a shadow flicker assessment for the Project in accordance with the EA Guide. The results of the Project shadow flicker assessment are presented in this report.

The shadow flicker assessment report is structured as follows:

- Section 1.0 provides a brief introduction.
- Section 2.0 presents a description of the wind turbines proposed for the Project.
- Section 3.0 outlines the assessment approach, including:
 - assessment cases
 - shadow flicker receptors
 - assessment criteria
 - shadow flicker modelling methods
- Section 4.0 provides results for each assessment case.
- Section 5.0 summarizes and discusses the results of the shadow flicker assessment.

2.0 PROJECT DESCRIPTION

The Project will consist of 49 Nordex N163 7.0-megawatt (MW) wind turbines, along with a collector system and substation. The Project wind turbines will consist of three-blade rotors and tubular towers. The Project wind turbines will have a hub height of 118 metres (m) and a rotor diameter of 163 m.

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

Table 1: Location of Project Wind Turbines

Turbine Identification Code ^(a)	Description	Universal Transverse Mercator Coordinates [Zone 20]	
		Easting [m]	Northing [m]
T01	Nordex N163 7.0-MW wind turbine	462185	5049631
T02	Nordex N163 7.0-MW wind turbine	462324	5048848
T03	Nordex N163 7.0-MW wind turbine	462504	5048115
T04	Nordex N163 7.0-MW wind turbine	463175	5049112
T05	Nordex N163 7.0-MW wind turbine	463697	5048754
T06	Nordex N163 7.0-MW wind turbine	463716	5050480
T07	Nordex N163 7.0-MW wind turbine	464458	5050100
T08	Nordex N163 7.0-MW wind turbine	464817	5049502
T09	Nordex N163 7.0-MW wind turbine	465186	5048971
T14	Nordex N163 7.0-MW wind turbine	463270	5047629
T16	Nordex N163 7.0-MW wind turbine	464501	5047251
T17	Nordex N163 7.0-MW wind turbine	464413	5046308
T18	Nordex N163 7.0-MW wind turbine	463796	5045763
T20	Nordex N163 7.0-MW wind turbine	463614	5045047
T21	Nordex N163 7.0-MW wind turbine	464060	5044629
T28	Nordex N163 7.0-MW wind turbine	461400	5042101
T29	Nordex N163 7.0-MW wind turbine	461890	5042126
T30	Nordex N163 7.0-MW wind turbine	462166	5041722
T31	Nordex N163 7.0-MW wind turbine	462556	5041401
T32	Nordex N163 7.0-MW wind turbine	463369	5041376
T33	Nordex N163 7.0-MW wind turbine	463950	5040934
T34	Nordex N163 7.0-MW wind turbine	462259	5043336
T35	Nordex N163 7.0-MW wind turbine	462946	5042563
T37	Nordex N163 7.0-MW wind turbine	463094	5044285
T38	Nordex N163 7.0-MW wind turbine	463493	5043499
T39	Nordex N163 7.0-MW wind turbine	464052	5042775
T40	Nordex N163 7.0-MW wind turbine	459968	5038532
T41	Nordex N163 7.0-MW wind turbine	460585	5039108
T42	Nordex N163 7.0-MW wind turbine	462433	5039240
T43	Nordex N163 7.0-MW wind turbine	463940	5039010
T44	Nordex N163 7.0-MW wind turbine	464596	5039103
T45	Nordex N163 7.0-MW wind turbine	466105	5044229
T46	Nordex N163 7.0-MW wind turbine	466401	5044570
T47	Nordex N163 7.0-MW wind turbine	467250	5044807
T52	Nordex N163 7.0-MW wind turbine	467552	5040935
T53	Nordex N163 7.0-MW wind turbine	467988	5040234
T55	Nordex N163 7.0-MW wind turbine	468383	5042790
T56	Nordex N163 7.0-MW wind turbine	469026	5042254
T57	Nordex N163 7.0-MW wind turbine	469351	5041875

Table 1: Location of Project Wind Turbines

Turbine Identification Code ^(a)	Description	Universal Transverse Mercator Coordinates [Zone 20]	
		Easting [m]	Northing [m]
T58	Nordex N163 7.0-MW wind turbine	470101	5042750
T60	Nordex N163 7.0-MW wind turbine	470690	5044771
T61	Nordex N163 7.0-MW wind turbine	471543	5044896
T62	Nordex N163 7.0-MW wind turbine	472074	5044470
T63	Nordex N163 7.0-MW wind turbine	472358	5045374
T65	Nordex N163 7.0-MW wind turbine	474017	5044989
T67	Nordex N163 7.0-MW wind turbine	474746	5044985
T68	Nordex N163 7.0-MW wind turbine	474750	5044392
T69	Nordex N163 7.0-MW wind turbine	471955	5041251
T72	Nordex N163 7.0-MW wind turbine	473846	5041399

(a) Although there are 49 turbine locations in the Project, the turbine identification codes are not sequential because some locations were removed during the planning process.

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. As the turbine blades alternately block sunlight and allow sunlight to shine through, the shadow at the receptor 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, the wind turbine must be active (i.e., the rotor must be turning), and the rotor must be oriented such that the blades are not parallel to the line joining the sun and receptor. The shadow flicker assessment for the Project considered two assessment cases, which represent two different sets of environmental conditions.

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

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

3.2 Receptors

The EA Guide requires that potential shadow flicker effects be assessed at houses, cottages, camps, and other sensitive receptors (e.g., schools, campgrounds, hospitals) located within 2 km of the Project wind turbines (Nova Scotia 2021). WSP established a study area for the shadow flicker assessment as a 2 km buffer on the Project wind turbines. All receptors within this study area were considered in the Project shadow flicker assessment.

Potential shadow flicker receptors were initially identified using publicly available satellite imagery and information provided to WSP by Windy Ridge and their other consultants. In January 2024, WSP executed a field program that attempted to visit and verify potential shadow flicker receptors. A total of 14 shadow flicker receptors were identified within the study area. Another eight shadow flicker receptors were identified just outside the study area; these receptors were maintained in the assessment in the interest of fully capturing all potential shadow flicker effects.

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 2 presents locations for the 22 receptors considered in the Project shadow flicker assessment. For each receptor, Table 2 also identifies and provides the distance to the closest Project wind turbine. As noted above, some receptors are located slightly more than 2 km from the closest Project wind turbine (i.e., just beyond the 2 km study area). These receptors were maintained in the assessment in the interest of fully capturing all potential shadow flicker effects. Figure 1 presents a map showing the locations of the Project wind turbines and shadow flicker receptors.

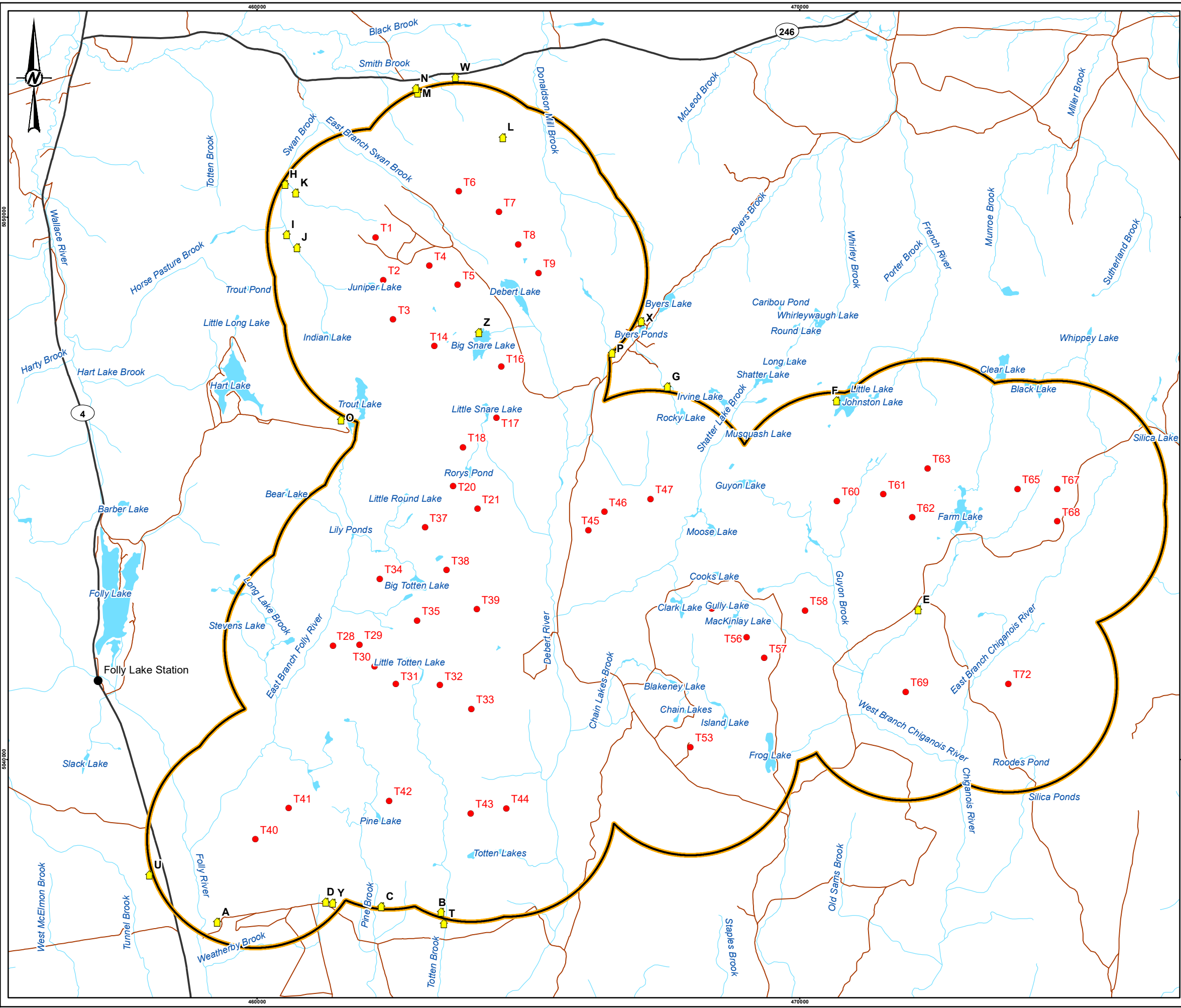
Table 2: Receptor Location and Distance to Turbines

Receptor Identification Code ^(a)	Universal Transverse Mercator Coordinates [Zone 20]		Closest Project Wind Turbine	Distance to Closest Project Wind Turbine [m]
	Easting [m]	Northing [m]		
A	459270	5037006	T40	1,678
B	463393	5037186	T43	1,904
C	462292	5037292	T42	1,953
D	461264	5037373	T40	1,739
E	472190	5042763	T69	1,530
F	470681	5046616	T60	1,845
G	467567	5046876	T47	2,093 ^(b)
H	460521	5050606	T01	1,929
I	460547	5049680	T01	1,639
J	460739	5049446	T01	1,458
K	460716	5050449	T01	1,681
L	464529	5051474	T06	1,284
M	462962	5052291	T06	1,962
N	462928	5052373	T06	2,050 ^(b)

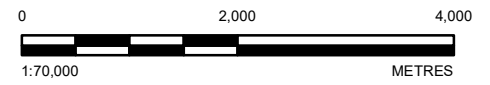
Table 2: Receptor Location and Distance to Turbines

Receptor Identification Code ^(a)	Universal Transverse Mercator Coordinates [Zone 20]		Closest Project Wind Turbine	Distance to Closest Project Wind Turbine [m]
	Easting [m]	Northing [m]		
O	461549	5046260	T03	2,086 ^(b)
P	466546	5047499	T09	2,004 ^(b)
T	463449	5036979	T43	2,090 ^(b)
U	458019	5037877	T40	2,056 ^(b)
W	463660	5052579	T06	2,100 ^(b)
X	467085	5048074	T09	2,100 ^(b)
Y	461393	5037358	T40	1,846
Z ^(c)	464092	5047877	T16	748

- (a) The receptor identification codes are not sequential because some locations were removed during the planning process.
- (b) This receptor is located more than 2 km from the nearest Project wind turbine but was maintained in the assessment in the interest of fully capturing all potential shadow flicker effects.
- (c) The owner of this camp has an agreement with Windy Ridge waiving the requirement to comply with shadow flicker limits.



- LEGEND**
- HIGHWAY
 - LOCAL ROAD
 - WATERCOURSE
 - WATERBODY
 - ▭ SHADOW FLICKER STUDY AREA
 - 📍 SHADOW FLICKER RECEPTOR
 - TURBINE LOCATION



REFERENCE(S)
 DIGITAL BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED
 DATUM: NAD83 PROJECTION: UTM ZONE 20

CLIENT
EVERWIND FUELS (EFW)

PROJECT
WINDY RIDGE WIND PROJECT

TITLE
STUDY AREA

CONSULTANT	YYYY-MM-DD	2024-03-22
DESIGNED	VY	
PREPARED	PT	
REVIEWED	VY	
APPROVED	TC	

PROJECT NO. CA0020489.7754 CONTROL 2002 REV. 2 FIGURE 1

PATH: I:\CLIENTS\BES Canada\CA0020489_7754\Mapping\Shadow Flicker\Rev2\CA0020489_7754_FWI_StudyArea_Rev2.mxd PRINTED ON: 2024-03-22 AT 9:39:04 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

It should be noted that the Kmntuk Wind Power Project (Kmntuk) is being proposed for development east of the Project, and the Higgins Mountain Wind Power Project (Higgins Mountain) is being proposed for development west of the Project. Windy Ridge provided WSP with the locations of proposed Kmntuk wind turbines, and WSP identified the locations of proposed Higgins Mountain wind turbines from the Nova Scotia Environment and Climate Change website. This information was used to support an assessment of potential cumulative shadow flicker effects. The smallest distance between a Kmntuk wind turbine and a shadow flicker receptor from Table 2 is more than 3 km. Similarly, the smallest distance between a Higgins Mountain wind turbine and a shadow flicker receptor from Table 2 is more than 3 km. At this distance, there is no potential for cumulative shadow flicker effects, and so the Kmntuk wind turbines and the Higgins Mountain wind turbines were not considered in the shadow flicker assessment for the Project.

3.3 Assessment Criteria

The EA Guide indicates that shadow flicker at receptors should not exceed a total of 30 hours per year and/or a maximum of 30 minutes on a single day (Nova Scotia 2021). Compliance with the first limit is best assessed in the context of the Expected-Case, which incorporates historical sunshine and wind direction data when estimating annual shadow flicker at each receptor. Compliance with the second limit is best assessed in the context of the Worst-Case which represents environmental conditions that would lead to maximum shadow flicker on a single day (i.e., full sunshine and favourable turbine orientation).

3.4 Modelling Methods

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

Inputs to the WindPro® models for both assessment cases included the location, hub height, and rotor diameter for the Project wind turbines, location of shadow flicker receptors, and terrain elevation data. Additional inputs to the WindPro® model for the Expected-Case assessment included historical data about monthly sunshine and annual wind direction.

Table 3 presents historical sunshine data used in the WindPro® model for the Expected-Case assessment. This historical sunshine data was obtained from a meteorological station in Charlottetown, Prince Edward Island. Table 4 presents historical wind direction data used in the WindPro® model for the Expected-Case assessment. This historical wind direction data was collected in the Project area and provided to WSP by Windy Ridge.

Table 3: Historical Sunshine Data Used to Model the Expected-Case

Month	Average Hours of Sunshine Per Day
January	3.37
February	4.18
March	4.42
April	5.04
May	6.34
June	7.54
July	7.95
August	7.19
September	5.76

Table 3: Historical Sunshine Data Used to Model the Expected-Case

Month	Average Hours of Sunshine Per Day
October	3.98
November	2.63
December	2.31

Table 4: Historical Wind Direction Data Used to Model the Expected-Case

Wind Direction	Hours Per Year
north	821
north-northeast	521
east-northeast	265
east	96
east-southeast	212
south-southeast	520
south	1,379
south-southwest	1,308
west-southwest	893
west	776
west-northwest	1,050
north-northwest	919
total	8,760

The WindPro® models predicted shadow flicker effects at each of the receptors listed in Table 2 based on the daily and yearly path of the sun through the sky at the Project latitude. In the Worst-Case assessment, the WindPro® model assumed the sun was always shining, the wind turbine generators were always active, and the turbine rotors were always oriented perpendicular to the line joining the sun and each receptor. In the Expected-Case assessment, the WindPro® model adjusted the predictions to account for historical monthly sunshine data (see Table 3) and to account for turbine orientation based on historical wind direction data (see Table 4). In both the Worst-Case and Expected-Case modelling, each receptor was modelled in greenhouse mode (i.e., sensitive to shadow flicker in every direction). Modelling both the Worst-Case and Expected-Case considered screening by terrain features (e.g., hills and valleys), but neither assessment case considered screening effects from trees, outbuildings, or other local structures.

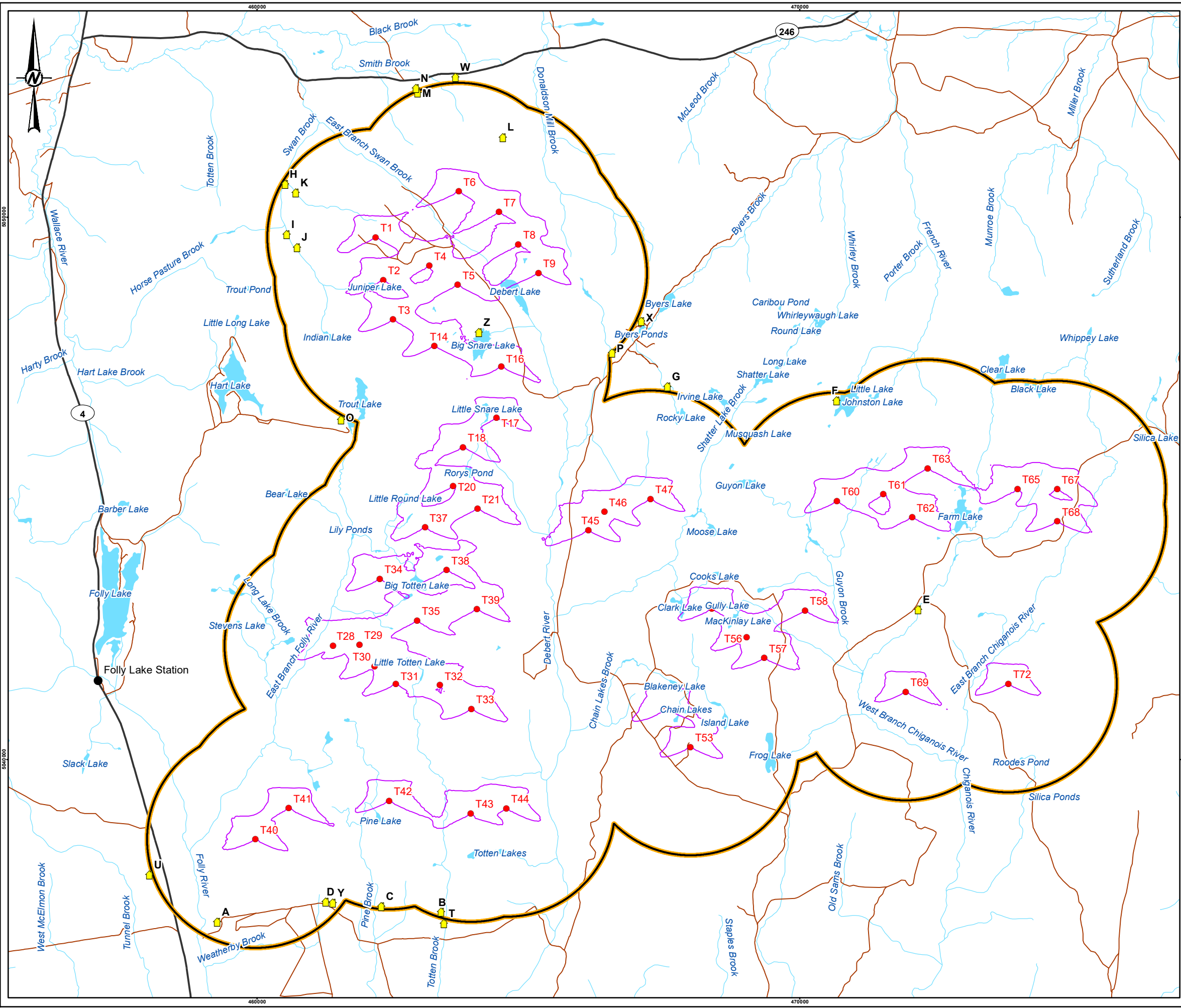
4.0 RESULTS

Table 5 presents shadow flicker modelling results for the Project. Shadow flicker results are presented for each of the receptors identified in Table 2. For the Worst-Case assessment, modelling results are presented in the form of total hours of shadow flicker per year and maximum minutes of shadow flicker on a single day. For the Expected-Case assessment, modelling results are presented in the form of total hours of shadow flicker per year. Note that daily results are not available for the Expected-Case assessment 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 per year for the Expected-Case, and Figure 3 presents a contour map of modelling results in the form of maximum minutes per day for the Worst-Case.

Table 5: Shadow Flicker Modelling Results for the Project

Receptor Identification Code	Worst-Case Assessment		Expected-Case Assessment
	Total Hours of Shadow Flicker Per Year	Maximum Minutes of Shadow Flicker on a Single Day	Total Hours of Shadow Flicker Per Year
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
E	0	0	0
F	0	0	0
G	0	0	0
H	8.20	20	1.82
I	16.22	23	3.80
J	21.58	26	5.08
K	10.28	23	2.35
L	0	0	0
M	0	0	0
N	0	0	0
O	0	0	0
P	0	0	0
T	0	0	0
U	0	0	0
W	0	0	0
X	0	0	0
Y	0	0	0
Z ^(a)	66.95	44	14.15

(a) The owner of this camp has an agreement with Windy Ridge waiving the requirement to comply with shadow flicker limits.

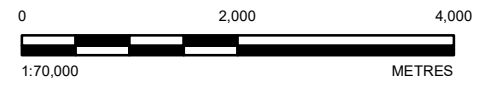


LEGEND

- HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- ▭ SHADOW FLICKER STUDY
- 📍 SHADOW FLICKER RECEPTOR
- TURBINE LOCATION

TOTAL HOURS OF SHADOW FLICKER PER YEAR

- 30 - PROVINCIAL LIMIT



REFERENCE(S)
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CLIENT
EVERWIND FUELS (EFW)

PROJECT
WINDY RIDGE WIND PROJECT

TITLE
TOTAL HOURS OF SHADOW FLICKER PER YEAR (EXPECTED-CASE)

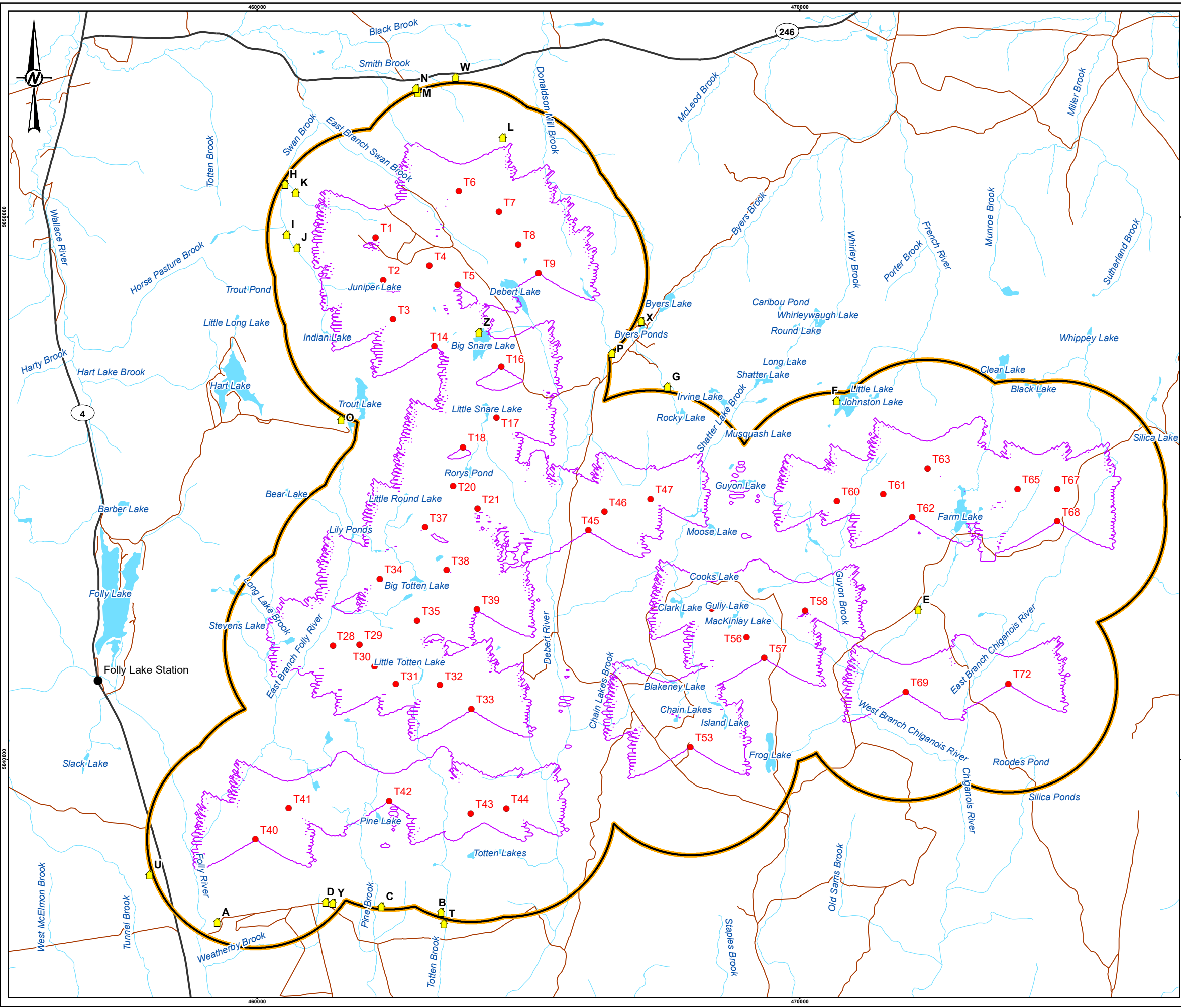
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	DESIGNED	VY
	PREPARED	PT
	REVIEWED	VY
	APPROVED	TC



PROJECT NO.	CONTROL	REV.	FIGURE
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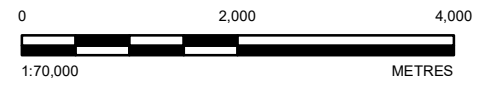


LEGEND

- HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- ▭ SHADOW FLICKER STUDY
- 🏠 SHADOW FLICKER RECEPTOR
- TURBINE LOCATION

MAXIMUM MINUTES OF SHADOW FLICKER ON A SINGLE DAY

- 30 - PROVINCIAL LIMIT



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 DATUM: NAD83 PROJECTION: UTM ZONE 20

CLIENT
EVERWIND FUELS (EFW)

PROJECT
WINDY RIDGE WIND PROJECT

TITLE
MAXIMUM MINUTES OF SHADOW FLICKER ON A SINGLE DAY (WORST-CASE)

CONSULTANT	YYYY-MM-DD	2024-03-22
	DESIGNED	VY
	PREPARED	PT
	REVIEWED	VY
	APPROVED	TC

PROJECT NO. CA0020489.7754 CONTROL 2002 REV. 2 FIGURE 3

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Table 6 compares total hours of shadow flicker per year predicted for the Expected-Case to the 30 hours per year shadow flicker limit from the EA Guide (Nova Scotia 2021). Table 6 also compares maximum minutes of shadow flicker on a single day predicted for the Worst-Case to the 30 minutes per day shadow flicker limit from the EA Guide (Nova Scotia 2021). Table 6 indicates that shadow flicker from the Project is predicted to comply with limits from the EA Guide at all receptors where these limits are applicable.

Table 6: Compliance Assessment

Receptor Identification Code	Total Hours Per Year of Shadow Flicker			Maximum Minutes of Shadow Flicker on a Single Day		
	Project Prediction (Expected-Case)	Limit from EA Guide	Assessment	Project Prediction (Worst-Case)	Limit from EA Guide	Assessment
A	0	30	Project is compliant	0	30	Project is compliant
B	0	30	Project is compliant	0	30	Project is compliant
C	0	30	Project is compliant	0	30	Project is compliant
D	0	30	Project is compliant	0	30	Project is compliant
E	0	30	Project is compliant	0	30	Project is compliant
F	0	30	Project is compliant	0	30	Project is compliant
G	0	30	Project is compliant	0	30	Project is compliant
H	1.82	30	Project is compliant	20	30	Project is compliant
I	3.80	30	Project is compliant	23	30	Project is compliant
J	5.08	30	Project is compliant	26	30	Project is compliant
K	2.35	30	Project is compliant	23	30	Project is compliant
L	0	30	Project is compliant	0	30	Project is compliant
M	0	30	Project is compliant	0	30	Project is compliant
N	0	30	Project is compliant	0	30	Project is compliant
O	0	30	Project is compliant	0	30	Project is compliant
P	0	30	Project is compliant	0	30	Project is compliant
T	0	30	Project is compliant	0	30	Project is compliant
U	0	30	Project is compliant	0	30	Project is compliant
W	0	30	Project is compliant	0	30	Project is compliant

Table 6: Compliance Assessment

Receptor Identification Code	Total Hours Per Year of Shadow Flicker			Maximum Minutes of Shadow Flicker on a Single Day		
	Project Prediction (Expected-Case)	Limit from EA Guide	Assessment	Project Prediction (Worst-Case)	Limit from EA Guide	Assessment
X	0	30	Project is compliant	0	30	Project is compliant
Y	0	30	Project is compliant	0	30	Project is compliant
Z	14.15	n/a ^(a)	n/a ^(a)	44	n/a ^(a)	n/a ^(a)

(a) The owner of this camp has an agreement with Windy Ridge waiving the requirement to comply with shadow flicker limits.

5.0 SUMMARY AND DISCUSSION

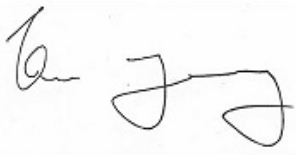
A shadow flicker assessment was completed for the Project in accordance with guidance set out in the EA Guide (Nova Scotia 2021). The shadow flicker assessment considered potential effects to 22 receptors located within approximately 2 km of the Project. Compliance with the EA Guide was assessed by comparing predicted Project shadow flicker levels to a limit of 30 hours per year and 30 minutes per day.

The shadow flicker assessment evaluated two conservative modelling scenarios: Worst-Case and Expected-Case. The Worst-Case assessment assumed the sun is always shining during daylight hours (i.e., no cloudy periods), all Project wind turbines are always active (i.e., rotors always turning), and all Project wind turbines are always oriented with their rotors perpendicular to the line joining the sun and all receptors. The Expected-Case assessment used historical weather data to estimate the probability of sunshine for each month of the year and to estimate the probability of different wind directions (and hence turbine orientations). Both assessment cases assumed that receptors are sensitive to shadow flicker in every direction (i.e., greenhouse mode) and neither assessment case accounted for screening of shadow flicker by vegetation, outbuildings, or other structures.

The shadow flicker assessment concluded the Project will comply with both the 30 hours per year limit and the 30 minutes per day limit from the EA Guide (Nova Scotia 2021) at all receptors where these limits are applicable. As such, the Project will not result in unacceptable shadow flicker effects. In addition, the shadow flicker assessment found no potential for cumulative effects from the Kmtnuk Wind Power Project, which is being proposed for development east of the Project, or from the Higgins Mountain Wind Power Project, which is being proposed for development west of the Project.

Signature Page

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[https://wsponlinecan.sharepoint.com/sites/ca-ca00204897754/shared documents/05. technical/noise and shadow - windy ridge/shadow flicker report/rev2 - 20 march 2024/ca0020489.7754_2002 windyridge sfassessment_22march2024.docx](https://wsponlinecan.sharepoint.com/sites/ca-ca00204897754/shared%20documents/05.%20technical/noise%20and%20shadow%20-%20windy%20ridge/shadow%20flicker%20report/rev2%20-%2020%20march%202024/ca0020489.7754_2002%20windyridge%20sfassessment_22march2024.docx)

6.0 REFERENCES

Nova Scotia (Nova Scotia Policy Division Environmental Assessment Branch). 2021. Guide to Preparing an EA Registration Document for Wind Power Projects in Nova Scotia.

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