SHADOW FLICKER ANALYSIS – PORTER TOWNSHIP

Meridian Wind Park

B&V PROJECT NO. 198674

PREPARED FOR

DTE Electric Company

12 FEBRUARY 2021

BLACK & VEATCH

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 Executive Summary

Porter Township Ordinance #249, Site Plan Review paragraph 3.b limits shadow flicker to no more than 20 hours per year at any occupied building. Per paragraph 3.a., occupied buildings include residences, schools, hospitals, churches, public libraries, and other occupied buildings.

Using modeling software that estimates shadow flicker using worst-case assumptions and historical sunshine data, it is estimated that over a typical year in Porter Township, 65 occupied buildings may experience 20 hours or more of shadow flicker each year prior to applying operational turbine controls, and 214 occupied buildings likely to experience less than 20 hours of shadow flicker, with 98 of these 214 occupied buildings predicted to experience no shadow flicker.

The extent to which shadow flicker may fall upon occupied buildings in excess of applicable limits will depend on whether existing vegetation and structures – which are not factored into the shadow flicker model – block the shadow cast by the turbine, and will also depend on future weather events. Where natural and man-made barriers to shadow flicker do not fully mitigate potential issues, additional mitigation measures, such as curtailment of turbine operations during defined periods, will be applied so that all wind turbines operate in compliance with township zoning requirements.

2.0 Introduction and Modeling

2.1 SHADOW FLICKER OVERVIEW

Like any tall structure, wind turbines can cast shadows in sunny conditions. As the wind turbine rotor turns, the blades can cast moving shadows, resulting in an effect known as shadow flicker. The strength of this effect depends greatly on distance and atmospheric conditions. Whether shadow flicker will fall on a property depends on the position of the sun and the yaw orientation of the turbine. Shadow flicker does not occur when the sun is obscured by clouds or fog at the turbine or receptor (an occupied building), or when turbines are not operating. Shadow flicker also does not occur when the receptor is shaded by other objects, including trees or buildings.

The distance between a wind turbine and a shadow flicker receptor affects the strength of the shadows cast at the receptor, and therefore the perceptibility of the flicker effect. Shadows cast near a turbine are more distinct, while those cast farther away tend to be significantly less distinct, with weaker effect. Shadow flicker effects are typically considered negligible at distances greater than 10 rotor diameters (up to approximately 4,462 feet, or 0.85 miles, in this case.)

This report examines the predicted extent of shadow flicker that may fall on occupied buildings in Porter Township within approximately one mile of the wind park boundary.

2.2 STUDY METHODOLOGY

WindFarmer is an industry-standard software program used to estimate potential shadow flicker effects on nearby receptors. The program calculates sun positions throughout the year and determines those positions relative to the wind turbines and any shadow receptors throughout a full year. The presence of shadow flicker at a given location and time is determined based on a line of sight calculation between the sun and the turbines, and the projection of the shadow from the turbine rotor to the receptor. The shadow flicker calculations include the effects of terrain on shadow projection and visibility.

The WindFarmer shadow model incorporates several very conservative assumptions that overestimate the number of hours that flicker may be visible, and tends to present what could be considered a "worst case" scenario. These assumptions include that the sky is always clear, the turbines are always operating and are always facing directly into the sun, creating maximum shadowed areas behind them. Under actual operating conditions, cloudy or hazy weather may reduce or eliminate the casting of defined shadows, buildings and trees may block the shadows, or turbines may be facing into oncoming wind in a manner that does not correspond to the position of the sun, and low wind or turbine maintenance periods may result in turbines idling during shading hours.

Inputs to the WindFarmer shadow flicker model include:

- All proposed wind turbine locations shown on the site plan submitted to Porter Township as part of DTE's special land use permit application, including primary

and alternate sites. The turbine layout is Revision 25, which is current as of February 8, 2021.

- The locations of all receptors – all buildings meeting the definition of an occupied building – within Porter Township. Receptors were identified based on review of aerial photography
- Elevation data from the USGS National Map at an approximately 10 meter (approximately 32.8 feet) resolution

As the results of the WindFarmer model represent a worst-case scenario, statistical post-processing of the raw results is required to produce realistic results for a typical operating year. The primary inputs to the statistical analysis are historical weather and cloud cover data for the region and estimated typical wind conditions for the project site based on measurements at two SODAR wind profiling units within the project area.

Historical monthly sunshine data for the project area based on 20 years of annual data from 1998 to 2017 was also obtained from the National Solar Radiation Database (NSRDB) (https://nsrdb.nrel.gov/). Average sunshine hours for each month as a percent of total possible sunshine hours for is shown in Table 2-1.

Table 2-1 Average Sunshine Hours from NSRDB (1998 to 2017)

MONTH	SUNSHINE PERCENTAGE[1]
January	32%
February	40%
March	50%
April	52%
May	54%
June	60%
July	65%
August	61%
September	62%
October	47%
November	40%
December	35%
Annual	**52%**

* Calculated as percentage of sunny hours from sunrise to sunset

On an annual basis, approximately 52 percent of available daylight hours are considered sunny hours, capable of casting shadows. In addition, as turbines will not operate continuously because of low winds and maintenance, and will not always be oriented directly between the sun and homes, it is estimated that actual shadow flicker effects will be significantly lower than the worst-case impacts forecast by the WindFarmer shadow model. Based on review of historical wind speed data and average sunshine hours, annual shadow flicker hours are estimated to be approximately 32 percent of the maximum "worst case" results calculated by the WindFarmer model for the Meridian Wind Park in a typical operating year.

Additionally, shadow flicker effects will typically be reduced by the presence of trees and awnings, which will also serve to reduce the actual perceived flicker impact hours, however these effects have not been incorporated into the results.

Figure 2-1 shows a representative annual 20-hour shadow flicker contour for a single wind turbine in Porter Township, after accounting for sunshine hours and other effects as summarized above. A consolidated map including cumulative effects from all wind turbines is included in Appendix C.

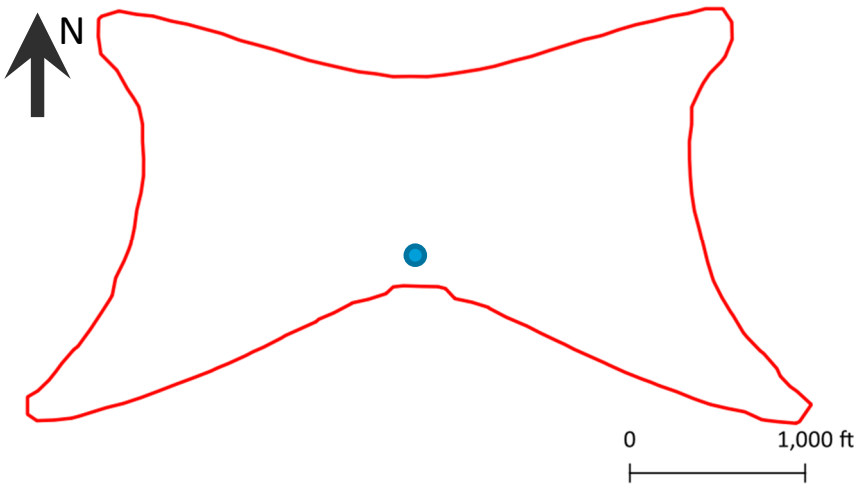


Figure 2-1. Typical 20-hour Shadow Flicker Contour

3.0 Study Results

Porter Township limits shadow flicker to no more than 20 hours per year at the nearest wall of an occupied building. Because of calculation setup constraints, most residences are represented in the study by the center point of the structure. An additional set of calculations is completed on a regular grid as the basis for creating contour lines for mapping purposes. Additional calculations were also performed at each wall of residences near the 20-hour target. Table 3-1 summarizes the expected shadow flicker effect by hours for occupied buildings located within Porter Township.

Table 3-1 Predicted Shadow Flicker Impact Summary*

HOURS PER YEAR	TOTAL STRUCTURES	PERCENTAGE
0	98	35.1%
0 to 10	71	25.4%
10 to 20	45	16.1%
Over 20	65	23.3%

* Estimated, not actual hours, without mitigating conditions (trees, buildings) or operational controls factored in.

The predicated shadow flicker for each occupied building examined as part of this study is provided in Appendix A. Where natural and man-made barriers to shadow flicker do not fully mitigate potential issues, additional mitigation measures, such as curtailment of turbine operations during defined periods, will be applied so that all wind turbines operate in compliance with township zoning requirements.

In total, it is estimated that over a typical year in Porter Township, 65 occupied buildings may experience 20 hours or more of shadow flicker each year, and 214 occupied buildings are likely to experience less than 20 hours of shadow flicker, with 98 of the 214 occupied buildings predicted to experience no shadow flicker.

Appendix A. Shadow Flicker Receptors

The table below summarizes the shadow flicker results by receptor, sorted by predicted impact in a typical year. Coordinates are NAD83 Michigan State Plane, South Zone, International Feet.

Table A-1 Shadow Flicker Receptors

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_543	13,106,532	719,974	20	73.2
SR_609	13,117,333	724,716	20	61.9
SR_876	13,117,142	730,663	20	61.2
SR_586	13,122,358	719,980	20	59.7
SR_548	13,106,857	719,653	20	57.3
SR_875	13,117,159	730,872	20	54.9
SR_844	13,117,369	730,687	20	54.1
SR_559	13,122,401	723,160	20	53.3
SR_879	13,117,365	730,871	20	53.0
SR_570	13,106,803	725,324	20	51.4
SR_263	13,101,513	725,296	20	50.7
SR_533	13,101,295	723,910	20	44.3
SR_1026	13,117,152	724,478	20	42.2
SR_560	13,117,131	722,575	20	40.3
SR_503	13,111,851	723,964	20	39.7
SR_1540	13,122,390	719,345	20	38.9
SR_613	13,106,767	725,970	20	38.7
SR_561	13,116,940	725,370	20	38.4
SR_264	13,106,554	721,958	20	37.0
SR_542	13,106,510	719,355	20	36.2
SR_611	13,113,813	726,883	20	35.3
SR_547	13,106,065	721,706	20	35.2
SR_333	13,122,402	719,219	20	34.9
SR_1541	13,122,139	719,286	20	33.8

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_511	13,111,840	718,427	20	33.2
SR_525	13,096,243	725,077	20	33.2
SR_519	13,118,143	721,884	20	32.9
SR_606	13,114,433	721,393	20	30.3
SR_874	13,115,927	732,174	20	30.1
SR_599	13,111,983	718,236	20	28.5
SR_558	13,117,861	721,898	20	28.3
SR_508	13,106,818	720,924	20	28.1
SR_580	13,096,043	721,746	20	27.5
SR_1539	13,112,007	718,177	20	27.3
SR_565	13,101,283	718,588	20	26.8
SR_574	13,096,059	721,956	20	26.7
SR_528	13,101,278	726,407	20	26.0
SR_882	13,111,885	730,573	20	25.7
SR_883	13,111,862	730,139	20	25.6
SR_585	13,117,379	721,665	20	25.1
SR_625	13,103,464	721,938	20	24.8
SR_1537	13,095,837	719,152	20	24.6
SR_1537	13,095,932	719,153	20	24.6
SR_509	13,106,777	718,659	20	24.5
SR_809	13,113,496	727,289	20	23.7
SR_878	13,122,412	730,237	20	23.5
SR_629	13,111,855	725,619	20	23.3
SR_566	13,096,169	718,674	20	22.2
SR_507	13,104,127	721,750	20	21.9
SR_531	13,096,434	721,993	20	21.9
SR_818	13,111,801	728,580	20	21.9
SR_801	13,122,372	731,278	20	21.5
SR_624	13,112,691	721,952	20	21.2
SR_1030	13,113,796	721,732	20	21.1

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_820	13,111,089	727,245	20	21.1
SR_610	13,117,126	726,331	20	21.0
SR_576	13,095,713	722,108	20	20.8
SR_1022	13,106,782	722,554	20	20.7
SR_582	13,119,130	721,689	20	20.7
SR_848	13,117,374	727,839	20	20.6
SR_526	13,096,274	725,430	20	20.6
SR_512	13,111,859	719,835	20	20.4
SR_845	13,117,387	732,180	20	20.3
SR_607	13,114,072	721,730	20	20.2
SR_1538	13,106,799	727,032	20	20.1
SR_847	13,117,374	727,664	20	19.8
SR_1524	13,102,158	727,288	20	18.8
SR_600	13,112,072	720,430	20	18.8
SR_881	13,111,879	731,607	20	18.7
SR_541	13,101,493	718,951	20	18.6
SR_628	13,113,904	721,922	20	18.6
SR_527	13,098,084	726,907	20	18.5
SR_513	13,111,822	720,930	20	18.5
SR_201	13,102,083	727,410	20	18.5
SR_517	13,117,349	726,171	20	18.5
SR_1021	13,117,330	725,837	20	18.3
SR_603	13,122,333	718,372	20	17.7
SR_819	13,116,857	732,227	20	17.5
SR_836	13,111,893	729,139	20	17.1
SR_564	13,096,192	718,491	20	17.0
SR_204	13,101,723	727,241	20	16.6
SR_627	13,112,181	719,582	20	16.4
SR_1023	13,101,331	721,918	20	16.0
SR_849	13,117,372	728,109	20	15.3

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_186	13,101,603	727,238	20	15.2
SR_614	13,111,308	721,941	20	15.0
SR_202	13,102,622	727,230	20	14.9
SR_505	13,096,206	721,260	20	14.9
SR_567	13,096,205	719,916	20	14.8
SR_630	13,091,397	721,734	20	14.8
SR_1019	13,101,738	720,027	20	14.5
SR_545	13,101,551	721,360	20	14.3
SR_579	13,096,024	720,458	20	13.9
SR_544	13,101,543	720,584	20	13.9
SR_501	13,102,980	727,041	20	13.4
SR_593	13,122,361	718,748	20	13.2
SR_870	13,106,843	727,204	20	12.8
SR_601	13,116,770	721,691	20	12.3
SR_546	13,102,681	721,687	20	11.9
SR_826	13,107,025	728,103	20	11.7
SR_523	13,106,777	723,397	20	11.6
SR_206	13,106,568	727,380	20	11.5
SR_530	13,101,136	721,967	20	11.4
SR_602	13,116,677	721,698	20	10.7
SR_872	13,106,914	728,689	20	10.5
SR_518	13,122,413	726,388	20	10.2
SR_520	13,120,813	721,886	20	10.2
SR_808	13,122,391	727,150	20	10.1
SR_884	13,106,764	728,522	20	10.1
SR_504	13,096,267	726,003	20	10.1
SR_621	13,092,022	721,746	20	9.9
SR_877	13,117,123	728,609	20	9.9
SR_500	13,106,426	723,946	20	9.6
SR_846	13,117,391	727,186	20	9.3

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_107	13,121,635	734,026	20	9.2
SR_532	13,096,259	722,521	20	9.2
SR_583	13,119,490	721,696	20	9.1
SR_887	13,122,404	728,910	20	9.0
SR_327	13,117,387	718,709	20	8.3
SR_514	13,111,833	721,387	20	8.3
SR_516	13,109,756	721,747	20	7.9
SR_534	13,095,900	726,294	20	7.9
SR_620	13,117,080	718,284	20	7.9
SR_868	13,108,270	727,215	20	7.9
SR_108	13,122,360	735,046	20	7.8
SR_835	13,117,114	733,234	20	7.8
SR_871	13,106,990	727,302	20	7.8
SR_584	13,091,080	720,657	20	7.7
SR_619	13,117,400	718,368	20	7.6
SR_873	13,106,828	729,470	20	7.5
SR_205	13,105,044	727,280	20	6.9
SR_110	13,122,367	736,528	20	6.9
SR_581	13,109,357	721,748	20	6.9
SR_866	13,106,784	730,116	20	6.9
SR_867	13,106,764	729,871	20	6.6
SR_594	13,117,330	718,923	20	6.2
SR_851	13,121,929	727,158	20	6.2
SR_524	13,104,545	721,935	20	6.2
SR_850	13,119,053	727,168	20	6.0
SR_1027	13,099,044	721,733	20	5.9
SR_563	13,101,271	716,632	20	5.5
SR_810	13,117,871	733,574	20	5.5
SR_106	13,120,060	732,639	20	5.5
SR_109	13,121,954	736,535	20	5.4

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_521	13,108,036	722,003	20	5.4
SR_163	13,095,939	728,111	20	5.1
SR_515	13,110,409	721,746	20	5.1
SR_618	13,108,193	722,001	20	5.0
SR_605	13,115,481	721,701	20	4.9
SR_104	13,121,676	733,359	20	4.8
SR_549	13,108,090	721,621	20	4.8
SR_162	13,096,063	727,866	20	4.7
SR_164	13,095,798	728,434	20	4.6
SR_203	13,103,259	727,206	20	4.6
SR_616	13,108,731	722,020	20	4.6
SR_185	13,101,597	727,968	20	4.5
SR_598	13,117,098	718,081	20	4.2
SR_869	13,108,894	727,222	20	4.1
SR_604	13,116,005	721,675	20	4.0
SR_837	13,121,733	736,151	20	4.0
SR_540	13,101,443	717,923	20	3.9
SR_617	13,108,394	722,001	20	3.9
SR_575	13,093,570	722,016	20	3.8
SR_502	13,104,266	727,048	20	3.8
SR_1029	13,122,369	716,577	20	3.6
SR_535	13,096,036	727,091	20	3.1
SR_529	13,100,019	721,938	20	2.7
SR_105	13,121,907	733,575	20	2.6
SR_551	13,109,691	716,606	20	2.6
SR_569	13,097,504	721,754	20	2.6
SR_802	13,121,650	716,722	20	2.5
SR_608	13,114,394	718,720	20	2.2
SR_103	13,114,890	732,485	20	2.0
SR_166	13,095,642	728,801	20	1.9

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_557	13,091,070	718,550	20	1.8
SR_96	13,104,568	731,326	20	1.6
SR_612	13,109,658	727,044	20	1.5
SR_597	13,114,104	716,656	20	1.5
SR_880	13,109,951	732,323	20	1.3
SR_592	13,117,326	718,021	20	1.2
SR_95	13,105,608	732,563	20	1.2
SR_27	13,120,714	740,384	20	0.0
SR_28	13,122,350	740,410	20	0.0
SR_29	13,121,115	741,621	20	0.0
SR_30	13,122,220	741,699	20	0.0
SR_31	13,120,441	742,554	20	0.0
SR_32	13,120,905	741,962	20	0.0
SR_33	13,122,036	742,218	20	0.0
SR_34	13,121,437	742,422	20	0.0
SR_35	13,122,391	742,450	20	0.0
SR_36	13,122,394	742,589	20	0.0
SR_37	13,122,307	742,741	20	0.0
SR_38	13,122,125	742,724	20	0.0
SR_39	13,121,925	742,806	20	0.0
SR_40	13,121,738	742,813	20	0.0
SR_41	13,121,675	743,119	20	0.0
SR_42	13,121,619	743,010	20	0.0
SR_43	13,121,136	743,148	20	0.0
SR_44	13,122,365	743,036	20	0.0
SR_92	13,103,203	732,888	20	0.0
SR_93	13,107,183	736,578	20	0.0
SR_94	13,106,322	735,851	20	0.0
SR_97	13,107,288	734,499	20	0.0
SR_98	13,106,257	734,451	20	0.0

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_99	13,107,034	736,493	20	0.0
SR_100	13,108,180	732,556	20	0.0
SR_101	13,108,592	732,589	20	0.0
SR_102	13,109,243	732,880	20	0.0
SR_153	13,091,153	726,626	20	0.0
SR_154	13,091,531	727,251	20	0.0
SR_155	13,091,630	730,730	20	0.0
SR_156	13,091,851	730,822	20	0.0
SR_157	13,094,058	732,102	20	0.0
SR_158	13,093,897	732,011	20	0.0
SR_159	13,093,706	731,933	20	0.0
SR_160	13,093,411	731,677	20	0.0
SR_161	13,092,843	731,395	20	0.0
SR_165	13,096,293	728,597	20	0.0
SR_167	13,095,653	729,337	20	0.0
SR_168	13,096,536	729,068	20	0.0
SR_169	13,095,842	729,661	20	0.0
SR_170	13,096,400	729,556	20	0.0
SR_171	13,097,595	730,340	20	0.0
SR_172	13,096,977	730,741	20	0.0
SR_173	13,097,111	730,952	20	0.0
SR_174	13,098,609	730,887	20	0.0
SR_175	13,096,955	730,079	20	0.0
SR_176	13,097,754	729,986	20	0.0
SR_177	13,098,422	730,001	20	0.0
SR_178	13,098,676	729,997	20	0.0
SR_179	13,099,062	730,362	20	0.0
SR_180	13,096,975	729,684	20	0.0
SR_181	13,097,274	729,569	20	0.0
SR_182	13,097,545	729,361	20	0.0

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_183	13,097,710	729,645	20	0.0
SR_184	13,098,301	729,339	20	0.0
SR_187	13,101,274	728,699	20	0.0
SR_188	13,101,237	729,867	20	0.0
SR_189	13,101,508	729,858	20	0.0
SR_190	13,101,235	730,268	20	0.0
SR_191	13,101,634	730,570	20	0.0
SR_192	13,099,062	731,004	20	0.0
SR_193	13,099,032	732,007	20	0.0
SR_194	13,099,045	732,085	20	0.0
SR_195	13,100,314	732,258	20	0.0
SR_196	13,099,987	732,339	20	0.0
SR_197	13,100,503	732,295	20	0.0
SR_198	13,101,263	732,193	20	0.0
SR_199	13,101,324	732,319	20	0.0
SR_200	13,102,951	730,980	20	0.0
SR_322	13,106,779	716,620	20	0.0
SR_329	13,120,901	716,732	20	0.0
SR_506	13,096,448	716,650	20	0.0
SR_510	13,117,570	717,527	20	0.0
SR_536	13,091,440	724,638	20	0.0
SR_538	13,091,134	725,666	20	0.0
SR_539	13,105,139	716,638	20	0.0
SR_550	13,107,659	716,687	20	0.0
SR_552	13,110,546	716,632	20	0.0
SR_554	13,092,867	721,767	20	0.0
SR_556	13,093,871	716,672	20	0.0
SR_562	13,095,604	716,697	20	0.0
SR_571	13,091,176	725,928	20	0.0
SR_572	13,091,170	726,216	20	0.0

RECEPTOR	X	Y	LIMIT	PREDICTED HOURS BEFORE MITIGATION
SR_577	13,091,088	724,177	20	0.0
SR_588	13,118,681	716,626	20	0.0
SR_589	13,119,572	716,718	20	0.0
SR_590	13,120,202	716,707	20	0.0
SR_591	13,120,498	716,707	20	0.0
SR_595	13,116,124	716,625	20	0.0
SR_806	13,099,685	727,308	20	0.0
SR_812	13,107,845	732,370	20	0.0
SR_841	13,106,788	732,116	20	0.0
SR_842	13,107,449	732,349	20	0.0
SR_843	13,106,766	732,331	20	0.0
SR_1016	13,098,867	727,369	20	0.0
SR_1024	13,091,073	724,760	20	0.0
SR_1025	13,111,293	716,638	20	0.0
SR_1525	13,108,136	732,646	20	0.0

Appendix B. Wind Turbine Layout (Revision 25)

The wind turbine layout represented in this report is summarized in Table B-1. Coordinates are NAD83 Michigan State Plane, South Zone, International Feet.

Table B-1 Wind Turbine Layout

TURBINE	X	Y	MODEL	HUB HEIGHT, M	ROTOR DIAMETER, M
02	13,093,566	720,077	GE 2.82-127	88.5	127.2
03	13,097,785	723,803	GE 2.82-127	88.5	127.2
04	13,099,689	723,581	GE 2.82-127	88.5	127.2
05	13,099,653	725,441	GE 2.82-127	88.5	127.2
06	13,098,830	719,715	GE 2.82-127	88.5	127.2
08	13,103,029	723,761	GE 2.82-127	88.5	127.2
10	13,105,278	725,048	GE 2.82-127	88.5	127.2
12	13,104,904	718,530	GE 2.82-127	88.5	127.2
13	13,105,040	720,439	GE 2.82-127	88.5	127.2
14	13,109,399	729,307	GE 2.82-127	88.5	127.2
15	13,108,763	725,480	GE 2.82-127	88.5	127.2
16	13,109,308	723,489	GE 2.82-127	88.5	127.2
17	13,108,745	719,849	GE 2.82-127	88.5	127.2
18	13,109,922	719,121	GE 2.82-127	88.5	127.2
19	13,114,540	730,929	GE 2.82-127	88.5	127.2
20	13,114,624	729,182	GE 2.82-127	88.5	127.2
21	13,115,842	729,638	GE 2.82-127	88.5	127.2
22	13,113,484	723,658	GE 2.82-127	88.5	127.2
23	13,115,263	723,508	GE 2.82-127	88.5	127.2
24	13,114,987	725,764	GE 2.82-127	88.5	127.2
25	13,115,916	720,063	GE 2.82-127	88.5	127.2
26	13,119,265	731,023	GE 2.82-127	88.5	127.2
27	13,118,872	723,563	GE 2.82-127	88.5	127.2
28	13,120,676	723,573	GE 2.82-127	88.5	127.2
29	13,120,530	719,999	GE 2.82-127	88.5	127.2
30	13,125,589	735,933	GE 2.82-127	88.5	127.2

TURBINE	X	Y	MODEL	HUB HEIGHT, M	ROTOR DIAMETER, M
31	13,126,335	734,515	GE 2.82-127	88.5	127.2
32	13,124,287	730,225	GE 2.82-127	88.5	127.2
33	13,125,875	730,119	GE 2.82-127	88.5	127.2
34	13,126,321	728,797	GE 2.82-127	88.5	127.2
35	13,124,364	723,958	GE 2.82-127	88.5	127.2
36	13,125,292	726,228	GE 2.82-127	88.5	127.2
38	13,130,397	735,722	GE 2.82-127	88.5	127.2
39	13,130,402	733,998	GE 2.82-127	88.5	127.2
40	13,128,961	728,912	GE 2.82-127	88.5	127.2
41	13,129,354	730,765	GE 2.82-127	88.5	127.2
42	13,131,280	730,807	GE 2.82-127	88.5	127.2
45	13,131,599	723,988	GE 2.82-127	88.5	127.2
46	13,134,914	734,675	GE 2.82-127	88.5	127.2
47	13,136,892	734,491	GE 2.82-127	88.5	127.2
48	13,136,888	731,374	GE 2.82-127	88.5	127.2
49	13,134,245	726,304	GE 2.82-127	88.5	127.2
51	13,135,562	723,557	GE 2.82-127	88.5	127.2
52	13,139,652	735,329	GE 2.82-127	88.5	127.2
54	13,142,163	735,861	GE 2.82-127	88.5	127.2
55	13,142,727	734,049	GE 2.82-127	88.5	127.2
56	13,139,797	728,722	GE 2.82-127	88.5	127.2
58	13,141,337	730,708	GE 2.82-127	88.5	127.2
59	13,139,885	726,077	GE 2.82-127	88.5	127.2
60	13,140,289	723,936	GE 2.82-127	88.5	127.2
61	13,141,322	725,669	GE 2.82-127	88.5	127.2
62	13,123,659	720,526	GE 2.82-127	88.5	127.2
63	13,125,037	719,570	GE 2.82-127	88.5	127.2
64	13,126,084	718,653	GE 2.82-127	88.5	127.2
66	13,125,883	713,269	GE 2.82-127	88.5	127.2
67	13,126,097	711,946	GE 2.82-127	88.5	127.2

TURBINE	X	Y	MODEL	HUB HEIGHT, M	ROTOR DIAMETER, M
68	13,124,047	707,459	Vestas V136	82	136
69	13,126,057	708,714	GE 2.82-127	88.5	127.2
70	13,125,962	703,577	Vestas V136	82	136
71	13,129,294	720,897	GE 2.82-127	88.5	127.2
72	13,131,388	720,555	GE 2.82-127	88.5	127.2
73	13,131,128	717,841	GE 2.82-127	88.5	127.2
74	13,131,401	716,592	GE 2.82-127	88.5	127.2
75	13,129,579	711,248	GE 2.82-127	88.5	127.2
76	13,130,245	713,631	GE 2.82-127	88.5	127.2
77	13,129,035	702,443	Vestas V136	82	136
78	13,130,222	701,554	Vestas V136	82	136
79	13,135,851	717,876	GE 2.82-127	88.5	127.2
80	13,136,364	720,019	GE 2.82-127	88.5	127.2
81	13,135,260	711,200	Vestas V136	82	136
82	13,134,790	707,997	Vestas V136	82	136
83	13,140,867	720,636	GE 2.82-127	88.5	127.2
84	13,140,699	719,109	GE 2.82-127	88.5	127.2
85	13,139,918	706,294	Vestas V136	82	136
86	13,141,908	707,237	Vestas V136	82	136
87	13,140,164	702,105	Vestas V136	82	136
88	13,140,161	700,116	Vestas V136	82	136

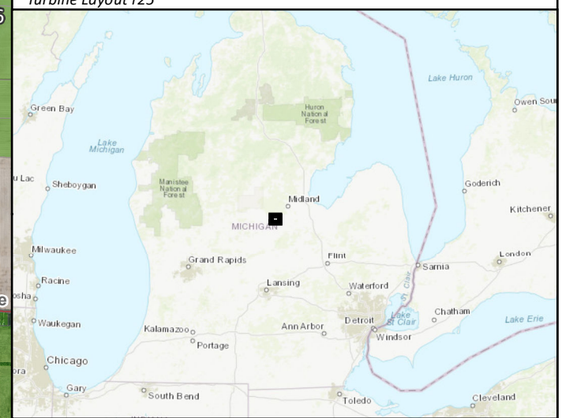
Appendix C. Shadow Flicker Maps

DTE

Meridian Wind Park
Porter Township
Shadow Flicker Study
Cumulative Shadow Flicker Contours
Midland County, Michigan
12 February 2021

- GE Wind Turbine
- Vestas Wind Turbine
- Shadow Flicker 10 Hour Line
- Shadow Flicker 20 Hour Line
- Shadow Flicker 30 Hour Line
- Shadow Receptor
- Shadow Flicker Mitigation Required
- Project Site

Turbine Layout r25



0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

N

NAD 1983 2011 StatePlane Michigan South FIPS 2113 Ft Intl

BLACK & VEATCH

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community