ARCUS

MOORSHIELD WIND TURBINES PLANNING APPLICATION

APPENDIX **2.**7: SHADOW FLICKER ASSESSMENT

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1 INTRODUCTION

Arcus Consultancy Services Ltd (Arcus) has been commissioned by Moorshield Wind Farm Ltd to carry out an assessment of shadow flicker effects of the proposed Moorshield Wind Turbines in East Renfrewshire (the Development). This report presents details of the methodology and results of the assessment.

This report is supported by the following figure:

- Annex A - Figure 1: Shadow Flicker Assessment Area

This report is structured as follows:

- Legislation, policy and guidance;
- Assessment methodology and significance criteria;
- Baseline conditions;
- Assessment of potential effects;
- Assessment of cumulative effects;
- Mitigation measures and residual effects; and
- Summary.

2 LEGISLATION, POLICY AND GUIDANCE

2.1 Online Planning Guidance for Renewables and Low Carbon Energy[1]

Online planning guidance for onshore wind provides information for consideration surrounding shadow flicker. This is the most current guidance available in terms of Shadow Flicker; therefore, this guidance has been used to inform the assessment methodology for this assessment. It states:

"...where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), "shadow flicker" should not be a problem"

2.2 Review of Light and Shadow Effects from Wind Turbines in Scotland[2]

A review of light and shadow effects from wind turbines was commissioned by ClimateXChange to review how light and shadow flicker effects are considered in the development planning process in Scotland.

This document includes a review of current UK guidance, along with a review of how the current guidance is applied through the selection and review of case studies.

The review provides a number of recommendations regarding the content of guidance on shadow flicker. These include:

- Guidance should not include reference to the occurrence of shadow flicker 'within 130 degrees of north'; and
- There is a need for guidance on the thresholds of exposure to shadow flicker in Scotland.

It should be noted that since the publication of this review (2017), shadow flicker guidance in Scotland has not changed, and as such, the guidance in the Online Planning Guidance for Renewables and Low Carbon Energy remains extant.

[1] Scottish Government (2014) Onshore Wind Turbines: planning advice [online] Available at: https://beta.gov.scot/publications/onshore-wind-turbines-planning-advice/ [Accessed on 13/02/2020]

[2] LUC (2017) Review of Light and Shadow Flicker Effects from Wind Turbines in Scotland, [online] Available at: https://www.climatexchange.org.uk/media/2075/light_and_shadow_effects_from_wind_turbines_in_scotland_stages_1_and_2.pdf [Accessed on 21/02/2020]

3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

3.1 Study Area

Properties with the potential to be affected by shadow flicker as a result of the Development have been identified using GIS (Geographical Information Systems).

Shadow flicker is known to occur beyond 10 rotor diameters, as reflected in the Review of Light and Shadow Effects from Wind Turbines in Scotland; however, the intensity of shadows decreases as the distance to the turbines increases. Given the Scottish Government Online Guidance refers to 10 rotor diameters as the distance above which shadow flicker should not be a problem, any properties within this area are assumed to be most at risk of shadow flicker effects.

Based on the Scottish Government Online Guidance, the study area around each proposed turbine location within a distance of ten rotor diameters was mapped (1,380 m), as shown in Annex A, Figure 1 Shadow Flicker Assessment Area.

Potential sensitive receptors in the area around the Development were identified from Ordinance Survey (OS) 1:25,000 scale digital mapping and online aerial imagery. Potential receptors were also identified using OS AddressBase data; a database which combines Royal Mail address data with buildings identified on large-scale Ordnance Survey mapping and provides addresses, descriptions and grid references.

The following two properties were identified within the zone of potential shadow flicker effects (Annex A).

- Shieldhill; and
- Highfield Farm.

3.2 Survey Methodology

The assessment of shadow flicker is a desk-based assessment, and as such, no on-site survey specific to shadow flicker has been undertaken.

3.3 Assessment Methodology

A recognised computer software package[3] was used to calculate theoretical specific times and durations of shadow flicker effects for each property.

This software creates a mathematical model of the Development and its surroundings, based on:

- Turbine locations, hub height and rotor diameter;
- Topography (obtained from Ordnance Survey Land-Form Panorama elevation data on a 50 m horizontal grid); and
- Latitude and longitude of the Proposed Development site (used in calculating the position of the sun in relation to time of day and year).

A cut-off distance of 1,380 m (i.e. 10 rotor diameters) from each turbine was employed during this calculation in accordance with the guidance noted earlier.

Certain worst-case assumptions are made in the calculation, including:

- Weather conditions are such that shadows are always cast during each day of the year, i.e. bright sunshine every day;
- The turbine rotor will always be facing directly towards a given window, maximising the size of the shadow and hence the frequency and duration of the effect;
- The turbines will always be rotating; and

3 Resoft WindFarm 4.2.1.7.

- There will not be intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect.

The following assumptions have been made for all potential receptors in order to identify all potential effects as a worst case:

- All windows have been assumed to measure 1 m by 1 m (for larger windows the intensity of the effect would be reduced), to be situated at a height of 3 m above ground level, to the window's centre (representing an average of ground and first floor levels that may be typically 1.5 and 4.5 m, respectively);
- Each property is located at the grid reference given in Table 1 (as per details from OS AddressBase data); and
- Windows facing towards each of the cardinal compass point directions (North, South, East and West) have been modelled in order to identify effects from all possible directions. In practice, not all of these directions face the Proposed Development, and the buildings may not have windows on each facade.

The above calculations are intended to indicate a theoretical maximum potential duration of effects and to provide an approximation of the times of day and year that these would occur rather than a precise prediction.

For much of a given year, weather conditions will be such that shadows would not be cast, or would be weak and thus would not give rise to shadow flicker effects. In Giffnock, East Renfrewshire, cloud cover typically occurred for 72 % resulting in bright sunshine occurring for around 28% of daylight hours from October 2018 to October 2019[4]. Of this time, some would be in non-windy conditions when the turbine blades would not be rotating. In windy conditions, the wind direction may not have been aligned with the direction of the sun, such that shadows were not being cast as widely as in the worst-case. In practice, other factors such as the potential for screening by vegetation or intervening structures, will also reduce or prevent flicker incidence even further, as compared to the theoretical maximum period or the likely period of effect suggested by the calculations. The actual potential impact is therefore likely to be only a fraction of the theoretical maximum.

3.4 Effect Criteria

No formal guidance is available regarding what levels of shadow flicker may be considered acceptable in the UK. However, Wind Energy Development Guidelines published by the Northern Ireland Department of the Environment, Heritage and Local Government (2006)[5] states that:

"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."

This assessment predicts the potential maximum effects that occur, and a likely maximum duration for effects once prevailing weather conditions are taken into account. The Irish guidance threshold has been adopted for all residential receptors as a measure of assessing predicted shadow flicker effects.

Mitigation is proposed to minimise or remove predicted effects, if levels of shadow flicker are deemed to be unacceptable in practice.

[4] World Weather Online [Online]. Available at: https://www.worldweatheronline.com/giffnock-weather-averages/east-renfrewshire/gb.aspx [Accessed on 13/02/2020]

[5] Department of the Environment, Best Practice Guidance to Planning Policy Statement 18 'Renewable Energy', 2009

4 BASELINE CONDITIONS

Two properties (potential receptors, used as assessment locations) have been identified within 1380 m of the proposed turbine locations. Table 1 details the two properties within the shadow flicker study area. These are also shown in Annex A.

Table 1: Shadow Flicker Assessment Locations

Property Name	Easting	Northing	Nearest Turbine	Distance to Nearest Turbine (meters)
Shieldhill	251201	649221	2	442
Highfield Farm	250372	649631	1	1250

5 ASSESSMENT OF POTENTIAL EFFECTS

Table 2 details the results of the calculations carried out for the two assessment locations identified using the shadow flicker modelling software. It also shows the calculation of the predicted likely number of hours of shadow flicker per annum (assuming 28% per annum bright sunshine).

It has been calculated that theoretical shadow flicker is likely to occur at the two properties individually assessed.

A conservative approach has been taken, initially, whereby the screening effects provided by trees or other buildings have not been taken into account, nor has any account been taken of which building facades actually do have windows (it has been assumed that all facades have windows). In practice, if screening is established and/or if assessed facades have no windows, the occurrence of shadow flicker will be reduced or eliminated. The degree of effects will depend on the precise position of windows facing the proposed turbines and the precise location of screening, which itself may change over time as vegetation grows or is removed. In addition, the atmospheric conditions will further reduce the actual effects arising, as described in Section 3.3 Assessment Methodology. As a result, the production of exact predictions of shadow flicker is not practicable, and this assessment considers a worst-case approach.

Table 2: Potential Shadow Flicker Effects at the Assessed Locations

Name	Window Orientation	Days per Year	Maximum Minutes per Day	Theoretical Maximum Hours per Annum	Likely Hours per Annum (28% daylight)
Shieldhill	North	102	37	47	13
	East	163	96	148	41
	South	107	73	101	28
	West	0	0	0	0
Highfield Farm	North	0	0	0	0
	East	68	28	24	7
	South	69	28	24	7
	West	0	0	0	0

The theoretical maximum number of hours per annum, as shown in Table 2, are for all windows and account for any overlap where effects may be experienced at different windows or from different turbines simultaneously. As such, shadow flicker effects are calculated as being possible for up to a theoretical maximum of 148 hours at Shieldhill and 24 hours at Highfield Farm.

Based upon weather conditions required to facilitate shadow flicker occurring for only 28% of the time, the likely number of hours per year where shadow flicker could potentially occur is reduced to 41 hours per annum at Shieldhill and 7 hours per annum at Highfield Farm.

Even this figure is likely to comprise an over-estimate of actual effects, given the other conservative aspects of this assessment as set out in Section 3.3 Assessment Methodology.

As discussed in Section 3.3, shadow flicker effects are known to occur beyond 10 rotor diameters; however, due to the greater distance, the intensity of shadows decreases. Other than the properties identified in Table 1, the next nearest property, Moor Farm, is located to the south of the Proposed Development, at a distance of approximately 1405 m. Given the distance and direction from the turbines (shadows are generally not cast outside 130 degrees either side of north), it is considered that shadow flicker effects outside the 10 rotor diameter study area are unlikely.

As Table 2 shows, Shieldhill exceeds the 30 hours per year identified within the Northern Ireland guidance. Given the north west to south east orientation of the farmhouse, absence of windows facing the turbines, and the position of the large barn at its eastern gable, there would be few if any windows facing the turbines with minimal possibility for shadow flicker.

6 ASSESSMENT OF CUMULATIVE EFFECTS

The nearest wind farm, either existing or proposed, is Whitelee Wind Farm. The nearest Whitelee turbine to Shieldhill and Highfield Farm (the only receptors from Moorshield within the Development study area) is located approximately 1,440 m from Shieldhill and 2,300 m from Highfield. As these distances exceed the 10 rotor diameter distance for likely shadow flicker effects (930 m), it is considered that shadow flicker impacts from Whitelee at both properties are unlikely to occur in practice[6]. Cumulative shadow flicker effects from Whitelee have therefore not been considered further.

[6] Whitelee Wind Farm has a rotor diameter of 93 m, sourced from Arcus Internal Database, UK Renewables Database, and Online database from: thewindpower.net [Accessed on 13/02/2020]

7 MITIGATION MEASURES AND RESIDUAL EFFECTS

It has been demonstrated that shadow flicker effects may occur at two receptors within the shadow flicker study area, i.e. Shieldhill and Highfield Farm. A conservative approach has been taken, whereby the screening effects provided by trees or other buildings have not been taken in account, and it has been assumed that there are windows on all sides of each receptor. Screening, or the absence of windows, may reduce or eliminate flicker from occurring in practice.

Several forms of mitigation for shadow flicker are recommended, including:

- Control at Receptor: The provision of blinds, shutters or curtains to affected properties;
- Control on Pathway: for example, screening planting close to an affected property; and
- Control at Source: for example, shutdown of turbines at times when effects occur.

In practice, control at receptor and on pathway is only possible with the cooperation of the residents, which cannot be assumed to be forthcoming. In addition, planting screening may take some time before it is effective.

Control at source is likely to be the preferable method for mitigating shadow flicker. This involves shutting the turbine down at times that flicker is likely to occur. These times can be pre-calculated and programmed into the wind farms SCADA system (shutdown calendar), although this does not take account of weather conditions occurring at specific times, resulting in excessive shutdowns. Photocells can be installed that determine whether ambient light levels are sufficient for distinct shadows (and therefore shadow flicker) to be generated to prevent unnecessary shutdowns.

Alternatively, a shadow flicker protection system could be incorporated into the SCADA system. This calculates the locations of shadows in real time, determines whether these coincide with pre-programmed locations and takes into account ambient lighting before triggering a shutdown. These systems provide greater flexibility than shutdown calendars as it allows for new locations to be programmed.

In the event of a complaint being received by the Site Operator or Local Authority, and an appropriate investigation confirms occurrence, then measures such as those outlined above will be used to prevent re-occurrence and protect residential amenity.

Application of the above measures will ensure that effects are minimised or removed entirely. Following implementation of the proposed mitigation measures, all shadow flicker effects will be reduced.

A suitably worded planning condition may be included to mitigate against any potential effects associated with shadow flicker.

8 SUMMARY

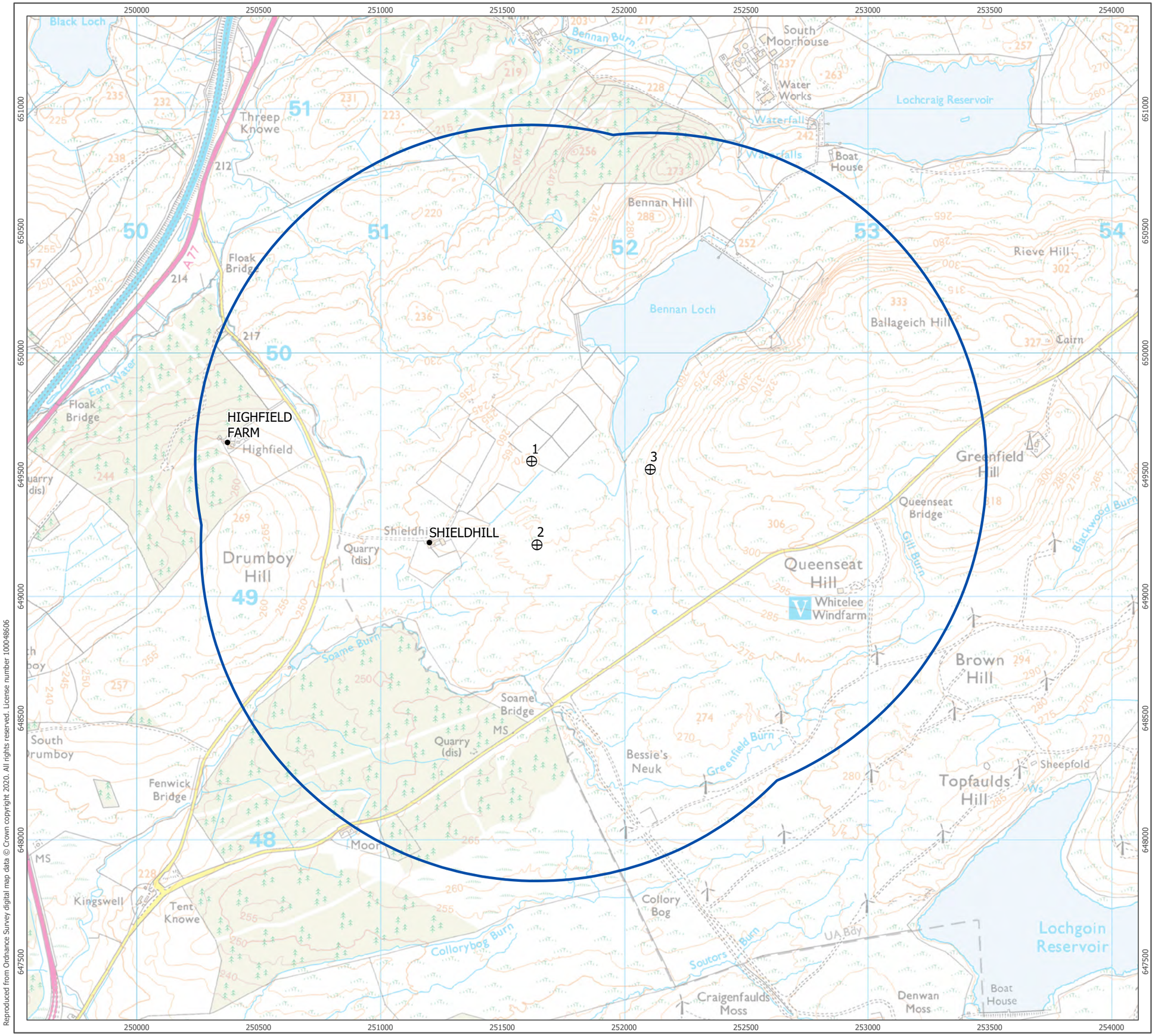
An assessment of potential shadow flicker effects associated with the Development has been carried out. The theoretical maximum and likely hours of shadow flicker occurrence per year have been calculated for properties located within 10 rotor diameters.

During the operational phase, it has been found that shadow flicker is likely to occur at properties within 10 rotor diameters. Shadow flicker effects at Shieldhill have been predicted to exceed the 30 hours per year in line with the appropriate guidance. Mitigation measures have been recommended to reduce and avoid shadow flicker effects.

The flicker effects are expected to be further reduced in practice at both properties due to local screening from woodland and farm buildings. The potential for shadow flicker effects at distances greater than ten rotor diameters is predicted to be minimal.

In practice, if residential amenity at any property is found to be unacceptably affected by shadow flicker, mitigation measures will be implemented to reduce the effects or remove flicker effects entirely. The applicant is content if East Renfrewshire Council requires the imposition of a mitigation condition to ensure that these measures are implemented.

ANNEX A – SHADOW FLICKER ASSESSMENT AREA FIGURE



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wind2

ARCUS

- Shadow Flicker Study Area
- ⊕ Proposed Turbines
- • Receptors within 10 Rotor Diameters (1380 m)

1:15,000 Scale @ A3

0 0.25 0.5 km

NORTH

Produced By: SW	Ref: 3520-REP-029
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Shadow Flicker Assessment Area
Figure 1

Moorshield Wind Turbines
Shadow Flicker Assessment