

Crookwell Development Pty Ltd
Suite 403, 68 York Street
Sydney
New South Wales 3000

DNV GL - Energy
Renewables Advisory
Suite 25, Level 8
401 Docklands Drive
Docklands
Victoria 2008
Tel : 03 9600-1993
Fax: 03 9602-1714
ABN: 19 094 520 760

Our reference:
170691-AUME-L-01-D

Your reference:

Date:
24 February 2016

Re: Shadow flicker assessment for proposed Crookwell 3 Wind Farm

Dear Shaq Mohajerani,

Garrad Hassan Pacific Pty Ltd (now trading as DNV GL) has been commissioned by Union Fenosa Wind Australia Pty Ltd (UFWA) on behalf of Crookwell Development Pty Ltd to independently assess the expected annual shadow flicker duration in the vicinity of the proposed Crookwell 3 Wind Farm. UFWA intends to amend the proposed Crookwell 3 Wind Farm to use a larger rotor diameter of up to 130 m in comparison to the original proposal of 104 m; this change will result in a reduction in tower height from 105 m to 95 m, and a reduction in number of proposed turbines from 28 to 23. At the request of UFWA, DNV GL has also included the wind turbines at the adjacent Crookwell 1 and Crookwell 2 Wind Farms in order to assess any cumulative shadow flicker impact upon dwellings neighbouring the Crookwell 3 Wind Farm. The results of this work are presented here. DNV GL has previously assessed the shadow flicker for the Crookwell 3 Wind Farm based on a different turbine layout and dimensions (reported in document 45235/PR/01 issue B). DNV GL has also assessed the shadow flicker for the Crookwell 2 Wind Farm (reported in document 170691-AUME-R-01-D), and further details of the assessment methodologies employed by DNV GL, together with the current turbine layouts and dimensions for all three Crookwell wind farms, are available in that document.

A shadow flicker assessment was carried out at all dwelling locations within 1.5 km of the proposed Crookwell 3 Wind Farm, as outlined in Table 1. The theoretical predicted shadow flicker durations at all dwellings identified to be affected by shadow flicker, and the maximum predicted theoretical shadow flicker durations within 50 m of these dwellings, are presented in Table 2. The results of the current assessment are also presented in the form of shadow flicker maps in Figure 1 to Figure 4.

The results indicate that five dwellings in the vicinity of the Crookwell 3 Wind Farm are predicted to experience some shadow flicker within 50 m of the house location, based on the methodology recommended in the *EPHC Draft National Wind Farm Development Guidelines* (July 2010). One host landowner dwelling (house 18) and one non-participating dwelling (house 66) are predicted to be affected by theoretical shadow flicker durations within 50 m of the house locations that are greater than

Page 2 of 8

Our reference: 170691-AUME-L-01-D

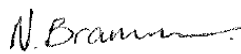
the limit of 30 hours per year recommended in the *Draft NSW Planning Guidelines: Wind Farms* (December 2011).

An assessment of the level of conservatism associated with the theoretical results has been conducted by calculating the possible reduction in shadow flicker duration due to turbine orientation and cloud cover. The results of this analysis, also presented in Table 2, show that both dwellings that exceed the 30 hour limit for theoretical shadow flicker are predicted to experience actual annual shadow flicker durations within 50 m of the house location that are greater than the limit of 10 hours per year recommended in the *EPHC Draft National Wind Farm Development Guidelines*.

The predicted theoretical and actual shadow flicker durations obtained in the previous assessment of the Crookwell 3 Wind Farm (reported in document 45235/PR/01 issue B) are presented for comparison in Table 3. For the turbine layout and dimensions assessed previously, only four dwellings in the vicinity of the Crookwell 3 Wind Farm were predicted to experience some shadow flicker within 50 m of the house location. One host landowner dwelling (house 79) was predicted to be affected by theoretical shadow flicker durations within 50 m of the house location that exceeded the recommended 30 hour limit. This dwelling was also predicted to experience actual shadow flicker durations within 50 m of the house location that exceeded the recommended 10 hour limit. It should be noted that this dwelling is *not* predicted to experience shadow flicker above the recommended limits with the current turbine layout and dimensions.

The results of the cumulative shadow flicker assessment show that shadow flicker from the Crookwell 1 and Crookwell 2 wind turbines is not expected to affect the dwellings that receive shadow flicker from the Crookwell 3 wind turbines.

Sincerely
for Garrad Hassan Pacific Pty Ltd



Naomi Brammer
Engineer



Trenton Gilbert
Senior Engineer

Direct: +61 3 9600 1993
trenton.gilbert@dnvgl.com

| House ID | Easting ¹ (m) | Northing ¹ (m) | Status | Distance to nearest turbine (m) |
|----------|--------------------------|---------------------------|-------------------|---------------------------------|
| 17 | 736692 | 6171234 | Host landowner | 1261 |
| 18 | 736232 | 6171276 | Host landowner | 951 |
| 19 | 735698 | 6171835 | Non-participating | 1072 |
| 63 | 741181 | 6173622 | Non-participating | 1056 |
| 64 | 740395 | 6174100 | Non-participating | 1316 |
| 65 | 740315 | 6174217 | Non-participating | 1296 |
| 66 | 743524 | 6174343 | Non-participating | 1028 |
| 67 | 743724 | 6174675 | Non-participating | 1185 |
| 69 | 740191 | 6175752 | Non-participating | 1334 |
| 79 | 740830 | 6174313 | Host landowner | 874 |
| 80 | 741434 | 6172956 | Host landowner | 1281 |

Notes: 1. Coordinate system is MGA Zone 55 GDA94

Table 1: Dwelling locations within 1.5 km of turbines at the proposed Crookwell 3 Wind Farm

| House ID | Easting ¹ [m] | Northing ¹ [m] | Dwelling status | Contributing Turbines | Theoretical Annual | | | | Predicted Actual Annual ³ | | | |
|---------------|--------------------------|---------------------------|-------------------|-----------------------|----------------------------------|-----------|--|-----------|--------------------------------------|-----------|--|-----------|
| | | | | | At Dwelling ² [hr/yr] | | Max Within 50 m of Dwelling ² [hr/yr] | | At Dwelling ² [hr/yr] | | Max Within 50 m of Dwelling ² [hr/yr] | |
| | | | | | SF at 2 m | SF at 6 m | SF at 2 m | SF at 6 m | SF at 2 m | SF at 6 m | SF at 2m | SF at 6 m |
| 18 | 736232 | 6171276 | Host landowner | A32 | 22.5 | 21.9 | 34.5 | 33.8 | 7.8 | 7.7 | 12.1 | 11.9 |
| 63 | 741181 | 6173622 | Non-participating | A10 | 19.6 | 19.8 | 22.0 | 22.2 | 6.2 | 6.3 | 6.8 | 6.8 |
| 66 | 743524 | 6174343 | Non-participating | A5, A9 | 26.0 | 29.1 | 30.0 | 32.0 | 8.9 | 9.9 | 10.2 | 10.8 |
| 67 | 743724 | 6174675 | Non-participating | A5, A9 | 12.0 | 12.3 | 24.5 | 25.1 | 4.2 | 4.3 | 8.1 | 8.2 |
| 79 | 740830 | 6174313 | Host landowner | A3, A8 | 10.0 | 20.5 | 20.6 | 24.8 | 3.4 | 6.4 | 6.2 | 7.7 |
| Limits | | | | n/a | 30 | | 30 | | 10 | | 10 | |

¹ MGA Zone 55 (GDA94 datum)

² Dwellings with zero hours shadow flicker have been omitted from this table, and values above the recommended limits are highlighted in red

³ Considering likely reductions in shadow flicker duration due to cloud cover and turbine orientation

Table 2: Theoretical and predicted actual annual shadow flicker durations for dwellings affected by shadow flicker – current assessment

| House ID | Easting ¹ [m] | Northing ¹ [m] | Dwelling status | Contributing Turbines | Theoretical Annual | | | | Predicted Actual Annual ³ | | | |
|---------------|--------------------------|---------------------------|-------------------|-----------------------|----------------------------------|-----------|--|-----------|--------------------------------------|-----------|--|-----------|
| | | | | | At Dwelling ² [hr/yr] | | Max Within 50 m of Dwelling ² [hr/yr] | | At Dwelling ² [hr/yr] | | Max Within 50 m of Dwelling ² [hr/yr] | |
| | | | | | SF at 2 m | SF at 6 m | SF at 2 m | SF at 6 m | SF at 2 m | SF at 6 m | SF at 2m | SF at 6 m |
| 18 | 736232 | 6171276 | Host landowner | - | 0 | 0 | 28 | 28 | - | - | 10 | 10 |
| 63 | 741181 | 6173622 | Non-participating | - | 0 | 0 | 13 | 13 | - | - | 4 | 4 |
| 66 | 743524 | 6174343 | Non-participating | - | 0 | 0 | 9 | 12 | - | - | 3 | 4 |
| 79 | 740830 | 6174313 | Host landowner | - | 28 | 32 | 36 | 38 | - | - | 11 | 12 |
| Limits | | | | n/a | 30 | | 30 | | 10 | | 10 | |

¹ MGA Zone 55 (GDA94 datum)

² Dwellings with zero hours shadow flicker have been omitted from this table, and values above the recommended limits are highlighted in red

³ Considering likely reductions in shadow flicker duration due to cloud cover and turbine orientation

Table 3: Theoretical and predicted actual annual shadow flicker durations for dwellings affected by shadow flicker – previous assessment (reported in document 45235/PR/01 issue B)

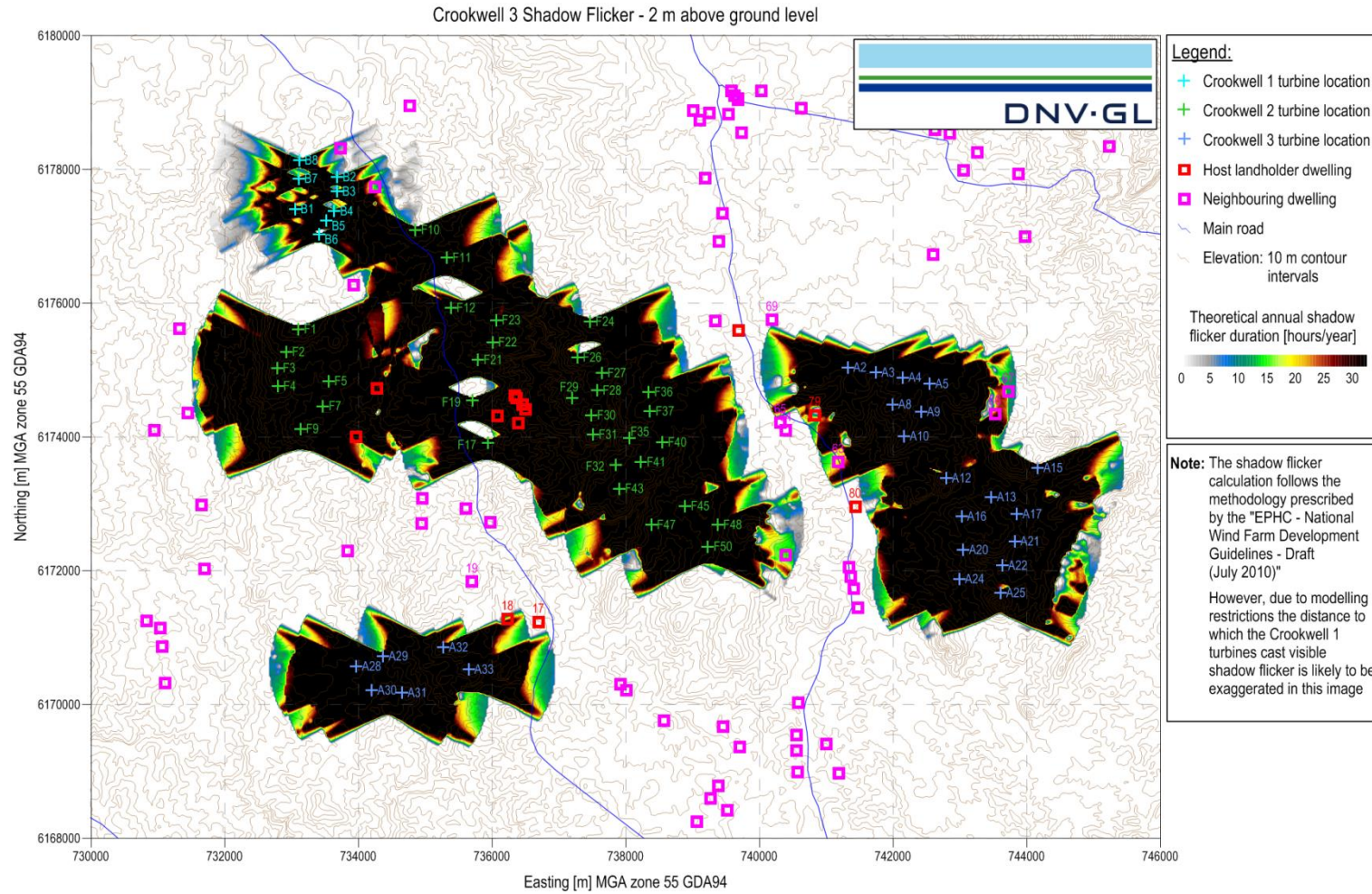


Figure 1: Map of the proposed Crookwell 3 Wind Farm with proposed turbines, neighbouring turbines, dwelling locations and theoretical annual shadow flicker duration at 2 m above ground level

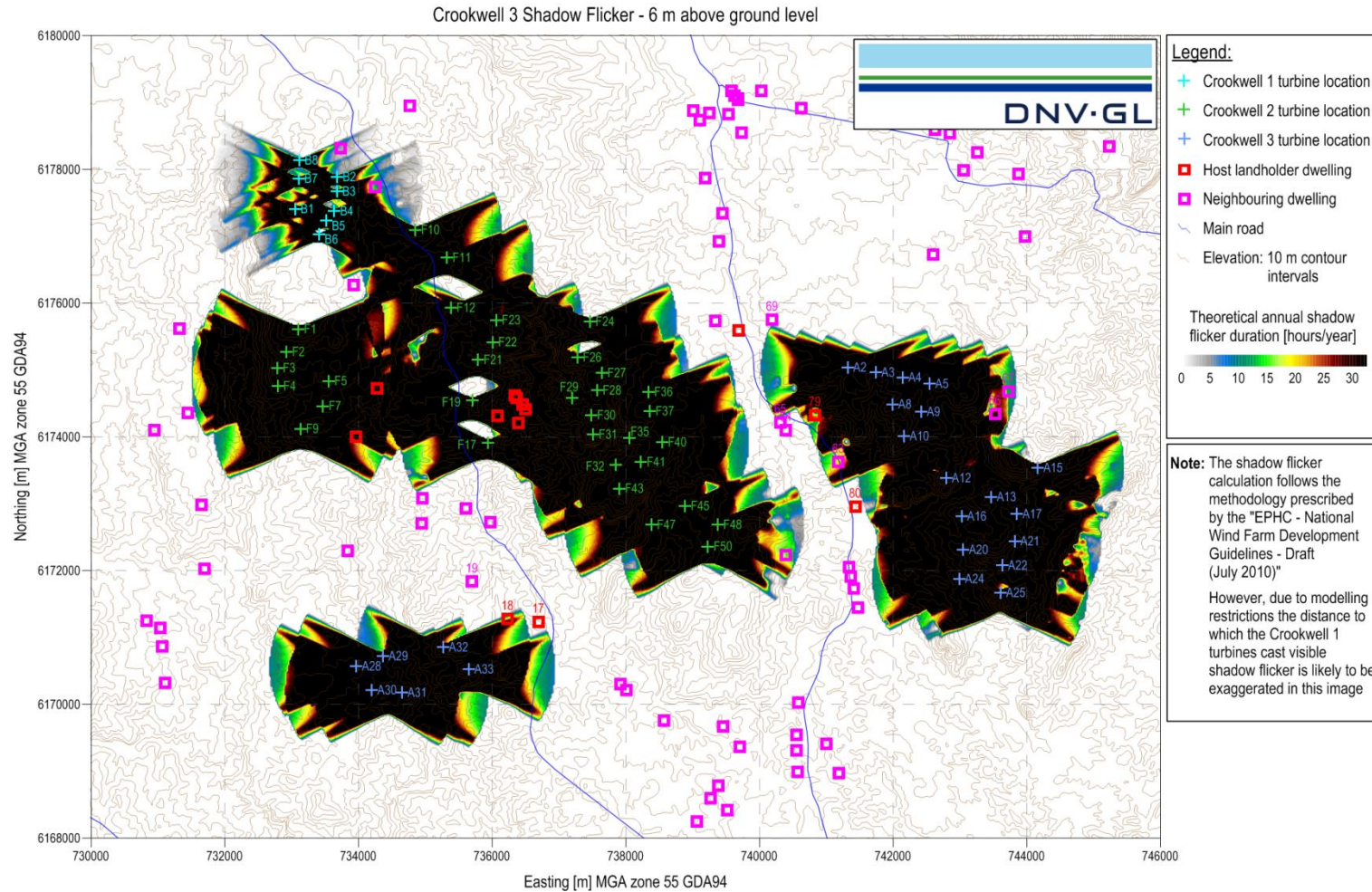


Figure 2: Map of the proposed Crookwell 3 Wind Farm with proposed turbines, neighbouring turbines, dwelling locations and theoretical annual shadow flicker duration at 6 m above ground level

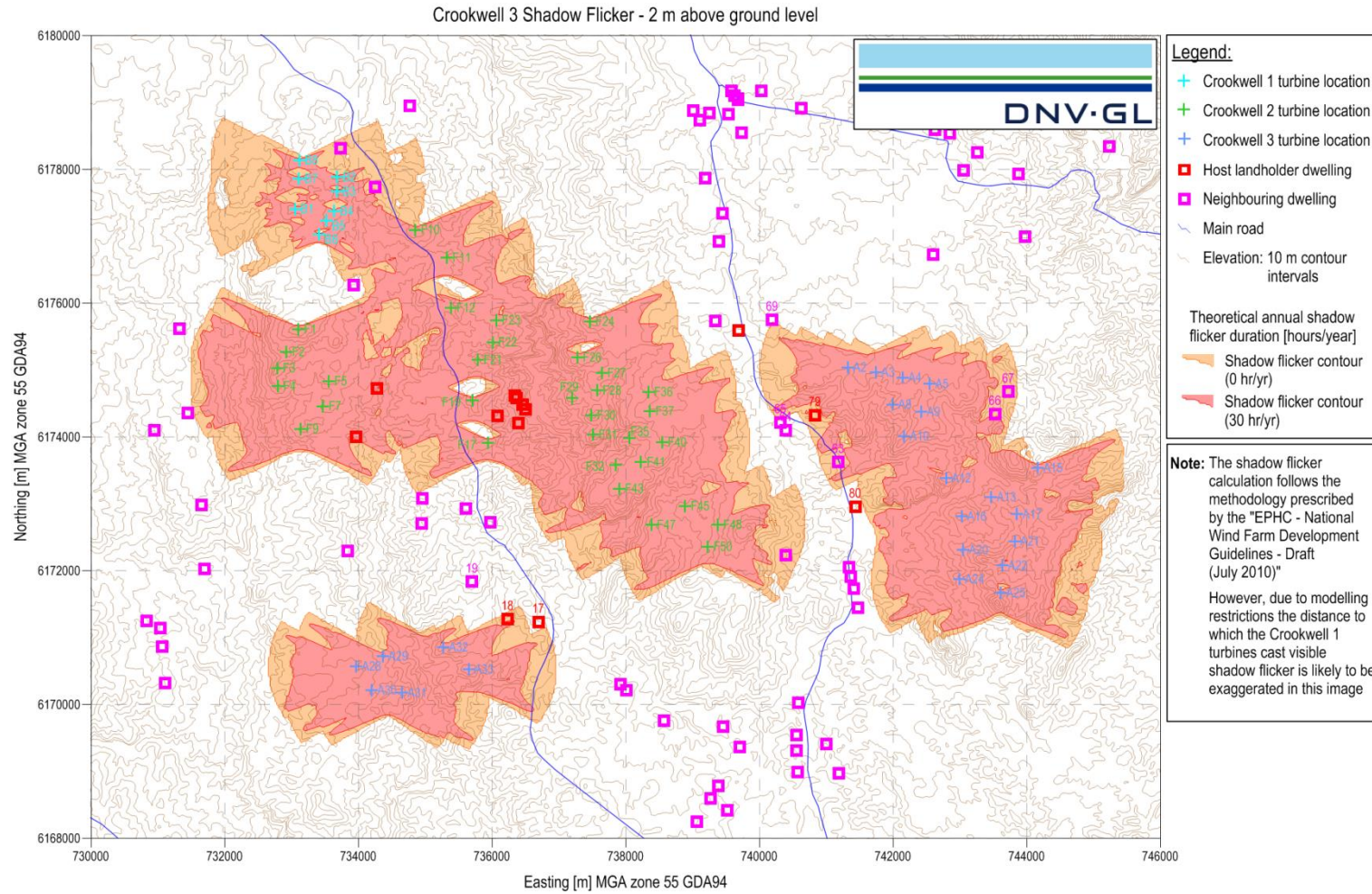


Figure 3: Map of the proposed Crookwell 3 Wind Farm with proposed turbines, neighbouring turbines, dwelling locations and theoretical annual shadow flicker duration at 2 m above ground level

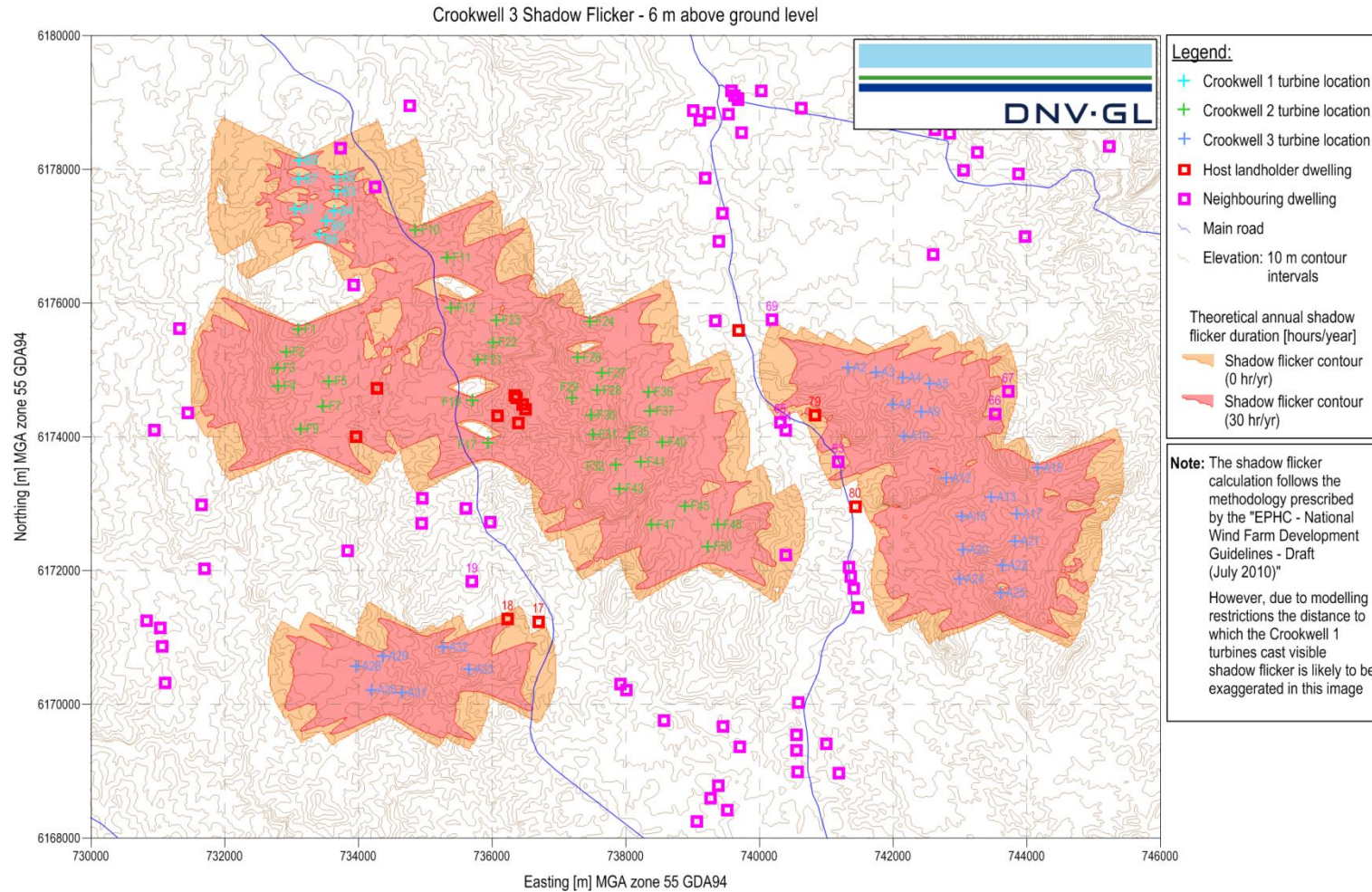


Figure 4: Map of the proposed Crookwell 3 Wind Farm with proposed turbines, neighbouring turbines, dwelling locations and theoretical annual shadow flicker duration at 6 m above ground level