KOJONUP WIND FARM

Shadow Flicker and Blade Glint Assessment

Kojonup Wind Farm Pty Ltd

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D	2025-10-15	Edited text in Executive Summary, Mitigation options and Conclusions sections. Final report.	PD, DP	ET	KB

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EXECUTIVE SUMMARY

DNV has been commissioned by Moonies Hill New Energy Pty Ltd ("the Customer") to independently assess the expected annual shadow flicker durations in the vicinity of the proposed Kojonup Wind Farm ("the Project") in Western Australia. The results of the shadow flicker assessment are described in this document. The Customer has requested that this report is addressed to Kojonup Wind Farm Pty Ltd.

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 33 wind turbines with a maximum rotor diameter of 162 m and a hub height of 125 m has been considered in this assessment. The locations of 118 dwellings in the vicinity of the Project have been provided by the Customer, of which up to 25 dwellings 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, 14 dwellings are 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. Of these 14 dwellings, 12 are project participants.

Out of the 14 dwellings predicted to experience shadow flicker above a moderate level of intensity, 7 are predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling. All 7 dwellings are project participants. When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, for all of these dwellings, the predicted actual shadow flicker durations within 50 m of the dwelling are also above the recommended limit of 10 hours per year. The predicted shadow flicker durations at dwellings 9 and 10 significantly exceed the recommended limits.

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.

For project participant Dwelling 1, 10, 17, 31 and 207 in the vicinity of the wind farm, DNV has also carried out an additional assessment based on photomontages and associated metadata supplied to DNV. This information has been used by DNV to assess whether the predicted shadow flicker at these locations could be reduced further because of existing vegetation, screening or other obstacles affecting the line of sight between the dwelling location and the relevant turbines

identified as contributing to shadow flicker at or above a moderate level of intensity at that dwelling, with the results of this assessment as follows:

- For Dwelling 1 and 31, it is unlikely that the existing amenity of the dwelling for its occupants will be affected by shadow flicker impacts from the wind farm. For Dwelling 31, there is likely to be a similar reduction in the predicted shadow flicker for all areas within 50 m of the dwelling also, however for Dwelling 1 it is not possible to be completely conclusive in this regard.
- For Dwelling 10, it is likely that the shadow flicker at the dwelling, as well as some areas within 50 m of the dwelling, will be significantly reduced compared to the predicted durations. However, without additional shadow flicker modelling, it is not clear if this will result in the shadow flicker durations falling below recommended thresholds. While it is not expected that there will be shadow flicker occurring during afternoon periods at the dwelling and some areas within 50 m of the dwelling, during morning periods there may still be potential for shadow flicker.
- For Dwelling 17 and 207, the shadow flicker at the dwelling could potentially be reduced compared to the predicted durations. However, without additional shadow flicker modelling, the extent of the shadow flicker reduction is not clear, including if this will result in the shadow flicker durations falling below recommended thresholds. For Dwelling 17, the potential reduction in the shadow flicker anticipated at the dwelling may not apply for all areas within 50 m of the dwelling, while for Dwelling 207 the potential reduction in the shadow flicker anticipated at the dwelling is unlikely to apply for all areas within 50 m of the dwelling.

For the current proposed layout and turbine parameters, the effects of shadow flicker for the operating wind farm may be reduced through the following mitigation measures:

- Mitigation strategy type 1: installation of blinds, screening structures or planting of trees to block shadows cast by the turbines, if acceptable to the landowner.
- Mitigation strategy type 2: if type 1 mitigation strategies are not acceptable or insufficient, additional reductions in shadow flicker to acceptable levels could be achieved through the use of turbine control strategies to shut down specific turbines when shadow flicker is likely to occur.

For a number of the dwellings investigated, as detailed in the supplementary photomontage visual assessments referred to in this report, it is likely that excessive shadow flicker durations would be significantly reduced through the use of type 1 mitigation strategies outlined above, if it is experienced at the dwellings due to operation of the wind farm.

Regarding dwellings where the shadow flicker is predicted to exceed the recommended limits based on the shadow flicker modelling (prior to any consideration of vegetation or obstacle screening effects), it is noted that these are all Project Participants. The Customer has informed DNV that for these Project Participants an agreement is being developed to accept increased shadow flicker above the recommended limits and allow for the proposed mitigation measures. Based on the shadow flicker and additional visual assessment it is likely that, for a number of the affected dwellings, the predicted shadow flicker will be significantly reduced by the existing vegetation. The Customer has informed DNV that, if shadow flicker is a problem at these dwellings during project operation, then the Customer, in consultation with the affected landowners, is committed to mitigation measures such as the installation of blinds and/or vegetation screening as required.

The shadow flicker results and proposed mitigation in this assessment apply to the proposed layout and turbine parameters considered in this report. If the layout or turbine parameters are changed, then this report should be updated.

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 Customer ensures that the turbine blades used have a surface finish with a low reflectivity to avoid occurrences of blade glint.

1 INTRODUCTION

Moonies Hill New Energy Pty Ltd ("the Customer") has commissioned DNV to independently assess the expected annual shadow flicker durations in the vicinity of the proposed Kojonup Wind Farm ("the Project") in Western Australia. The results of this work are reported here. This document has been prepared in accordance with DNV proposal OPP-00396038-AUMEL-P-01 Issue A, dated 30 January 2025, and is subject to the terms and conditions in that agreement. The Customer has requested that this report is addressed to Kojonup Wind Farm Pty Ltd.

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 The site

The Project is located approximately 260 km south-east of Perth and 15 km South of the township of Kojonup.

The terrain at the site is relatively simple with elevations ranging from approximately 280 m to 390 m above sea level. The site is comprised of agricultural land with pockets of forest and shrubs throughout. A digital elevation model of the surrounding terrain was derived from publicly available SRTM data [2].

2.2 The Project

2.2.1 Proposed wind farm layout

The Project is proposed to consist of 33 wind turbines [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 2.

DNV has modelled the shadow flicker based on a theoretical turbine model with a rotor diameter of 162 m and hub height of 125 m.

2.2.2 Dwelling locations

The locations of 118 dwellings in the vicinity of the Project have been provided by the Customer [4, 5] .

For the purposes of this assessment, 25 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. Of those 25 dwellings, 15 have been identified by the Customer as project participants.

The remaining 93 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 25 dwellings considered in this assessment are shown in Figure 3 and presented in Table 3.

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 1620 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 2430 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 4.

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:

- Kojonup (10582), located approximately 15 km north of the centre of the Project [10]
- Katanning (10579), located approximately 50 km north-east of the centre of the Project [11]
- Mount Barker (9581), located approximately 86 km south-east of the centre of the Project [12]
- Franklin Vineyards (9843), located approximately 54 km south of the centre of the Project [13]
- Bridgetown (9510), located approximately 90 km west of the centre of the Project [14].

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 40% and 67%, and the average annual cloud cover is approximately 57%. This implies that on an average day, 57% 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 derived from wind measurements at the site was provided by the Customer [15] 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.

4.1.5 Additional reductions in shadow flicker reductions due to existing vegetation, screening and other obstacles

The modelling carried out by DNV for both the theoretical and actual shadow flicker durations do not account for the presence of vegetation, obstacles, screening, or other physical barriers around a particular dwelling location, which may shield the view of wind turbines, and therefore reduce the incidence of shadow flicker, for that location.

For a number of dwellings in the vicinity of the wind farm, DNV has been supplied with photomontages and associated metadata [16, 17], which have been derived from photos taken from adjacent to the dwelling location, and in directions facing the wind farm. This information has been used by DNV to assess whether the predicted shadow flicker at these locations could be reduced further because of existing vegetation, screening or other obstacles affecting the line of sight between the dwelling location and the relevant turbines identified as contributing to shadow flicker at or above a moderate level of intensity at that dwelling. This visual assessment has been carried out for the dwellings given in Table 1 below, which also includes details of each photomontage.

Table 1 Dwellings with supporting photomontage visual assessments

Dwelling ID	Dwelling status	Photomontage viewpoint location (approx.)		Viewing direction (approx.)	Nearest turbine (Distance m)[2]	Turbines contributing to shadow flicker[3]
		Easting[1] [m]	Northing[1] [m]			
1	Project participant	514460	6243017	W	T10 (664 m)	T08, T09
10	Project participant	512461	6239935	W	T24 (783 m)	T22, T24, T25
		512461	6239942	NNW		
		512476	6239934	NE		
17	Project participant	508352	6242269	E	T15 (1047 m)	T15, T16
31	Project participant	510003	6240456	E	T23 (998 m)	T22, T23, T25
207	Project participant	508875	6241719	E	T16 (826 m)	T16

1. Coordinate system: MGA zone 50, GDA94 datum. These 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. In some cases the viewpoint coordinates were also edited by DNV based on information supplied by the Customer [17], features visible in the photos, and Google Earth aerial imagery.
2. Turbine distance from the nominal dwelling location.
3. Turbines contributing to predicted theoretical shadow flicker of a moderate level of intensity or above, within 50 m of dwelling.

In each case, the photos used in the photomontages were taken at approximately 1.7 m above ground level.

Note that the conclusions drawn regarding the predicted theoretical shadow flicker, based on the supplied photomontages, are subject to the following comments:

- DNV's assessment of the reduction in shadow flicker for the selected viewpoints is based on visual inspection of photomontage images of the wind farm that were supplied to DNV and produced by a third-party. DNV does not take responsibility for the accuracy of these images. In some cases, where vegetation in the near field view is thick and obscures the terrain horizon, it can be additionally challenging to align the wind farm model with the terrain.

- It is DNV's understanding that these photomontages are using the same turbine layout and dimensions (hub height and rotor diameter) that DNV has used in the shadow flicker assessment report here.
- DNV's assessment of the reduction in shadow flicker due to surrounding vegetation, screening and obstacles is based on a visual inspection of these photomontages, and is therefore a qualitative assessment based on DNV's experience in both shadow flicker impacts and photomontage production, but is not based on any supplementary computational modelling that directly incorporates vegetation, screening or obstacle effects.
- The assessment of the reduction in shadow flicker based on each photomontage is applicable only to the immediate location of that viewpoint only. In some cases, if the angle of view is sufficiently changed by moving from the viewpoint location, then the level of visibility of the turbines may change, to an extent that depends also on the location and porosity of the vegetation or obstacles relative to the viewpoint.
- Considering the point above, even if reductions in shadow flicker are suggested by the photomontages for a particular viewpoint, in some cases there may still be no reduction in the predicted shadow flicker for specific areas within 50 m of the dwelling. The Draft National Guidelines 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.
- DNV has not visited the locations of the assessed dwellings and is relying on a desktop analysis based on the supplied information only. This includes an assessment of the level of porosity of the surrounding vegetation to visible light, which when low may contribute to a reduction in shadow flicker. DNV has also assumed that the level of vegetation visible in the photomontages is generally consistent throughout the year (i.e. that there is not any loss of foliage during specific seasons).
- The assessment considers the effect of turbines contributing to shadow flicker of a moderate level of intensity or above, that is likely to cause annoyance. These turbines are labelled in each of the photomontages given in Appendix A. However, even if there are reductions in this type of shadow flicker, some low intensity shadow flicker may still be possible from these turbines even after accounting for the effect of vegetation, other obstacles, or screening effects, or from other turbines in the wind farm that are visible at these viewpoints.

For each of the dwellings considered, DNV has inspected the photomontages and made a high-level assessment on the potential for reduction in the predicted theoretical shadow flicker of a moderate level or above, including:

- commentary on the predicted shadow flicker at the dwelling prior to any consideration of vegetation, screening or other obstacles
- identification in each photomontage the turbines which are contributing to shadow flicker for each dwelling, according to the modelling
- for each contributing turbine an assessment of the approximate proportion of the turbine rotor that may be no longer visible, considering blockage by existing vegetation (including porosity to visible light), screening effects or obstacles
- an assessment on how the reduction in visibility of the identified turbines at the viewpoints may affect the shadow flicker at those dwelling locations. Note a reduction in the visibility of a turbine may not necessarily be directly proportional to a reduction in shadow flicker, except in cases where the turbines is completely hidden from view.

- commentary regarding occupant use or features of the dwelling, where such information is available, for example in the rooms or associated areas adjacent the photomontage viewpoint locations, that may mitigate the shadow flicker impacts at those locations
- commentary on potential options for mitigation at the dwelling.

If a quantitative adjustment of the shadow flicker durations reported in Table 5 is required, based on turbine visibility from each dwelling accounting for line-of sight obstructions (as seen in the photomontages), this would require detailed shadow flicker modelling incorporating the turbine specific visibility results detailed below.

4.1.5.1 Estimated shadow flicker reduction at Dwelling 1

For Dwelling 1, the theoretical and actual shadow flicker at or above a moderate level of intensity, both at and within 50 m of the dwelling, is predicted to be above the recommended limits. For this dwelling, while T10 is the closest turbine, only turbines T08 and T09 are predicted to contribute to shadow flicker at or above a moderate level of intensity. These turbines are located approximately to the northwest and west of the dwelling respectively.

A photomontage for a viewpoint located near the northwest corner of the dwelling, with the view facing west, is presented in Figure 7 in Appendix A.

For this viewpoint, both turbines T08 and T09 are completely obscured by vegetation and other obstacles. The porosity of the vegetation also appears to be low, meaning that it is unlikely that shadow flicker will be visible though the vegetation. As a result, it is likely that shadow flicker durations at the viewpoint location will be significantly reduced to minimal durations, if any, and therefore well below the recommended thresholds, though it might be possible for some shadow flicker to occasionally permeate through the vegetation.

According to information supplied by the Customer [17], it is understood that adjacent the viewpoint is a laundry that is not frequently occupied. The other window on that side of the dwelling, further to the south on the west facing wall, is a window to a former sleepout that is now used as a craft/utility/storage room with low occupancy. While the view to the turbines may change for this window, compared to the photomontage viewpoint, the level of vegetation and other obstacles visible in the photomontage suggest that the turbines are likely to remain obscured when viewed from this window also, however this conclusion would need to be confirmed by a photomontage from this viewing position.

Based on the above assessment and review of aerial imagery, it is unlikely that the existing amenity of this dwelling for its occupants, or many areas in the near vicinity of the dwelling, will be affected by shadow flicker impacts from the wind farm. However, it is not possible to be completely conclusive regarding whether the reduction in the predicted shadow flicker at the dwelling applies for all areas within 50 m of the dwelling.

If there is any loss of amenity for areas within 50 m of the dwelling that is of concern to the landowner, as a mitigation strategy it may be possible infill any gaps in the existing vegetation through which the turbines may be visible in those areas.

4.1.5.2 Estimated shadow flicker reduction at Dwelling 10

For Dwelling 10, the theoretical and actual shadow flicker at or above a moderate level of intensity, both at and within 50 m of the dwelling, is predicted to be above the recommended limits. Both the predicted theoretical and actual shadow flicker durations are high compared to recommended levels. For this dwelling, the turbines T22, T24 and T25 are predicted to contribute to shadow flicker at or above a moderate level of intensity. These turbines are located approximately to the northwest, northeast and west of the dwelling respectively.

Photomontages for viewpoints located near the west and northwest and east sides of the dwelling, with the view facing west, north-northwest and northeast are presented in Figure 8, Figure 9, Figure 10 respectively in Appendix A.

For the viewpoints on the west and northwest sides of the building, it is apparent in the photomontages that turbines T22 and T25 are completely obscured by vegetation. The porosity of the vegetation also appears to be low, meaning that it is unlikely that shadow flicker will be visible though this vegetation. While it may be possible for some shadow flicker to occasionally permeate through the vegetation, it is not expected to be significant. For the viewpoint on the east side of the dwelling, T24 is partially obscured, with rotor visibility reduced by approximately 40 to 70%, depending on if only vegetation or also the veranda is considered as blocking mechanisms. As a result, it is likely that the average annual shadow flicker durations at the dwelling will be significantly reduced, with minimal or no shadow flicker experienced during afternoon periods.

According to information supplied by the Customer [17], it is understood that adjacent the viewpoint on the east side of the dwelling is a kitchen window.

Based on the above assessment and review of aerial imagery, it is likely that the shadow flicker at the dwelling, as well as some areas within 50 m of the dwelling, will be significantly reduced compared to the predicted durations. However, without additional shadow flicker modelling, it is not clear if this will result in the shadow flicker durations falling below recommended thresholds. While it is not expected that there will be shadow flicker occurring during afternoon periods at the dwelling and some areas within 50 m of the dwelling, during morning periods there may still be potential for shadow flicker durations.

As a possible mitigation strategy, a blind could be installed on the kitchen window to reduce the shadow flicker impact on the amenity of this dwelling for the occupants.

4.1.5.3 Estimated shadow flicker reduction at Dwelling 17

For Dwelling 17, the theoretical and actual shadow flicker at or above a moderate level of intensity, both at and within 50 m of the dwelling, is predicted to be above the recommended limits. For this dwelling, the turbines T15 and T16 are predicted to contribute to shadow flicker at or above a moderate level of intensity. These turbines are located approximately to the northeast and east of the dwelling respectively.

A photomontage for a viewpoint located near the east side of the dwelling, with the view facing east, is presented in Figure 11 in Appendix A.

For this viewpoint, it is apparent in the photomontage that turbine T15 is not obscured at all, while the rotor for turbine T16 is partially obscured by approximately 60 to 70% due to vegetation. As a result, the average annual shadow flicker durations at the dwelling should be reduced, the extent of which depends on how the sun angles occurring through this turbine during the year align with this vegetation.

According to information supplied by the Customer [17], it is understood that, while the viewpoint is adjacent a bedroom, there is generally a permanently drawn blind on the veranda obscuring the view from the bedroom towards the east. In addition, this dwelling is currently vacant.

Based on the above assessment and review of aerial imagery, the shadow flicker at the dwelling could potentially be reduced compared to the predicted durations. However, without additional shadow flicker modelling, the extent of the shadow flicker reduction is not clear, including if this will result in the shadow flicker durations falling below recommended thresholds. Also, the potential reduction in the shadow flicker anticipated at the dwelling may not apply for all areas within 50 m of the dwelling.

While the shadow flicker impact at this dwelling will likely be mitigated to a large extent by the pre-existing blind, as a further mitigation strategy suitable vegetation or screening could be installed near the dwelling that obscures any remaining views from the dwelling towards the contributing turbines.

4.1.5.4 Estimated shadow flicker reduction at Dwelling 31

For Dwelling 31, the theoretical and actual shadow flicker at or above a moderate level of intensity, both at and within 50 m of the dwelling, is predicted to be above the recommended limits. For this dwelling, the turbines T22, T23 and T25 are predicted to contribute to shadow flicker at or above a moderate level of intensity. These turbines are located approximately to the east, northeast and southeast of the dwelling respectively.

A photomontage for a viewpoint located near the east side of the dwelling, with the view facing east, is presented in Figure 12 in Appendix A.

For this viewpoint, it is apparent in the photomontage that turbines T22, T23 and T25 are all completely obscured by vegetation. The porosity of the vegetation also appears to be low, and it is unlikely that shadow flicker will be significantly visible though the vegetation. As a result, it is likely that shadow flicker durations at the viewpoint location will be significantly reduced to minimal durations, if any, and therefore well below the recommended thresholds, though it might be possible for some shadow flicker to occasionally permeate through the vegetation.

Based on the above assessment and review of aerial imagery, it is unlikely that the existing amenity of this dwelling for its occupants, or areas within 50 m of the dwelling, will be affected by shadow flicker impacts from the wind farm.

Given the lack of visibility of the contributing turbines near the dwelling, it is not expected that additional mitigation options will be required for this dwelling location.

4.1.5.5 Estimated shadow flicker reduction at Dwelling 207

For Dwelling 207, the theoretical and actual shadow flicker at or above a moderate level of intensity, both at and within 50 m of the dwelling, is predicted to be above the recommended limits. For this dwelling, only the turbine T16 is predicted to contribute to shadow flicker at or above a moderate level of intensity. This turbine is located approximately to the northeast of the dwelling.

A photomontage for a viewpoint located near the east side of the dwelling, with the view facing east, is presented in Figure 13 in Appendix A.

For this viewpoint, it is apparent in the photomontage that turbine T16 is only partially obscured by approximately 40% due to vegetation of medium porosity and a building structure. As a result, the average annual shadow flicker durations at the dwelling should be reduced, the extent of which depends on how the sun angles occurring through this turbine during the year align with these obstructions.

According to information supplied by the Customer [17], it is understood that adjacent the viewpoint on the east side of the dwelling is a kitchen window.

Based on the above assessment and review of aerial imagery, the shadow flicker at the dwelling could potentially be reduced compared to the predicted durations. However, without additional shadow flicker modelling, the extent of the shadow flicker reduction is not clear, including if this will result in the shadow flicker durations falling below recommended thresholds. Also, the potential reduction in the shadow flicker anticipated at the dwelling is unlikely to apply for all areas within 50 m of the dwelling.

As a possible mitigation strategy to reduce the shadow flicker impact on the amenity of this dwelling for the occupants, an upgraded blind could be installed on the kitchen window, or suitable vegetation or screening installed near the dwelling that obscures any remaining views from the dwelling towards the contributing turbine.

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 5.

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, 14 dwellings are 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. Of these 14 dwellings, 12 are project participants.

Out of the 14 dwellings predicted to experience shadow flicker above a moderate level of intensity, 7 are predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling (project participants 1, 9, 10, 14, 17, 31 and 207). When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, for all of these dwellings the predicted actual shadow flicker durations within 50 m of the dwelling are above the recommended limit of 10 hours per year. The predicted shadow flicker durations at dwellings 9 and 10 significantly exceed the recommended limits. Dwelling 14 is expected to receive shadow flicker below the recommended limits at the coordinates of the dwelling but exceedances are predicted within 50 m of the dwelling coordinates.

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 dwellings expected to be affected by shadow flicker above a moderate level of intensity, seven dwellings may have the potential to be exposed to low intensity shadow flicker. These dwellings are noted in Table 5.

5.1.2 Mitigation options

For the current proposed layout and turbine parameters, the effects of shadow flicker for the operating wind farm may be reduced through the following mitigation options:

- Mitigation strategy type 1: installation of blinds, screening structures or planting of trees to block shadows cast by the turbines, if acceptable to the landowner.
- Mitigation strategy type 2: if type 1 mitigation strategies are not acceptable or insufficient, additional reductions in shadow flicker to acceptable levels could be achieved through the use

of turbine control strategies to shut down specific turbines when shadow flicker is likely to occur.

For a number of the dwellings investigated, as detailed in the supplementary photomontage visual assessments referred to in this report, it is likely that excessive shadow flicker durations would be significantly reduced through the use of type 1 mitigation strategies outlined above, if it is experienced at the dwellings due to operation of the wind farm.

Regarding dwellings where the shadow flicker is predicted to exceed the recommended limits based on the shadow flicker modelling (prior to any consideration of vegetation or obstacle screening effects), it is noted that these are all Project Participants. The Customer has informed DNV that for these Project Participants an agreement is being developed to accept increased shadow flicker above the recommended limits and allow for the proposed mitigation measures. Based on the shadow flicker and additional visual assessment it is likely that, for a number of the affected dwellings, the predicted shadow flicker will be significantly reduced by the existing vegetation. The Customer has informed DNV that, if shadow flicker is a problem at these dwellings during project operation, then the Customer, in consultation with the affected landowners, is committed to mitigation measures such as the installation of blinds and/or vegetation screening as required.

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 33 turbines with a rotor diameter of 162 m and a hub height of 125 m. These dimensions represent the maximum turbine dimensions currently under consideration for the Project.

Based on this assessment, 14 dwellings are 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. Of these dwellings, 12 are project participants.

Out of the 14 dwellings predicted to experience shadow flicker above a moderate level of intensity, 7 are predicted to experience theoretical shadow flicker durations above the recommended limit of 30 hours per year within 50 m of the dwelling. All 7 dwellings are project participants. When considering the likely reduction in shadow flicker due to cloud cover and rotor orientation, for all of these 7 dwellings the predicted actual shadow flicker durations within 50 m of the dwelling are above the recommended limit of 10 hours per year. The predicted shadow flicker durations at dwellings 9 and 10 significantly exceed the recommended limits.

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.

For project participant Dwelling 1, 10, 17, 31 and 207 in the vicinity of the wind farm, DNV has also carried out an additional assessment based on photomontages and associated metadata supplied to DNV. This information has been used by DNV to assess whether the predicted shadow flicker at these locations could be reduced further because of existing vegetation, screening or other obstacles affecting the line of sight between the dwelling location and the relevant turbines identified as contributing to shadow flicker at or above a moderate level of intensity at that dwelling, with the results of this assessment as follows:

- For Dwelling 1 and 31, it is unlikely that the existing amenity of the dwelling for its occupants will be affected by shadow flicker impacts from the wind farm. For Dwelling 31, there is likely to be a similar reduction in the predicted shadow flicker for all areas within 50 m of the dwelling also, however for Dwelling 1 it is not possible to be completely conclusive in this regard.
- For Dwelling 10, it is likely that the shadow flicker at the dwelling, as well as some areas within 50 m of the dwelling, will be significantly reduced compared to the predicted durations. However, without additional shadow flicker modelling, it is not clear if this will result in the shadow flicker durations falling below recommended thresholds. While it is not expected that there will be shadow flicker occurring during afternoon periods at the dwelling and some areas within 50 m of the dwelling, during morning periods there may still be potential for shadow flicker.
- For Dwelling 17 and 207, the shadow flicker at the dwelling could potentially be reduced compared to the predicted durations. However, without additional shadow flicker modelling, the extent of the shadow flicker reduction is not clear, including if this will result in the shadow flicker durations falling below recommended thresholds. For Dwelling 17, the potential reduction in the shadow flicker anticipated at the dwelling may not apply for all areas within

50 m of the dwelling, while for Dwelling 207 the potential reduction in the shadow flicker anticipated at the dwelling is unlikely to apply for all areas within 50 m of the dwelling.

For the current proposed layout and turbine parameters, the effects of shadow flicker for the operating wind farm may be reduced through the following mitigation measures:

- Mitigation strategy type 1: installation of blinds, screening structures or planting of trees to block shadows cast by the turbines, if acceptable to the landowner.
- Mitigation strategy type 2: if type 1 mitigation strategies are not acceptable or insufficient, additional reductions in shadow flicker to acceptable levels could be achieved through the use of turbine control strategies to shut down specific turbines when shadow flicker is likely to occur.

For a number of the dwellings investigated, as detailed in the supplementary photomontage visual assessments referred to in this report, it is likely that excessive shadow flicker durations would be significantly reduced through the use of type 1 mitigation strategies outlined above, if it is experienced at the dwellings due to operation of the wind farm.

Regarding dwellings where the shadow flicker is predicted to exceed the recommended limits based on the shadow flicker modelling (prior to any consideration of vegetation or obstacle screening effects), it is noted that these are all Project Participants. The Customer has informed DNV that for these Project Participants an agreement is being developed to accept increased shadow flicker above the recommended limits and allow for the proposed mitigation measures. Based on the shadow flicker and additional visual assessment it is likely that, for a number of the affected dwellings, the predicted shadow flicker will be significantly reduced by the existing vegetation. The Customer has informed DNV that, if shadow flicker is a problem at these dwellings during project operation, then the Customer, in consultation with the affected landowners, is committed to mitigation measures such as the installation of blinds and/or vegetation screening as required.

The shadow flicker results and proposed mitigation in this assessment apply to the proposed layout and turbine parameters considered in this report. If the layout or turbine parameters are changed, then this report should be updated.

It is recommended that the Customer ensures the turbine blades are coated with a non-reflective paint to avoid the occurrence of blade glint from the wind farm.

7 REFERENCES

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[17] “KWF_Shadow_Flicker_Additional_Info_with_Logo,” Attachment to email, Re: Kojonup Wind Farm - Shadow Flicker, S Rankin (Moonies Hill New Energy Pty Ltd) to D. Price (DNV), 15 September 2025.

LIST OF TABLES

Table 2 Proposed turbine layout for the Project [3]

Turbine ID	Easting[1] [m]	Northing[1] [m]	Base elevation [m]
T01	511793	6246626	350
T02	512289	6245670	360
T03	511332	6245747	342
T04	512091	6244646	346
T05	511400	6244934	347
T06	511361	6243131	347
T07	512562	6243769	344
T08	513448	6243714	355
T09	513619	6243050	361
T10	514798	6242430	357
T11	513617	6242225	380
T12	512216	6242161	348
T13	511270	6242263	362
T14	510288	6242753	345
T15	509244	6242775	317
T16	509593	6242116	337
T17	510670	6241802	348
T18	511840	6241639	374
T19	512700	6241211	370
T20	513509	6240997	372
T21	512295	6240979	366
T22	511492	6240417	366
T23	510837	6240988	342
T24	513168	6240310	378
T25	511446	6239717	358
T26	511600	6238792	347
T27	512370	6238638	355
T28	512022	6237851	351
T29	511102	6238495	348
T30	510545	6237941	359
T31	509485	6237940	357
T32	510300	6237162	353
T33	509462	6237113	357

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 3 Locations of dwellings considered in this assessment [4]

Dwelling ID	Easting[2] [m]	Northing[2] [m]	Dwelling status	Nearest turbine	
				Distance[3] [m]	Turbine ID
1	*514474*	*6243010*	*Project Participant*	*664*	*T10*
2	*514104*	*6241464*	*Project Participant*	*756*	*T20*
4	*509385*	*6247137*	*Project Participant*	*2392*	*T03*
5	507510	6242858	Not Project Participant	1736	T15
6	*508214*	*6238071*	*Project Participant*	*1278*	*T31*
8	*512059*	*6247860*	*Project Participant*	*1263*	*T01*
9	*511465*	*6244182*	*Project Participant*	*755*	*T05*
10	*512476*	*6239944*	*Project Participant*	*783*	*T24*
11	516411	6242077	Not Project Participant	1650	T10
12	516826	6242597	Not Project Participant	2035	T10
14	*510096*	*6239305*	*Project Participant*	*1291*	*T29*
16	*508552*	*6242094*	*Project Participant*	*971*	*T15*
17	*508333*	*6242258*	*Project Participant*	*1047*	*T15*
18	*509753*	*6240705*	*Project Participant*	*1120*	*T23*
19	*509758*	*6240878*	*Project Participant*	*1085*	*T23*
24	508042	6236697	Not Project Participant	1479	T33
27	508333	6240815	Not Project Participant	1811	T16
28	508125	6244601	Not Project Participant	2141	T15
29	*509340*	*6239277*	*Project Participant*	*1345*	*T31*
31	*509990*	*6240459*	*Project Participant*	*998*	*T23*
32	507108	6238379	Not Project Participant	2417	T31
35	507012	6242199	Not Project Participant	2305	T15
63	514494	6237502	Not Project Participant	2409	T27
73	510010	6235079	Not Project Participant	2104	T32
207	*508870*	6241716	*Project Participant*	*825*	*T16*

1. Project participants 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.

Table 4 Shadow flicker model settings for theoretical shadow flicker calculation

Model setting	
Shadow distance limit (10D)	1620 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 5 Theoretical and predicted actual annual shadow flicker duration

Dwelling ID	Easting[1] [m]	Northing[1] [m]	Dwelling status	Contributing turbines[2]	Theoretical annual At dwelling [hr/yr] 2 m	Theoretical annual At dwelling [hr/yr] 6 m	Theoretical annual Max within 50 m [hr/yr] 2 m	Theoretical annual Max within 50 m [hr/yr] 6 m	Predicted actual annual[3] At dwelling [hr/yr] 2 m	Predicted actual annual[3] At dwelling [hr/yr] 6 m	Predicted actual annual[3] Max within 50 m [hr/yr] 2 m	Predicted actual annual[3] Max within 50 m [hr/yr] 6 m
1	514474	6243010	Project Participant	T08 T09	**64.5**	**63.8**	**74.0**	**73.4**	**16.8**	**16.6**	**19.7**	**19.5**
2	514104	6241464	Project Participant	T19	11.7	11.3	13.1	12.6	3.8	3.7	4.3	4.2
4[4]	509385	6247137	Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5[4]	507510	6242858	Not Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	508214	6238071	Project Participant	T31	15.4	14.9	17.0	16.6	4.8	4.7	5.4	5.3
9	511465	6244182	Project Participant	T04 T07	**112.2**	**110.0**	**123.8**	**122.9**	**32.4**	**31.5**	**36.3**	**36.1**
10	512476	6239944	Project Participant	T22 T24 T25	**124.3**	**124.9**	**143.4**	**143.6**	**31.9**	**31.9**	**35.8**	**35.7**
11	516411	6242077	Not Project Participant	T10	0.0	0.0	8.2	7.8	0.0	0.0	2.1	2.0
12[4]	516826	6242597	Not Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	510096	6239305	Project Participant	T25 T26	29.3	28.5	**34.3**	**33.4**	8.8	8.6	**10.5**	**10.2**
16	508552	6242094	Project Participant	T16	23.8	23.8	26.0	26.0	7.1	7.1	7.8	7.8
17	508333	6242258	Project Participant	T15 T16	**65.0**	**63.5**	**70.9**	**69.1**	**16.9**	**16.5**	**18.8**	**18.4**
18	509753	6240705	Project Participant	T23	22.0	21.7	24.2	23.9	5.8	5.8	6.4	6.3
19	509758	6240878	Project Participant	T23	21.8	21.6	23.8	23.6	6.5	6.5	7.1	7.1
24	508042	6236697	Not Project Participant	T33	12.1	11.8	13.1	12.8	3.2	3.1	3.5	3.4
29[4]	509340	6239277	Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	509990	6240459	Project Participant	T22 T23 T25	**60.4**	**66.5**	**71.9**	**74.6**	**15.5**	**17.1**	**20.7**	**21.1**
32[4]	507108	6238379	Not Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35[4]	507012	6242199	Not Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63[4]	514494	6237502	Not Project Participant		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
207	508870	6241716	Project Participant	T16	**73.4**	**74.4**	**84.0**	**83.9**	**16.9**	**17.3**	**20.3**	**20.4**
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. Contributing turbines shown are for the theoretical shadow flicker calculated at 2 m above ground level.
3. Considering likely reductions in shadow flicker duration due to cloud cover and turbine orientation.
4. Dwelling is not predicted to experience any shadow flicker above a moderate level of intensity, but may experience low-intensity shadow flicker.

LIST OF FIGURES

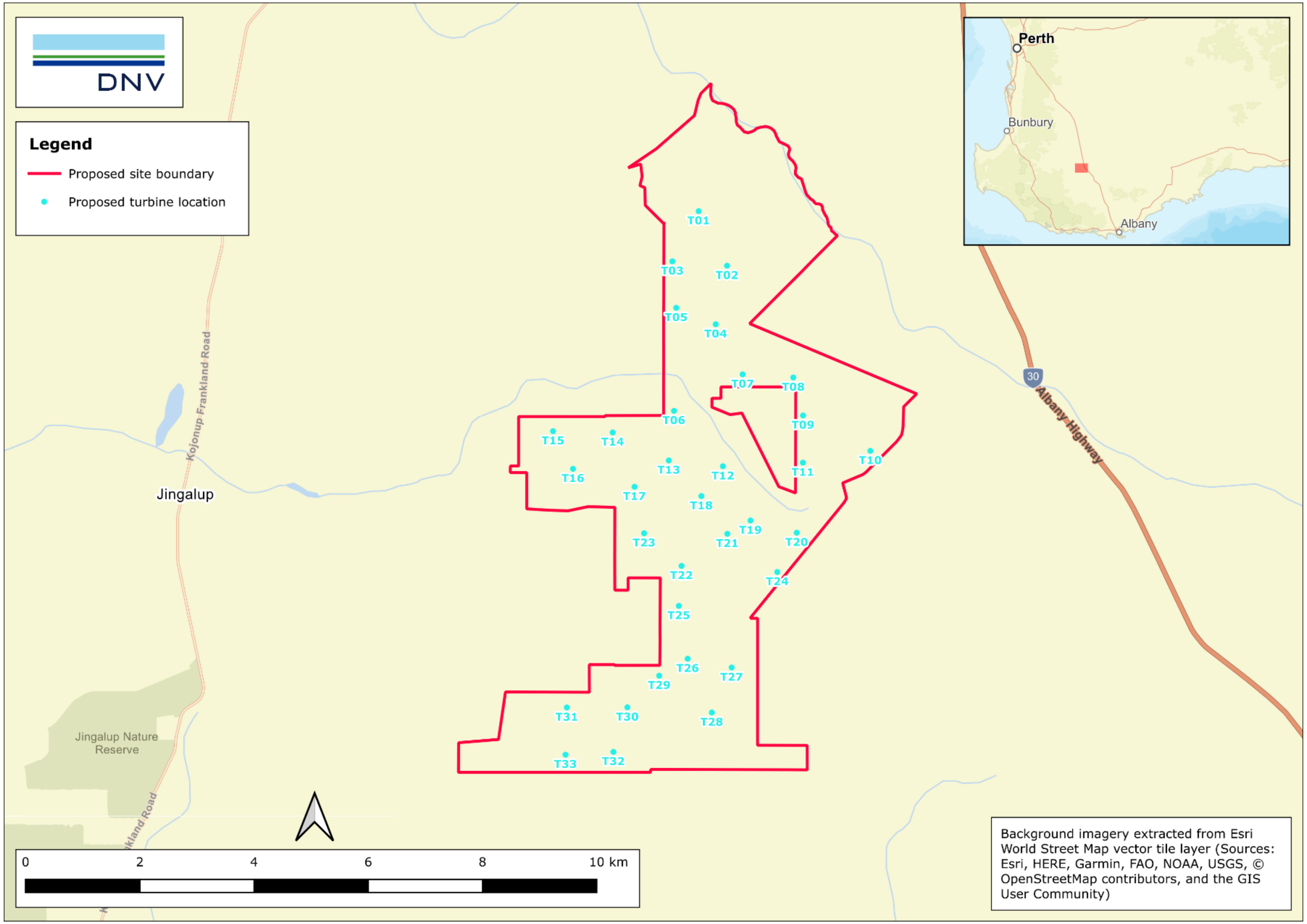

Figure 2 Location of the Project

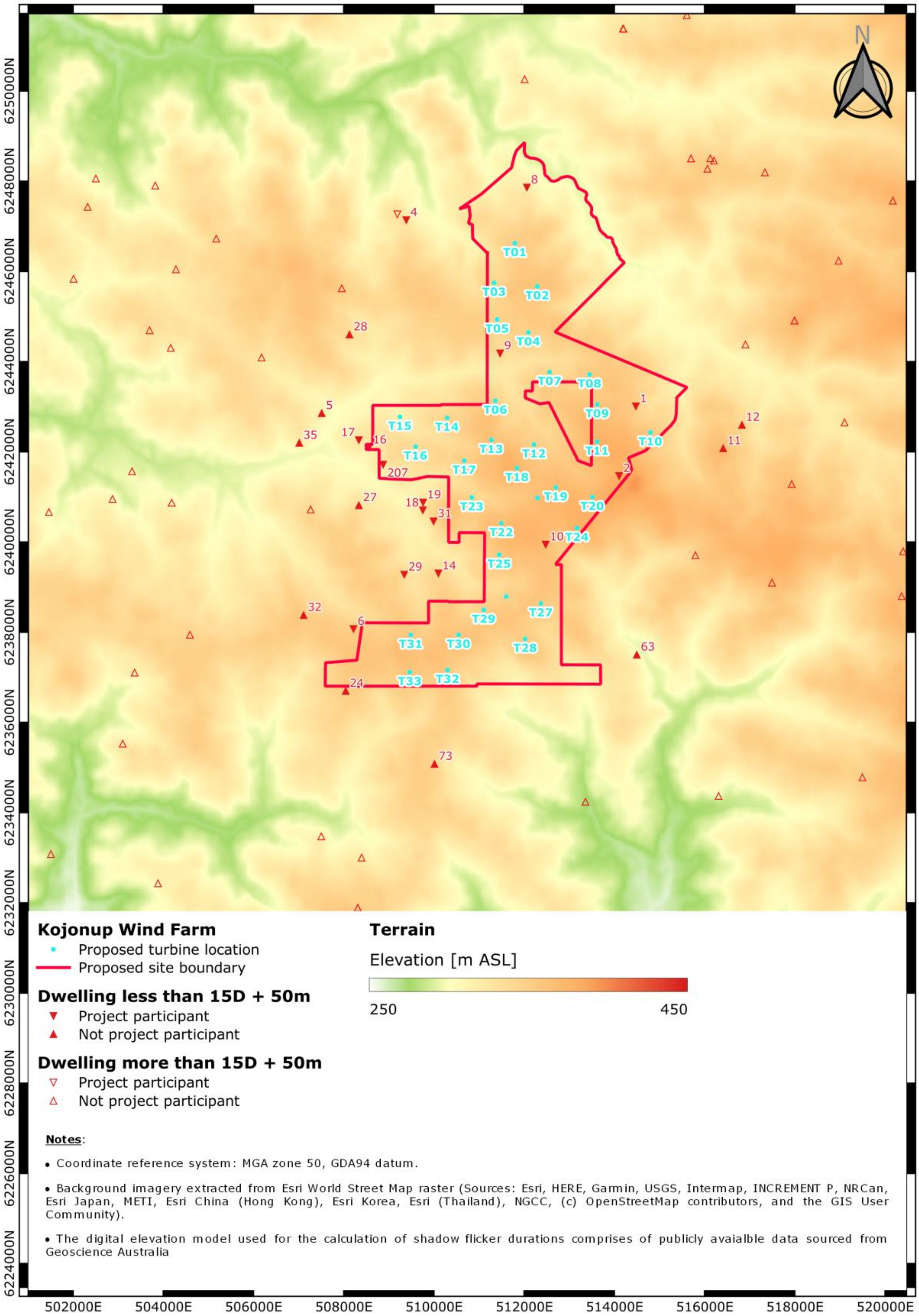

Figure 3 Map of the proposed Project, showing proposed turbine locations, nearby dwellings, and terrain elevation

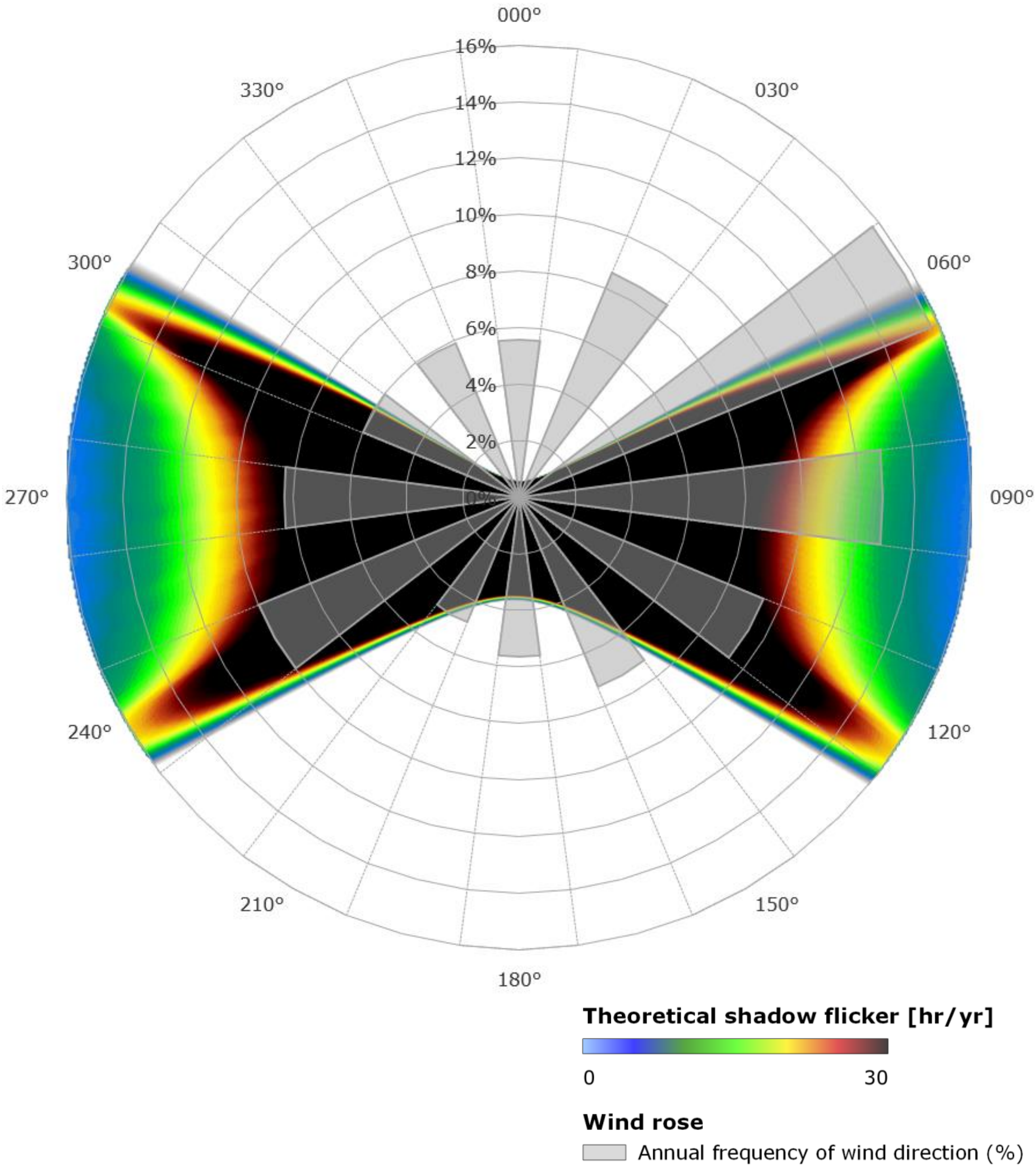

Figure 4 Indicative shadow flicker map and wind direction frequency distribution

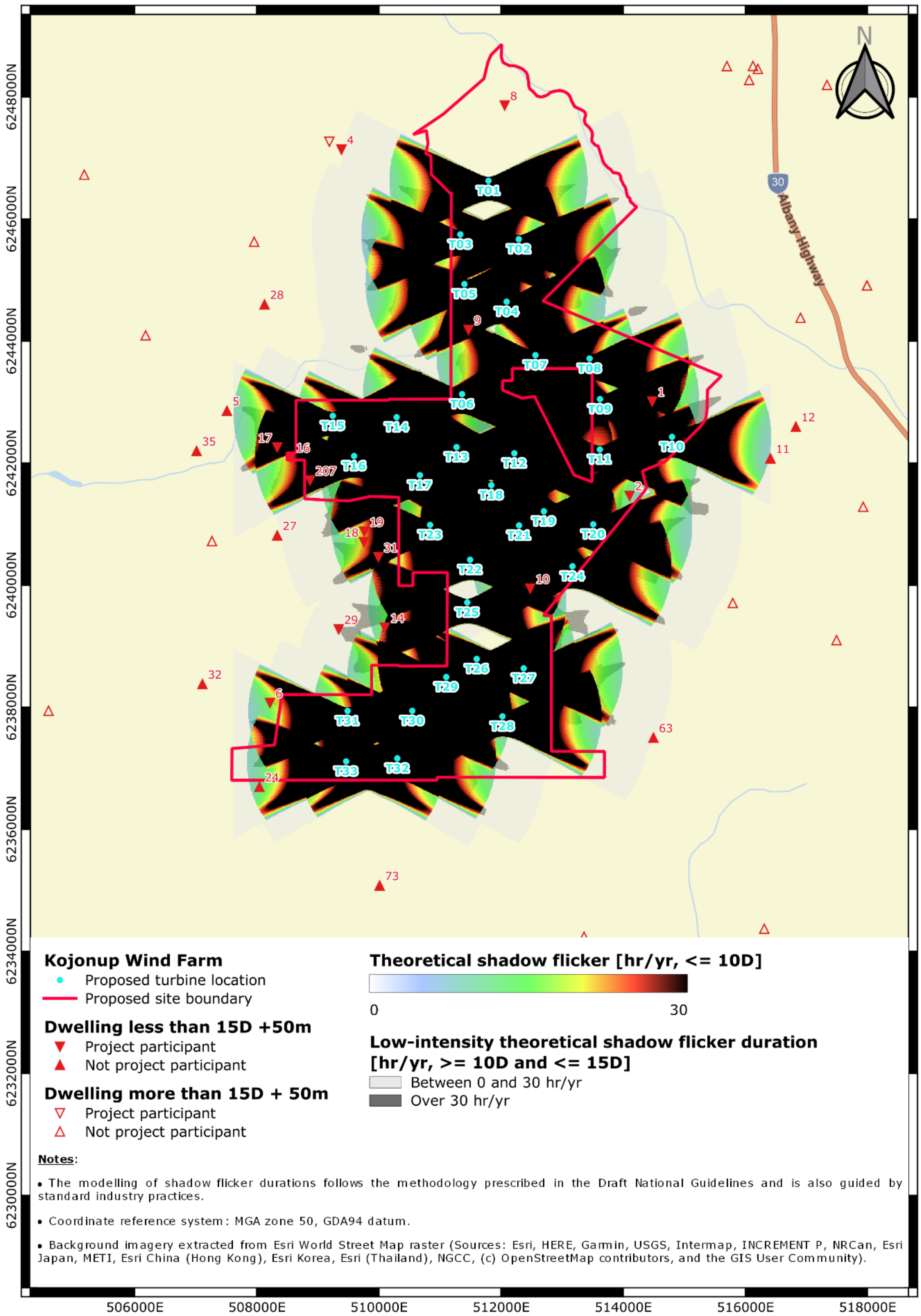

Figure 5 Theoretical annual shadow flicker duration map for the Project

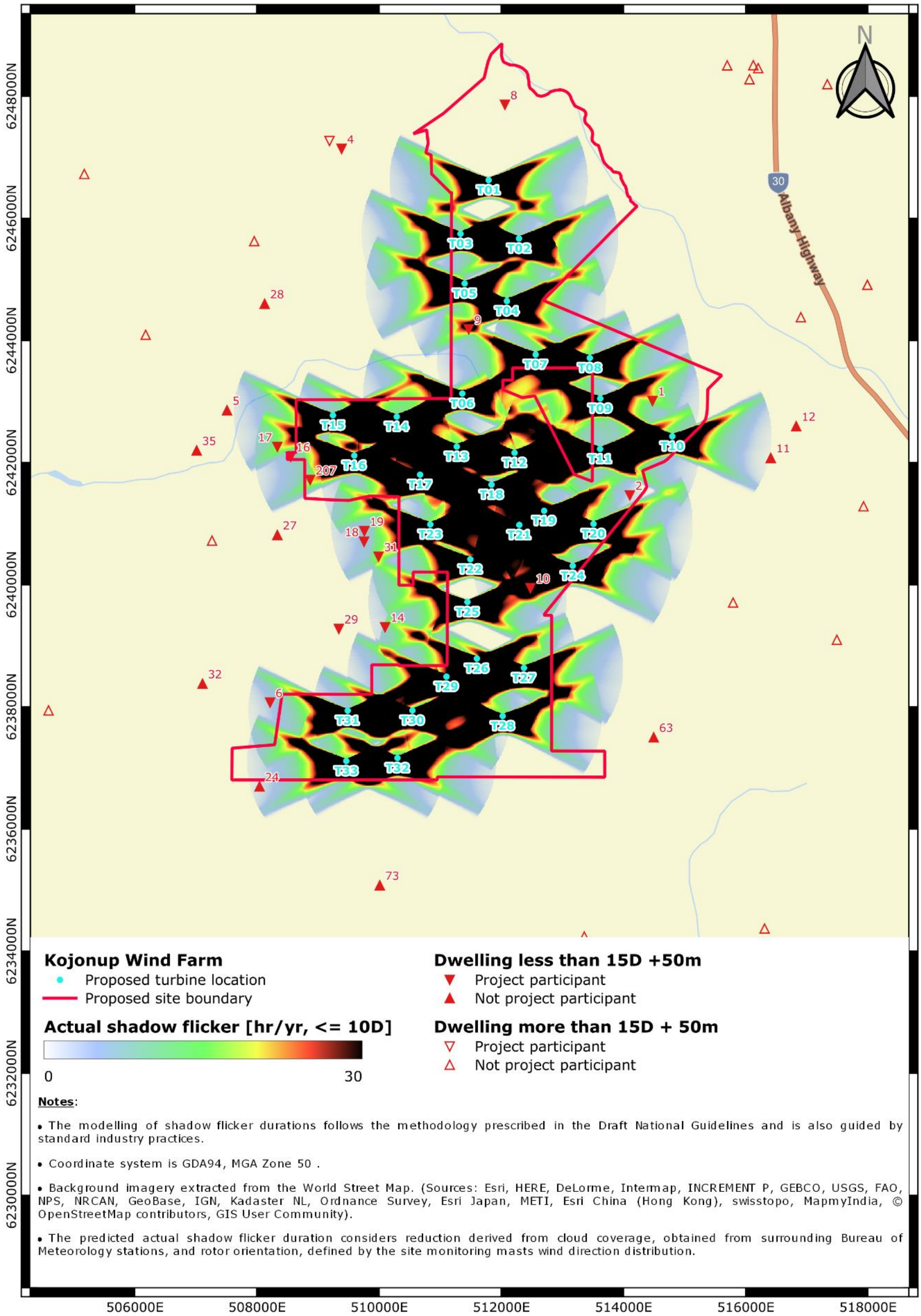

Figure 6 Predicted actual annual shadow flicker duration map for the Project

APPENDIX A – PHOTOMONTAGES

Note: Third-party created image supplied to DNV [16]

Figure 7 Photomontage taken near Dwelling 1 (view towards the West)

Note: Third-party created image supplied to DNV [16]

Figure 8 Photomontage taken near Dwelling 10 (view towards the West)

Note: Third-party created image supplied to DNV [16]

Figure 9 Photomontage taken near Dwelling 10 (view towards the North-northwest)

Note: Third-party created image supplied to DNV [16]

Figure 10 Photomontage taken near Dwelling 10 (view towards the Northeast)

Note: Third-party created image supplied to DNV [16]

Figure 11 Photomontage taken near Dwelling 17 (view towards the East)

Note: Third-party created image supplied to DNV [16]

Figure 12 Photomontage taken near Dwelling 31 (view towards the East)

Note: Third-party created image supplied to DNV [16]

Figure 13 Photomontage taken near Dwelling 207 (view towards the East)

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimising the performance of a wind farm, analysing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.