FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED FAHY BEG WIND FARM, CO. CLARE

VOLUME 2 – MAIN EIAR

CHAPTER 12 – SHADOW FLICKER

Prepared for: RWE Renewables Ireland Ltd.

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12. SHADOW FLICKER

12.1 Introduction

This chapter considers the potential for shadow flicker effects at nearby sensitive buildings associated with the operation of the Fahy Beg Wind Farm. The specific objectives of the chapter are to:

- describe the assessment methodology and relevant guidance;
- describe the potential impacts;
- describe the need for any mitigation measures, if required; and
- assess the residual impacts remaining, following the implementation of any mitigation measures.

This assessment has been undertaken by Jake Collins-May and reviewed by Jim Singleton, both of TNEI Services Ltd.

Dr. Jake Collins-May has experience of shadow flicker modelling for both proposed wind turbine developments and complaints investigations. He has a Masters in Geography and a PhD in Geography as a Science. Jim Singleton MIOA is the Team Manager of TNEI's Environment and Engineering Team. He has 15 years environmental consultancy experience and has worked on many wind turbine developments, ranging from single turbines to over 300 MW developments, and including feasibility studies, authoring of ES chapters, compliance surveys, due diligence and appeals.

A detailed description of the project assessed in this EIAR is provided in Chapter 3.

12.1.1 Scope of Assessment

12.1.1.1 Conditions required for Shadow Flicker

Under certain combinations of geographical position, wind direction, weather conditions, and times of day and year, the sun may pass behind the rotors of a wind turbine and cast a shadow over the windows of nearby buildings. When the blades rotate and the shadow passes a window, to a person within that room the shadow appears to 'flick' on and off; this effect is known as 'shadow flicker'. The phenomenon occurs only within buildings where shadows are cast across a window aperture, and the effects are typically considered up to a maximum distance of 10 times the rotor diameter from each wind turbine.

The 10 times rotor diameter criterion, which effectively sets the size of the study area, is detailed in a number of international publications including the German 'Guideline for Identification and Evaluation of the Optical Emissions of Wind Turbines' (2002), the UK's 'Update of UK Shadow Flicker Evidence Base' (Parsons Brinkerhoff for DECC, 2011) and Ireland's own Wind Energy Development Guidelines (WEDG 2006 and draft WEDG 2019).

Specifically, the WEDG 2006 state that *"At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low"*.

12.1.1.2 Study Area

A study area of 1380 m from each of the 8 wind turbines was selected for this assessment, which is ten times the maximum rotor diameter (138 m) that would be used within the proposed development. The assessment considers all identified potential shadow flicker sensitive receptors within the study area, which includes habitable residential buildings and buildings that are both residential and commercial.

No other sensitive property types were identified within the study area.

The study area is detailed in Figure 12.1.

12.1.1.3 Effects to be Assessed

This chapter presents the results and findings of the potential shadow flicker effects at all the identified receptors. The chapter quantifies the theoretical maximum number of hours per annum and per day where shadow flicker may occur at a building.

12.2 Methodology

The suns path in the sky starts in the morning from the eastern horizon, increases in elevation until it is at its highest in the sky in the afternoon, and then decreases in elevation before setting in the western horizon in the evening. This path differs depending on the time of the year as the suns angle (or azimuth) and its elevation are higher during the summer months and lower in the winter months. Considering the suns position in the sky and its angle to the wind turbines it is possible to predict the total theoretical number of hours per year that shadow flicker effects may occur in a building. These predictions can then be used to identify the times when curtailment may be required to mitigate the effects.

The assessment assumes, during daylight hours, that the sun is shining all day, every day, however, the potential for shadow flicker to occur and the intensity and duration of any effects will depend upon the following factors:

1. the location and orientation of the window relative to the turbines;
2. whether a window has direct, unobstructed line of sight to the turbine rotor;
3. the distance of the building to the turbines;
4. the turbine geometry;
5. the time of year (which impacts the trajectory of the sun's path across the sky);
6. the frequency of cloudless skies (particularly at low elevations above the horizon); and,
7. the wind direction (which impacts on turbine orientation).

Several specialist software packages are available that can take account of variables 1-5 listed above to determine the maximum theoretical number of shadow flicker hours that could occur at each window under worst-case conditions. Weather conditions, however, which affects items 6 and 7, cannot be accounted for accurately. Therefore, the software model assumes cloudless skies 100% of the time and that all turbines are face on to all receptors. This cannot happen in reality and the output from the model will be inherently conservative, although estimates of typical weather conditions can be factored into the assessment at a later stage to provide a more realistic estimate of the likely occurrence of shadow flicker.

Where obstructions are present between a window and turbine due to terrain, this is accounted for within the software model, however, the model does not consider other obstructions that may be present, such as walls, buildings, trees etc.

For this assessment, predictions of shadow flicker effects have been undertaken using industry standard software package *ReSoft WindFarm*, based on the proposed turbine locations and a range of turbine dimensions, which consider the full extent of the proposed turbine envelope. The modelling parameters used in the assessment are detailed in section 12.2.4 below.

12.2.1 Relevant Guidance

'International Legislation and Regulations for Wind Turbine Shadow Flicker Impact ' (Koppen, 2017) presents an overview of the assessment methodologies most commonly used in countries that have their own specific legislation or guidance with regards to shadow flicker effects. The paper states that nearly all countries base their guidance on the German guidelines '*Guideline for Identification and Evaluation of the Optical Emissions of Wind Turbines*' (2002).

The limit values within the German guidelines are 30 minutes per day and 30 days per year. These limits are, however, based on worst case conditions i.e., the total theoretical number of hours per year that shadow flicker may occur, assuming that the sun is always shining during daylight hours. If it is found that mitigation measures are required, then a further limit value of 8 hours per year is set based on the real case shadow flicker i.e., what is actually occurring and not the theoretical maximum that may occur.

Many countries have adopted the German guideline limits, either directly or with some small adjustments. Australia, Belgium (Walloon region), Brazil, Canada, India, Sweden, and USA all have a worst-case limit of 30 hours a year or 30 minutes a day. The UK has no set limit but also typically adopts these guideline levels for assessment purposes.

Belgium (Flanders region) sets a real case limit of 8 hours a year or 30 mins a day, Denmark a real case limit of 10 hours a year and Netherlands a real case limit of 17 days a year where shadow flicker occurs for more than 20 minutes a day.

There is no standard for the assessment of shadow flicker in Ireland, although a maximum of 30 hours per year and 30 mins per day within 500 m of a wind turbine is recommended, as detailed in Wind Energy Development Guidelines (2006).

12.2.1.1 County Clare Development Plan 2017-2023

The County Clare Development Plan (County Clare Council, 2017) states the following in relation to wind developments:

> *"The Council will assess applications for wind farm developments in relation to the Wind Farm Development Guidelines (DoEHLG, 2006) and the Wind farm Designations in the County Development Plan 2005-2011."*

12.2.1.2 Wind Energy Strategy for County Clare

The County Clare Development Plan 2017-2023 (County Clare Council, 2017) includes a Wind Energy Strategy Map, which identifies four categories of 'Wind Development Area' for large scale commercial wind energy developments. These categories are: "strategic areas", "preferred areas", "areas open for consideration", and "no-go" areas. The proposed Fahy Beg Wind Farm is located within an area marked "Open to Consideration", for which the County Clare Development Plan 2017 states the following:

> *"Wind energy applications in these areas will be evaluated on a case-by-case basis subject to viable wind speeds, environmental resources and constraints and cumulative impacts."*

Wind Energy Strategy Map also states that:

> *"Applications must have regard to the thresholds, limits and buffer zone in the Planning Guidelines for Wind Energy Development for Planning Authorities 2006 in order to mitigate against potential impacts on human health in terms of* ***shadow flicker****, visual impact and noise."*

12.2.1.3 Wind Energy Development Guidelines (2006)

The current guidance provided by the Department of the Environment, Heritage and Local Government (DoEHLG) states:

> *"Careful site selection, design and planning, and good use of relevant software, can help avoid the possibility of shadow flicker in the first instance. It is recommended that shadow flicker at neighbouring offices and dwellings within 500 m should not exceed 30 hours per year or 30 minutes per day.*

At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take measures to prevent or ameliorate the potential effect, such as by turning off a particular turbine at certain times."

12.2.1.4 Draft Revised Wind Energy Development Guidelines (2019)

The Department of Housing, Planning and Local Government published the Draft Revised Wind Energy Development Guidelines in December 2019. The draft revised guidelines set out a zero-shadow flicker policy, encouraging the use of technology for shadow flicker control, to prevent it occurring at sensitive receptors.

The 2019 revised guidelines are currently at draft stage and were subject to consultation and liable to change before the final version is issued. As such, until the 2019 Draft guidelines are finalised and published, the currently adopted WEDG 2006 guidelines will continue to be considered for the assessment of shadow flicker at the proposed development.

12.2.1.5 IWEA Best Practice Guidelines

In March 2012, the Irish Wind Energy Association (IWEA, now Wind Energy Ireland) issued a document detailing best practice guidance for wind farms (IWEA, 2012).

The document provides a preferred methodology to predict the worst-case shadow flicker conditions to provide the most robust results from the assessment. With regards to shadow flicker, the IWEA guidelines support those given in the WEDG 2006, stating:

> *"The assessment of potentially sensitive locations or receptors within a distance of ten rotor diameters from proposed turbine locations will normally be suitable for EIA purposes."*

12.2.1.6 Use of Guidelines in the Assessment

With due consideration of the above, the assessment has been made as follows:

- A study area of 10 rotor diameters has been defined;
- The WEDG 2006 assessment criteria has been adopted but extended out to cover the entire study area; and,
- The Draft 2019 WEDG have been adopted with regard to mitigation i.e. mitigation is proposed to reduce shadow flicker to zero hours.

In comparison to both the current WEDG and international recognised guidance, the assessment is therefore inherently conservative.

12.2.1.7 Adopted assessment criteria

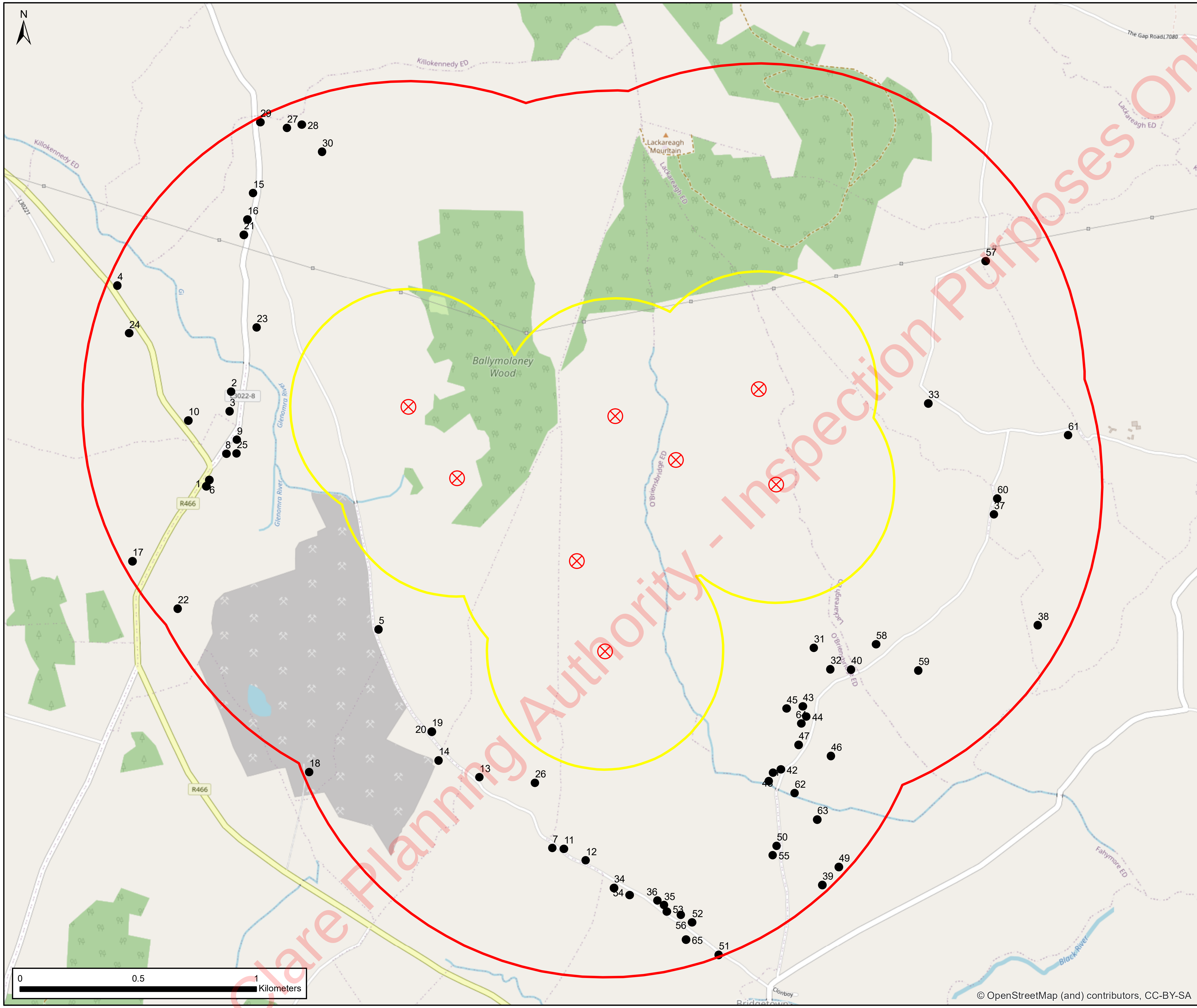
With due regard to the above documents, the assessment of shadow flicker considers the guideline levels presented in WEDG 2006 i.e., a threshold of 30 hours per year or 30 minutes per day, however, the assessment is applied to all sensitive receptors identified within the 1380 m study area, rather than limiting the assessment to a 500 m assessment area.

12.2.2 Field Assessment

Building location data was supplied by Fehily Timoney & Company, derived from a combination of site surveys and supplementary GIS data. The supplied dataset covered an area in excess of 10 rotor diameters of the max rotor within the range from the turbines. The dataset was refined to only include buildings within the 1380 m study area around the Fahy Beg turbine locations, then further refined to remove all commercial properties from the search, aside from those that have a mixed residential / commercial usage. The building centre-point co-ordinates were also refined where required. Any building that was clearly identified as uninhabitable (such as a farm outbuilding) was removed from the assessment, however, where it was not possible to confirm, the building was included for assessment.

Due to the large separation distances between the closest receptors and the proposed development, no sensitive receptors are located within the 2006 WEDG 500 m assessment area. A total of 65 sensitive receptors have been identified within the adopted 1380 m shadow flicker study area. The closest receptor is 719 m from the closest wind turbine.

Figure 12.1 details the identified receptors included for assessment and Appendix 12.1 contains the model input data for all these receptors.



NOTES

Legend

- Fahy Beg Wind Farm
- 500 m from Fahy Beg Turbines
- 1380 m Study Area
- Potential Shadow Flicker Receptors

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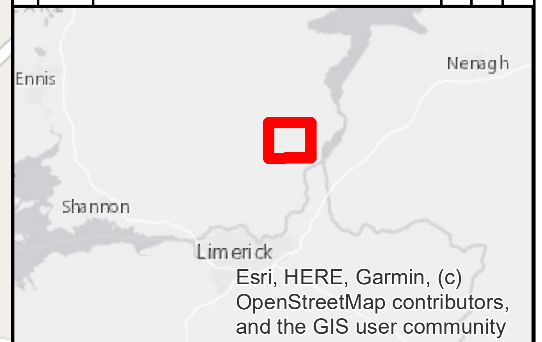
0	26/08/22	First Issue	JCM	JS	JS



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Client: FEHILY TIMONEY 30 YEARS

Drawing Status: FOR INFORMATION

Project Title: Fahy Beg Wind Farm

Drawing Title: Figure 12.1: Shadow Flicker Study Area and Receptors

Scale	Designed	Drawn	Checked	Approved
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12.2.3 Extent of Shadow Flicker Assessment

The shadow flicker model calculates the total theoretical occurrence of shadow flicker at all receptors per year based on a theoretical worst-case scenario that assumes the sky is always clear, the turbines are always aligned face-on to each window and that there is a clear and undisturbed line of sight between the windows and the turbines (except where this is prevented due to topography). In reality this will not occur; the turbines will not always be orientated as described, clouds will obscure the sun and line of sight may be obscured, for example, by leaves on trees. The theoretical worst-case scenario allows predictions of all possible shadow flicker occurrences, however actual shadow flicker effects will only be possible for some of this time.

In order to provide a more realistic prediction of potential shadow flicker effects, historical weather data can be used to apply a correction factor to predicted annual shadow flicker, which considers the frequency of clear skies when shadows may be cast. Met Éireann provide 30 year average weather data, the most recent of which is from the time period 1981 to 2010. Data has been taken from the nearest long-term weather station to Fahy Beg Wind Farm, which is at Shannon Airport, to determine the average sunshine hours. This is presented in Table 12-1:

Table 12-1: Average Monthly Sunshine Hours at Shannon Airport (1981-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Sunshine Hours: Mean Daily Duration[i]	1.6	2.3	3.2	5.1	5.8	5.2	4.5	4.5	3.9	2.9	2	1.4	3.5
Daylight Hours[ii]	8.1	9.5	11.5	13.6	15.5	16.4	16.1	14.4	12.4	10.3	8.4	7.4	12.0
% Sunshine	19.7	24.2	27.8	37.6	37.5	31.6	27.9	31.3	31.6	28.1	23.8	18.9	29.2

i Based on meteorological data from Shannon Airport 1981-2010 (https://www.met.ie/climate-ireland/1981-2010/shannon.html).

ii Based on sunrise and sunset times for Shannon 2022 (https://www.sunrise-and-sunset.com/en/sun/ireland/shannon/2022).

The annual average percentage of sunshine hours is 29.2%, therefore a correction factor of 29.2% can be applied to the annual total theoretical predicted levels of shadow flicker to account for the amount of time when the correct sunshine conditions are present for shadows to be cast. It is worth noting that this correction does not account for the additional reductions that would occur as a result of variations in wind speed and wind direction, or by determining whether there is line of sight between a turbine and receiver. Therefore, these 'likely' levels of shadow flicker are still considered to be a conservative estimate.

12.2.4 Modelling Parameters

The levels of shadow flicker at each receptor have been calculated based on a 'greenhouse' modelling approach, where the full length of each façade of a building is modelled as a window (and is therefore sensitive to shadow flicker). Each modelled window is assumed to have a height of 2 m. This approach presents a worst-case estimate of shadow flicker; in reality, only the window area of a façade would be sensitive to shadow flicker effects, so the modelling of the full façade will result in higher predicted levels than would normally occur.

Three scenarios have been assessed to consider the extent of the proposed range of turbine dimensions, which is detailed in Table 12-2:

Table 12-2: Proposed Range of Turbine Dimensions

Hub Height (m)		Rotor Diameter		Tip Height (m)	
Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
110	102.5	138	131	176	168

Specifically, the following scenarios are considered:

1. Scenario 01: Largest rotor on smallest hub height (138m rotor diameter, 102.5m hub height)
2. Scenario 02: Smallest rotor on the largest hub height (131m rotor diameter, 110m hub height)
3. Scenario 03: Largest rotor with maximum possible tip height (138m rotor diameter, with 107.5m hub height)

Assessing shadow flicker effects using the scenarios above covers the full range of potential shadow flicker impacts that may occur. Changes in hub height may have a relatively small impact on the predicted levels, however, having a smaller tower does not necessarily mean that the impacts will decrease at all properties (or vice versa). Rather it will result in changes to the time of day and time of year that flicker is predicted at a given property. Using the largest possible rotor diameter to determine the study area for all three scenarios ensures the maximum number of sensitive properties are accounted for.

12.3 Existing Environment

The area around the site is predominantly open farmland, with limited potential for screening. A number of the receptors considered in this chapter are therefore likely to have clear line of sight to the proposed turbines. There are currently no other wind turbines in the area that would create existing shadow flicker effects.

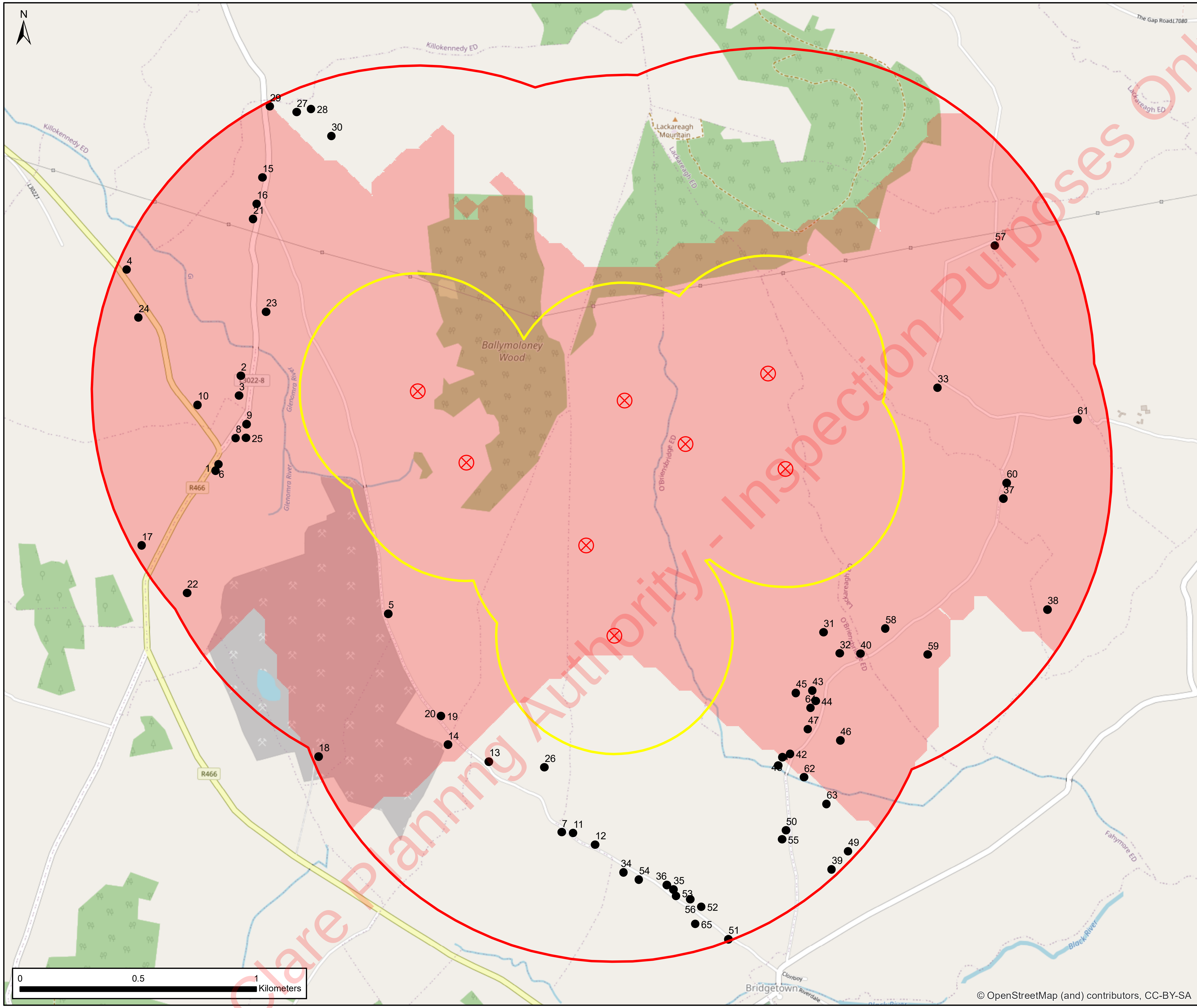
12.4 Potential Impacts

The calculated areas over which shadows from the turbines may be cast (resulting in the potential for shadow flicker to occur) are shown in Figure 12.2 (for Scenario 01), Figure 12.3 (for Scenario 02) and Figure 12.4 (for Scenario 03). The impacts of any other turbine dimensions within the range proposed will fall within the range of potential impacts assessed here.

There is the potential for shadow flicker to occur at up to:

- 20 of the 65 receptors considered within the study area for Scenario 01;
- 19 of the 65 receptors for Scenario 02; and;
- 20 of the 65 receptors for Scenario 03.

For the remaining receptors there is no potential for shadow flicker effects to occur because the suns angle relative to the turbines and receptors never reaches the required position e.g., at some locations south of proposed turbines.



NOTES

Legend

- Fahy Beg Wind Farm
- 500 m from Fahy Beg Turbines
- 1380 m Study Area
- Potential Shadow Flicker Receptors
- Area Over Which Shadows May Be Cast From Fahy Beg Turbines (up to 10RD)

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Client

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Drawing Status: FOR INFORMATION

Project Title: Fahy Beg Wind Farm

Drawing Title: Figure 12.2: Shadow Flicker Assessment - Scenario 01: 138 m rotor diameter, 102.5 m hub height

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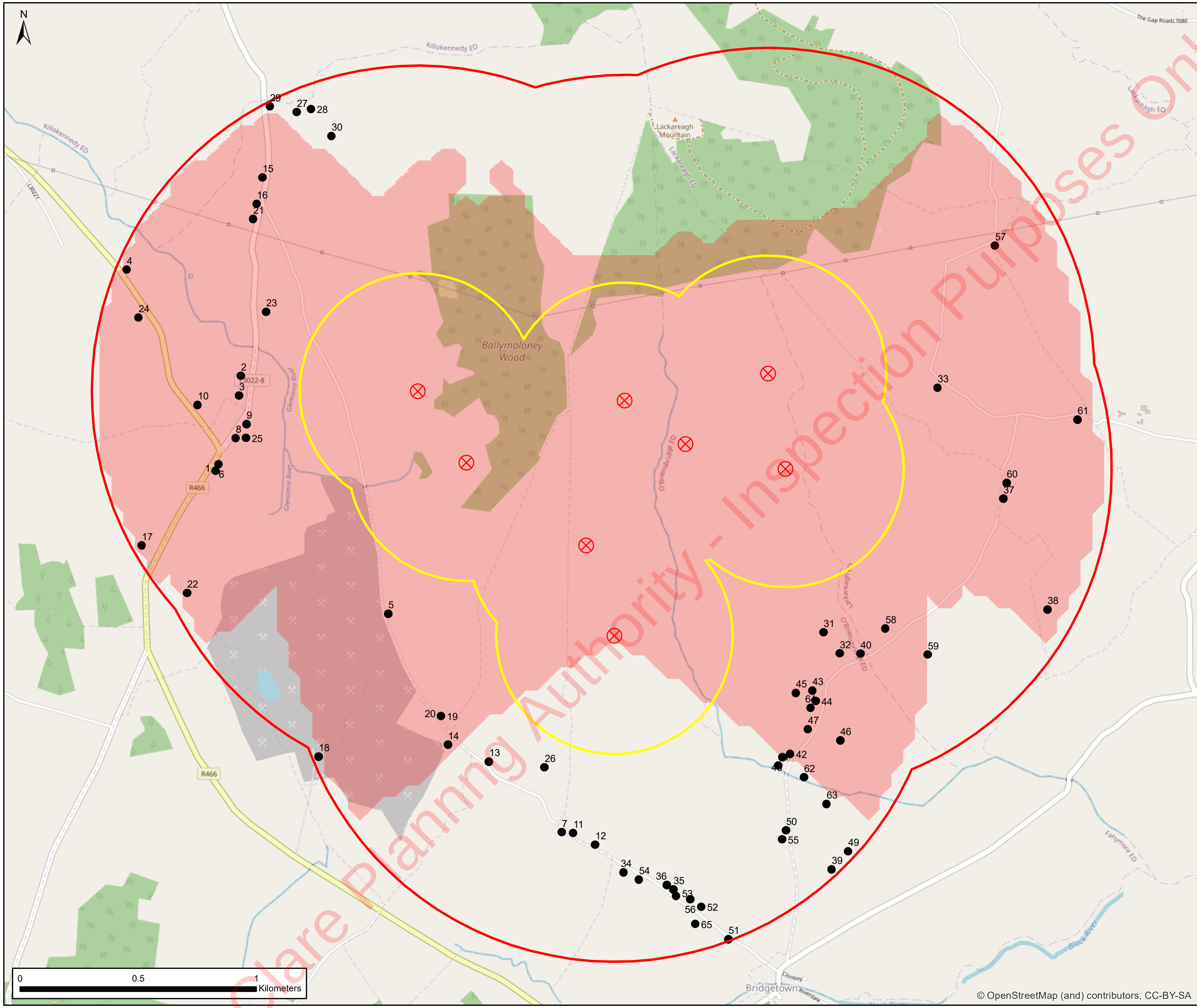

NOTES

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- Fahy Beg Wind Farm
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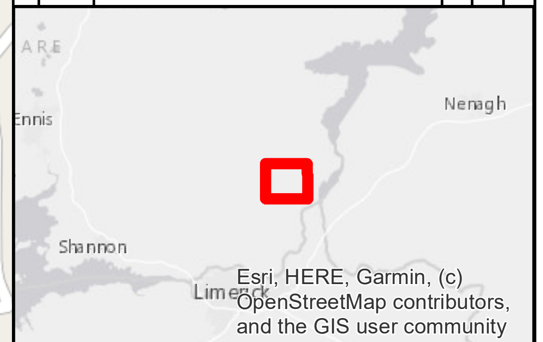

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Client: FEHILY TIMONEY 30 YEARS

Drawing Status: FOR INFORMATION

Project Title: Fahy Beg Wind Farm

Drawing Title: Figure 12.2: Shadow Flicker Assessment - Scenario 02: 131 m rotor diameter, 110 m hub height

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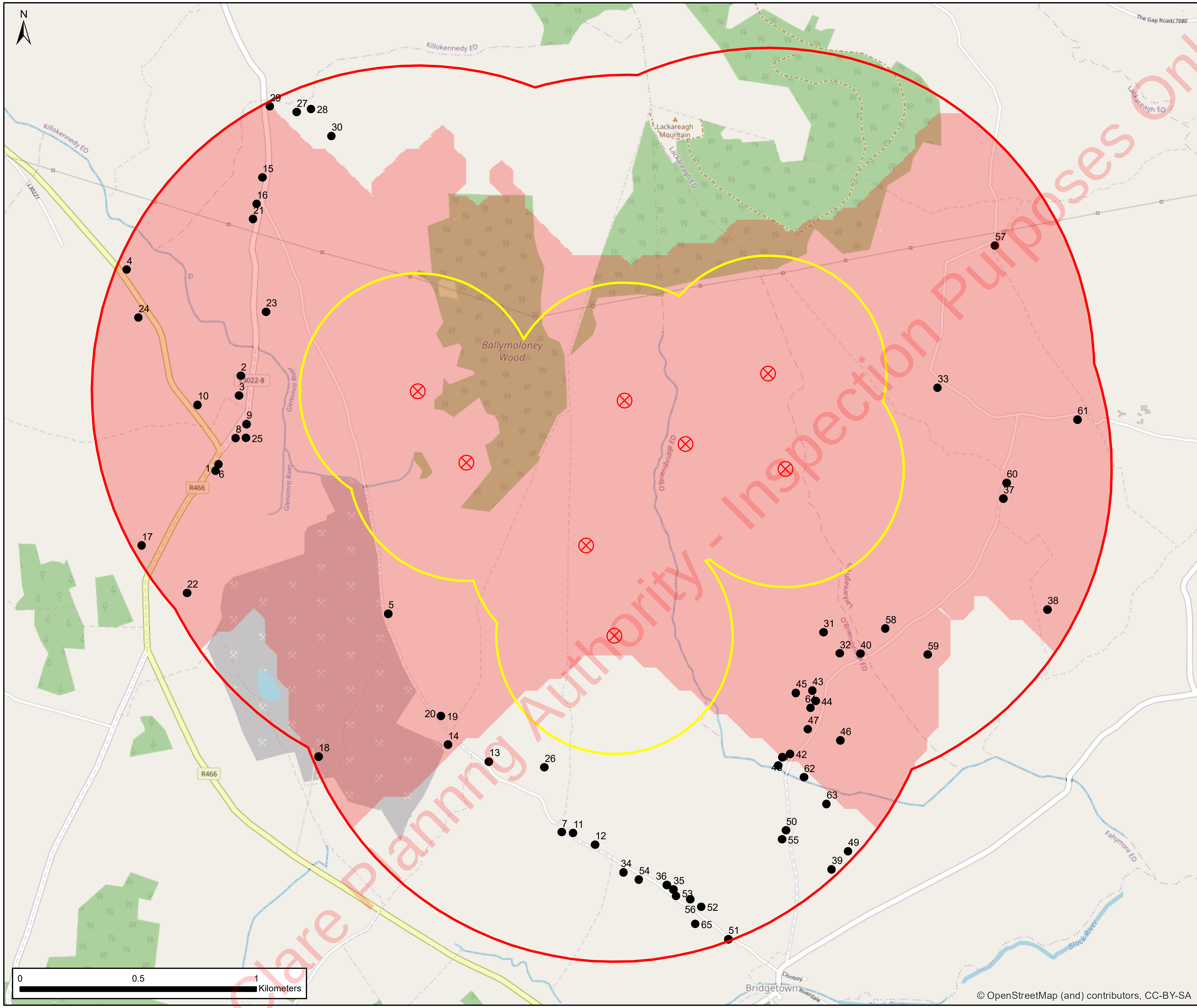

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NOTES

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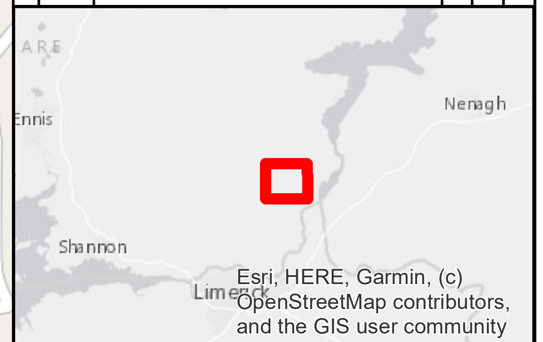

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Client: FEHILY TIMONEY 30 YEARS

Drawing Status: FOR INFORMATION

Project Title: Fahy Beg Wind Farm

Drawing Title: Figure 12.2: Shadow Flicker Assessment - Scenario 03: 138 m rotor diameter, 107.5 m hub height

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12.4.1 Annual Impacts

The shadow flicker model for potential annual impacts sets out the total theoretical hours per year that each receptor can potentially receive shadow flicker; however, it does not account for weather conditions, which have a significant impact upon the amount of shadow flicker that may actually occur.

To consider a more realistic situation, annual average sunshine hours for the region have also been taken into account (as detailed in section 12.2.3) and the resultant 'likely' levels of shadow flicker for each scenario also predicted.

The annual impacts for both theoretical and 'likely' are presented in Table 12-3, which shows the number of receptors that may be exposed to annual periods of shadow flicker for longer than the recommended limits:

Table 12-3: Number of Receptors Exceeding WEDG 2006 Recommendations

	Assessment of Maximum Theoretical Hours per Year	Assessment of 'Likely' Theoretical Hours per Year	Assessment of Maximum Theoretical Minutes per Day
Scenario	Numbers of Receptors Exceeding Recommended Limits		
Scenario 01	16	1	17
Scenario 02	14	0	16
Scenario 03	16	1	17

12.4.2 Daily Impacts

It is not appropriate to apply the annual average sunshine hours correction to the predicted daily totals as the sunshine data is based upon monthly averages that cannot be applied to daily levels with sufficient accuracy. Accordingly, the calculated daily impacts consider the maximum theoretical amount of shadow flicker only and are, therefore, inherently conservative. The daily impacts are also presented in Table 12-3, which shows the number of receptors that may be exposed to daily periods of shadow flicker for more than the recommended limits.

12.4.3 Potential Cumulative Impacts

The nearest wind turbine development to the proposed Fahy Beg Wind Farm is Carranagowan Wind Farm, a consented 19 turbine scheme located several kilometers away to the north east.

There are no wind turbines from other developments within 10 rotor diameters of the receptors considered in this study, therefore there are no cumulative impacts.

12.4.4 Summary of Annual and Daily Impacts

For Scenario 01 (the largest rotor on the smallest hub height) and Scenario 03 (the largest rotor with maximum possible tip height) 16 receptors may receive levels of shadow flicker above the recommended annual levels, although corrected for typical sunshine hours this value is reduced to just 1 receptor for each scenario.

17 receptors may experience levels of shadow flicker above the recommended daily levels for both scenarios.

For Scenario 02 (the smallest rotor on the largest hub height) 14 receptors may receive levels of shadow flicker above the recommended annual levels, although corrected for typical sunshine hours this value is reduced to zero. 16 receptors may experience levels of shadow flicker above the recommended daily levels.

Tables 12-4, 12-5 and 12-6 (overleaf) provide the assessment results for each individual receptor for each scenario. Shaded cells indicate receptors where levels of shadow flicker exceed the recommended levels.

Appendix 12-2 presents the calculated shadow flicker times that could occur on a turbine-by-turbine basis for Scenario 01.

Appendix 12-3 presents the calculated shadow flicker times that could occur at individual receptors for Scenario 01.

Table 12-4: Shadow Flicker Predicted Levels by Receptor - Scenario 01

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
1	562186	670276	0	0	0	0.0
2	562292	670677	44	0.55	18.6	5.4
3	562285	670593	0	0	0	0.0
4	561809	671126	0	0	0	0.0
5	562916	669670	0	0	0	0.0
6	562198	670303	0	0	0	0.0
7	563651	668745	0	0	0	0.0
8	562271	670414	0	0	0	0.0
9	562316	670472	0	0	0	0.0
10	562109	670554	37	0.5	14.7	4.3
11	563698	668741	0	0	0	0.0
12	563792	668692	0	0	0	0.0
13	563342	669044	0	0	0	0.0
14	563169	669116	0	0	0	0.0
15	562384	671517	72	0.58	35.8	10.5
16	562360	671405	91	0.64	45.1	13.2
17	561874	669959	0	0	0	0.0
18	562622	669066	0	0	0	0.0
19	563140	669237	0	0	0	0.0
20	563140	669237	0	0	0	0.0
21	562344	671341	103	0.63	44.4	13.0

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
22	562065	669758	0	0	0	0.0
23	562399	670948	0	0	0	0.0
24	561859	670924	0	0	0	0.0
25	562314	670415	0	0	0	0.0
26	563577	669020	0	0	0	0.0
27	562528	671793	0	0	0	0.0
28	562590	671807	0	0	0	0.0
29	562415	671817	0	0	0	0.0
30	562676	671692	0	0	0	0.0
31	564757	669591	132	0.65	60.5	17.7
32	564827	669502	142	0.61	62	18.1
33	565241	670627	182	0.91	108	31.5
34	563911	668575	0	0	0	0.0
35	564123	668503	0	0	0	0.0
36	564095	668522	0	0	0	0.0
37	565519	670157	107	0.76	52.8	15.4
38	565705	669688	0	0	0	0.0
39	564792	668588	0	0	0	0.0
40	564914	669501	115	0.57	45.4	13.3
41	564566	669028	0	0	0	0.0
42	564617	669077	0	0	0	0.0
43	564710	669344	78	0.67	39.7	11.6
44	564725	669301	0	0	0	0.0
45	564641	669335	113	0.72	59.1	17.3
46	564829	669134	84	0.59	43.5	12.7
47	564692	669181	76	0.66	44.2	12.9
48	564584	669063	0	0	0	0.0
49	564862	668664	0	0	0	0.0
50	564600	668753	0	0	0	0.0
51	564355	668292	0	0	0	0.0
52	564241	668429	0	0	0	0.0
53	564134	668475	0	0	0	0.0
54	563976	668545	0	0	0	0.0

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
55	564583	668714	0	0	0	0.0
56	564194	668461	0	0	0	0.0
57	565484	671229	121	0.57	54	15.8
58	565020	669607	86	0.51	32.4	9.5
59	565199	669497	37	0.45	12.8	3.7
60	565533	670224	51	0.78	30.2	8.8
61	565833	670492	78	0.48	28.6	8.4
62	564676	668977	0	0	0	0.0
63	564771	668865	0	0	0	0.0
64	564703	669271	101	0.67	56.2	16.4
65	564216	668356	0	0	0	0.0
Totals				**Number of Receptors that May Experience:**		
				>30 Minutes / Day	**>30 Hours / Year**	
				17	**16**	**1**

Appendix 12-4 presents the calculated shadow flicker times that could occur on a turbine-by-turbine basis for Scenario 02.

Appendix 12-5 presents the calculated shadow flicker times that could occur at individual receptors for Scenario 02.

Table 12-5: Shadow Flicker Predicted Levels by Receptor - Scenario 02

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
1	562186	670276	0	0	0	0.0
2	562292	670677	40	0.53	16.7	4.9
3	562285	670593	0	0	0	0.0
4	561809	671126	0	0	0	0.0
5	562916	669670	0	0	0	0.0
6	562198	670303	0	0	0	0.0
7	563651	668745	0	0	0	0.0
8	562271	670414	0	0	0	0.0
9	562316	670472	0	0	0	0.0
10	562109	670554	36	0.48	13.5	3.9
11	563698	668741	0	0	0	0.0
12	563792	668692	0	0	0	0.0
13	563342	669044	0	0	0	0.0
14	563169	669116	0	0	0	0.0
15	562384	671517	74	0.56	34.8	10.2
16	562360	671405	92	0.61	41.6	12.1
17	561874	669959	0	0	0	0.0
18	562622	669066	0	0	0	0.0
19	563140	669237	0	0	0	0.0
20	563140	669237	0	0	0	0.0
21	562344	671341	68	0.6	30.7	9.0
22	562065	669758	0	0	0	0.0
23	562399	670948	0	0	0	0.0
24	561859	670924	0	0	0	0.0
25	562314	670415	0	0	0	0.0
26	563577	669020	0	0	0	0.0
27	562528	671793	0	0	0	0.0

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
28	562590	671807	0	0	0	0.0
29	562415	671817	0	0	0	0.0
30	562676	671692	0	0	0	0.0
31	564757	669591	129	0.62	56.4	16.5
32	564827	669502	137	0.58	57.8	16.9
33	565241	670627	158	0.86	92.5	27.0
34	563911	668575	0	0	0	0.0
35	564123	668503	0	0	0	0.0
36	564095	668522	0	0	0	0.0
37	565519	670157	99	0.63	42	12.3
38	565705	669688	0	0	0	0.0
39	564792	668588	0	0	0	0.0
40	564914	669501	114	0.55	43.7	12.8
41	564566	669028	0	0	0	0.0
42	564617	669077	0	0	0	0.0
43	564710	669344	76	0.64	37	10.8
44	564725	669301	0	0	0	0.0
45	564641	669335	109	0.69	56.1	16.4
46	564829	669134	80	0.56	39.6	11.6
47	564692	669181	71	0.63	38.8	11.3
48	564584	669063	0	0	0	0.0
49	564862	668664	0	0	0	0.0
50	564600	668753	0	0	0	0.0
51	564355	668292	0	0	0	0.0
52	564241	668429	0	0	0	0.0
53	564134	668475	0	0	0	0.0
54	563976	668545	0	0	0	0.0
55	564583	668714	0	0	0	0.0
56	564194	668461	0	0	0	0.0
57	565484	671229	120	0.54	51.1	14.9
58	565020	669607	82	0.49	29.7	8.7
59	565199	669497	0	0	0	0.0
60	565533	670224	50	0.58	22.7	6.6

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
61	565833	670492	34	0.46	12.5	3.7
62	564676	668977	0	0	0	0.0
63	564771	668865	0	0	0	0.0
64	564703	669271	97	0.64	52.3	15.3
65	564216	668356	0	0	0	0.0
Totals				**Number of Receptors that May Experience:**		
				>30 Minutes / Day	**>30 Hours / Year**	
				16	**14**	**0**

Appendix 12-6 presents the calculated shadow flicker times that could occur on a turbine-by-turbine basis for Scenario 03.

Appendix 12-7 presents the calculated shadow flicker times that could occur at individual receptors for Scenario 03.

Table 12-6: Shadow Flicker Predicted Levels by Receptor - Scenario 03

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
1	562186	670276	0	0	0	0
2	562292	670677	42	0.55	18.5	5.4
3	562285	670593	0	0	0	0
4	561809	671126	0	0	0	0
5	562916	669670	0	0	0	0
6	562198	670303	0	0	0	0
7	563651	668745	0	0	0	0
8	562271	670414	0	0	0	0
9	562316	670472	0	0	0	0
10	562109	670554	38	0.5	14.9	4.4
11	563698	668741	0	0	0	0
12	563792	668692	0	0	0	0
13	563342	669044	0	0	0	0
14	563169	669116	0	0	0	0
15	562384	671517	74	0.58	36.6	10.7
16	562360	671405	93	0.64	44.9	13.1
17	561874	669959	0	0	0	0.0
18	562622	669066	0	0	0	0.0
19	563140	669237	0	0	0	0.0
20	563140	669237	0	0	0	0.0
21	562344	671341	104	0.63	42.6	12.4
22	562065	669758	0	0	0	0.0
23	562399	670948	0	0	0	0.0
24	561859	670924	0	0	0	0.0
25	562314	670415	0	0	0	0.0
26	563577	669020	0	0	0	0.0
27	562528	671793	0	0	0	0.0

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
28	562590	671807	0	0	0	0.0
29	562415	671817	0	0	0	0.0
30	562676	671692	0	0	0	0.0
31	564757	669591	137	0.65	61.9	18.1
32	564827	669502	142	0.61	62.7	18.3
33	565241	670627	184	0.94	109.5	32.0
34	563911	668575	0	0	0	0.0
35	564123	668503	0	0	0	0.0
36	564095	668522	0	0	0	0.0
37	565519	670157	105	0.76	51.5	15.0
38	565705	669688	0	0	0	0.0
39	564792	668588	0	0	0	0.0
40	564914	669501	117	0.57	47.1	13.8
41	564566	669028	0	0	0	0.0
42	564617	669077	0	0	0	0.0
43	564710	669344	79	0.67	40.6	11.9
44	564725	669301	0	0	0	0.0
45	564641	669335	111	0.72	61	17.8
46	564829	669134	82	0.59	42.8	12.5
47	564692	669181	74	0.66	42.7	12.5
48	564584	669063	0	0	0	0.0
49	564862	668664	0	0	0	0.0
50	564600	668753	0	0	0	0.0
51	564355	668292	0	0	0	0.0
52	564241	668429	0	0	0	0.0
53	564134	668475	0	0	0	0.0
54	563976	668545	0	0	0	0.0
55	564583	668714	0	0	0	0.0
56	564194	668461	0	0	0	0.0
57	565484	671229	122	0.57	54.6	15.9
58	565020	669607	85	0.51	32.5	9.5
59	565199	669497	36	0.45	12.8	3.7
60	565533	670224	53	0.78	30.6	8.9

Receptor ID	Easting (ITM)	Northing (ITM)	Total Theoretical Days Per Year	Maximum Theoretical Hours Per Day	Total Theoretical Hours Per Year	'Likely' Hours Per Year
61	565833	670492	78	0.48	28.7	8.4
62	564676	668977	0	0	0	0.0
63	564771	668865	0	0	0	0.0
64	564703	669271	99	0.67	56.3	16.4
65	564216	668356	0	0	0	0.0
Totals				**Number of Receptors that May Experience:**		
				>30 Minutes / Day	**>30 Hours / Year**	
				17	**16**	**1**

12.5 Mitigation Measures

Shadow flicker control modules, consisting of light sensors and specialised software, will be installed on the turbines as part of a system to prevent operation during periods when shadow flicker may occur. The calculated potential shadow flicker periods will be inputted into the turbine control software and when the correct conditions are met e.g., the light intensity is sufficient, turbine orientation is correct etc. during these periods, individual turbines will cease operation until the conditions for shadow flicker are no longer present. These are standard, widely accepted control modules that are installed in most wind turbines.

When the conditions for shut down are met the turbines will gradually come to a stop. However, it should be recognized there will be a short period of time before complete shutdown occurs. This will depend on the reaction time of the shadow flicker control modules and the particular turbine type, as well as a gradual reduction in rpm i.e., the blades will not come to a sudden stop.

For all three scenarios a scheme of mitigation will be implemented into the turbine control software to cease turbine operation during periods of shadow flicker. The proposed method of mitigation will be used to mitigate all shadow flicker effects resulting in zero shadow flicker within the 10-rotor diameter study area, allowing for a short time for the rotor to come to a stop. Appendices 12.2, 12.4, and 12.6 contains all calculated potential shadow flicker periods for each turbine for Scenario 01, Scenario 02, and Scenario 03 respectively. The relevant data (depending on which scenario is constructed) can be input into the turbine control software. Where the final turbine specification does not match exactly with one of the three modelled scenarios an additional shadow flicker model can be run with the finalised dimensions.

12.6 Residual Impacts

The proposed method of mitigation will be used to mitigate all shadow flicker effects resulting in zero shadow flicker within the 10-rotor diameter study area, allowing for a short time for the rotor to come to a stop.

12.7 Do Nothing Scenario

In the 'Do-Nothing' Scenario, Fahy Beg Wind Farm would not be constructed and the potential impacts from shadow flicker on receptors within the study area would not occur. No mitigation measures would be required.

12.8 Conclusion

A shadow flicker assessment has been undertaken on all receptors within 10 rotor diameters of the proposed Fahy Beg Wind Farm. The assessment considers three turbine specifications to address potential variations in turbine envelope including maximum and minimum rotor diameter, hub height and tip height. The assessment therefore comprehensively assesses the full range of shadow flicker effects that may occur.

Based on the WEDG 2006 thresholds, the predicted 'Maximum Theoretical Hours Per Day' of shadow flicker exceeds 30 minutes at up to 17 receptors.

When considering the 'Total Theoretical Hours Per Year', up to 16 receptors are predicted to exceed the WEDG 2006 threshold of more than 30 hours per year. However, when accounting for a more 'likely' scenario, where the average annual sunshine hours are taken into account, the levels are predicted to exceed more than 30 hours per year at no more than one receptor.

A scheme of mitigation will be implemented using turbine control software to cease turbine operation during periods when shadow flicker is predicted. If this mitigation strategy is adopted, then zero shadow flicker would occur (allowing for a short time for the rotor to come to a stop) within 10 rotor diameters of the wind farm. As such, the proposed development would meet the requirements of both WEDG 2006 and the draft WEDG 2019.

No cumulative impacts with other proposed or operational wind farms in the area are predicted to occur on any receptors in the study area.

12.9 References

Clare County Council (2017). Clare County Development Plan 2017 – 2023. Available at: https://www.clarecoco.ie/services/planning/ccdp2017-2023/vol1/clare-county-development-plan-2017-2023-volume-1-written-statement-24125.pdf

Department of the Environment, Heritage and Local Government (DoEHLG) (2006). Wind Energy Development Guidelines. Available at: https://www.opr.ie/wp-content/uploads/2019/08/2006-Wind-Energy-Development-1.pdf

Department of Housing, Planning and Local Government (2019), Draft Revised Wind Energy Development Guidelines. Available at: https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf

Irish Wind Energy Association (2012). Best Practice Guidelines for the Irish Wind Energy Industry. Available at: https://www.iwea.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf

ReSoft Ltd (2014), WindFarm Release 4.2.1.9. (1997-2014).

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