TATHRA WIND FARM

Shadow Flicker and Blade Glint Assessment

Urbis Ltd

Report No.: 10565442-AUMEL-R-01, Rev. C
Document No.: 10565442-AUMEL-R-01-C
Date: 13 August 2025
Status: Final

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Date of issue:	13 August 2025	
Project No.:	10565442	
Organisation unit:	E-KA-ST	
Report No.:	10565442-AUMEL-R-01, Rev. C	
Document No.:	10565442-AUMEL-R-01-C	

Applicable contract(s) governing the provision of this Report:

Urbis Sub Consultancy Agreement “Tathra Wind Farm Project: Provision of services by DNV Australia Pty Ltd”, dated 15 April 2025

Objective: Tathra Wind Farm Shadow Flicker and Blade Glint Assessment

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Document classification:

Customer's discretion

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Keywords:

Tathra Wind Farm Shadow Flicker and Blade Glint Assessment

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	2025-06-18	First issue - DRAFT	J Villalba	E Tomlinson	N Brammer
B	2025-07-16	Update in response to dwelling revisions	J Villalba, K Orth	E Tomlinson	K Bleibler
C	2025-08-13	FINAL - Updated in response to customer comments	E Tomlinson	P Degorski	G Slack

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EXECUTIVE SUMMARY

DNV has been commissioned by Urbis Ltd (“the Customer”) to independently assess the expected annual shadow flicker durations in the vicinity of the proposed Tathra Wind Farm (“the Project”) in Western Australia. The results of the shadow flicker assessment are described in this document.

Background and methodology

DNV has assessed the expected annual shadow flicker durations for the Project against limits specified in the Draft National Wind Farm Development Guidelines (Draft National Guidelines). The methodology used in this assessment has been informed by these guidelines and various standard industry practices.

The Draft National Guidelines recommend limits of 30 hours per year on the theoretical shadow flicker duration, and 10 hours per year on the actual shadow flicker duration.

A Project layout consisting of 140 wind turbines with a maximum rotor diameter of 180 m and a hub height of 160 m has been considered in this assessment. The locations of 44 dwellings in the vicinity of the Project have been provided the Customer, of which 9 may potentially be affected by shadow flicker.

The theoretical shadow flicker durations at dwellings in the vicinity of the Project have been determined using a purely geometric analysis. The actual shadow flicker duration likely to be experienced at each dwelling has also been predicted by estimating the possible reduction in shadow flicker due to turbine orientation and cloud cover.

Outcomes of the assessment

Based on this assessment, one dwelling is expected to experience shadow flicker above a moderate level of intensity within 50 m of the dwelling. For the purposes of this assessment, shadow flicker above a moderate level of intensity is assumed to occur up to a distance of 10 rotor diameters from the wind turbines.

The affected dwelling (R_17) is an involved dwelling, and is predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling. When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, the predicted actual shadow flicker duration within 50 m of the dwelling is above the recommended limit of 10 hours per year.

DNV understands that the current layout reflects the maximum turbine dimensions under consideration, and that appropriate mitigation measures will be considered during the detailed design phase and final turbine siting. Once the final turbine layout and configuration is confirmed, detailed modelling will be required to calculate the expected shadow flicker durations at dwellings surrounding the Project. The calculation of the predicted actual shadow flicker duration does not take into account other potential reductions due to low wind speed, vegetation, or other shielding effects around each house.

If required, the effects of shadow flicker may be reduced through a number of mitigation measures such as the removal or relocation of turbines, the use of smaller turbines, installation of screening structures or planting of trees to block shadows cast by the turbines, or the use of turbine control strategies to shut down turbines when shadow flicker is likely to occur.

The effects of blade glint have not been quantified in this study as the Draft National Guidelines do not provide any quantification methodology. The guidelines, however, recommend that the turbine blades used have a surface finish with a low reflectivity to avoid occurrences of blade glint.

1 INTRODUCTION

Urbis Ltd (Urbis or "the Customer") has commissioned DNV to independently assess the expected annual shadow flicker durations in the vicinity of the proposed Tathra Wind Farm ("the Project") in Western Australia. The results of this work are reported here. This document has been prepared in accordance with the Urbis Sub Consultancy Agreement "Tathra Wind Farm Project: Provision of services by DNV Australia Pty Ltd" dated 15 April 2025, and is subject to the terms and conditions in that agreement.

This assessment evaluates the shadow flicker durations in the vicinity of the Project for the current proposed turbine layout and configuration in accordance with the Draft National Wind Farm Development Guidelines (Draft National Guidelines) [1]. The methodology used in this study has been informed by these guidelines and various standard industry practices.

2 DESCRIPTION OF THE SITE AND PROJECT

2.1 Project description

The following information has been provided by the Customer:

"Synergy Renewable Energy Developments (referred to as SynergyRED or the Proponent) proposes to develop a renewable energy project in the mid-west of Western Australia, referred to as the Tathra Wind Farm. The site is located within the Shire of Carnamah, approximately 15 km east of Eneabba town site and approximately 300 km north of Perth, Western Australia.

The project is proposed to include up to 140 wind turbine generators (WTGs) (total capacity of up to 1,000 MW across the site), 500 MW in solar and 500 MW in battery storage, with supporting infrastructure (the Proposal). The Proposal, located on predominantly cleared land currently used for agriculture will connect into the South-West Interconnected System (SWIS) via the existing 330 kV transmission lines which are situated within the development envelope.

The associated infrastructure for the Proposal comprises of the following:

- *Up to 140 wind turbine generators (WTGs) with a total capacity of up to 1,000 MW across the site.*
- *Up to 500 MW capacity in solar and 500 MW in battery energy storage systems (BESS), including associated roads, foundations and drainage.*
- *Associated turbine foundations and hard stand areas.*
- *A turbine design comprising:*
    - *Blade length up to 90 m.*
    - *Tower/hub height between 110 m and 160 m; and*
    - *Turbine tip height up to 250 m.*
- *Site entrances from public roads and internal access roads between wind turbines and supporting infrastructure.*
- *Overhead transmission poles or tower and power lines, and underground electrical cables.*
- *Electrical substations and switchyards, including ancillary electrical equipment (e.g. STATCOM).*
- *Operations and maintenance buildings, workshops, and associated car parking.*
- *Temporary construction facilities, including site offices, construction compounds, laydown areas, gravel borrow pits and concrete batching plant.*
- *Water abstraction bore(s) for construction activities and associated infrastructure (dams/turkey's nests).*
- *Fire water tanks.*
- *Communication towers and monitoring masts (meteorological masts) up to 150 m tall."*

2.2 The Project

2.2.1 Proposed wind farm layout

This assessment considers a wind farm layout consisting of up to 140 wind turbines, as provided to DNV by the Customer [2]. A digital elevation model of the Project terrain extending approximately 40 km from the site was derived from publicly available SRTM1 data [3]. A map of the site showing the turbine layout and terrain elevations considered in this assessment is shown in Figure 3, and the coordinates of the proposed turbine locations are given in Table 1.

DNV has modelled the shadow flicker based on a theoretical turbine model with a rotor diameter of 180 m and hub height of 160 m. Although a hub height of 160 m has been modelled, DNV understands that a range of hub heights between 110 m and 160 m is currently being considered for the Project.

2.2.2 Dwelling locations

The locations of 44 dwellings in the vicinity of the Project have been provided by the Customer [4]. Buildings identified as sheds have not been considered in this assessment.

The Customer has advised that after engagement with landholders, two dwellings (R_22, R_56) will not be inhabited while the wind farm is operational [5]. Accordingly, these 2 dwellings were removed from this analysis, resulting in 42 dwellings for further consideration.

For the purposes of this assessment, 9 dwellings have been identified as having the potential to experience shadow flicker, based on their distances from the proposed turbine locations, and these have been considered in this assessment. It is noted that of those 9 dwellings, 6 have been identified by the Customer as involved dwellings.

The remaining 33 dwellings are at locations that are considered unlikely to be impacted by shadow flicker at intensities typically considered sufficient to cause annoyance, as discussed further in Sections 3.1 and 4.1.2, and have not been considered further in this assessment.

The 9 dwellings considered in this assessment are shown in Figure 3 and presented in Table 2.

It should be noted that the scope of the work reported here does not include a comprehensive survey of dwellings in the vicinity of the Project, and so DNV is relying on dwelling information provided by the Customer.

3 REGULATORY REQUIREMENTS

3.1 Shadow flicker

The development of wind farms in Western Australia is governed by the Western Australian Planning Commission's Position Statement on renewable energy facilities ("the WA Position statement"), published in March 2020 [6]. However, the WA Position Statement does not address the potential for wind farms to cause shadow flicker impacts at nearby dwellings. Therefore DNV has relied on other suitable guidelines to assess the shadow flicker for the Project, as discussed below.

The Environment Protection and Heritage Council (EPHC), in conjunction with Local Governments and the Planning Ministers' Council, released a draft version of the National Wind Farm Development Guidelines in July 2010 (Draft National Guidelines) [1]. The Draft National Guidelines cover a range of issues across the different stages of wind farm development. In relation to shadow flicker, the Draft National Guidelines provide background information, a proposed methodology, recommended limits, and a suite of assumptions for assessing shadow flicker durations in the vicinity of a wind farm.

The Draft National Guidelines recommend that the modelled theoretical shadow flicker duration at any dwelling should not exceed 30 hours per year at any dwelling, and that the actual or measured shadow flicker duration should not exceed 10 hours per year. The Draft National Guidelines also recommend that the shadow flicker duration at a dwelling be assessed by calculating the maximum shadow flicker occurring within 50 m of the centre of the dwelling. These limits are assumed to apply to a single dwelling, and it is noted that there is no requirement under the Draft National Guidelines to assess shadow flicker durations at locations other than in the vicinity of dwellings.

The impact of shadow flicker is typically only significant up to a limited distance from the wind turbines. Beyond this distance limit the shadow is diffused such that the variation in light levels is not likely to be sufficient to cause annoyance. This issue is discussed in the Draft National Guidelines, where it is stated that:

> *"Shadow flicker can theoretically extend many kilometres from a wind turbine. However the intensity of the shadows decreases with distance. While acknowledging that different individuals have different levels of sensitivity and may be annoyed by different levels of shadow intensity, these guidelines limit assessment to moderate levels of intensity (i.e., well above the minimum theoretically detectable threshold) commensurate with the nature of the impact and the environment in which it is experienced."*

The Draft National Guidelines suggest a shadow flicker distance limit equal to 265 times the maximum blade chord length, which would correspond to approximately 1000 to 1600 m for modern wind turbines (which typically have maximum blade chord lengths of 4 to 6 m). However, the UK wind industry considers that a distance limit of around 10 rotor diameters from a turbine [7, 8] or approximately 1200 m to 1900 m for modern wind turbines (which typically have rotor diameters of 120 m to 190 m), is appropriate.

For the purposes of this assessment, DNV has considered the guidance and recommendations given in the Draft National Guidelines in relation to shadow flicker along with the shadow flicker distance limit applied by the UK wind industry, as discussed further in Section 4.1.2.

3.2 Blade glint

Blade glint involves the regular reflection of the sun off rotating turbine blades. Its occurrence depends on a combination of circumstances arising from the orientation of the nacelle, angle of the blade and the angle of the sun. The reflectiveness of the surface of the blades is also important. Blade glint is not generally a problem for modern wind turbines [1].

A methodology for the quantification of blade glint impacts as well as a regulatory limit are not provided by the Draft National Guidelines [9]. However, the Draft National Guidelines suggest that the Customer ensures the blades of the wind turbines have a finish with low reflectivity.

In relation to blade glint, guidance from the Draft National Guidelines [1] states that:

> *"Blade glint can be produced when the sun's light is reflected from the surface of wind turbine blades. Blade glint has potential to annoy people.*
>
> *All major wind turbine blade manufacturers currently finish their blades with a low reflectivity treatment. This prevents a potentially annoying reflective glint from the surface of the blades and the possibility of a strobing reflection when the turbine blades are spinning. Therefore the risk of blade glint from a new development is considered to be very low.*
>
> *Proponents should ensure that blades from their supplier are of low reflectivity."*

4 ASSESSMENT METHODOLOGY

4.1 Shadow flicker

4.1.1 Overview

Shadow flicker may occur under certain combinations of geographical position and time of day when the sun passes behind the rotating blades of a wind turbine and casts a moving shadow over neighbouring areas. When viewed from a stationary position the moving shadows cause periodic flickering of the light from the sun, giving rise to the phenomenon of 'shadow flicker'.

The effect is most noticeable inside buildings, where the flicker appears through a window opening. The likelihood and duration of the effect depends upon a number of factors, including:

- the direction of the property relative to the turbine
- the distance of the property from the turbine (the further the observer is from the turbine, the less pronounced the effect will be)
- the turbine height and rotor diameter
- the time of year and day (the position of the sun in the sky)
- the weather conditions (cloud cover reduces the occurrence of shadow flicker)
- the wind direction (the shape of the shadow will be determined by the position of the sun relative to the blades which will be oriented to face the wind).

Example photographs of wind turbines and associated shadows which have the potential to cause flicker are shown in Figure 1 below.

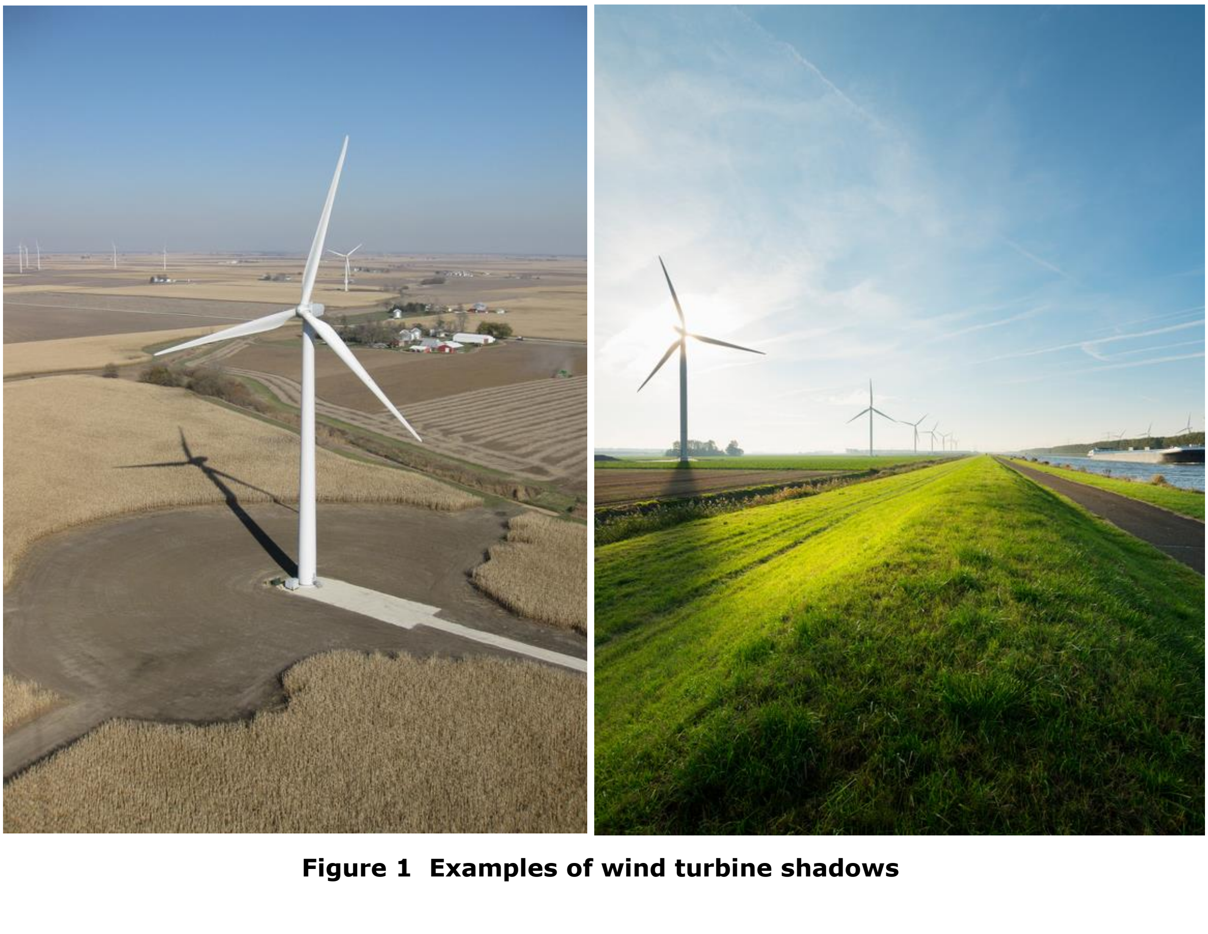

Figure 1 Examples of wind turbine shadows

4.1.2 Theoretical modelled duration

The theoretical number of hours of shadow flicker experienced annually at a given location can be calculated using a geometrical model which incorporates the sun path, topographic variation over the site area, and wind turbine details such as rotor diameter and hub height.

The wind turbines have been modelled assuming they are spherical objects, which is equivalent to assuming the turbines are always oriented perpendicular to the sun-turbine vector. This assumption will mean the model calculates the maximum duration for which there is potential for shadow flicker to occur, up to a specified distance limit.

In line with the methodology proposed in the Draft National Guidelines, DNV has assessed the shadow flicker at the provided dwellings and has determined the highest shadow flicker duration within 50 m of each of these locations.

In the absence of detailed dwelling height information, shadow flicker has been calculated at the dwellings at heights of 2 m, to represent ground floor windows, and 6 m, to represent second floor windows. The shadow receptors are simulated as fixed points, representing the worst-case scenario, as real windows could be facing a particular direction less affected by shadows cast from the turbines. The shadow flicker calculations for dwelling locations have been carried out with a temporal resolution of 1 minute. The shadow flicker map was generated using a temporal resolution of 5 minutes and a spatial resolution of 10 m to reduce computational requirements to acceptable levels.

As part of the shadow flicker assessment, it is necessary to make an assumption regarding the maximum length of a shadow cast by a wind turbine that is likely to cause annoyance due to shadow flicker. As noted in Section 3.1, the UK wind industry considers that 10 rotor diameters is appropriate [7, 8] while the Draft National Guidelines suggest a distance limit equivalent to 265 times the maximum blade chord [1].

For the current assessment, DNV has applied a maximum shadow length of 10 times the rotor diameter (10D), corresponding to a distance limit of 1800 m for the Project, which DNV considers is more appropriate than a limit of 265 times the maximum blade chord. Beyond this distance limit, it is assumed that any shadow flicker experienced will be below a “moderate level of intensity” and unlikely to cause annoyance. However, it is recognised that different people have different levels of sensitivity to shadow flicker and may therefore be affected by shadow flicker intensities below the “moderate level of intensity” assumed by this distance limit. To account for this possibility, DNV has also calculated the shadow flicker to a distance of up to 15 times the rotor diameter (15D), or 2700 m, which should include shadow flicker below a “moderate level of intensity”.

In this assessment, shadow flicker of a moderate level of intensity or above is assumed to occur up to a distance of approximately 10D from the wind farm. Conversely, shadow flicker below a moderate level of intensity, described as “low intensity” shadow flicker in this report, is assumed to occur beyond a distance of 10D and up to a distance of approximately 15D from the wind turbines.

The model also makes the following assumptions and simplifications:

- there are clear skies every day of the year
- the blades of the turbines are always perpendicular to the direction of the line of sight from the location of interest to the sun
- the turbines are always rotating.

The first two of these items are addressed in the calculation of the predicted actual shadow flicker duration as described in Section 4.1.4. The third item is not considered but is unlikely to have a significant impact on the results. The settings used to execute the model can be seen in Table 3.

To illustrate typical results, an indicative shadow flicker map for a turbine located in a flat area is shown in Figure 4. The geometry of the shadow flicker map can be characterised as a butterfly shape, with the four protruding lobes corresponding to slowing of solar north-south travel around the summer and winter solstices for morning and evening. The lobes to the north of the indicative turbine location result from the summer months and conversely the lobes to the south result from the winter months. The lobes to the west result from morning sun while the lobes to the east result from evening sun. When the sun is low in the sky, the length of shadows cast by the turbine increases, increasing the area around the turbine affected by shadow flicker.

4.1.3 Factors affecting duration

Shadow flicker duration calculated in this manner overestimates the annual number of hours of shadow flicker experienced at a specified location for several reasons, including:

1. The wind turbine will not always be oriented such that its rotor is in the worst-case position (i.e., perpendicular to the sun-turbine vector). Any other rotor orientation will reduce the area of the projected shadow and hence the shadow flicker duration.

   The wind speed frequency distribution or wind rose at the site can be used to determine probable turbine orientation and to calculate the resulting reduction in shadow flicker duration.

2. The occurrence of cloud cover has the potential to significantly reduce the number of hours of shadow flicker. Cloud cover measurements recorded at nearby meteorological stations may be used to estimate probable levels of cloud cover and to provide an indication of the resulting reduction in shadow flicker duration.

3. Aerosols (moisture, dust, smoke, etc.) in the atmosphere have the ability to influence shadows cast by a wind turbine. The length of the shadow cast by a wind turbine is dependent on the degree that direct sunlight is diffused, which is in turn dependent on the amount of dispersants (humidity, smoke, and other aerosols) in the path between the light source (sun) and the receiver.

4. The modelling of the wind turbine rotor as a sphere rather than individual blades results in an overestimation of the shadow flicker duration. Turbine blades are of non-uniform thickness with the thickest part of the blade (maximum chord) close to the hub and the thinnest part (minimum chord) at the tip. Diffusion of sunlight, as discussed above, results in a limit to the maximum distance that a shadow can be perceived. This maximum distance will also be dependent on the thickness of the turbine blade, and the human threshold for perception of light intensity variation. As such, a shadow cast by the blade tip will be shorter than the shadow cast by the thickest part of the blade.

5. The analysis does not consider that when the sun is positioned directly behind the wind turbine hub, there is no variation in light intensity at the receiver location and therefore no shadow flicker.

6. The presence of vegetation or other physical barriers around a shadow receptor location may shield the view of the wind turbine, and therefore reduce the incidence of shadow flicker.

7. Periods where the wind turbine is not in operation due to low winds, high winds, or for operational and maintenance reasons will also reduce the annual shadow flicker duration.

4.1.4 Predicted actual duration

As discussed above in Section 4.1.3, there are a number of factors which may reduce the incidence of shadow flicker that are not taken into account in the calculation of the theoretical shadow flicker duration. An attempt has been made to quantify the likely reduction in shadow flicker duration due to cloud cover and, therefore, produce a prediction of the actual shadow flicker duration likely to be experienced at a dwelling.

Cloud cover is typically measured in 'oktas', effectively eighths of the sky covered with cloud. DNV has obtained data from the following Bureau of Meteorology stations:

- Enneaba (8225), located approximately 19 km west of the centre of the Project [10]
- Carnamah (8025), located approximately 46 km northeast of the centre of the Project [11]
- Jurien Bay (9131), located approximately 63 km southwest of the centre of the Project [12]
- Morawa (8093), located approximately 84 km northeast of the centre of the Project [13].

The number of oktas of cloud cover visible across the sky at these stations is recorded twice daily, at 9 am and 3 pm, and the observations are provided as monthly averages. After averaging the 9 am and 3 pm observations for the stations considered, the results indicate that the average monthly cloud cover in the region ranges between 26% and 51%, and the average annual cloud cover is approximately 41%. This implies that on an average day, 41% of the sky in the vicinity of the wind farm is covered with clouds. Although it is not possible to definitively calculate the effect of cloud cover on shadow flicker duration, a reduction in the shadow flicker duration proportional to the amount of cloud cover is considered to be a reasonable assumption.

Similarly, turbine orientation can have an impact on the shadow flicker duration. The shadow flicker duration is greatest when the turbine rotor plane is approximately perpendicular to a line joining the sun and an observer, and a minimum when the rotor plane is approximately parallel to a line joining the sun and an observer. A wind direction frequency distribution for the site was derived from publicly available wind direction data [14] and used to estimate the reduction in shadow flicker duration due to rotor orientation. The site wind rose is shown overlaid on the indicative shadow flicker map in Figure 4. The assessment of the likely reduction in shadow flicker duration due to variation in turbine orientation was conducted on an annual basis.

It should be noted that the method prescribed by the Draft National Guidelines for assessing actual shadow flicker duration recommends that only reductions due to cloud cover, and not turbine orientation, be included. However, DNV considers that the additional reduction due to turbine orientation is appropriate as the projected area of the turbine, and therefore the expected shadow flicker duration, is reduced when the turbine rotor is not perpendicular to the line joining the sun and dwelling. Due to limitations in the availability of suitable cloud cover data, the methodology used in this assessment also deviates somewhat from the method recommended by the Draft National Guidelines for assessing the reduction in shadow flicker due to cloud cover. However, considering the available cloud cover data, the approach described above is deemed to provide a reasonable estimate of the likely impact of cloud cover on the shadow flicker duration.

While the calculation of the predicted actual shadow flicker duration considers the likely reductions due to cloud cover and rotor orientation, it does not take into account other potential reductions due to low wind speed (or turbine shutdown), vegetation, or other shielding effects around each dwelling.

4.2 Blade glint

Blade glint involves the regular reflection of sun off rotating turbine blades. Its occurrence depends on a combination of circumstances arising from the orientation of the nacelle, angle of the blade and the angle of the sun. The reflectiveness of the surface of the blades is also important. Blade glint is not generally a problem for modern wind turbines, provided the blades are coated with a non-reflective paint, and it is not considered further here.

5 ASSESSMENT RESULTS

5.1 Shadow flicker

5.1.1 Predicted shadow flicker durations

Shadow flicker predictions were generated at the provided dwelling locations, and the results are summarised in Table 4.

The results of the theoretical and predicted actual shadow flicker modelling are also shown in the form of shadow flicker maps in Figure 5 and Figure 6 respectively. The shadow flicker values presented in these maps represent the worst case between the results calculated at 2 m and 6 m above ground level for each modelled grid point.

Based on this assessment, one dwelling (R_17) is expected to experience shadow flicker above a moderate level of intensity within 50 m of the dwelling. For the purposes of this assessment, shadow flicker above a moderate level of intensity is assumed to occur up to a distance of around 10 rotor diameters from the wind turbines.

The affected dwelling (R_17) is an involved dwelling and is predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling. When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, the predicted actual shadow flicker duration within 50 m of the dwelling is above the recommended limit of 10 hours per year.

Beyond the 10D distance limit, it is assumed that any shadow flicker experienced will be below a moderate level of intensity and unlikely to cause annoyance. However, as discussed in Section 4.1.2, it is recognised that different people have different levels of sensitivity to shadow flicker and may therefore be affected by low intensity shadow flicker assumed by this distance limit. To inform the potential for this outcome, although not part of the methodology outlined in the Draft National Guidelines, DNV has also calculated the theoretical shadow flicker impacts for the Project for an increased distance limit of 15D that is intended to include shadow flicker of low intensity. The results of this additional assessment are also included in the map presented in Figure 5.

These results indicate that, in addition to the dwelling expected to be affected by shadow flicker above a moderate level of intensity, four dwellings may have the potential to be exposed to low intensity shadow flicker. These dwellings are noted in Table 4.

5.1.2 Mitigation options

If required, the effects of shadow flicker may be reduced through a number of mitigation measures. These include the removal or relocation of turbines, the use of turbines with a smaller rotor diameter, installation of screening structures or planting of trees to block shadows cast by the turbines, or the use of turbine control strategies to shut down turbines when shadow flicker is likely to occur.

DNV understands that appropriate mitigation measures will be considered during the detailed design phase, for example through final turbine siting. Once the final turbine layout is confirmed, detailed modelling will be required to calculate expected shadow flicker durations.

5.2 Blade glint

As discussed in Section 4.2, blade glint is not expected to be an issue for the Project provided that a non-reflective paint is applied to the wind turbine blades.

6 CONCLUSIONS

A shadow flicker assessment was carried out for dwelling locations in the vicinity of the Project.

For the purpose of this assessment, DNV has considered a layout consisting of 140 turbines with a rotor diameter of 180 m and a hub height of 160 m. These dimensions represent the maximum turbine dimensions currently under consideration for the Project.

Based on this assessment, one dwelling is predicted to experience some shadow flicker above a moderate level of intensity within 50 m of the dwelling. For the purposes of this assessment, shadow flicker above a moderate level of intensity is assumed to occur up to a distance of 10 rotor diameters from the wind turbines.

The affected dwelling (R_17) is an involved dwelling and is predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling. When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, the predicted actual shadow flicker duration within 50 m of the dwelling is above the recommended limit of 10 hours per year.

Given that dwelling R_17 is affected and that the current layout reflects the maximum turbine dimensions under consideration - DNV understands that appropriate mitigation measures will be considered during the detailed design phase and final turbine siting. Once the final turbine layout and configuration is confirmed, detailed modelling will be required to calculate the expected shadow flicker durations at dwellings surrounding the Project..It is recommended that the turbine blades are coated with a non-reflective paint to avoid the occurrence of blade glint from the wind farm.

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Table 1 Proposed turbine layout for the Project [2]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]
1_ES	346079	6705430	230	47_ES	354139	6702930	269
2_ES	346199	6706310	237	1_TN	349779	6698650	235
3_ES	346239	6703770	206	2_TN	350639	6698310	256
4_ES	346259	6704930	234	3_TN	351599	6698950	248
5_ES	346304	6706704	234	4_TN	351619	6697610	244
6_ES	346519	6704430	225	5_TN	351879	6698490	253
7_ES	346699	6702650	234	6_TN	352499	6697910	260
8_ES	346919	6703510	226	7_TN	353059	6695170	242
9_ES	347059	6705650	232	8_TN	353339	6697950	273
10_ES	347479	6706670	244	9_TN	353539	6698990	250
11_ES	347659	6705650	257	10_TN	353779	6694630	247
12_ES	347699	6704110	237	11_TN	353799	6696190	270
13_ES	347899	6702190	237	12_TN	353819	6698470	275
14_ES	348059	6700910	223	13_TN	353939	6697210	294
15_ES	348139	6706830	264	14_TN	354279	6694990	273
16_ES	348179	6699530	227	15_TN	354419	6697450	309
17_ES	348319	6699010	220	16_TN	354479	6699010	272
18_ES	348319	6705090	260	17_TN	354679	6696350	286
19_ES	348339	6698370	221	18_TN	354839	6697810	289
20_ES	348359	6701530	233	19_TN	354999	6695390	285
21_ES	348399	6702850	225	20_TN	355339	6698990	292
22_ES	348519	6706270	276	21_TN	355419	6694110	281
23_ES	348927	6704647	272	22_TN	355919	6696230	311
24_ES	348998	6703577	255	23_TN	355999	6694270	274
25_ES	349099	6705550	285	24_TN	356059	6699030	288
26_ES	349259	6706890	273	25_TN	356179	6696890	316
27_ES	349279	6706370	269	26_TN	356219	6695410	291
28_ES	349699	6703990	289	27_TN	356219	6698370	301
29_ES	349719	6704970	308	28_TN	356459	6697650	313
30_ES	350079	6702290	263	29_TN	356519	6693950	264
31_ES	350379	6704870	304	30_TN	356539	6696210	309
32_ES	350539	6702550	273	31_TN	356719	6694650	279
33_ES	350859	6705070	284	32_TN	356999	6699030	313
34_ES	350959	6702870	282	33_TN	357019	6698130	319
35_ES	351059	6704190	302	34_TN	357019	6697250	301
36_ES	351379	6703550	292	35_TN	357119	6695550	294
37_ES	351639	6702890	277	36_TN	357179	6694150	263
38_ES	351759	6702370	266	1_TS	344819	6690530	231
39_ES	351779	6704190	285	2_TS	344819	6691390	211
40_ES	352019	6705090	281	3_TS	345039	6690050	219
41_ES	352559	6704410	262	4_TS	345135	6692805	255
42_ES	352599	6703470	247	5_TS	345159	6690950	219
43_ES	353599	6705110	257	6_TS	345421	6692229	235
44_ES	353859	6702470	252	7_TS	345666	6693106	237
45_ES	353999	6703470	250	8_TS	346099	6691530	211
46_ES	354139	6704390	243	9_TS	346199	6689990	206

Table 1 Proposed turbine layout for the Project [2] (continued)

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]	Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]
10_TS	346559	6689550	227	34_TS	350279	6694450	270
11_TS	347199	6693090	201	35_TS	350339	6693070	265
12_TS	347219	6690670	217	36_TS	350419	6690830	269
13_TS	347259	6691650	216	37_TS	350519	6693650	262
14_TS	347539	6689570	212	38_TS	350859	6694790	262
15_TS	347699	6693470	216	39_TS	350879	6695870	251
16_TS	347879	6692330	219	40_TS	350919	6691870	282
17_TS	347999	6694130	208	41_TS	350939	6696430	237
18_TS	348019	6690950	217	42_TS	350999	6690970	301
19_TS	348139	6695870	219	43_TS	351499	6692330	286
20_TS	348319	6696770	226	44_TS	351519	6690330	282
21_TS	348379	6690330	231	45_TS	351579	6693650	254
22_TS	348679	6692270	231	46_TS	351719	6689570	277
23_TS	348779	6689690	237	47_TS	352039	6692730	267
24_TS	348779	6697430	240	48_TS	352059	6690870	272
25_TS	348899	6695530	251	49_TS	352499	6689850	261
26_TS	348959	6694510	238	50_TS	352679	6691730	289
27_TS	349099	6693370	253	51_TS	352959	6692230	284
28_TS	349119	6696910	254	52_TS	353019	6691230	267
29_TS	349579	6696350	241	53_TS	353099	6690070	260
30_TS	349619	6690390	256	54_TS	353199	6692730	260
31_TS	349739	6689610	264	55_TS	353579	6690370	253
32_TS	349819	6691590	263	56_TS	353759	6691550	254
33_TS	349999	6695370	262	57_TS	354159	6690530	252

1. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.

Table 2 Locations of dwellings considered in this assessment [4]

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Dwelling status	Nearest turbine	
				Distance [m][2]	Turbine ID
R_17	*344750*	*6703990*	*Involved*	*1506*	*ES 3*
R_18	344981	6708695	Non-involved	2391	ES 5
R_19	345168	6688459	Non-involved	1596	TS 3
R_20	345389	6700617	Non-involved	2418	ES 7
R_22[5]	*345548*	*6692945*	*Involved*	*200*	*TS 7*
R_33	*347695*	*6687379*	*Involved*	*2197*	*TS 14*
R_34	*347741*	*6687438*	*Involved*	*2141*	*TS 14*
R_35	*347793*	*6687280*	*Involved*	*2304*	*TS 14*
R_43	*350094*	*6700567*	*Involved*	*1723*	*ES 30*
R_56[5]	*354935*	*6698941*	*Involved*	*407*	*TN 20*
R_59	*355264*	*6692623*	*Involved*	*1495*	*TN 21*

1. Involved dwellings are indicated by *underlined italic text*.
2. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
3. The shadow flicker assessment has considered dwellings up to a maximum distance of 15D + 50 m from the Project wind turbines.
4. Locations listed as sheds in the data provided have not been considered in this assessment.
5. The Customer has advised that this dwelling will not be inhabited while the wind farm is operational and as a result this dwelling has been excluded from the analysis.

Table 3 Shadow flicker model settings for theoretical shadow flicker calculation

Model setting	
Shadow distance limit (10D)	1800 m
Year of calculation	2037
Minimum elevation of the sun	3°
Time step	1 min (5 min for map)
Rotor modelled as	Sphere (disc for turbine orientation reduction calculation)
Sun modelled as	Disc
Offset between rotor and tower	None
Receptor height (single storey)	2 m
Receptor height (double storey)	6 m
Locations used for determining maximum shadow flicker within 50 m of each dwelling	8 points evenly spaced (every 45°) on 25 m and 50 m radius circles centred on the provided dwelling location

Table 4 Theoretical and predicted actual annual shadow flicker duration for dwellings expected to be affected by shadow flicker above a moderate level of intensity

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Dwelling status	Contributing turbines[2]	Theoretical annual At dwelling [hr/yr]		Theoretical annual Max within 50 m [hr/yr]		Predicted actual annual[2] At dwelling [hr/yr]		Predicted actual annual[2] Max within 50 m [hr/yr]	
					2 m	6 m	2 m	6 m	2 m	6 m	2 m	6 m
17	344750	6703990	Involved	3 ES, 4 ES, 6 ES	**43.8**	**43.6**	**59.1**	**58.7**	**16.4**	**16.3**	**22.1**	**22.0**
19[3]	345167	6688458	Non-involved	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20[3]	345389	6700617	Non-involved	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43[3]	350094	6700567	Involved	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59[3]	355264	6692623	Involved	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Recommended duration limits (hr/yr)					**30**	**30**	**30**	**30**	**10**	**10**	**10**	**10**

1. Coordinate system: MGA zone 50, GDA94 datum. Coordinates were provided by the Customer in a different coordinate system and/or datum and have been converted using mapping software, which may result in small discrepancies depending on the software and transformation approach used.
2. Considering likely reductions in shadow flicker duration due to cloud cover and turbine orientation.
3. Dwelling is not predicted to experience any shadow flicker above a moderate level of intensity, but may experience low-intensity shadow flicker.

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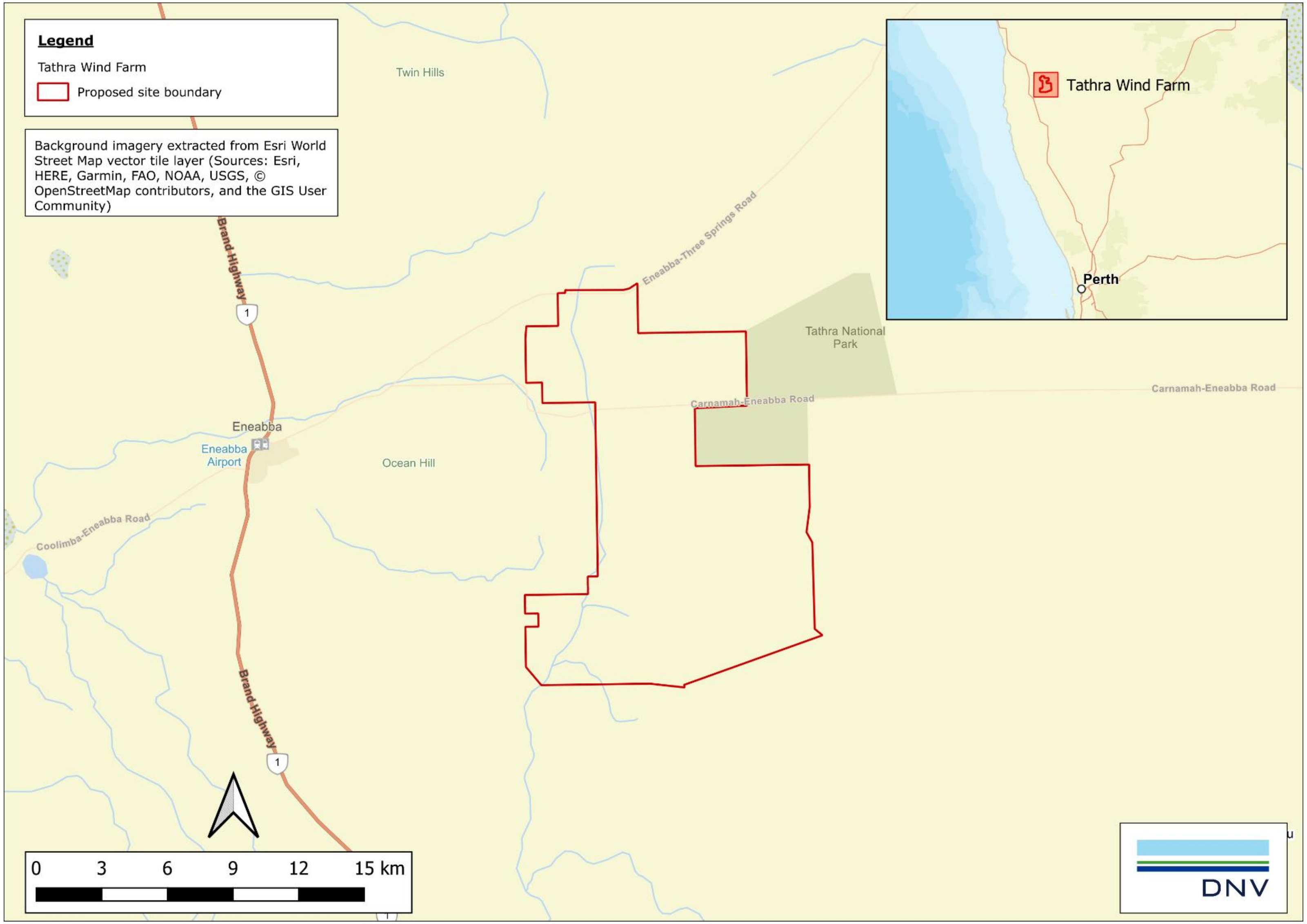

Figure 2 Location of the Project

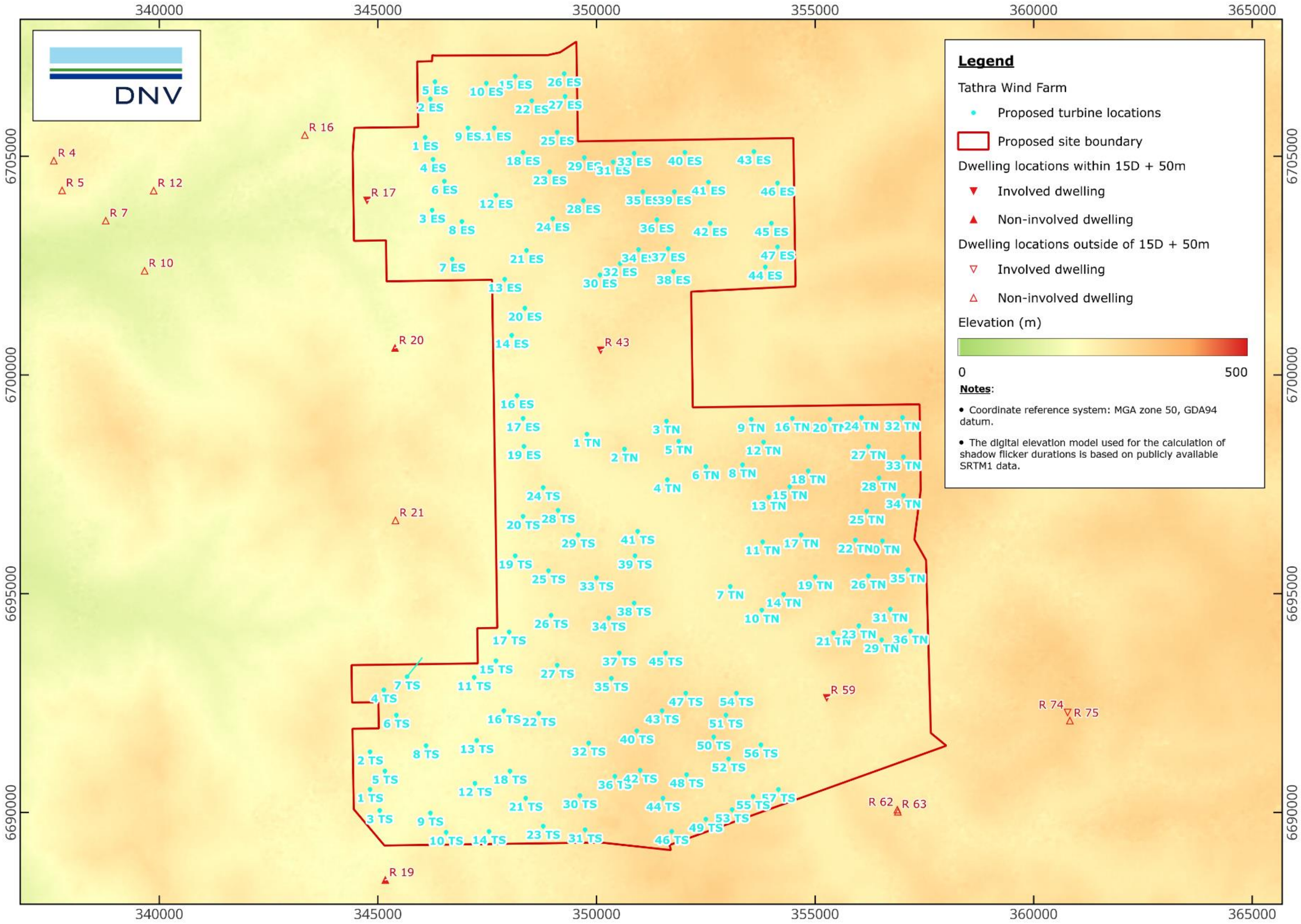

Figure 3 Map of the proposed Project, showing proposed turbine locations, nearby dwellings, and terrain elevation [3]

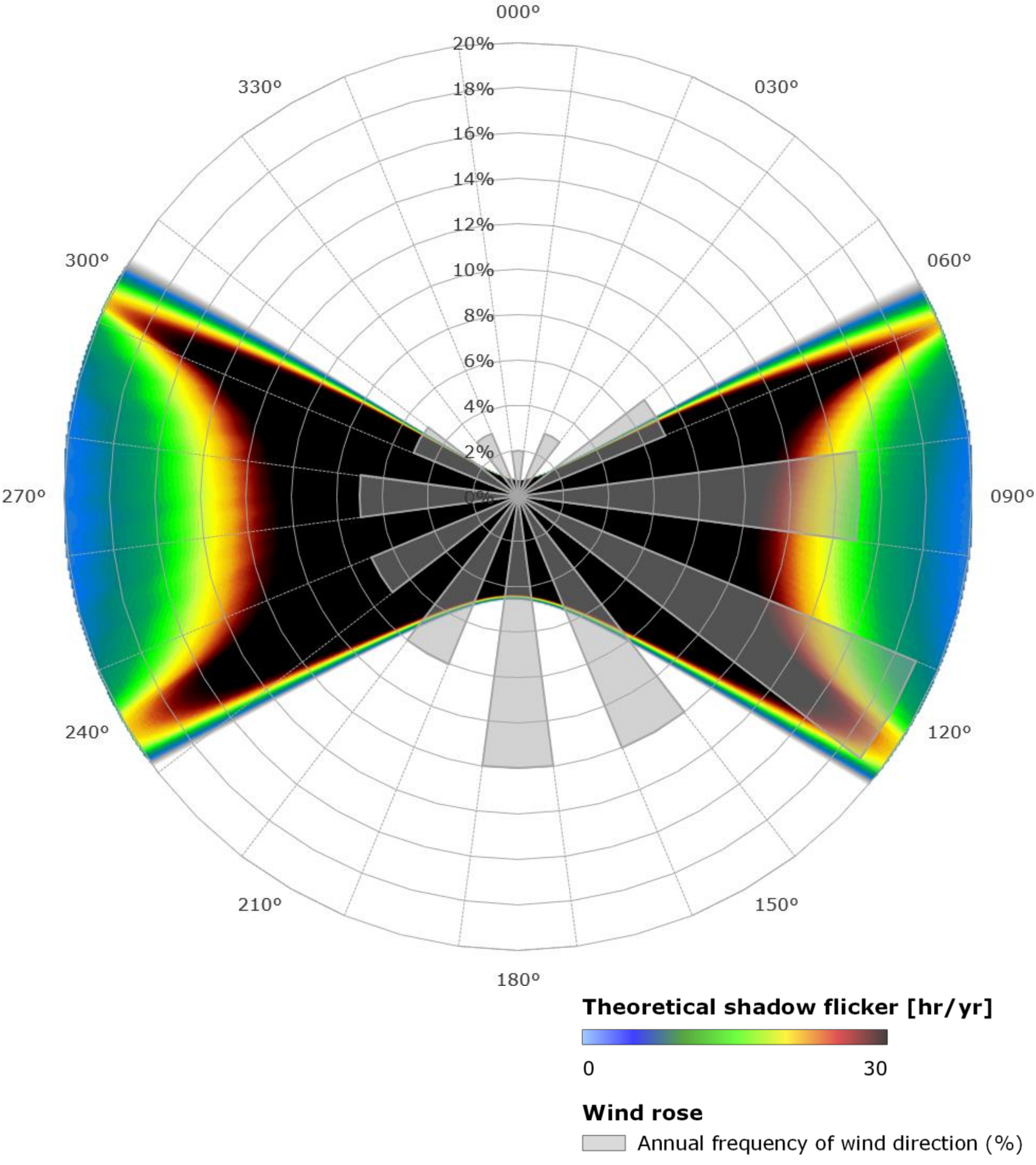

Figure 4 Indicative shadow flicker map and wind direction frequency distribution

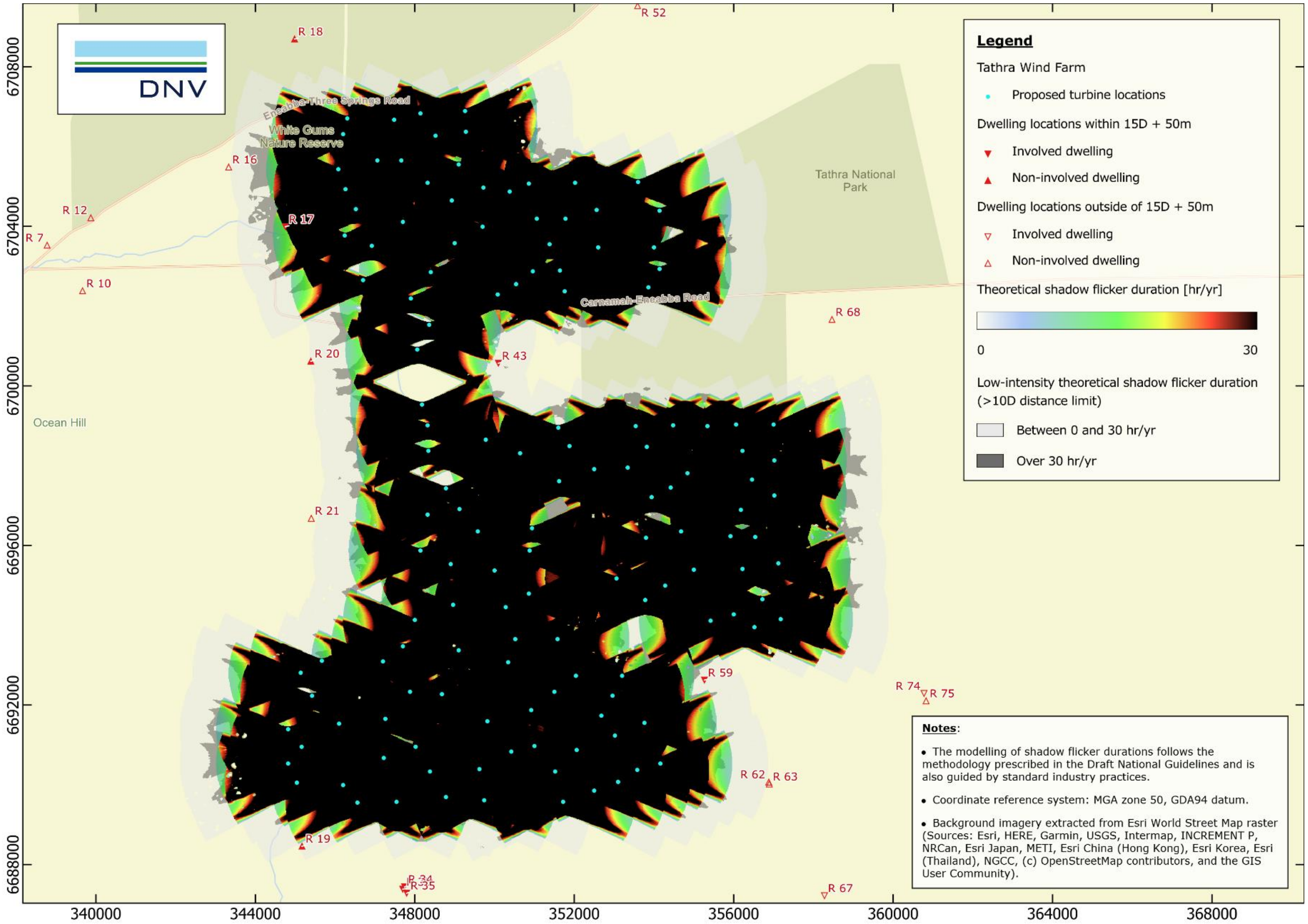

Figure 5 Theoretical annual shadow flicker duration map for the Project

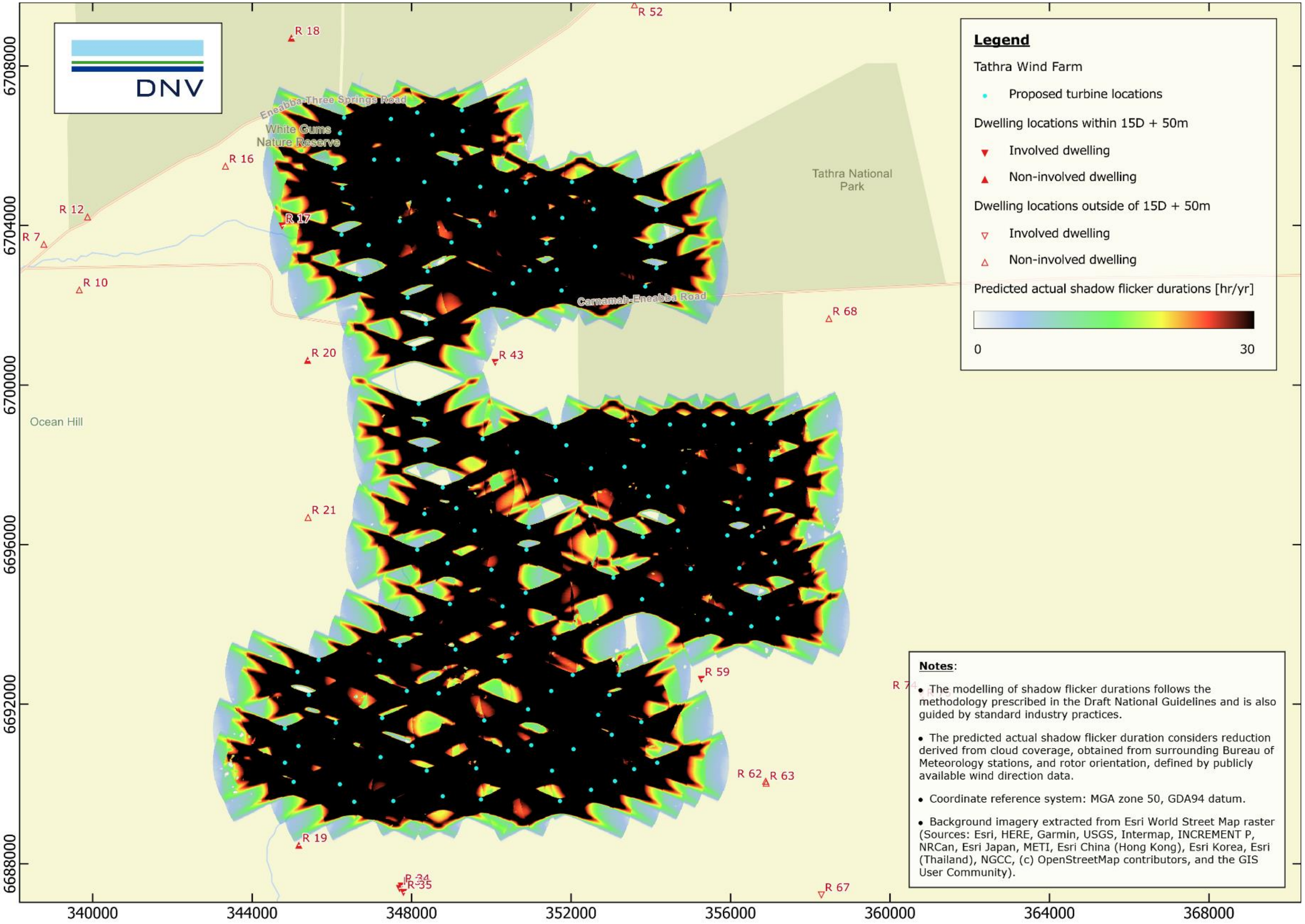

Figure 6 Predicted actual annual shadow flicker duration map for the Project

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