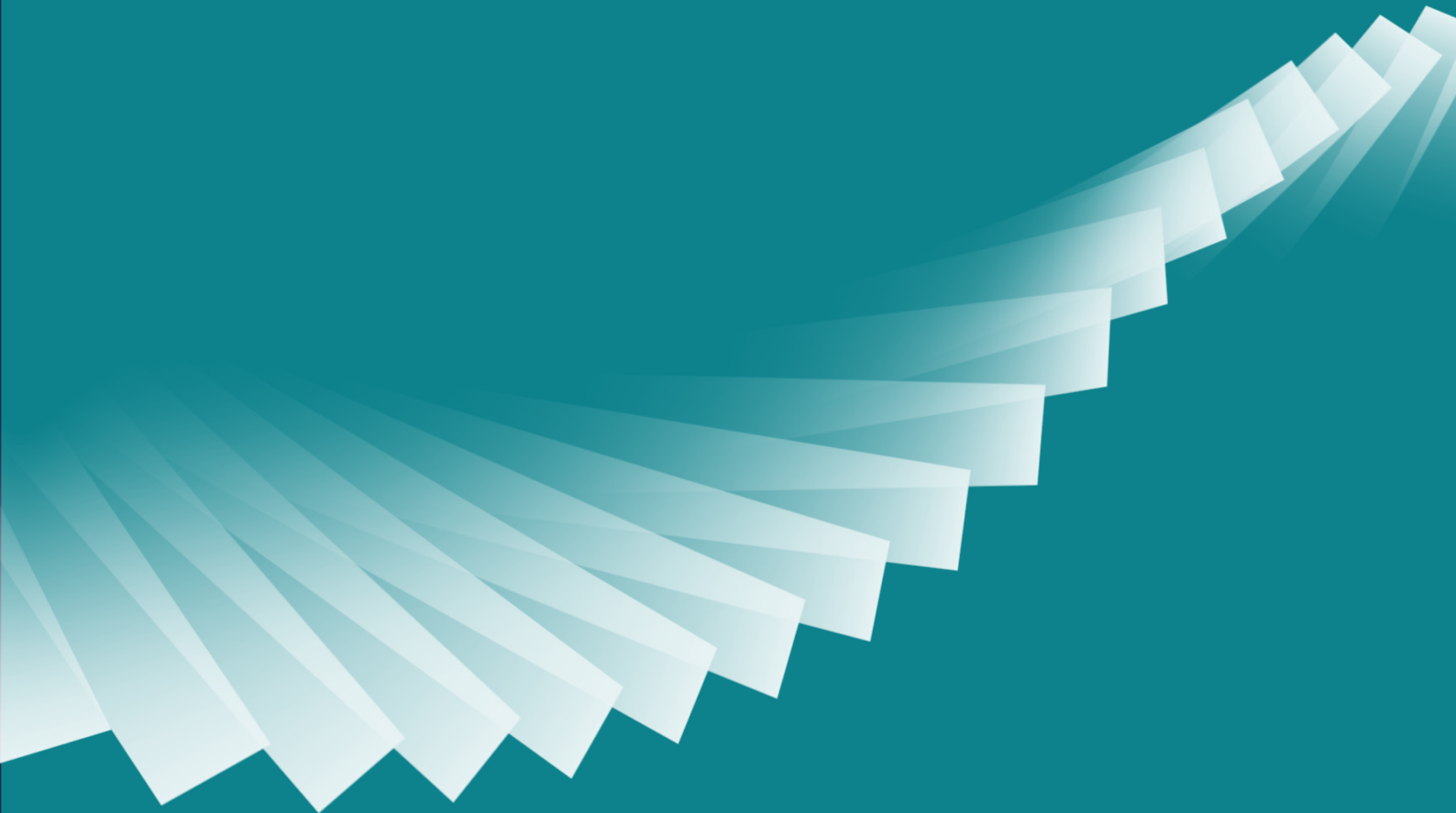




Bute Energy
Aberedw Energy Park

Appendix 5.8:

Aviation Lighting Impact Assessment



Aberedw Energy Park Limited

Aberedw Energy Park
Appendix 5.8: Aviation Lighting Impact
Assessment

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1. Introduction

- 1.1.1 In the interests of aviation safety, structures of ≥ 150 m, including wind turbines, require steady red visible aviation lighting, as set out in the UK Air Navigation Order (ANO) 2016, Article 222¹, sets out the statutory requirement for the lighting of 'en-route obstacles'. The Proposed Development comprises 18 turbines with a maximum blade tip height of 200 m and will therefore require visible aviation lighting which may be perceptible to receptors (people) from locations across the study area.
- 1.1.2 The introduction of visible aviation lighting in rural locations, where there are fewer sources of artificial lighting, and where darkness or dark skies are an integral and valued aspect of the landscape, may lead to potentially significant landscape and visual effects.
- 1.1.3 The requirement for visible aviation lighting is an emerging consideration for the wind energy sector, and consequently the approach to the assessment of likely environmental effects which may arise is evolving.
- 1.1.4 In August 2021 the Scottish Government established the Aviation Lighting Guidance Working Group² to develop guidance to ensure that landscape and visual impacts of visible aviation lighting systems' are consistently assessed. LUC has contributed to the development of the guidance with direct representation on the working group. The final guidance³ was published collaboratively by the Scottish Government and NatureScot in November 2024 and sets out a three-step process to be taken to the assessment of landscape and visual effects. The three steps are defined as follows:
- Step 1 – Defining the lighting proposal
 - Step 2 – Understanding the baseline
 - Step 3 – Assessing the effects
- 1.1.5 This appendix sets out the background to the requirements for visible aviation lighting, followed by an assessment of landscape and visual effects arising for representative receptors within the study area. Receptors considered in the assessment are identified based on the Landscape and Visual Impact Assessment (LVIA) presented in Environmental Statement (ES) **Chapter 5: Landscape and Visual Amenity**, and this appendix should be read with reference to the main assessment and the accompanying figures (presented in ES **Volume 2**) and the visualisations (presented in ES **Volume 4**), along with ES **Appendix 5.1: LVIA and CLIVA Methodology** and ES **Appendix 5.2: Zone of Theoretical Visibility (ZTV) and Visualisation Methodology**.
- 1.1.6 Whilst effects arising from the introduction of visible aviation lighting for the Bannau Brycheiniog National Park (BBNP) are considered in this appendix, potential effects of the Proposed Development on the relevant special landscape qualities of this nationally designated landscape are considered in detail in ES **Appendix 5.6: Assessment of Effects on Designated Landscapes**.
- 1.1.7 The Applicant commissioned a specialist aviation consultant (Wind Power Aviation Consultants (WPAC) Ltd) to design, in consultation with the Civil Aviation Authority (CAA), the aviation lighting scheme for the Proposed Development. ES **Appendix 2.7: Aviation Lighting and Mitigation Report** sets out the details of the agreed aviation lighting scheme (with CAA) which should be read in conjunction with this appendix.
- 1.1.8 Throughout this appendix the following terms are used:
- Candela (cd) – The measurement of luminous intensity (i.e. light emitted in a particular direction by a light source) [NB a candle emits light with a luminous intensity of roughly one cd].
 - Micro-lux (μlx) – One millionth of a lux (lx) which is the measurement of illuminance (i.e. the amount of light falling on a surface). 1 μlx is equivalent to 1 micro-lumen per square metre.
- 1.1.9 There is a relationship between the luminous intensity of the light source, how much light hits a surface and distance between the two. For example, 100 lx will fall on a surface located 10 m from a light source with a luminous intensity of 10,000 cd.

¹ HM Government (2016) The Air Navigation Order 2016 (SI No. 2016/765)

² <https://www.gov.scot/groups/aviation-lighting-guidance-working-group/>

³ Scottish Government and NatureScot (2024) Guidance on Aviation Lighting Impact Assessment

2. Regulatory Background

- 2.1.1 The regulatory background to the requirements for visible aviation lighting on wind turbines is outlined in detail in ES **Appendix 2.7** and summarised below.

2.2 Aviation Lighting Requirements

- 2.2.1 The requirement to install aviation lighting on wind turbines is set at the international level by the International Civil Aviation Organisation ('ICAO'), an agency of the United Nations set up to manage the Convention on International Civil Aviation, also known as the Chicago Convention.
- 2.2.2 Chapter 6 of Annex 14 to the Convention on International Civil Aviation contains the ICAO set of internationally agreed Standards and Recommended Practices relating to the marking and lighting of obstacles, including wind turbines.
- 2.2.3 As noted above, the UK Air Navigation Order (ANO) 2016, Article 222, sets out the statutory requirement for the lighting of 'en-route obstacles', which applies to structures of 150 m or more above ground level to assist their detection by aircraft. Article 222 (1) of the CAA's ANO 2016 and Regulations states: *"The person in charge of an en-route obstacle must ensure that it is fitted with medium-intensity steady red lights positioned as close as possible to the top of the obstacle and at intermediate levels spaced so far as practicable equally between the top lights and ground level with an interval of not more than 52 metres"*.
- 2.2.4 Article 222 (8) defines an en-route obstacle as *"an 'en-route obstacle' means any building, structure or erection, the height of which is 150 metres or more above ground level, but it does not include a building, structure or erection:*
- 2.2.5 *a) which is in the vicinity of a licensed aerodrome; and*
- 2.2.6 *b) to which section 47 of the Civil Aviation Act 1982 (warning of presence of obstructions near licensed aerodromes) applies"*.
- 2.2.7 For structures, including wind turbines, of 150 m or greater the exceptions listed in ANO Article 222 (8) a) and b) (set out above) do not apply, and therefore the regulations necessitate the installation of medium-intensity steady red lights on all turbines, emitting a minimum average luminous intensity of 2000 cd at a vertical angle of 0° (degrees) and with a minimum vertical beam spread of 3° and a horizontal spread of 360° (see Table 2 in ES **Appendix 2.7**).
- 2.2.8 This article has been incorporated into the CAA's Policy Statement⁴ on the lighting of onshore wind turbines (June 2017), and states that *"The person in charge of the wind turbine generator must ensure that it is fitted with a medium-intensity (2000 candela) red light positioned as close as practicable to the top of the fixed structure. A second light serving as an alternative should be provided in case of failure of the operating light"*. The Policy Statement confirms the position in relation to lighting of onshore wind turbines in the UK, considering the statutory requirements set out in Article 222 of the ANO. In practice this means the installation of lights on the top surface of the turbine hub/nacelle.
- 2.2.9 Additionally, the CAA requires that *"at least three (to provide 360 degree coverage) low-intensity Type B6 lights (32 candela) lights should be provided at an intermediate level of half the nacelle height"*. However, no intermediate level lights are proposed on turbine towers as set out in the ES **Appendix 2.7**.

2.3 Lighting Specification Requirements

- 2.3.1 Informed by the International Civil Aviation Organisation (ICAO) Code – Annex 14, Table 6-3⁵ which sets out the specification requirements for medium-intensity obstacle lights (MIOL), the CAA Policy Statement details the required and recommended minimum intensity lighting settings for 2000 cd lights (with the 200 cd rated option, for clear weather conditions, highlighted in brackets). These requirements vary at different vertical angles of elevation, relative to the lighting horizontal plane, which in this case will be the nacelle height of the wind turbines. The intensity of the light emitted from an aviation obstruction light is designed to vary with the observed angle. It aims to be at its brightest when observed from a similar level or just above, but less bright as the observer falls significantly below or

⁴ Civil Aviation Authority (CAA) (2017) Policy Statement – Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150 m Above Ground Level

⁵ International Civil Aviation Organisation (ICAO) (2018) Annex 14 to the Convention on International Civil Aviation – Aerodromes – Volume 1: Aerodrome Design and Operations

above the light. Different manufacturers produce lights with slightly varying characteristics, though broadly similar in complying with the minimum requirements, and maximum recommendations, of these international standards.

- 2.3.2 Note that, in reality, 2000 cd lights will exceed this minimum requirement in the centre of the beam spread (at $+1^\circ$), as it is difficult to meet the average intensity requirement across the full range of the minimum beam spread ($-1^\circ > +2^\circ$). A modern light may for example reach approximately 2500 cd in the centre of the beam, and some older lights may further exceed this value. Noting that there is a degree of inaccuracy inherent when illustrating lighting, Scottish Government and NatureScot guidance⁶ and⁷ states that 2000 cd should be treated as a reasonable maximum/worst case.

3. The Perception of Light

- 3.1.1 The main effect of aviation lighting comes from visibility of the aviation lights situated on the nacelle and mid-tower of the turbines. This type of lighting will not cause sky glow, but can contrast with natural darkness, and can draw attention. At distance, they are generally seen as sharply defined points of red light, especially where seen against a dark sky or dark landform or where seen in landscapes with little or no existing sources of artificial light present.
- 3.1.2 The human perception of light intensity over distance follows an inverse square relationship, meaning that as the distance increases, the light must spread out over a larger surface and the surface brightness decreases. Although the actuality of the lights remains constant, the apparent light intensity (brightness) and size of a light source as perceived by visual people will vary dependent on distance, angle of view, and atmospheric conditions. As distances increase, the light source will appear smaller. As atmospheric conditions become less clear (a reduction in clarity with increased humidity, rain, drizzle, snow, or the presence of haze, mist, fog, or a low cloud base etc) the brightness will appear reduced. Clarity varies at different levels within the sky, and across different places. Decline in brightness over distance is not uniform.
- 3.1.3 The brightness at which lights are perceived also depends on the background against which they are seen. They may seem brighter because of the stronger contrast when there is no moonlight for example, or when they are seen against a dark landmass rather than against a sky where there is some residual twilight. Perception of red lights by humans in periods of low light and darkness is also variable from person to person, and therefore what the eye sees in practice at night is very inconstant, and influenced, for example, by the age of the viewer.
- 3.1.4 Due in part to this variability in the way that the human eye can perceive light during periods of low light and darkness, it is considered that no aviation lighting visualisation will ever be able to consistently replicate what individuals may experience in the field and should therefore only be used as a tool to aid understanding of potential effects, and not as a replacement for observations made in the field.

4. Potential Mitigation

- 4.1.1 A number of potential mitigation options are currently available or are being developed by the wind energy sector in collaboration with the CAA and other stakeholders. Mitigation options which may have the potential to influence the resultant landscape and visual effects which may occur from the introduction of visible aviation lighting are outlined below. Many of these mitigation measures have been available to developers for some time and have been relied upon for the assessment and determination of numerous other wind energy developments, including in relatively close proximity to sensitive locations in the UK such as nationally designated landscapes and internationally designated dark sky parks.

4.2 Reduced Lighting Scheme

- 4.2.1 The lighting of cardinal or peripheral turbines located at the outer extremities of a wind farm development is an established mitigation option for wind farms.
- 4.2.2 Current ICAO Annex 14 guidance for lighting of wind turbines states that aviation lights should be installed to identify the perimeters of the wind farm, respecting the maximum spacing between lights “*not exceeding 900 m*” (paragraph

⁶ Scottish Government and NatureScot (2024) Guidance on Aviation Lighting Impact Assessment

⁷ NatureScot (2024) NatureScot pre-application guidance for onshore wind farms

6.2.3.15) unless in situations where “a dedicated assessment shows that a greater spacing can be used”, and also that any wind turbines of significantly higher elevation are also identified.

- 4.2.3 Furthermore, a reduced lighting design may enable the requirement for low-intensity (32 cd) lights installed at mid-mast level to be removed.
- 4.2.4 Through consultation with the CAA, a reduced lighting scheme has been secured for the Proposed Development⁸. Details of which turbines are proposed to be lit are described below, with further detail provided in the ES **Appendix 2.7**.

4.3 Intensity Reduction (Automatic Dimming)

- 4.3.1 The CAA Policy Statement also includes provision for the medium-intensity 2000 cd lights to be controlled by visibility sensors that may reduce the intensity of the light to not less than 10% of the minimum peak intensity (e.g. 200 cd) in times of clear meteorological conditions (if the horizontal meteorological visibility in all directions from every wind turbine in the group is more than 5 km).
- 4.3.2 This is achieved with the installation of a sensors on wind turbines within different parts of a wind farm. These sensors measure prevailing atmospheric conditions and visibility range. Where atmospheric conditions limit visibility (based on measurements local to the site of the sensor) to distances of less than 5 km in any direction (e.g. through the presence of low cloud cover, rain, mist, haze or fog) the lights are illuminated at the necessary 2000 cd. Therefore, 2000 cd lights will normally only be seen near to their fullest intensity in closer views (i.e. somewhat less than 5 km), or perhaps due to a local patch of poor visibility (e.g. localised mist or rain) at a sensor based on the wind farm. Whilst possibly still visible in such conditions, the perceptibility of the lights will likely to be much reduced, and typically not visible at distances greater than 5 km.
- 4.3.3 This form of mitigation is permitted in the UK by the CAA through the 2017 policy statement itself and does not, therefore, require project-specific approval from the CAA.

4.4 Vertical Directional Intensity

- 4.4.1 Vertical directional intensity mitigation (sometimes called ‘narrow vertical beam spread’ or ‘angle intensity mitigation’) comprises the use of particular aviation lights that have greater control of the light intensity emitted at certain angles above and below the horizontal plane. It can be a very effective form of mitigation, especially in reducing potential effects for receptors located at lower elevations relative to the aviation lights but can be less effective for elevated or more distant receptors at similar vertical elevations towards which a greater luminous intensity may be emitted.
- 4.4.2 Aviation lighting is required to operate at the minimum intensities defined in ICAO, across a relatively narrow (3°) vertical beam spread, projecting horizontally from the nacelle light, between -1° to +2°, as explained in ICAO Table 6-3. Individual lights have slightly varying characteristics, though broadly similar in complying with international standards with sharply declining intensity when viewed from a lower level.
- 4.4.3 The perceived luminous intensity of a 2000 cd/200 cd light mounted on the turbine nacelle therefore reduces at vertical angles below the horizontal plane. This results in a reduction in visible lighting at elevations of less than -1° vertical angle. That is to say, the light will appear less bright to an observer looking up at the nacelle from below, than it will to an observer at the same elevation as the nacelle. The intensity at angles below -1° may also vary dependent on the specific obstacle lighting manufacturer’s specification. Note that this does not take account of emitted light spill on to passing blades, which may be visible from all elevations as a reflected glow across the immediate surfaces of the turbine blades and nacelle.
- 4.4.4 As such, this embedded mitigation within the design of the lights has the potential to substantially reduce the extent and perceived intensity of lights visible when viewed from different elevations (effectively the angle of view), when seen from either below (lower elevations) or above (higher elevations) the height of the turbine hub. A lighting intensity ZTV can be helpful to illustrate the potential mitigation from an assumed aviation lighting, to demonstrate how light emissions may reduce relative to vertical angle from the horizontal plane.
- 4.4.5 There is no need to seek project-specific approval from CAA for this form of mitigation.

⁸ CAA Approval of Proposed Obstacle Lighting Scheme for Aberedw Wind Farm – Letter dated 22 April 2025.

4.5 Radar or Transponder Activated Lighting

- 4.5.1 ICAO Annex 14 also details guidance on ‘Visual Aids for Denoting Obstacles’. With specific reference to mitigation of effects on visual amenity, Note 2 outlines that *“An autonomous aircraft detection system may be installed on or near an obstacle (or group of obstacles such as wind farms), designed to operate the lighting only when the system detects an aircraft approaching the obstacle, in order to reduce light exposure to local residents”*.
- 4.5.2 A number of manufacturers have developed radar activated aviation lighting systems (aviation obstruction lighting detection system), whereby the lights will only be switched on when aircraft approach within a specified airspace zone, and this technology is currently permitted by aviation authorities in EU countries (German Federal Aviation Office (LBA) and the Netherlands Aerospace Centre (NAC)) and the United States (United States Federal Aviation Authority (FAA)).
- 4.5.3 This technology is not currently approved by the CAA and as such is not considered further as a potential mitigation option, at this stage. However, it may become available in the UK and deployable in the lifetime of this project, and if it were to be adopted will likely enable the duration of when visible lighting is illuminated to be substantially reduced.
- 4.5.4 An Aviation Detection Lighting System (ADLS) based on use of aircraft transponders is sometimes referred to as a ‘transponder-activated lighting’ system (or TAL). This form of mitigation means that visible turbine lights are only illuminated when an aircraft (carrying a transponder) entered an activation zone around the wind farm, in relatively proximity to the turbines. These systems are currently deployed on operational wind farm developments in Germany and Austria and have been proven to greatly reduce predicted lighting effects because triggering of lights happens very rarely. This is illustrated, whilst acknowledging that the circumstances may differ for the Proposed Development, by a study undertaken for the now consented Kirkan Wind Farm⁹ located in the Scottish Highlands, which estimated the frequency with which the aviation warning lights on the turbines will be switched on by passing aircraft if a transponder-activated lighting system was fitted to the wind farm.
- 4.5.5 This study, prepared by Aviatica for Kirkan Wind Farm Limited, was reported as Appendix 4 to the Additional Information submitted for Kirkan Wind Farm in October 2021. Kirkan Wind Farm proposes 17 turbines with a maximum blade tip height of 175 m, located 5.8 km north-west of Garve, and is located within Allocated Region 1B East (AR1BE) in the military Night Low Flying System. The study assumed activation criteria advised by CAA (i.e. an aircraft entering a 4 km radius bubble around the outer perimeter of the wind farm at an altitude less than 300 m (1000 ft) above the blade tips of the highest turbine and higher than 150 m (500 ft) above the ground level at the lowest turbine) and reviewed flight data for military fixed wing, military helicopter, search and rescue (SAR) helicopter, air ambulance helicopter, police helicopter and other night low level aircraft traffic over the period 2016-2021. The study determined that, on worst case estimates, the transponder-activated lights will be switched on for less than 0.1% of the periods of official night (Sunset +30 minutes until Sunrise -30 minutes), or 225 minutes per year. The study also referred to comparative data for 11 wind farms with operational ADLS/TALs in Germany and Austria where lighting was activated for an average 2.31% of night-time, although five of the wind farms had activation times within a similar range to Kirkan (between zero and 0.1% of night-time).
- 4.5.6 ADLS/TAL has never been deployed in the UK so the regulatory guidance is still to be developed. Transponder-activated lighting relies on the carriage of transponders in aircraft, and not all aircraft in the UK carry or operate transponders (nor are required to in certain volumes of UK airspace).
- 4.5.7 One option being investigated is the use of localised Transponder Mandatory Zones (TMZs). This requires CAA approval to authorize an ‘airspace change’ to create a TMZ across a particular area e.g. a wind farm site or multiple wind farm sites (‘cluster’) where aircraft will be obligated to carry a suitable transponder. A trial is currently being progressed for a site in Scotland with a view to developing a safety case and guidance material for use of TAL. If successful, then it is possible that developers could apply to the CAA for similar airspace changes to create other TMZs covering different area of UK airspace, albeit success of the trial should not automatically set the same level of expectation on developers elsewhere.
- 4.5.8 In the long-term, legislative change requiring the mandatory UK carriage of transponders by all aircraft may make this form of mitigation widely available.

⁹ [Scottish Government \(2023\) Energy Consents Unit – Kirkan Wind Farm \(ECU Reference: ECU00001800\)](#)

5. Proposed Aviation Lighting

5.1.1 Due to the height of the turbines proposed (200 m to turbine blade tip) visible aviation safety lighting is required.

5.2 Committed Mitigation

5.2.1 The proposed aviation lighting included in this assessment has been agreed through consultation with the CAA⁸. The lighting design is described in more detail in the ES **Appendix 2.7** (and summarised below):

- Two medium-intensity 'steady' red (2000 cc.) lights on the nacelles of 6 of the 18 turbines of the Proposed Development (turbines T2, T6, T7, T10, T16, T18) (the secondary light on each turbine is fitted for use in the event of failure of the primary light, and will not be lit concurrently);
- Infra-red lights to Ministry of Defence (MoD) specification installed on the nacelles of each turbine of the Proposed Development (18 in total); and
- Intermediate level 32 cd lights (low-intensity) red lights are not required to be fitted on the turbines towers as part of the lighting scheme.

5.2.2 The Applicant is committed to the implementation of intensity reduction (automatic dimming) mitigation as described above of the medium-intensity aviation lights to be installed on the Proposed Development. This will therefore allow for the 2000 cd lights to be dimmed to not less than 10% of the minimum peak intensity (e.g. 200 cd) when horizontal meteorological visibility exceeds 5 km.

5.2.3 As set out in ES **Appendix 2.7**, Met Office tables indicate that the visibility is below 5 km for an average of 12% of the time at Birmingham Airport and Cardiff Airport. This suggests that the lights at the Proposed Development will operate (e.g. be illuminated) at 2000 cd for approximately 12% of the time (visibility below 5 km) and operate at the equivalent of not less than 10% of the minimum peak intensity (e.g. 200 cd) when visibility is greater than 5 km for approximately 88% of the time. This situation is considered to represent the most reasonable maximum effect (e.g. worst case) scenario, and the predominant state in which the lights will be experienced by people across the study area.

5.3 Additional Mitigation

5.3.1 Whilst the Applicant is also committed to the implementation of vertical directional intensity mitigation comprising the use of aviation lights that are designed to operate close to the minimum required intensities (as discussed above), this mitigation is not relied upon in assessment of effects arising from aviation lighting. Whilst the assessment acknowledges the potential additional mitigation offered by this option (illustrated by the visible aviation lighting intensity ZTVs shown on **Figure A5.8.4** to **Figure A5.8.6**, and illuminance values presented in ES **Appendix 2.7**), it does not rely upon this when coming to judgements on the magnitude of landscape or visual change, or overall level (and significance) of landscape and visual effects. This appropriately cautious approach has been taken to reflect the likely variations in assumed reductions in luminous intensity (brightness) which may arise in relation to aviation lights produced by different manufacturers.

5.3.2 The aviation warning light specified in ES **Appendix 2.7** (CEL-WT-MIC¹⁰) meets the minimum ICAO requirements set out in Annex 14 – Table 6.3 for medium-intensity nacelle mounted aviation lights – including the ICAO minimum 2000 cd average intensity required between 0° (horizontal) and +3°. To deliver vertical directional intensity mitigation outlined above the light uses the latest finely tuned LEDs which are designed to minimise the spillage and over-brightness, and the vertical beam spread is minimised, with the brightest beam between -1° and +2°. **Table 5.1** below sets out the specific maximum and minimum luminous intensity values emitted at different vertical angles of elevation, as derived from the manufacturer's specification and performance statistics.

5.3.3 This information is outlined in more detail in ES **Appendix 2.7** and ES **Appendix 5.2**.

¹⁰ Contarnex Europe Ltd. (CEL) (2024) Medium Intensity Red 2,000 cd Light, 230VAC – LED Aircraft Warning Light – Datasheet

Table 5.1 Maximum and minimum luminous intensity relative to viewing angle – CEL-WT-MIC light

Vertical Angle of Lighting from Nacelle	Approximate Maximum and Minimum Candela (cd)	Approximate Maximum and Minimum Candela (cd) at 10% (clear weather conditions)
Above 5°	147 to 34	15 to 3
4° to 5°	247 to 134	25 to 13
3° to 4°	481 to 237	48 to 24
2° to 3°	1160 to 481	116 to 48
1° to 2°	2119 to 1170	212 to 117
0° to 1°	2206 to 1968	221 to 197
-1° to 0°	2036 to 987	204 to 99
-2° to -1°	996 to 383	100 to 38
-3° to -2°	394 to 197	39 to 20
-4° to -3°	199 to 131	20 to 13
-5° to -4°	131 to 92	13 to 9
Below -5°	94 to 38	9 to 4

- 5.3.4 **Table A.1** presented in **Annex A** provides the equivalent predicted emitted luminous intensity of the nacelle mounted aviation lights where vertical directional intensity mitigation is considered and informed by **ES Appendix 2.7**.
- 5.3.5 **Table 8a** in **ES Appendix 2.7** illustrates the comparative reduction in light intensity for a standard light emitting 2000 cd or 200 cd exclusive of viewing angle, when only distance is taken into account. Whilst the increase in distance clearly demonstrates a substantial reduction in the illuminance experienced by a receptor, as detailed in the aviation lighting and mitigation report, “For example at Viewpoint 2 at a distance of 2.05km the light intensity for a 2000cd light would be 476 lux^{10-6} whilst the same brilliance of light source viewed from Viewpoint 10 at a distance of 3.62km is 205 lux^{10-6} and at Viewpoint 28 at a distance of 27.55km it is only 3 lux^{10-6} ” (paragraph 30), vertical directional intensity reduction mitigation delivers a considerable further reduction in the illuminance perceived by receptors, particularly for locations in proximity to the aviation lights where they are often experienced from angles below the horizontal (i.e. < 0 degrees).
- 5.3.6 At the time of writing, neither the proposed manufacturer or precise model and specification of aviation light to be used on the Proposed Development is known. Although the precise details of performance, and thus the mitigation delivered, will vary according to the exact manufacturer and light used, the principles as assumed in **ES Appendix 2.7** will apply (i.e. decline in intensity with increased or decreased angle from the horizontal plane – i.e. 0 degrees), and these are referred to in the assessment where relevant. However, no specific values of luminous intensity experienced at different angles of elevation are relied upon in the assessment that may not be capable of being secured at the time of any future installation and operation of the aviation lights.

Representing Additional Mitigation

- 5.3.7 The representative photomontage visualisations which accompany the two assessment viewpoints do not take account of the potential reduction in light intensity emitted at certain angles above and below the horizontal plane – e.g. the impact of vertical directional intensity mitigation. This mitigation, embedded in the design of many modern aviation lights has the potential to substantially reduce the light intensity emitted in the direction of a particular viewpoint or the receptors it represents, and thus the illuminance experienced from particularly locations. The impact of this additional mitigation is however illustrated by the visible aviation lighting intensity ZTVs shown on **Figure A5.8.4** to **Figure A5.8.6**, and results in often vastly reduced cd values emitted at specific vertical elevation angles, and towards particularly viewpoints as set out in **Table A.1** in **Annex A**.

- 5.3.8 When viewing aviation lights from the two representative assessment viewpoints, the intensity of the light emitted at the relative angle towards the viewpoint will be reduced to the following levels:
- From Dusk/Night-time Assessment Viewpoint N1 (VP 6): Perthi Common, the maximum cd level emitted is 1262 cd during the maximum intensity scenario and 26 cd in the reduced intensity scenario (not less than 10% of maximum) from T7; however, the brightest turbine perceived from the viewpoint will be T16 with an illuminance of 14.8 μlx reducing to 1.5 μlx when the lights are operating in their reduced intensity scenario.
 - From Dusk/Night-time Assessment Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park, the maximum cd level emitted is 2132 cd during the maximum intensity scenario and 213 cd in the reduced intensity scenario (not less than 10% of maximum) from T7. This will be the brightest turbine perceived from the viewpoint with an illuminance of 5.5 μlx reducing to 0.6 μlx when the lights are operating in their reduced intensity scenario.
- 5.3.9 To provide some context, **Table 7** of ES **Appendix 2.7** outlines that the brightest star in the sky (Sirius) is approximately 13 μlx , with a typical bright star (e.g. Orion) being between 0.5 to 2.0 μlx . This suggests that under the reduced lighting intensity scenario, from the representative viewpoints the aviation lighting is likely to be perceived close to the range of brightness at which stars are typically seen.
- 5.3.10 The visualisations also do not take account of the influence of weather conditions which are often not as clear as when the photography was captured. In conditions of meteorological visibility of less than 5 km, the perceived brightness of maximum intensity lights, whilst possibly still visible, are likely to be substantially reduced. In such conditions the lights will typically not be visible at distances much greater than 5 km from turbines. Weather conditions therefore will influence the actual brightness of the lights perceived. This will include from upland areas of the BBNP at distances exceeding 14 km, where the increased viewing distance will further reduce the actual brightness of the light perceived.

5.4 Future Mitigation

- 5.4.1 The assessment of effects does not consider the potential implications of further mitigation measures which may be feasibly adopted in the future to reduce the extent, frequency and perceptibility of the necessary visible aviation lighting (such as radar activated lighting, or ADLS). While the effects of ADLS have not been assessed, the adoption of such a system is likely greatly reduce the incidence of visible aviation lighting.
- 5.4.2 Nevertheless, the Applicant is closely monitoring advancements in technology, guidance and legislation in this area and is committed to reviewing new forms of mitigation as they become available for deployment in the UK.

6. Approach to Assessment of Lighting Effects

- 6.1.1 The assessment of lighting effects follows the same approach detailed in ES **Appendix 5.1**. However, it is important to note that the assessment is not a lighting assessment based on a quantitative measurement of light levels; it is dependent on professional judgement of what the naked human eye can reasonably perceive in the context of the baseline situation with regard to existing sources of artificial lighting.
- 6.1.2 GLVIA3¹¹ provides the following guidance on the assessment of lighting effects *“For some types of development the visual effects of lighting may be an issue. In these cases, it may be important to carry out night-time ‘darkness’ surveys of the existing conditions in order to assess the potential effects of lighting and these effects need to be taken into account in generating the 3D model of the scheme. Quantitative assessment of illumination levels, and incorporation into models relevant to visual effects assessment, will require input from lighting engineers, but the visual effects assessment will also need to include qualitative assessments of the effects of the predicted light levels on night-time visibility”* (paragraph 6.12, page 103).
- 6.1.3 The assessment considers the potential effects associated with two potential scenarios: when the aviation lights are illuminated at 2000 cd; and at 200 cd. The 2000 cd scenario represents the maximum illumination or lighting intensity possible (noting that at certain angles of view the perceived brightness will exceed 2000 cd). The 200 cd scenario

¹¹ Landscape Institute and Institute of Environmental Management and Assessment (2013) Guidelines for Landscape and Visual Impact Assessment (3rd Edition)

represents the lower intensity mode which will be activated in clear meteorological conditions, where visibility exceeds 5 km (e.g. not less than 10% of their peak intensity).

6.1.4 The Welsh Government issued in February 2025 the Good Practice Guidance: Planning for the Conservation and Enhancement of Dark Skies in Wales¹².

6.1.5 Under section 3.9 Landscape, it notes if a night-time assessment is required, it should:

- Describe the type, timing and direction of lighting, its location and visibility in the wider landscape taking into account the screening provided by, for example, landform, buildings and vegetation.
- Identify and describe the baseline of dark skies and light pollution.
- Identify landscape characteristics and features which are sensitive to lighting and with reference to available evidence, explain why/how they are sensitive.
- Describe how lighting may adversely affect the characteristics, qualities and visual amenity that can be readily perceived at night.
- Identify the sensitivity of visual receptors (people) at night and whether their activities may be dark sky or low light dependant.
- Identify and describe any potential cumulative effects with other sources of lighting.
- Designated landscapes and landscapes with a high or outstanding LANDMAP Visual and Sensory evaluation may be more sensitive to change. The value of the landscape will not vary between day and night, although the visual impact and experience may differ.

6.1.6 ES **Appendix 2.7** provides detailed information on the light emitted towards each viewpoint for each turbine nacelle light (in cd) as well as the perceived brightness of each nacelle light at each viewpoint in micro-lumens per square metre (or 'micro-lux') - refer to Appendix A of ES **Appendix 2.7**. In order to place these values in context, **Table 7** of ES **Appendix 2.7** provides some examples of approximate values placed on a number of environmental comparators including car brake lights and the International Space Station. Where relevant, these useful comparisons are referred to in the assessment.

6.1.7 Taking a precautionary approach informed by the simple inverse relationship between the attenuation of light over distance, intervening distance alone will result in a substantial reduction in the perceived brightness (illuminance) of the aviation lights from different locations across the study area. The lights will be perceived at their brightest at locations closest to the light source. **Table 8a** of ES **Appendix 2.7** details the predicted illuminance from each viewpoint, for example, where seen from **Viewpoint 3: A481 at Hundred House** at 1.7 km from the nearest lit turbine (T16) the illuminance will be 709 µlx in the maximum intensity scenario and 70.9 µlx in the reduced intensity scenario (e.g. not less than 10% of their maximum luminous intensity). Conversely, from more distant locations such as **Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park** at 19.6 km from the nearest lit turbine (T7) the illuminance will be 5 µlx in the maximum intensity scenario and 0.5 µlx in the reduced intensity scenario (e.g. not less than 10% of their maximum luminous intensity).

6.1.8 Although the assessment is based on effects arising in relation to the medium-intensity steady red light, as illustrated in the supporting visualisations, it is acknowledged that in some situations a potential flicker effect may be experienced by receptors as blades pass the stationary light positioned on the turbine nacelle. It is not possible to represent this effect in static photomontages. However, the reflected glow across the immediate surfaces of the turbine blades which may be evident from locations within relatively close proximity to the turbines and under certain conditions (from experience, this is typically only discernible at distances of less than 5 km) is illustrated in the accompanying visualisations.

6.1.9 With regard to cumulative effects associated with visible aviation lighting, the following proposed wind development will also require aviation lighting should it be constructed:

¹² Welsh Government (2025) Dark Skies Guidance. Available at: <https://www.gov.wales/sites/default/files/publications/2025-02/dark-skies-guidance.pdf> [Accessed 6 May 2025]

- Nant Mithil (30 turbines up to a blade tip height of 220 m¹³ – with 14 of the 30 turbines lit), located approximately 10.5 km to the north-east of the nearest lit turbine of the Proposed Development.

6.1.10 This has been considered in the assessment below where applicable.

6.2 Zone of Theoretical Visibility and Illuminance Mapping

- 6.2.1 The 'maximum case' hub height (125.45 m height) Zone of Theoretical Visibility (ZTV), shown on **Figure A5.8.1** to **Figure A5.8.3** (illustrating visibility over a 28 km, 15 km and 2 km radius respectively), highlights the areas across the study area from which the visible lighting will be evident. This is based on the proposed aviation lighting scheme detailed in ES **Appendix 2.7**, which comprises two medium-intensity 'steady' red (2000 cd) lights on the nacelles of 6 of the 18 turbines of the Proposed Development (T2, T6, T7, T10, T16 and T18). The ZTV does not take account of potential screening provided by vegetation or built form.
- 6.2.2 To illustrate the potential variability in candela levels emitted in relation to vertical viewing angle (in respect to vertical directional intensity mitigation) of the nacelle lighting for the six turbines noted above, a visible aviation lighting intensity ZTV is shown on **Figure A5.8.4** to **Figure A5.8.6** (illustrating visibility over a 28 km, 15 km and 2 km radius respectively). The ZTV does not illustrate the reduction in the brightness of lights as perceived over distance, given it will be highly variable depending upon atmospheric conditions, but illustrates the effect of vertical directional intensity mitigation in reducing the cd value emitted from the lights at particular angles.
- 6.2.3 As illustrated by the ZTVs, visibility of the nacelle lights at their highest luminous intensity will generally be limited to views from more elevated locations where views are experienced close to the horizontal plane. This will typically include upland areas, hill flanks and summits at similar elevations to the lights found across the study area. These areas include elevated landform and hill summits in the BBNP, as represented by **Viewpoint N2 (VP27): Hay Bluff, Bannau Brycheiniog National Park**. These areas are generally less likely to be frequented during the hours of darkness, given their relative remoteness and sometimes challenging terrain.
- 6.2.4 Conversely, from lower lying areas, which are the focus of most settlement and habitation, and communication routes across the LVIA study area, the lights (where visible) will generally be perceived at a reduced intensity due to the viewing angle being substantially below the horizontal plane.
- 6.2.5 **Annex A** provides detailed information on the cd level emitted for each turbine nacelle light, evident from each LVIA viewpoint, dependent on the angle of view and distance as informed by ES **Appendix 2.7**.
- 6.2.6 **Figure A5.8.7** illustrates the level of perceived brightness (i.e. the illuminance) that will be experienced at each viewpoint taking account of the distance from the nearest visible aviation light when seen at both their maximum luminous intensity and reduced lower intensity mode (e.g. not less than 10% of their peak intensity).
- 6.2.7 **Figure A5.8.8** illustrates the maximum level of perceived brightness that will be experienced at each viewpoint taking account of distance from the aviation lights when seen at both their maximum luminous intensity and reduced lower intensity mode (e.g. not less than 10% of their peak intensity), and the angle of view, accounting for the impact of vertical directional intensity mitigation.

6.3 Visualisations

- 6.3.1 It is important to note that visualisations represent just one source of information that informs a LVIA. Visualisations have been produced for two representative dusk/night-time assessment viewpoints, and are presented in accordance with the industry standard guidance prescribed in NatureScot¹⁴ and Landscape Institute¹⁵ guidance.
- 6.3.2 The methodology for the preparation of dusk/night-time visualisations is detailed in full in ES **Appendix 5.2**.
- 6.3.3 The NatureScot guidance states *"The visualisation should use photographs taken in low light conditions, preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night... We have found that approximately 30 minutes after sunset*

¹³ The Nant Mithil Energy Park will comprise three turbines at 220 m blade tip height, 24 turbines at 205 m blade tip height, and three turbines at 180 m blade tip height.

¹⁴ Scottish Natural Heritage (2017) Visual Representation of Wind Farms – Guidance (Version 2.2)

¹⁵ Landscape Institute (2019) Technical Guidance Note 06/19 – Visual Representation of Development Proposals

provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image” (paragraphs 174-177, page 35 and 36).

- 6.3.4 Photography taken at this time represents a relatively small window (during periods of dusk and dawn, the length of which varies with the time of year) when the landform is visible along with existing and proposed light sources, and the perception of landscape character under conditions of fading light or darkness is possible. The actual night-time view, for most of the proposed hours when the turbines are lit, will usually be darker. The proposed lighting and other natural and manmade light sources will be seen against a dark sky or dark landform. In such conditions, the landscape character is harder to perceive. Bright moonlit conditions, or periods when the landscape is snow covered, may provide an exception to this. It is noted that some other light sources will be switched off when people go to bed, and that at this time people may be less susceptible to experiencing views of lighting.
- 6.3.5 Multiple ranges of baseline dusk/night-time photography were captured from each viewpoint with reference to the NatureScot guidance. Photography was captured after dusk in clear atmospheric conditions and sought to capture the presence of existing baseline sources of artificial lighting (e.g. lighting associated with settlement, street lighting, motor vehicles and other sources) present in the landscape as closely as is experienced by the human eye as is feasible. However, dependant on seasonal conditions, day length and view direction the surveyors’ discretion were applied when determining the most appropriate time for capturing the photography.
- 6.3.6 Selection of the most appropriate range of photography to be used for the preparation of visualisations was not limited to that captured closest to 30 minutes following sunset, as photography captured in the summer months often needs to be captured much later once the ambient light has reduced sufficiently to allow darkness to be fully experienced, whilst still maintaining an appreciation of the underlying landscape.
- 6.3.7 Guidance on the approach to aviation lighting impact assessment, developed by Scottish Government and NatureScot was published in November 2024¹⁶. This guidance advocates that where automatic dimming mitigation is adopted photomontage visualisations showing lights illuminated only to the 200 cd scenario (e.g. not less than 10% of the minimum peak intensity) need be presented.
- 6.3.8 The representative dusk/night-time photomontage visualisations are presented in **ES Volume 4** and illustrate the appearance of the proposed visible aviation lighting at dusk/periods of darkness during clear viewing conditions from:
- **Dusk/Night-time Assessment Viewpoint N1: Perthi Common**, approximately 2.4-2.9 km to the north-west and north-east of the nearest lit turbines (**Figures 5.32 in Volume 4**, illustrating the reduced intensity (200 cd) scenario). This is the same as LVIA **Viewpoint 6**. [N.B. Contact was made with Enplan¹⁷ to seek agreement of this dusk/ night-time viewpoint but no response was received].
 - **Dusk/Night-time Assessment Viewpoint N2: Hay Bluff, Bannau Brycheiniog National Park** (and International Dark Sky Reserve), approximately 19.6 km to the south-west of the nearest lit turbine (**Figures 53 in Volume 4**, illustrating the reduced intensity (200 cd) scenario). This is in a very similar location to LVIA **Viewpoint 27**. [N.B. This dusk/ night-time viewpoint was agreed with NRW – see **Table 5.1 in Chapter 5** for more details].
- 6.3.9 NatureScot guidance also states that *“The developer should attempt to formally agree the lighting requirements with the aviation authorities in advance of the application. Where this is not possible the visualisations should illustrate the lighting as described in the current legislation”* (paragraphs 177, page 36). The visualisations were created by setting the candela level at the light source within the visualisation software when dimmed to 10% (i.e. 200 cd). The representative visualisations do not take account of the potential reduction in light intensity which may be perceived in relation to the relevant vertical elevation angle, and do not account for the attenuation of the light emitted over distance and in variable changing atmospheric conditions. The actual light perceived at these locations is likely to be less than that which is illustrated in the visualisations, and as set out in **Table A.1 of Annex A**.
- 6.3.10 Although the assessment is based on effects arising in relation to the steady red light fixed to the top of each turbine hub (nacelle), as illustrated in the supporting visualisations, it is acknowledged that in some situations a potential flicker effect may be experienced by receptors as rotating blades pass the stationary lights dependent on the location of the receptor and the prevailing wind direction (and thus orientation of the turbine). It is not possible to represent

¹⁶ [Scottish Government and NatureScot \(2024\) Guidance on Aviation Lighting Impact Assessment](#)

¹⁷ Enplan are an external environmental consultancy and have been commissioned by PCC to provide advice in relation to landscape and visual matters.

this situation in a static photomontage image. Furthermore, reflected glow across the immediate surfaces of the turbine blades and hub may be evident under certain conditions, which are reflected in the photomontage visualisations.

- 6.3.11 If the photomontages are being viewed on a screen, it is recommended this is done in a darkened environment with low levels of lighting, avoiding any screen glare (i.e. no reflections or light shining directly onto the surface of the screen which will alter the perceived light being cast out from the screen, as this has the effect of making things appear lighter or darker than they actually are to the human eye).

6.4 Assessing Significance of Landscape Effects arising from Visible Aviation Lighting

- 6.4.1 The assessment of landscape susceptibility to the introduction of visible lighting at night considers the extent to which an area is able to accommodate turbine lighting without undue negative consequences to the baseline night-time landscape. This is determined by the presence or absence of existing dark skies and/or lighting as part of the baseline and the extent to which visible turbine lighting may alter this. It is measured on a scale of high to low; where high is ascribed to landscapes that experience the darkest skies with minimal existing light sources, and low being ascribed to landscapes that experience the brightest night skies and where there may be many existing lights.
- 6.4.2 The night-time baseline against which the effects of the Proposed Development are assessed, has been informed by review of the Natural Resources Wales (NRW) map of Dark Skies and Light Pollution in Wales¹⁸ shown on **Figures 5.13a-b**, which illustrate the level of radiance is measured in nanowatts per square centimetre per steradian (NanoWatts/cm²/sr).
- 6.4.3 No other visible aviation lighting (low-intensity or medium-intensity steady or flashing red lighting) has been identified on structures, including wind turbines, within the LVIA study area.
- 6.4.4 The assessment of landscape value takes the same approach as detailed in the LVIA Methodology in ES **Appendix 5.1**.
- 6.4.5 An overall judgement of landscape sensitivity is derived by combining the separate judgements on landscape susceptibility and landscape value.
- 6.4.6 As for the LVIA, the assessment of the magnitude of landscape change is driven by the size/scale of change to landscape character, with duration and reversibility also a consideration. Geographical extent is recorded separately.
- 6.4.7 The size/scale of effect considers the extent to which additional lighting affects night-time character in the context of the baseline situation with regard to existing sources of artificial lighting and the predicted results provided by the aviation consultant, and detailed in ES **Appendix 2.7**.
- 6.4.8 When determining the magnitude of change associated with the Proposed Development, the methodology in ES **Appendix 5.1** considers the duration of the change. For operational effects this is deemed to be long-term (but subject to removal or change upon decommissioning, or future alteration of the Proposed Development or lighting requirements, such as the potential for adoption of radar or transponder activated solutions). However, and with relevance to night-time effects, the frequency and duration of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness (below 500 cd/m²) which changes with the seasons. As such in the summer months the duration of when the visible aviation lighting will be illuminated will reduce. It will also be activated much later at night, when fewer people may be around to experience the lighting. In the winter the converse will be the case. The period when visibility is greater than 5 km is also likely to be longer in summer, due to generally better weather conditions.

Table 6.1 Size and scale of landscape change

Size/Scale	Description
Large	Large change to the landscape at night, perhaps where the baseline landscape is dark, and turbine lighting becomes the brightest lighting to affect the dark skies values of the landscape (whether this is directly or indirectly).

¹⁸ [Natural Resources Wales \(NRW\) \(2021\) Dark Skies and Light Pollution in Wales Map](#)

Size/Scale	Description
Medium	Clearly perceptible change in the levels of lighting within the landscape, but with the additional lights being no brighter than the existing lights that affect the dark skies values of the landscape (whether this is directly or indirectly).
Small	Small change in the levels of lighting within the landscape, perhaps where additional lighting is visible but is not as bright as the existing lighting that affect the dark skies values of the landscape (whether this is directly or indirectly).
Barely Perceptible	Change in the levels of lighting within the landscape which is barely perceptible, or the change may go unnoticed.

6.4.9 Judgements on sensitivity and magnitude of landscape change are combined to assess the significance of effect, guided by the principles set out in **Diagram 1** in ES **Appendix 5.1**.

6.5 Assessing Significance of Visual Effects Arising from Visible Aviation Lighting

- 6.5.1 The susceptibility of visual receptors also differs at night reflecting the different activities people may undertake during the hours of darkness. For example, drivers using roads at night tend to be more focused on the road which will be illuminated by headlights, and may have oncoming headlights, reflective signage and dashboard lighting drawing their attention, resulting in lower susceptibility. This is particularly the case on unlit rural roads that may be narrow and winding. Conversely, people taking part in activities where darkness is essential, such as stargazing, are considered to be of higher susceptibility.
- 6.5.2 The value of views experienced at dusk/night is judged the same as for the day-time assessment unless specific factors suggest otherwise – e.g. the presence of a designation relative to dark sky qualities which will increase value; or where factors that contribute to value during day-time are irrelevant or imperceptible at night – which may reduce value of views experienced at night. Specific locations within designated dark sky areas (e.g. such as the BBNP International Dark Sky Reserve) as defined in supporting publications are likely to be especially sensitive as people are encouraged to use them to appreciate dark skies at night.
- 6.5.3 The assessment of visual susceptibility, value and sensitivity is the same as detailed in the LVIA Methodology in ES **Appendix 5.1**.
- 6.5.4 As for the LVIA, the assessment of magnitude of visual change is driven by the size/scale of change to views, with duration and reversibility also a consideration. Geographical extent is recorded separately.
- 6.5.5 The size/scale of effect considers the extent to which lighting impacts on the view, judging what the naked human eye can reasonably perceive in the context of the baseline situation with regard to existing sources of artificial lighting and the predicted results provided by the aviation consultant in ES **Appendix 2.7**.

Table 6.2 Size and scale of visual change

Size/Scale	Description
Large	Large change in the view, perhaps where the baseline is dark and turbine lighting becomes the brightest lighting in the field of view, drawing the eye and becoming the dominant feature of the view.
Medium	Clearly perceptible change in the view, perhaps where turbine lighting is visible, but of equivalent brightness to existing lights.
Small	Small change in the view, perhaps where turbine lighting is visible but not as bright as existing lighting in the view.
Barely Perceptible	Change in view which is barely perceptible, or the change may go unnoticed.

6.5.6 Judgements on sensitivity and magnitude of visual change are combined to assess the significance of effect, guided by the principles set out in **Diagram 1** in ES **Appendix 5.1**.

7. Effects of Lighting on Landscape Character at Night

- 7.1.1 In terms of effects on landscape character, and as noted previously, there will usually be a relatively small window of time, at dawn and dusk, or in conditions of bright moonlight or under snow cover, during which the landform is apparent along with existing and new light sources, and when an appreciation of landscape character and associated skylines is perceptible. Perception of landscape character in the true darkness of night and for most of the hours when it is proposed that turbines will be lit, will be limited, albeit that the skyline with its stars, planets, satellites etc will be seen when it is clear. Only the proposed aviation lighting, other human light sources, and human and natural sources in the night sky will be readily apparent when it is dark. As such, the main window during which effects on landscape character, and effects on many of the associated key characteristics will be experienced will be limited to the short period of twilight (shorter in winter, and more extended in summer), or moonlight (particularly under snow). Many key characteristics, and the experience of landscape character can only readily be appreciated during the day.

7.2 Aberedw Uplands LCA 50

- 7.2.1 The Site and Proposed Development is mostly located within the Aberedw Uplands LCA 50 (with all of the proposed turbines located within it). The LCA is described in the 2022 Powys LCA¹⁹. It is noted within the LCA profile²⁰ that *“The LCA experiences dark night skies as indicated by the Natural Resources Wales (NRW) map of Dark Skies and Light Pollution in Wales”*.
- 7.2.2 This landscape is a relatively remote, rural upland landscape. Existing light sources are limited to isolated dwellings and farmsteads predominantly nestled within the valleys around the edge of the LCA and outside of the Site. There are also some light sources within the small church settlement of Llanfihangel-nant-Melan, and from cars travelling along a short section of the A44 which clips the northern boundary of the LCA. Although the LCA is close to the settled valley of the River Wye, artificial lighting (which is mostly arising from Builth Wells) has limited influence. The landscape unit has a night sky value of under 0.5 NanoWatts/cm²/sr (the darkest category) within and up to 5 km from the Site (with the exception of the River Wye valley to the west of the Site), as illustrated on **Figure 5.13b**. The absence of existing light in the baseline night-time landscape is judged to result in a **medium-high** susceptibility. There is little evidence of the core upland area of the landscape being frequently accessed at dusk/during hours of darkness, and overall, the LCA is judged as having a **medium** value, and therefore the overall night-time landscape sensitivity is judged to be **medium-high**. The proposed aviation lighting will introduce additional artificial lighting into the night-time landscape resulting in a small-scale change to the levels of lighting within the landscape, but they will not be brighter than the existing lighting that affects the dark skies values of the peripheral areas of the LCA. This will result in a **low-medium** magnitude of landscape change at night during the ‘maximum intensity scenario, and a **low** magnitude of landscape change at night during the ‘reduced lighting intensity scenario’. Therefore, the overall level of effect during both scenarios is considered to be **minor-moderate (not significant)**.
- 7.2.3 In terms of the effects upon the wider landscape character outside the directly affected LCA, the proposed turbine lights will not change the levels of dark skies, but there will be impacts on views experienced from the surrounding landscape, as set out in the visual analysis below.
- 7.2.4 Overall, in summary, no significant effects on landscape character are predicted at night. Effects of lighting will primarily affect views rather than perceived underlying characteristics of the landscape (i.e. landscape character).
- 7.2.5 Taking account of the additional impact of vertical directional intensity reduction mitigation, the lights will be perceived at a considerably lower illuminance from a large extent of the LCA, as illustrated by **Figure A5.8.5** and **Figure A5.8.6**. This reduction will be experienced particularly from locations around the periphery of the LCA (from where the lights will be viewed from the greatest negative angles below the horizontal) where it is anticipated the greatest number of receptors (people) will perceive the lights at dusk/night-time.

¹⁹ LUC on behalf of Powys County Council (2022) Local Landscape Character Assessment for the Powys Local Development Plan Area – Landscape Character Assessment Report

²⁰ Landscape Character Area – LCA 50: Aberedw Uplands

8. Effects of Lighting on the Bannau Brycheiniog International Dark Sky Reserve At Night

8.1 Background

- 8.1.1 The BBNP is located approximately 14 km south from the outermost turbine of the Proposed Development. In 2013 the National Park was awarded International Dark Sky Reserve status (becoming only the fifth International Dark Sky Reserve in the world at the time), due to its internationally exceptional dark skies and a commitment from local partner groups to preserve and enhance the dark skies in the future.
- 8.1.2 The Y Bannau: The Future - The Management Plan For Bannau Brycheiniog National Park 2023-2028²¹ sets out the importance of the International Dark Sky Reserve *“Our Dark Skies are relatively unique in an increasingly urbanised world where light pollution dominates. The IDSR status allows us to put into place measures to prevent the spread of light pollution into the National Park to conserve and enhance our special qualities of darkness and tranquillity. We champion these as a precious resource, providing opportunities for quiet and deep reflection connecting the individual to the wonders of the universe. Through this highly prestigious status, we hope to preserve our magical night skies for future generations. The reserve status also has significant economic value to the National Park. Creating a mechanism to attract staying visitors through stargazing events and promotion. We also utilise the status to draw attention to the impacts of human activity on our environment and our climate, through the dark skies benefit to nocturnal wildlife and carbon saving from switching off the lights”* (Page 21).
- 8.1.3 Large areas of the National Park remain free from light pollution, and the majority of it experiences less than 0.5 NanoWatts/cm²/sr i.e. very low levels of radiance, as illustrated on **Figure 5.13a**.
- 8.1.4 In relation to light pollution, Policy 12 of the Bannau Brycheiniog National Park Authority’s Local Development Plan²² states *“Proposals where lighting is required shall include a full lighting scheme and will be permitted:-*
- *a) where the lighting proposed is appropriate to its purpose; and,*
 - *b) where there is not a significant adverse effect individually or cumulatively on*
 - *i) the character of the area;*
 - *ii) local residents;*
 - *iii) vehicle users;*
 - *iv) pedestrians;*
 - *v) biodiversity;*
 - *vi) the visibility of the night sky; and*
 - *vii) ‘dark corridors’ for bats and light sensitive species.”*
- 8.1.5 The supporting text of Policy 12 identifies dark skies as being a key contributor to the sense of tranquillity and remoteness of the National Park.
- 8.1.6 One of the National Park’s special qualities detailed in Y Bannau: The Future – The Management Plan For Bannau Brycheiniog National Park 2023-2028 includes reference to dark skies *“Peace, tranquillity and darkness: A National Park offering dark night time skies, peace and tranquillity with opportunities for quiet enjoyment, inspiration, relaxation and spiritual renewal”* (Page 47).
- 8.1.7 The management plan also details the Dark Sky Board of the BBNP whose core purpose *“aims to protect and enhance the dark skies and nighttime environment”* (Page 252), and goes on to state *“Our area of focus is the Bannau Brycheiniog National Park however we also seek to protect and maintain an External Buffer zone around this boundary to help prevent light spill into the protected area”* (Page 252), and sets out two aspirations in respect to the protection and enhancement of dark skies:

²¹ [Welsh Government \(2023\) Y Bannau: The Future – The Management Plan For Bannau Brycheiniog National Park 2023-2038](#)

²² Bannau Brycheiniog National Park Authority (2013) Brecon Beacons National Park Local Development Plan. Available at: <https://www.beacons-npa.gov.uk/wp-content/uploads/Brecon-Written-Statement.pdf>

- 1) *“A long established and high quality night sky and night time environment in the Bannau Brycheiniog National Park, appreciated locally and nationally for the benefits it brings.*
- 2) *The value and importance of darkness is mainstream in Wales with widespread lighting control measures in place and supported by the Welsh Government” (Page 253).*

8.1.8 Overall, it is considered that the night-time landscape susceptibility, value and sensitivity are all **high**.

8.2 Analysis

- 8.2.1 As illustrated by the visible aviation lighting ZTV on **Figure A5.8.1**, pockets of theoretical visibility of the visible turbine lights are indicated from the northern fringes of the National Park and International Dark Sky Reserve and from elevated hill summits along the great north-west scarp of the Black Mountains.
- 8.2.2 The turbine lighting will not change the night sky values for the areas within BBNP from which the lights will be seen, given the nature of the lights and the intervening distances at which they will be visible from (over 19 km). Any change will be barely perceptible when the lights are seen at their reduced intensity (i.e. when visibility exceeds 5 km as measured by sensors at the wind farm). When seen at their maximum intensity (2000 cd) or in this reduced intensity scenario (200 cd) turbine lighting will not significantly impact the special qualities of the National Park, namely the *“Peace, tranquillity and darkness: A National Park offering dark night time skies, peace and tranquillity with opportunities for quiet enjoyment, inspiration, relaxation and spiritual renewal”* (as considered in detail in ES **Appendix 5.6**) nor will it be contrary to the dark skies aspirations in the Management Plan.
- 8.2.3 During dusk/at night, it is considered that **the Proposed Development will not prejudice the values or integrity of this designated landscape by adversely impacting on the special qualities for which it was designated.**
- 8.2.4 The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced from the National Park. The lighting intensity ZTV illustrates that due to the elevated nature of these areas of the National Park from where visibility is predicted, the lights will be seen at an angle of between 0° and 1° where source intensity is brightest i.e. a luminous intensity ranging from 1968 and 2206 cd, when illuminated in the maximum intensity scenario or 197 cd to 221 cd during the reduced intensity scenario (e.g. at no less than 10% of maximum intensity). However, given the distance from the Proposed Development and taking account of the attenuation of light over distance, the levels of illuminance experienced on the ground will be much lower (as demonstrated in **Table 8a** of ES **Appendix 2.7**).
- 8.2.5 ES **Appendix 2.7** suggests that, taking account of this additional mitigation, the brightest turbine light on the nacelle of T7 (emitting 2132 cd during the maximum intensity scenario or 213 cd during the reduced intensity scenario) seen from **Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park** will be up to 5.5 μlx during the maximum intensity scenario, which is slightly brighter than a car brake light seen at 5 km (4 μlx), or up to 0.6 μlx during the reduced intensity scenario, which is similar to a typical bright star, e.g. Orion (0.5 to 2 μlx), or fainter than a car brake light seen at a distance of 10 km (1 μlx).

9. Effects of Lighting on Views and Visual Amenity At Night

- 9.1.1 As is the case for effects upon landscape character, effects arising at dusk/night-time will predominantly alter views of night skies rather than influence the landscape character of designated landscapes. Changes to views, including those experienced from the BBNP are described below.

9.2 Aviation Lighting Visibility from Assessment Viewpoints

- 9.2.1 **Table 9.1** below details the predicted visibility of the proposed turbine lighting from each LVIA viewpoint, informed by the results within ES **Appendix 2.7** and observations of the visualisations included in ES **Volume 4**.
- 9.2.2 As noted above the frequency of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness which changes with the seasons. As such in the summer months the length of time subject to visible aviation lighting will reduce.

Table 9.1 Summary of turbine lighting visibility

Viewpoint	Legend					
	•	Hub Lighting Potentially Visible (i.e. one medium-intensity nacelle light).				
	•	Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7).				
		Turbine light obscured by landform/terrain (informed by Appendix 2.7).				
		Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7).				
	Turbine Number					
	T2	T6	T7	T10	T16	T18
N1 (VP 6) – Perthi Common	•	•	•	•	•	•
N2 (VP 27) – Hay Bluff, Bannau Brycheiniog National Park	•	•	•	•	•	•
VP 1 – St. David’s Church, Cregrina						
VP 2 – A481 at Matts Common		•		•	•	•
VP 3 – A481 at Hundred House	•	•		•	•	•
VP 4 – A470 at Aberduhonw	•	•				
VP 5 – NCN 825 near Cregrina	•		•	•	•	•
VP 7 – Twm Tobacco’s Grave on Llandeilo Hill	•	•	•	•	•	•
VP 8 – Carneddau	•	•	•	•	•	•
VP 9 – Garth Hill	•	•		•		
VP 10 – Rhulen, south east of Aberedw	•	•	•	•	•	•
VP 11 – Castle Bank	•	•	•	•	•	•
VP 12 – Wye Bridge, Builth Wells	•	•				
VP 13 – Unnamed lane at Bettws	•	•		•	•	•
VP 14 – Unnamed lane, north-east of Llanbedr Hill	•	•	•	•	•	•
VP 15 – Royal Welsh Showground	•	•				

Viewpoint	Legend					
	•	Hub Lighting Potentially Visible (i.e. one medium-intensity nacelle light).				
	•	Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7).				
		Turbine light obscured by landform/terrain (informed by Appendix 2.7).				
		Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7).				
	Turbine Number					
	T2	T6	T7	T10	T16	T18
VP 16 – Wye Valley Walk near Banc y Celyn	•	•	•	•	•	•
VP 17 – NCN 8 near Cilmery	•	•		•	•	
VP 18 – Llanfihangel Hill		•			•	
VP 19 – The Begwns Roundabout	•	•		•	•	•
VP 20 – Bridleway off A44 near Castell Crugerydd	•	•	•	•	•	•
VP 21 – Heart of Wales Line Trail at Moelfre	•	•	•	•	•	•
VP 22 – Llandegley Rocks	•	•	•	•	•	•
VP 23 – Open access land on Mynd	•	•		•	•	
VP 24 – A4081 at Llanyre		•	•	•		
VP 25 – Promoted viewpoint south of Cwm Graig-ddu	•	•	•	•	•	
VP 26 – Elan Valley Way near Cwmwrach	•		•	•	•	•
VP 28 – Cefn Llechid, Bannau Brycheiniog National Park	•	•	•	•	•	•
VP 29 – Pen y Fan, Bannau Brycheiniog National Park	•	•	•	•	•	•

9.3 Representative Dusk/Night-time Viewpoints

9.3.1 Whilst the potential visibility of aviation lighting is summarised for each of the representative viewpoints (as set out in **Table 9.1** above) the following assessment focuses on two representative dusk/ night-time viewpoints.

Table 9.2 Dusk/Night-time Assessment Viewpoint N1 (VP 6): Perthi Common

Dusk/Night-time Assessment Viewpoint N1 (VP 6): Perthi Common				
Grid reference	309512	254676	Figure number	Figures 5.32 in Volume 4
LCA/landscape unit	Llanbister - Penybont Uplands (Powys LCA 40)		Designated Landscape	n/a
Direction of view towards lit turbines	South, south-east and south-west		Number of turbines with visible lights theoretically visible	6
Light Intensity: Accounting for Distance ONLY (see Table 8a ES Appendix 2.7)				
Nearest lit turbine (No. / km)	T16 at 2.4 km		Illuminance in Microlux (µlx) of nearest turbine	342 µlx during the 'maximum intensity scenario' and 34.2 µlx during the 'reduced lighting intensity scenario'.
Light Intensity: Accounting for Distance and Viewing Angle (see ES Appendix 2.7)				
Emitted Candela (cd) at maximum intensity (Table A.1, Annex A)	Between 87 cd and 262 cd		Emitted Candela (cd) at 10% of maximum intensity (Table A.1, Annex A)	Between 9 cd and 26 cd
Illuminance in Microlux (µlx) at maximum intensity	Between 7.4 µlx and 14.8 µlx		Illuminance in Microlux (µlx) at 10% of maximum intensity	Between 0.7 µlx and 1.5 µlx
Location, description of existing view and potential receptors	This viewpoint has been selected to represent close by residents (e.g. the local community at Llansantffraed-in-Elwe) and can be used to represent other local communities who are at this distance and elevation (e.g. the local community at Hundred House). It is located upon the open access land at Perthi Common, a small undulating upland area extending west of Llansantffraed-in-Elwel. At this location there are very few sources of artificial lighting (as shown in the dusk/ night-time baseline photography for Viewpoint N1 (VP 6), including no street lighting in the immediate vicinity. Lighting is limited to scattered isolated farmsteads on the hill side (such as a bright security light at the Bryntwppa farmstead in the west, which is the most prominent light source, visible in the far right of the view), and passing traffic along nearby roads, including sporadic vehicle lights along the A481 which are visible in the right of the view in the valley below Aberedw Hill. There are also some sources of light in distant views to the south-west towards Builth Wells and the River Wye valley. As illustrated on Figure 5.13b, Brightness at this viewpoint location is under 0.5 NanoWatts/cm2/sr²³). During hours of darkness no other visible aviation lighting on wind turbines or other structures are evident across the study area from the viewpoint. Baseline photography for this viewpoint (shown on Figures 5.32g and 5.32k in ES Volume 4) was captured on 01 April 2025 at 20:39. Sunset time on this date was at 19:48²⁴.			

²³ Natural Resources Wales (2021) Dark Skies and Light Pollution in Wales. Available at: <https://luc.maps.arcgis.com/apps/opsdashboard/index.html#/1cd6ba8a1d7d4a62aff635cfcba4aec>

²⁴ <https://www.suncalc.org/#/52.1825,-3.3254,17/2025.04.01/20:39/1/1>

Dusk/Night-time Assessment Viewpoint N1 (VP 6): Perthi Common					
Judgement on visual susceptibility at dusk/night	The visual susceptibility of this receptor is judged to be high as local communities have an interest in their surroundings, and views from this settlement are enjoyed by residents and contribute to the landscape setting of the settlement.				
Judgement on the value of views experienced by the visual receptor at dusk/night	Views experienced by this receptor are judged to be of medium value as there are some attractive views of the surrounding hillsides which are valued by the local community who experience them, and relative darkness is evident within the surrounding landscape.				
Judgement on visual sensitivity at dusk/night	By combining the separate judgements on visual susceptibility and the value of views experienced by the visual receptor at dusk/night, the sensitivity of this visual receptor is judged to be medium – high .				
	Low	Low – Medium	Medium	Medium – High	High
Judgement on magnitude of visual change at dusk/night	Scale of Effect at Dusk/Night The lights on the nacelles of all lit turbines (T2, T6, T7, T10, T16 and T18) will be seen against the darker skies above the elevated skyline of Aberedw Hill to the south of the viewpoint. The lights will be seen largely in the absence of other artificial lighting, limited to small sources of light associated with nearby agricultural buildings and sporadic vehicle lights. Although located at a substantially higher elevation from the valley, the aviation lights will draw the eye towards the skyline formed by the gently undulating and smooth hills associated with the Aberedw Hill upland complex and the lights will appear above the horizon and occupy a large horizontal field of view in views up to the hills from the surrounding lower-lying farmland and nearby properties. At this proximity (approximately 2.4 km to the nearest lit turbine, T16) the reflected glow across the immediate surfaces of the turbine, including the rear of the turbine blades and the turbine nacelle will be evident (subject to wind direction and the orientation of the turbines), and a potential flicker effect will be experienced as blades pass the stationary light positioned on the turbine nacelle. The prominence of the lights will, however, be substantially reduced when the lights are operating in their reduced intensity mode, which is predicted to be the case for approximately 88% of the time. The scale of effect at dusk/night is judged to be medium during the 'maximum intensity scenario' reducing to be at the lower end of medium during the 'reduced lighting intensity scenario'. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint. ES Appendix 2.7 suggests that at their maximum intensity the visible lights will emit between 87 cd (T16) and 262 cd (T7) and be perceived at up to 14.8 µlx (T16 at 2.4 km) which is slightly dimmer than a sodium streetlight at 2 km (20 µlx) or slightly brighter than the brightest star in the sky (Sirius) (13 µlx). During the 'reduced lighting intensity scenario', the visible lights will emit between 9 cd (T16) and 26 cd (T7) and be perceived at up to 1.5 µlx (T16 at 2.4 km) which is similar to a typical bright star (e.g. Orion) (0.5 to 2.0 µlx) or a car brake light at 10 km (1 µlx). Duration/Reversibility The changes in views resulting from aviation lighting on turbines will be long-term (beyond 10 years) and reversible as the turbines and lights will be dismantled and removed from the Site once the operational period has ceased. Based on the meteorological information presented in ES Appendix 2.7, it is understood that the frequency in which the aviation lights will operate in their reduced intensity mode will equate to approximately 88% of the time. Overall Judgement of Magnitude of Visual Change at Dusk/Night & Geographical Extent Overall, the medium scale of effect over a long-term during the 'reasonable maximum worst-case scenario' is judged to result in an overall magnitude of change of medium for close by residents (e.g. the local community at Llansantffraed-in-Elwe) and other local communities at a similar distance and elevation (e.g. the local community at Hundred House). The overall magnitude of change will reduce to low-medium during the 'reduced lighting intensity scenario'.				

Dusk/Night-time Assessment Viewpoint N1 (VP 6): Perthi Common						
	As described above, the influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint.					
	Barely Perceptible	Low	Low – Medium during the 'reduced lighting intensity scenario'.	Medium during the 'reasonable maximum worst-case scenario'.	Medium – High	High
Overall Level of Effect and Significance at Dusk/Night	A medium-high sensitivity combined with a medium magnitude is judged to result in a moderate effect during the 'reasonable maximum worst-case scenario'. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to between 7.4 μlx and 14.8 μlx during the 'reasonable maximum intensity scenario'. A medium-high sensitivity combined with a low-medium magnitude is judged to result in a minor-moderate effect during the 'reduced lighting intensity scenario'. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to between 0.7 μlx and 1.5 μlx during the 'reduced lighting intensity scenario'.					
	Negligible (not significant)	Minor (not significant)	Minor - Moderate (not significant) during the 'reduced lighting intensity scenario'.	Moderate (significant) during the 'reasonable maximum worst-case scenario'.	Moderate - Major (significant)	Major (significant)
Assessment of cumulative effects	The hubs of the proposed wind development at Nant Mithill that will require aviation lighting will be at a distance of over 10 km from this viewpoint, and so the aviation lighting associated with this development will be barely perceptible. Therefore, the effect will remain the same as in the primary assessment.					

Table 9.3 Dusk/Night-time Assessment Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park

Dusk/Night-time Assessment Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park			
Grid reference	324364	236635	Figure number
LCA/landscape unit	The Black Mountains (BBNP LCA 13) ²⁵	Designated Landscape	Figures 5.53 in Volume 4
Direction of view towards lit turbines	North-west	Number of turbines with visible lights theoretically visible	6
<i>Light Intensity: Accounting for Distance ONLY (see Table 8a ES Appendix 2.7)</i>			
Nearest lit turbine (No. / km)	T7 at 19.6 km	Illuminance in Microlux (µlx) of nearest turbine	5 µlx during the 'maximum intensity scenario' and 0.5 µlx during the 'reduced lighting intensity scenario'.
<i>Light Intensity: Accounting for Distance and Viewing Angle (see ES Appendix 2.7)</i>			
Emitted Candela (cd) at maximum intensity (Table A.1, Annex A)	Between 2093 cd and 2132 cd	Emitted Candela (cd) at 10% of maximum intensity (Table A.1, Annex A)	Between 209 cd and 213 cd
Illuminance in Microlux (µlx) at maximum intensity	Between 4.3 µlx and 5.5 µlx	Illuminance in Microlux (µlx) at 10% of maximum intensity	Between 0.4 µlx and 0.6 µlx
Location, description of existing view and potential receptors	This viewpoint has been selected to represent visitors of the Bannau Brycheiniog National Park and International Dark Sky Reserve (including those experiencing its dark night skies). It is located at the hill summit of Hay Bluff (677m AOD), situated at the northern edge of the Black Mountains within the Bannau Brycheiniog National Park and International Dark Sky Reserve, to the distant south-east of the Site. Very few light sources are visible from the viewpoint, and particularly across the vast extents of the National Park to the south-west. There are no sources of light at the location of the viewpoint; while very limited light sources are visible in the view towards the Site (as shown in the dusk/night-time baseline photography for Viewpoint N2 (VP 27)). Overall, views are very dark in all directions from the viewpoint. As illustrated on Figure 5.13a, brightness at the viewpoint is under 0.5 NanoWatts/cm²/sr²⁶). During hours of darkness no other visible aviation lighting on wind turbines or other structures are evident across the study area from the viewpoint. Baseline photography for this viewpoint (shown on Figure 5.53g in ES Volume 4) was captured on 23 July 2024 at 21:38. Sunset time on this date was at 21:16²⁷.		
Judgement on visual susceptibility at dusk/night	The viewpoint is representative of recreational walkers in the National Park, but is less likely to be accessed or the views appreciated by receptors during hours of darkness due to its remote upland location. The visual susceptibility of this receptor is judged to be high as a relatively small number of people who may be engaged in outdoor recreation will experience expansive views from the BBNP and the		

²⁵ Fiona Fyfe Associates on behalf of Brecon Beacons National Park Authority (2012) Brecon Beacons National Park Landscape Character Assessment

²⁶ Natural Resources Wales (2021) Dark Skies and Light Pollution in Wales. Available at: <https://luc.maps.arcgis.com/apps/opstdashboard/index.html#/1cd6ba8a1d7d4a62aff635cfcba4aec>

²⁷ SunCalc website

Dusk/Night-time Assessment Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park						
	International Dark Sky Reserve, which is recognised for its dark sky qualities, and may be in the National Park at night to experience its dark skies.					
Judgement on the value of views experienced by the visual receptor at dusk/night	Views experienced by receptors at this viewpoint are judged to be of high value as they are associated with the nationally designated landscape and internationally designated Dark Sky Reserve.					
Judgement on visual sensitivity at dusk/night	By combining the separate judgements on visual susceptibility and the value of views experienced by the visual receptor at dusk/night, the sensitivity of this visual receptor is judged to be high .					
	Low	Low – Medium	Medium	Medium – High	High	
Judgement on magnitude of visual change at dusk/night	Scale of Effect at Dusk/Night The lights on the nacelles of all lit turbines (T2, T6, T7, T10, T16 and T18) will be seen against a dark backdrop comprising upland areas to the north of the Site in views to the north-west during the 'reasonable maximum worst-case scenario' and during the 'reduced lighting intensity scenario'. The lights will be seen largely in the absence of any other artificial lighting and a substantial distance from the viewpoint and the neighbouring upland areas of the BBNP it represents. Given the long distance between the Proposed Development and the viewpoint, atmospheric conditions and the attenuation of light over distance will have a substantial influence and will further limit the perception of the aviation lighting from this distant location. The scale of effect at dusk/night is judged to be small during the 'reasonable maximum worst-case scenario' and barely perceptible during the 'reduced lighting intensity scenario'. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint. ES Appendix 2.7 suggests that at their maximum intensity the visible lights will emit between 2093 cd (T2) and 2132 cd (T7) and be perceived at up to 5.5 µlx (T7 at 19.6 km) which is slightly brighter than a car brake light seen at approximately 5 km (4 µlx) or a sodium street light at 5 km (5 µlx). During the reduced intensity scenario, the visible lights will emit between 209 cd (T2) and 213 cd (T7) and be perceived at up to 0.6 µlx (T7 at 19.6 km) which is similar to a typically bright star (e.g. Orion) (0.5 to 2.0 µlx) and dimmer than a car brake light seen at approximately 10 km (1 µlx). Duration/Reversibility The changes in views resulting from aviation lighting on turbines will be long-term (beyond 10 years) and reversible as the turbines and lights will be dismantled and removed from the Site once the operational period has ceased. Based on the meteorological information presented in ES Appendix 2.7 , it is understood that the frequency in which the aviation lights will operate in their reduced intensity mode will equate to approximately 88% of the time. Overall Judgement of Magnitude of Visual Change at Dusk/Night & Geographical Extent Overall, the small scale of effect over a long-term during the 'reasonable maximum worst-case scenario' is judged to result in an overall magnitude of change of low for visitors of the BBNP and International Dark Sky Reserve. The overall magnitude of change will reduce to barely perceptible during the 'reduced lighting intensity scenario'. As described above, the influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint.					
	Barely Perceptible during the 'reduced lighting	Low during the 'reasonable maximum	Low – Medium	Medium	Medium – High	High

Dusk/Night-time Assessment Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park						
	intensity scenario'.	worst-case scenario'.				
Overall Level of Effect and Significance at Dusk/Night	A high sensitivity combined with a low magnitude is judged to result in a minor effect during the 'reasonable maximum worst-case scenario'. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to between 0.4 μlx and 0.6 μlx during the 'reasonable maximum intensity scenario'. As the magnitude of change is barely perceptible during the 'reduced lighting intensity scenario', the overall effect is negligible.					
	Negligible (not significant) during the 'reduced lighting intensity scenario'.	Minor (not significant) during the 'reasonable maximum worst-case scenario'.	Minor - Moderate (not significant)	Moderate (significant)	Moderate - Major (significant)	Major (significant)
Assessment of cumulative effects	The hubs of the proposed wind development at Nant Mithill that will require aviation lighting will be at a distance of over 20 km from this viewpoint, and so the aviation lighting associated with this development will be barely perceptible. Therefore, the effect will remain the same as in the primary assessment.					

9.4 Overall Visual Analysis

- 9.4.1 This section provides an overall analysis of the effects resulting from the lighting on visual amenity at night. Where levels of illuminance (i.e. perceived brightness) are stated, these consider both the illuminance without the implementation of vertical directional intensity mitigation in place, as well as with it in place.
- 9.4.2 The visible aviation lighting ZTVs presented on **Figure A5.8.1** to **Figure A5.8.3** illustrate the theoretical visibility of the proposed aviation lights across the Study Area. It is evident that the areas from where the greatest number of lights (up to 6) will be seen are from the upper valley slopes and hill summits that surround the Site in all directions. Within the immediate valleys that surround the Site (e.g. River Wye, River Edw, Colwyn Brook and Cnithio Brook) a smaller number of lights will be seen (as shown on **Figure A5.8.3**), with intervening landform of the Aberedw Hill upland complex screening lit turbines in parts of the Site.
- 9.4.3 The lighting intensity ZTVs in **Figure A5.8.4** to **Figure A5.8.6** show that from areas closer to the Site (mostly within 5 km), there is a potential for visibility of the turbine lights, but the angle of the emitted light in relation to the ground (-1° or below from much of the area) means the intensity of light emitted in that direction will be lower than the maximum²⁸. Conversely, areas further from the Site have more patchy visibility but will be more aligned with the direction of light emitted (within -1° to $+1^\circ$ angle) and this means the intensity of light emitted in that direction will be higher, although distance and atmospheric conditions will have more of a part to play in reducing light reaching receptors at those distances. More detail is provided below, with reference to ES **Appendix 2.7**.
- 9.4.4 The visible aviation lighting intensity ZTV shown on **Figure A5.8.6** illustrate that within the vicinity of the Site (2 km), views of turbines from much lower lying land in all directions (i.e. the foot of the slopes associated with the Aberedw Hill upland complex and immediate valleys) will mostly be experienced at a viewing angle of less than -2° . Therefore, the cd emitted towards those areas will be less than 394 cd during the maximum intensity scenario, or less than 39

²⁸ As explained in the WPAC Aviation Lighting and Mitigation Report (ES **Appendix 2.7**), there is a significant decrease in the luminous intensity (candela) of the light emanating towards areas which are at lower angles of elevation in relation to the turbine light.

cd during the reduced intensity scenario. This includes views from the local communities of Hundred House (**Viewpoint 3**); those experienced by visitors to the Fforest Fields, Mid Wales Caravan & Camping Site and the Brynchrach Caravan and Camping Site; road users of the A481 (**Viewpoint 2**) and the A470 (**Viewpoint 4**); and cyclists along NCN 825 (**Viewpoint 5**). Most of the lit turbines are not visible from the local community of Cregina (**Viewpoint 1**) due to intervening landform. Areas along lower valley slopes between 2 km and 5 km will experience similar viewing angles and therefore a similar level of cd emitted. This includes views from the local communities of Llansantffraed-in-Elwel, Franksbridge, Builth Wells (**Viewpoint 12**) and Llanelwedd (**Viewpoint 15**), as well as recreational users of Perthi Common (**Viewpoint N1 / 6**). This will also be the case from the more elevated southern half of Gilwern Hills (**Viewpoint 11**).

9.4.5 From areas within 5 km of the Site, visibility of turbine lights will be more patchy, but where visible (such as from elevated summits and upper valley slopes), they will be more aligned with the direction of light emitted, either at an angle of 0° to 1° (where the greatest luminous intensity will be emitted) or slightly lesser angle of -1° to 0° (as indicated by **Figure A5.8.5**). This will be the case from the following summits where the cd emitted towards those areas will be between 987 cd and 2206 cd during the maximum intensity scenario, or 99 cd and 221 cd during the reduced intensity scenario:

- Carneddau (**Viewpoint 8**) to the north-west of the Site;
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance **Viewpoint 8** will reach 248 µlx (similar to a white LED street light at 0.7 km) and 24.8 µlx (similar to a car brake light at 2 km), respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 55 µlx (slightly brighter than a front cycle light at 1 km) and 5.5 µlx (similar to a sodium street light at 5 km) during the maximum intensity and reduced intensity scenarios respectively.
- Little Hill, Cefn Wylfre and Glascwm Hill to the east of the Site;
- Red Hill, Rhulen Hill, Llanbedr Hill (**Viewpoint 14**) and Llandeilo Hill (**Viewpoint 7**) to the south-east and south of the Site;
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 7** will reach 287µlx (slightly dimmer than a sodium street light at 0.5 km) and 28.7 µlx (similar to a white LED street light at 2 km) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 111 µlx (slightly brighter than a car break light at 1 km) and 11 µlx (similar to a front cycle light at 2 km or the brightest sky in the sky - Sirius), respectively.
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 14** will reach 111 µlx (slightly brighter than a car break light at 1 km) and 11.1 µlx (similar to a front cycle light at 2 km or the brightest sky in the sky - Sirius) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 65 µlx (slightly dimmer than a front cycle light at 0.7 km) and 6.5 µlx (similar to a sodium street light at 5 km) respectively.
- Banc y Celyn (**Viewpoint 16**) to the south-west of the Site;
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 16** will reach 81 µlx (slightly brighter than a sodium street light at 1 km) and 8.1 µlx (similar to a white LED street light at 5 km) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 33 µlx (similar to a front cycle light at 1 km) and 3.3 µlx (similar to a front cycle light at 5 km) respectively; and
- Garth Hill (**Viewpoint 9**) to the west of the Site.

9.4.6 During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 9** will reach 198 µlx (similar to a car brake light at 0.7 km) and 19.8 µlx (similar to a sodium street light at 2 km) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 10 µlx (similar to a front cycle light at 2 km or the brightest sky in the sky - Sirius), and 1 µlx (similar to a car brake light at 10 km) respectively.

- 9.4.7 Between 5 km and 15 km, elevated local communities and some upland areas will experience the lights at an angle between -1° to -3° , therefore the cd emitted towards those areas will be between 197 cd and 987 cd (during the 'reasonable maximum worst-case scenario') or 20 cd and 99 cd (during the 'reduced lighting intensity scenario'), as indicated by **Figure A5.8.5**. This will be the case from:
- the local community at Cilmerly to the west of the Site (with views similar to those represented from **Viewpoint 17: NCN 8 near Cilmerly**);
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 17** will reach 44 μlx (slightly brighter than a front cycle light at 1 km) and 4.4 μlx (similar to a car brake light at 5 km) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 5.2 μlx (similar to a sodium street light at 5 km) and 0.5 μlx (similar to a typical bright star, e.g. Orion) respectively;
 - Newbridge-on-Wye to the north-west of the Site; and
 - the summits at Cefn-poeth and Comin-y-garth to the north-west of the Site.
- 9.4.8 From higher elevations between 5 and 15 km, the lights will be experienced at an angle of -1° to 0° , and so the luminous intensity emitted towards those areas will be higher at between 987 cd and 2036 cd (during the 'reasonable maximum worst-case scenario') or 99 cd and 204 cd (during the 'reduced lighting intensity scenario'). This will be the case from:
- the summit at Mynd (**Viewpoint 23**);
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 23** will reach 21 μlx (similar to a sodium street light at 2 km) and 2.1 μlx (similar to a front cycle light at 5 km) respectively. With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.
 - the summit at The Begwns (**Viewpoint 19**);
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 19** will reach 33 μlx (similar to a front cycle light at 1 km) and 3.3 μlx (slightly dimmer than a car brake light at 5 km) respectively. With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.
 - the summit at Moelfre (**Viewpoint 21**);
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 21** will reach 26 μlx (similar to a car brake light at 2 km) and 2.6 μlx (similar to a front cycle light at 5 km or a typical bright sky star, e.g. Orion) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 12.6 μlx (similar to the brightest star in the sky, Sirius) and 1.3 μlx (similar to a car brake light at 10 km) respectively.
 - the summit at Llandegley Rhos (**Viewpoint 22**);
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 22** will reach 23 μlx (similar to a car brake light at 2 km) and 2.3 μlx (similar to a front cycle light at 5 km or a typical bright star, e.g. Orion) respectively. With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.
 - the summits at Cefn Gledwen, Cefn Llwydallt and Cefn Clawdd; and
 - the promoted viewpoint south of Cwm Graig-ddu (**Viewpoint 25**)
 - During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 25** will reach 12 μlx (similar to the brightest star in the sky, Sirius) and 1.2 μlx (similar to a car brake light at 10 km) respectively. With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.
- 9.4.9 The greatest luminous intensity will be emitted at an angle of 0° to 1° where at source it will be 2000 to 2200 cd (during the 'reasonable maximum worst-case scenario') or 200 to 220 (during the 'reduced lighting intensity scenario'). Between 5 km and 15 km, this will be experienced from:

- hill summits at Gwaunceste Hill and Colva Hill; and
- Elan Valley Way near Cwmwrach (**Viewpoint 26**)
 - At this distance (14.3 km), atmospheric conditions will reduce the amount of lighting reaching receptors. During the maximum intensity scenario and the reduced intensity scenario, the highest level of illuminance at **Viewpoint 26** will reach 10 μlx (similar to a front cycle light at 2 km) and 1 μlx (similar to a car brake light at 10 km or a typical bright star e.g. Orion) respectively. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 5.8 μlx for the worst-case scenario (similar to a sodium street light at 5 km away) or 0.6 μlx for the reduced intensity scenario (similar to a typical bright star, e.g. Orion).

9.4.10 From more distant locations across the study area, between 15 km and 28 km the lights will generally be seen at angles of between -1° and 1° where the luminous intensity emitted from the lights will be brightest (between 997 cd and 2206 cd), as indicated by **Figure A5.8.4**. However, owing to the influence of distance and the attenuation of light, the illuminance of the lights will be vastly reduced. For example, from **Viewpoint N2 / 27** (19.6 km from T7), the illuminance to be experienced at the viewpoint is predicted to be 5 μlx in the maximum intensity scenario (similar to a sodium street light at 5 km), or 0.5 μlx in the reduced intensity scenario (similar to a typical bright star, e.g. Orion). With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited. Similar observations can be made in the relation to **Viewpoints 28 and 29** (also within the BBNP) where the illuminance to be experienced at the viewpoints is predicted to be 2-3 μlx in the maximum intensity scenario (similar to a front cycle light at 5 km or a typical bright star, e.g. Orion), or 0.2-0.3 μlx in the reduced intensity scenario (similar to the faintest light visible from street lit area). Again, with vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.

9.4.11 In summary, the turbine lights will appear the brightest during the 'reasonable maximum worst-case scenario' from PROWs within the Site and in the elevated valley slopes and hill summits within 5 km. From areas within the vicinity of the Site (within 5 km of the nearest lit turbine) i.e. the foot of the slopes associated with the Aberedw Hill upland complex and lower valley slopes, as well as surrounding local communities, the turbine lights will be visible upon the dark horizon, although will appear relatively dim as a result of being below the angle at which the lights are most effective. The exception to this will be from elevated summits and upper valley slopes within 5 km where these areas will be more aligned with the direction of light emitted resulting in a greater luminous intensity e.g. from Carneddau, Little Hill, Cefn Wylfre and Glaschw Hill, Red Hill, Rhulen Hill, Llanbedr Hill, Llandeilo Hill, Banc y Celyn and Garth Hill). This will also be the case from higher elevations beyond 5 km (e.g. the hill summits at Mynd, The Begwns, Moelfre, Llandegley Rhos, Cefn Gledwen, Cefn Llwydallt, Cefn Clawdd, Gwaunceste Hill and Colva Hill; the promoted viewpoint south of Cwm Graig-ddu; the Elan Valley Way near Cwmwrach; and the BBNP, although the illuminance of the lights will be reduced by distance.

10. Effects of Aviation Lighting on Residential Visual Amenity

10.1.1 Effects on the day-time views and visual amenity of residents of properties within 2 km of the proposed turbines are assessed within ES **Appendix 5.7: Residential Visual Amenity Assessment (RVAA)**.

10.1.2 The majority of residents within 2 km of the outermost turbines of the Proposed Development are located in areas with a night sky value of <0.5 NanoWatts/cm²/sr as illustrated on **Figure 5.13b**, except for those in the west where they are slightly influenced by light sources from within Builth Wells. Some properties located within 2 km of the Proposed Development are located within or on the outskirts of small settlements such as Hundred House and Cregrina where there are street lights and numerous sources of artificial light associated with domestic dwellings and are generally brighter areas. Properties that are located outside of these small settlements tend to be in darker areas. At a local level in proximity of the Site, these variations in the presence of artificial light are not captured by the Natural Resources Wales (NRW) map of Dark Skies and Light Pollution in Wales²⁹ (as illustrated on **Figure 5.13b**), with the nearest sources of artificial light evident in the mapping associated with the settlement of Builth Wells, approximately 3.8 km west of the nearest lit turbines of the Proposed Development.

10.1.3 Taking account of the impact of vertical directional intensity reduction the visible aviation lighting intensity ZTV shown on **Figure A5.8.6** illustrates that within the vicinity of the Site (within 2 km of the proposed turbines), the

²⁹ [Natural Resources Wales \(NRW\) \(2021\) Dark Skies and Light Pollution in Wales Map](#)

residential properties are located at sharp angles below the lights and so lighting intensity is typically low for these residential receptors (people). Most residential properties are located at -5° or below the horizontal where the luminous intensity emitted from the lights will range from 94 to 38 cd (during the 'reasonable maximum worst-case scenario') or 9 to 4 (during the 'reduced lighting intensity scenario'). There are also some residential properties located at an angle of -3° or below the horizontal where the luminous intensity emitted from the lights will be <199 cd. when illuminated to their maximum luminous intensity, or <20 cd. when dimmed to 10% of maximum luminous intensity.

10.1.4 Although ES **Appendix 2.7** does not present data for individual residential properties considered in the RVAA³⁰, some of the representative viewpoints considered in the LVIA are located within 2 km and represent views from the closest settlements and residential properties to the Proposed Development. These viewpoints can be used as a proxy for the likely effects arising from the introduction of visible aviation lights from residential properties, as follows:

- Viewpoint 1: St. David's Church, Cregrina (**Figures 5.27 in Volume 4**);
- Viewpoint 2: A481 at Matts Common (**Figures 5.28 in Volume 4**);
- Viewpoint 3: A481 at Hundred House (**Figures 5.29 in Volume 4**);
- Viewpoint 4: A470 at Aberduhonw (**Figures 5.30 in Volume 4**);
- Viewpoint 5: NCN 825 near Cregrina (**Figures 5.31 in Volume 4**); and
- Viewpoint 6: Perthi Common (**Figures 5.32 in Volume 4**).

Viewpoint 1: St. David's Church, Cregrina

10.1.5 The nearest lit turbine from this viewpoint is T18; however, the ES **Appendix 2.7** indicates that this viewpoint is too close to T18 to get an accurate assessment. The next nearest lit turbine is T16 at a distance of approximately 1.5 km and at an angle of -9° below the horizontal. ES **Appendix 2.7** indicates that views towards this lit turbine and the others are likely to be obscured by landform. However, if visible from within the vicinity of this viewpoint, illuminance for T16 will reach 926 μlx (during the 'reasonable maximum worst-case scenario') which is slightly dimmer than the International Space Station (400 km up), or 92.6 μlx (during the 'reduced lighting intensity scenario') which is slightly dimmer than a car brake light at 1 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 26.8 μlx (similar to a car brake light at 2 km) and 2.7 μlx (similar to a front cycle light at 5 km) during the maximum intensity scenario and the reduced intensity scenario respectively. Properties that are at a similar distance and angle, and are therefore likely to experience similar effects of lighting include those around Cregrina i.e. Property Group 1 (P2: Penarth and P3: Penarth Bungalow), Property Group 5 (P30: Hollybush and P31: Weldon) and Property Group 6 (P32: The Grove, P33: Ty Rhos Pentwyn and P34: Pentwyn).

Viewpoint 2: A481 at Matts Common

10.1.6 This viewpoint is located approximately 2 km from the nearest turbine (T6) and at an angle of -8.6° below the horizontal. ES **Appendix 2.7** indicates there will be visibility of four aviation lights from this viewpoint (T6, T10, T16 and T18) with two aviation lights obscured by landform (T2 and T7). Illuminance for T6 will reach 476 μlx (during the 'reasonable maximum worst-case scenario') which is brighter than a car brake light at 0.5 km, or 47.6 μlx (during the 'reduced lighting intensity scenario') which is slightly brighter than a front cycle light at 1 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 17.9 μlx (during the 'reasonable maximum worst-case scenario') which is slightly dimmer than a sodium street light at 2 km, or 1.8 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 5 km or a typical bright star (e.g. Orion). Properties that are at a similar distance and angle and are therefore likely to experience similar effects of lighting, include Property Group 15 (P69: Tynrheol, P70: Colwyn Cottage, P71: Beili Bychan, P72: Springfield and P73: Matts Farm).

³⁰ It has not been possible to obtain data from residential properties within 2 km of the proposed turbines because the system is unable to model the results due to the close proximity of the lit turbines and the steep angle of elevation between many of the properties and the lit turbines.

Viewpoint 3: A481 at Hundred House

- 10.1.7 This viewpoint is located approximately 1.7 km from the nearest turbine (T16) and at an angle of -10.1° below the horizontal. ES **Appendix 2.7** indicates there will be visibility of five aviation lights from this viewpoint (T2, T6, T10, T16 and T18) with one aviation light obscured by landform (T7). Illuminance for T6 will reach 709 μlx (during the 'reasonable maximum worst-case scenario') which is brighter than a white LED street light at 0.5 km, or 70.9 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 0.7 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 26.5 μlx (during the 'reasonable maximum worst-case scenario') which is similar to a car brake light at 2 km, or 2.6 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 5 km. Properties that are at a similar distance and angle and are therefore likely to experience similar effects of lighting, include Property Group 7 (P39: 2, Fforest Cottages and P40: 1, Fforest Cottages), Property Group 8 (P41: The Moat House Mobile Home and P42: Fforest Farm), Property Group 10 (P51: Bevan House, P52: Woodland Lodge and P53: River Lodge) and Property Group 17 (properties within Hundred House).

Viewpoint 4: A470 at Aberduhonw

- 10.1.8 This viewpoint is located approximately 2.1 km from the nearest turbine (T2) and at an angle of -11.6° below the horizontal. ES **Appendix 2.7** indicates there will be visibility of two aviation lights from this viewpoint (T2 and T6) with four aviation lights obscured by landform (T7, T10, T16 and T18). Illuminance for T2 will reach 437 μlx (during the 'reasonable maximum worst-case scenario') which is slightly brighter than a car brake light at 0.5 km, or 43.7 μlx (during the 'reduced lighting intensity scenario') which is slightly brighter than a front cycle light at 1 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 16.4 μlx (during the 'reasonable maximum worst-case scenario') which is similar to the brightest star in the sky (Sirius), or 1.6 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 5 km or a typical bright star (e.g. Orion). Properties that are at a similar distance and angle and are therefore likely to experience similar effects of lighting, include Property Group 27 (P136: Aberduhonw Fach, P137: Aberduhonw and P138: Aberduhonw Mill).

Viewpoint 5: NCN 825 near Cregina

- 10.1.9 This viewpoint is located approximately 1.9 km from the nearest turbine (T18) and at an angle of -7.7° below the horizontal. ES **Appendix 2.7** indicates there will be visibility of five aviation lights from this viewpoint (T2, T7, T10, T16 and T18) with one aviation light obscured by landform (T6). Illuminance for T18 will reach 531 μlx (during the 'reasonable maximum worst-case scenario') which is brighter than a white LED street light at 0.5 km, or 53.1 μlx (during the 'reduced lighting intensity scenario') which is brighter than a front cycle light at 1 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 20 μlx (during the 'reasonable maximum worst-case scenario') which is similar to a sodium street light at 2 km, or 2 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 5 km or a typical bright star (e.g. Orion). Properties that are at a similar distance and angle and are therefore likely to experience similar effects of lighting, include Property Group 22 (P110: Box Farm and P111: Helyg).

Viewpoint 6: Perth Common

- 10.1.10 This viewpoint is located approximately 2.4 km from the nearest turbine (T16) and at an angle of -5.4° below the horizontal. ES **Appendix 2.7** indicates there will be visibility of five aviation lights from this viewpoint (T2, T6, T10, T16 and T18) with one aviation light (T7) identified as being screened by terrain but potentially visible within the vicinity of the viewpoint. Illuminance for T16 will reach 342 μlx (during the 'reasonable maximum worst-case scenario') which is brighter than a sodium street light at 0.5 km, or 34.2 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 1 km. The influence of vertical directional intensity mitigation could further reduce the perceived brightness (illuminance) experienced at the viewpoint to 14.8 μlx (during the 'reasonable maximum worst-case scenario') which is similar to the brightest star in the sky (Sirius), or 1.5 μlx (during the 'reduced lighting intensity scenario') which is similar to a front cycle light at 5 km or a typical bright star (e.g. Orion). Properties that are at a similar distance and angle and are therefore likely to experience similar effects of lighting, include Property Group 29 (P154: Brynsela Farm and P155: Llansantffraid School House).
- 10.1.11 Although the turbine lights will be noticeable at night from properties considered in the RVAA, their presence will not contribute to any breach of the Residential Visual Amenity Threshold and will not have a material effect on residential amenity or living conditions at any property. Whilst the presence of visible aviation lights in views from

these properties contributes to effects on residential visual amenity 'in the round', the presence of the visible steady red lights evident from some properties, and their curtilages' during hours of darkness will not substantially extend the duration of effects on residential visual amenity experienced. During the periods of time when the lights are anticipated to be illuminated, residents focus will be largely concerned with the use of the interior rooms of their properties and use of exterior spaces and curtilages will typically be undertaken under the coverage of other artificial light sources.

11. Summary of Aviation Lighting Effects

- 11.1.1 Due to the proposed reduced lighting scheme, which includes medium intensity 'steady' red (2000 cd /200 cd) lights on the nacelles of 6 of the 18 proposed turbines, the potential for significant landscape and visual effects associated with aviation lighting to arise is judged to be limited.
- 11.1.2 As set out in the ES **Appendix 2.7**, it is anticipated that the lights at the Proposed Development will operate in their automatically dimmer mode, at the equivalent of not less than 10% of the minimum peak intensity (e.g. 200 cd.) when visibility is below 5 km, for approximately 88% of the time. This situation is considered to represent the most reasonable maximum effect (e.g. worst case) scenario, and the predominant state in which the lights will be experienced by people across the study area.
- 11.1.3 No significant effects on landscape character are predicted to arise from the introduction of visible aviation lighting. Dark sky qualities are specifically recognised for the host Aberedw Uplands LCA 50 as well as for the BBNP designated landscape considered in this assessment. However, whilst some of these landscapes are remote, devoid of obvious man-made elements or have key characteristics to which dark skies contribute, the introduction of the proposed aviation lights will be perceived at relatively low intensities taking account of the committed mitigation outlined above.
- 11.1.4 The Proposed Development will increase the duration over which potential effects on landscape character and the special qualities of designated landscapes are experienced. However, at the distances concerned, it will be infrequent for the maximum cd. lighting to be seen, given this will typically be used when atmospheric visibility is below 5 km (as measured at the location of the sensor). More usually, clear conditions will be required for lighting to be seen over these distances, in which case the dimming of the lights to a maximum of a 10% of their luminous intensity will be activated. There will be some exceptions to this e.g. when atmospheric visibility is reduced by small or sporadic cloud at the point of measurement on the turbines, but is clear beyond this and at the location of the viewpoint, or for example when the cloud base is below the sensor, but visibility is good beneath it and at the location of viewpoints. In this instance though, there will still be some attenuation of the light by the presence of the same cloud cover.
- 11.1.5 In terms of visual effects, a **moderate (significant)** visual effect is judged to arise for **Dusk/Night-time Representative Viewpoint N1 (VP6): Perthi Common** when the lights are illuminated at their maximum luminous intensity (2000 cd). The lights will be seen above the smooth hills associated with the Aberedw Hill upland complex, which can often still be appreciated during dusk and hours of darkness. The lights will appear across a relatively wide horizontal extent of the available views from the viewpoint and from similar nearby locations, including the local communities at Llansantffraed-in-Elwe and Hundred House. However, the provision for the medium-intensity nacelle lights to be controlled by visibility sensors to reduce the intensity of the lights to approximately 10% of the minimum peak intensity in times of clear meteorological conditions (e.g. 200 cd where visibility exceeds 5 km, which is predicted to be up to 88% of the time), will substantially reduce the perceptibility of the visible aviation lights and the associated visual effects will reduce to **minor-moderate (not significant)**.
- 11.1.6 No significant effects are predicted to arise for receptors represented by **Dusk/Night-time Representative Viewpoint N2 (VP 27): Hay Bluff, Bannau Brycheiniog National Park** during either the maximum intensity (2000 cd) or reduced intensity (200 cd) scenarios, with **minor (not significant)** and **negligible (not significant)** effects predicted to arise for each respective scenario.
- 11.1.7 The visible aviation lighting present on the Proposed Development at dusk/night will not significantly affect the special qualities of the BBNP and International Dark Sky Reserve (its boundary is located approximately 14 km south from the closest lit turbine (T7) of the Proposed Development at its nearest point, but the turbine lights will be seen from the slopes at distances of over 19 km away). The predicted illuminance of the visible aviation lights experienced from Hay Bluff (**Viewpoint N2 / 27**) within the National Park is predicted to be up to 5.5 µlx during the

maximum intensity scenario, which is similar to a car brake light seen at 5 km (4 μlx), or up to 0.6 μlx during the reduced intensity scenario, which is similar to a typical bright star, e.g. Orion (0.5 to 2 μlx), or fainter than a car brake light seen at a distance of 10 km (1 μlx). With vertical directional intensity mitigation in place, the reduction in the level of illuminance will be limited.

- 11.1.8 Some of the closest receptors to the visible aviation lights will be residential receptors located within 2 km of the proposed turbines and considered in the RVAA (contained in ES **Appendix 5.7**). The residential properties are located at sharp angles below the lights and so lighting intensity is typically low for these residential receptors.

Annex A: Predicted Luminous Intensity of Nacelle Mounted Aviation Lighting Relative to Viewing Angle

Table A.1: Predicted luminous intensity of nacelle mounted aviation lighting relative to viewing angle for all LVIA viewpoints

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key							
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
			Turbine Number							
			T2	T6	T7	T10	T16	T18		
N1 (VP 6) – Perthi Common 0.3 NanoWatts /cm2/sr)	Full	342 μlx	140 cd	100 cd	262 cd	104 cd	87 cd	117 cd		
	10%	34.2 μlx	14 cd	10 cd	26 cd	10 cd	9 cd	12 cd		
N2 (VP 27) – Hay Bluff, Bannau Brycheiniog National Park 0.3 NanoWatts /cm2/sr)	Full	5 μlx	2093 cd	2117 cd	2132 cd	2117 cd	2117 cd	2117 cd		
	10%	0.5 μlx	209 cd	212 cd	213 cd	212 cd	212 cd	212 cd		
VP 1 – St. David’s Church, Cregrina 0.3 NanoWatts /cm2/sr)	Full	926 μlx	N/A	N/A	N/A	N/A	N/A	N/A		
	10%	92.6 μlx	N/A	N/A	N/A	N/A	N/A	N/A		
VP 2 – A481 at Matts Common	Full	476 μlx	N/A	75 cd	N/A	75 cd	75 cd	74 cd		
	10%	47.6 μlx	N/A	8 cd	N/A	8 cd	8 cd	7 cd		

³¹ Based on NRW Dark Skies and Light Pollution (Wales), CPRE Night Lights (England) as shown on **Figures 5.13a-b** – Note: datasets were made in different years, using slightly different parameters.

³² Informed by Table 8a in **Appendix 2.7: Aviation Lighting and Mitigation Report**.

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key						
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
			Turbine Number						
			T2	T6	T7	T10	T16	T18	
0.4 NanoWatts /cm2/sr)									
VP 3 – A481 at Hundred House 0.3 NanoWatts /cm2/sr)	Full	709 μlx	122 cd	100 cd	N/A	74 cd	75 cd	75 cd	
	10%	70.9 μlx	12 cd	10 cd	N/A	7 cd	8 cd	8 cd	
VP 4 – A470 at Aberduhonw 0.6 NanoWatts /cm2/sr)	Full	437 μlx	75 cd	75 cd	N/A	N/A	N/A	N/A	
	10%	43.7 μlx	8 cd	8 cd	N/A	N/A	N/A	N/A	
VP 5 – NCN 825 near Cregrina 0.3 NanoWatts /cm2/sr)	Full	531 μlx	176 cd	N/A	176 cd	108 cd	83 cd	75 cd	
	10%	53.1 μlx	18 cd	N/A	18 cd	11 cd	8 cd	8 cd	
VP 7 – Twm Tobacco's Grave on Llandeilo Hill 0.3 NanoWatts /cm2/sr)	Full	287 μlx	448 cd	1055 cd	776 cd	706 cd	1314 cd	858 cd	
	10%	28.7 μlx	45 cd	106 cd	78 cd	71 cd	131 cd	86 cd	
VP 8 – Carneddau 0.4 NanoWatts /cm2/sr)	Full	248 μlx	448 cd	448 cd	1314 cd	642 cd	1055 cd	949 cd	
	10%	24.8 μlx	45 cd	45 cd	131 cd	64 cd	106 cd	95 cd	
VP 9 – Garth Hill 0.8 NanoWatts /cm2/sr)	Full	198 μlx	89 cd	122 cd	N/A	196 cd	N/A	N/A	
	10%	19.8 μlx	9 cd	12 cd	N/A	20 cd	N/A	N/A	

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key						
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
			Turbine Number						
			T2	T6	T7	T10	T16	T18	
VP 10 – Rhulen, south east of Aberedw 0.3 NanoWatts /cm2/sr)	Full	205 μlx	154 cd	218 cd	128 cd	122 cd	136 cd	87 cd	
	10%	20.5 μlx	15 cd	22 cd	13 cd	12 cd	14 cd	9 cd	
VP 11 – Castle Bank 0.3 NanoWatts /cm2/sr)	Full	120 μlx	448 cd	409 cd	858 cd	409 cd	448 cd	488 cd	
	10%	12.0 μlx	45 cd	41 cd	86 cd	41 cd	45 cd	49 cd	
VP 12 – Wye Bridge, Builth Wells 4 NanoWatts /cm2/sr)	Full	107 μlx	78 cd	89 cd	N/A	N/A	N/A	N/A	
	10%	10.7 μlx	8 cd	9 cd	N/A	N/A	N/A	N/A	
VP 13 – Unnamed lane at Bettws 0.3 NanoWatts /cm2/sr)	Full	122 μlx	232 cd	206 cd	N/A	176 cd	133 cd	154 cd	
	10%	12.2 μlx	23 cd	21 cd	N/A	18 cd	13 cd	15 cd	
VP 14 – Unnamed lane, north-east of Llanbedr Hill 0.3 NanoWatts /cm2/sr)	Full	111 μlx	858 cd	1314 cd	1314 cd	949 cd	1314 cd	776 cd	
	10%	11.1 μlx	86 cd	131 cd	131 cd	95 cd	131 cd	78 cd	
VP 15 – Royal Welsh Showground 4.8 NanoWatts /cm2/sr)	Full	101 μlx	87 cd	92 cd	N/A	N/A	N/A	N/A	
	10%	10.1 μlx	9 cd	9 cd	N/A	N/A	N/A	N/A	

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key							
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).						
			Turbine Number							
			T2	T6	T7	T10	T16	T18		
VP 16 – Wye Valley Walk near Banc y Celyn 0.3 NanoWatts /cm2/sr)	Full	81 μlx	448 cd	858 cd	1055 cd	858 cd	1314 cd	1055 cd		
	10%	8.1 μlx	45 cd	86 cd	106 cd	86 cd	131 cd	106 cd		
VP 17 – NCN 8 near Cilmery 0.3 NanoWatts /cm2/sr)	Full	44 μlx	206 cd	232 cd	N/A	324 cd	448 cd	N/A		
	10%	4.4 μlx	21 cd	23 cd	N/A	32 cd	45 cd	N/A		
VP 18 – Llanfihangel Hill 0.3 NanoWatts /cm2/sr)	Full	32 μlx	1867 cd	1984 cd	2028 cd	1934 cd	2028 cd	1934 cd		
	10%	3.2 μlx	187 cd	198 cd	203 cd	193 cd	203 cd	193 cd		
VP 19 – The Begwns Roundabout 0.3 NanoWatts /cm2/sr)	Full	33 μlx	1055 cd	1580 cd	1580 cd	1314 cd	1580 cd	1314 cd		
	10%	3.3 μlx	106 cd	158 cd	158 cd	131 cd	158 cd	131 cd		
VP 20 – Bridleway off A44 near Castell Crugerydd 0.4 NanoWatts /cm2/sr)	Full	30 μlx	1181 cd	1314 cd	1580 cd	1181 cd	1181 cd	1055 cd		
	10%	3.0 μlx	118 cd	131 cd	158 cd	118 cd	118 cd	106 cd		
VP 21 – Heart of Wales Line Trail at Moelfre	Full	26 μlx	776 cd	1055 cd	1314 cd	1055 cd	1451 cd	1314 cd		
	10%	2.6 μlx	78 cd	106 cd	131 cd	106 cd	145 cd	131 cd		

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key						
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
			Turbine Number						
			T2	T6	T7	T10	T16	T18	
0.3 NanoWatts /cm2/sr)									
VP 22 – Llandegley Rocks 0.3 NanoWatts /cm2/sr)	Full	23 μlx	1451 cd	1697 cd	1790 cd	1580 cd	1697 cd	1580 cd	
	10%	2.3 μlx	145 cd	170 cd	179 cd	158 cd	170 cd	158 cd	
VP 23 – Open access land on Mynd 0.3 NanoWatts /cm2/sr)	Full	21 μlx	1697 cd	1867 cd	1934 cd	1790 cd	1867 cd	1790 cd	
	10%	2.1 μlx	170 cd	187 cd	193 cd	179 cd	187 cd	179 cd	
VP 24 – A4081 at Llanyre 0.5 NanoWatts /cm2/sr)	Full	16 μlx	N/A	584 cd	776 cd	584 cd	N/A	N/A	
	10%	1.6 μlx	N/A	58 cd	78 cd	58 cd	N/A	N/A	
VP 25 – Promoted viewpoint south of Cwm Graig-ddu 0.3 NanoWatts /cm2/sr)	Full	12 μlx	1697 cd	1790 cd	1934 cd	1790 cd	1867 cd	1867 cd	
	10%	1.2 μlx	170 cd	179 cd	193 cd	179 cd	187 cd	187 cd	
VP 26 – Elan Valley Way near Cwmwrach 0.3 NanoWatts /cm2/sr)	Full	10 μlx	1181 cd	N/A	1451 cd	1181 cd	1181 cd	1181 cd	
	10%	1.0 μlx	118 cd	N/A	145 cd	118 cd	118 cd	118 cd	
	Full	3 μlx	1790 cd	1790 cd	1867 cd	1790 cd	1867 cd	1790 cd	

Viewpoint and Dark Skies and Existing Light Pollution Levels at Viewpoint ³¹ (NanoWatts/cm2/sr)	Luminous Intensity (cd) – Full/Maximum or 10% of Maximum Intensity	Predicted Maximum Illuminance (μlx) accounting for attenuation of light over distance ONLY ³²	Key						
				Line of sight is under 10 metres above ground level but above 1.5 metres, therefore hub lighting should be screened by terrain but may be visible within the vicinity of the viewpoint (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Turbine light obscured by landform/terrain (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
				Viewpoint is too close to a turbine to get an accurate assessment (informed by Appendix 2.7: Aviation Lighting and Mitigation Report).					
			Turbine Number						
			T2	T6	T7	T10	T16	T18	
VP 28 – Cefn Llechid, Bannau Brycheiniog National Park 0.4 NanoWatts /cm2/sr)	10%	0.3 μlx	179 cd	179 cd	187 cd	179 cd	187 cd	179 cd	
VP 29 – Pen y Fan, Bannau Brycheiniog National Park 0.3 NanoWatts /cm2/sr)	Full	2 μlx	2142 cd	2142 cd	2142 cd	2142 cd	2142 cd	2142 cd	
	10%	0.2 μlx	214 cd	214 cd	214 cd	214 cd	214 cd	214 cd	

Annex B: Figures

Figure A5.8.1: Visible Aviation Lighting Zone of Theoretical Visibility (ZTV) – 28 km

Figure A5.8.2: Visible Aviation Lighting Zone of Theoretical Visibility (ZTV) – 15 km

Figure A5.8.3: Visible Aviation Lighting Zone of Theoretical Visibility (ZTV) – 2 km

Figure A5.8.4: Visible Aviation Lighting Intensity Zone of Theoretical Visibility (ZTV) – 28 km

Figure A5.8.5: Visible Aviation Lighting Intensity Zone of Theoretical Visibility (ZTV) – 15 km

Figure A5.8.6: Visible Aviation Lighting Intensity Zone of Theoretical Visibility (ZTV) – 2 km

Figure A5.8.7: Visible Aviation Lighting – Illuminance at Viewpoint and Assessment Point Locations – Accounting for Distance Only

Figure A5.8.8: Visible Aviation Lighting – Illuminance at Viewpoint and Assessment Point Locations – Accounting for Distance and Vertical Directional Intensity Mitigation

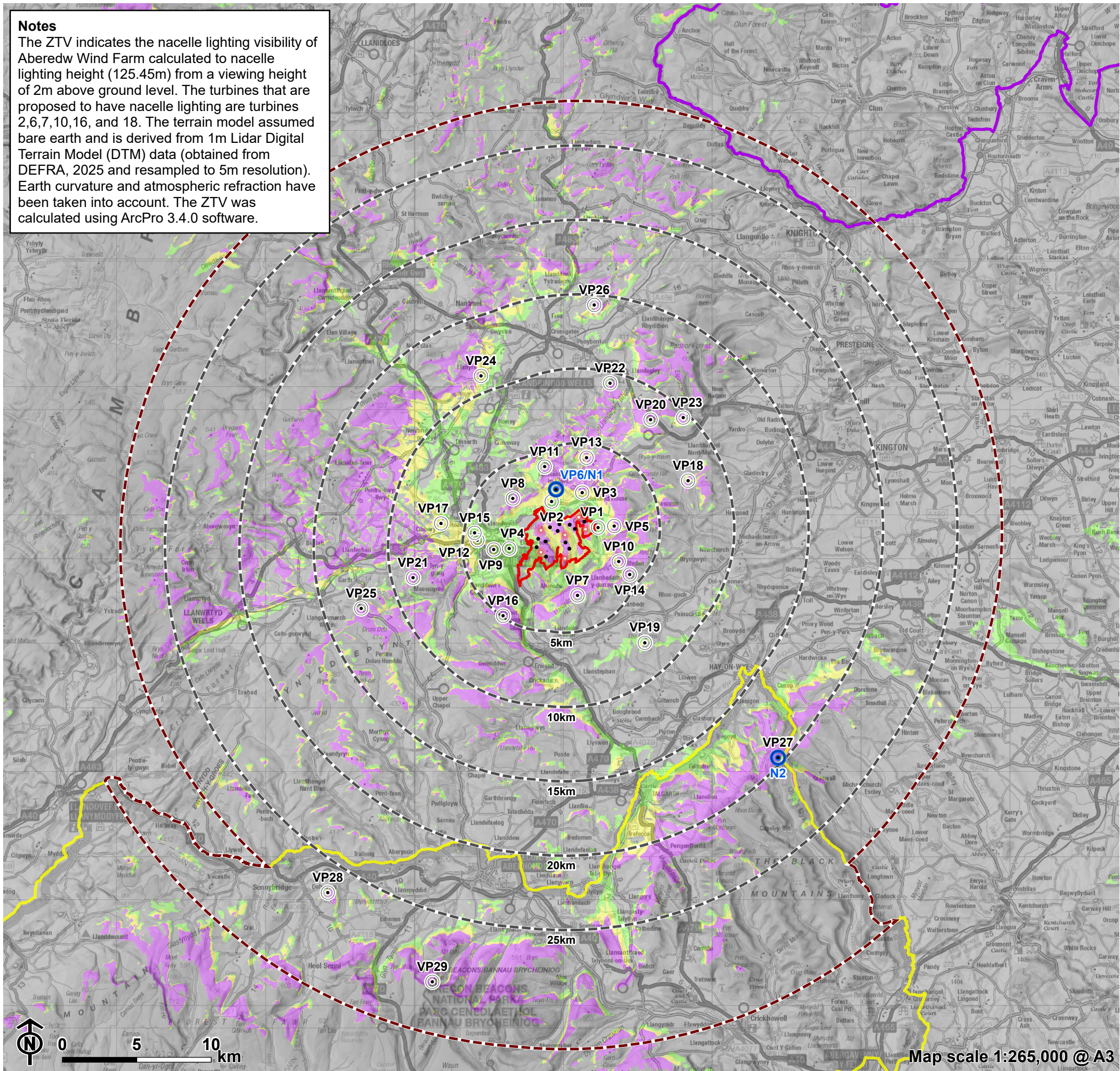


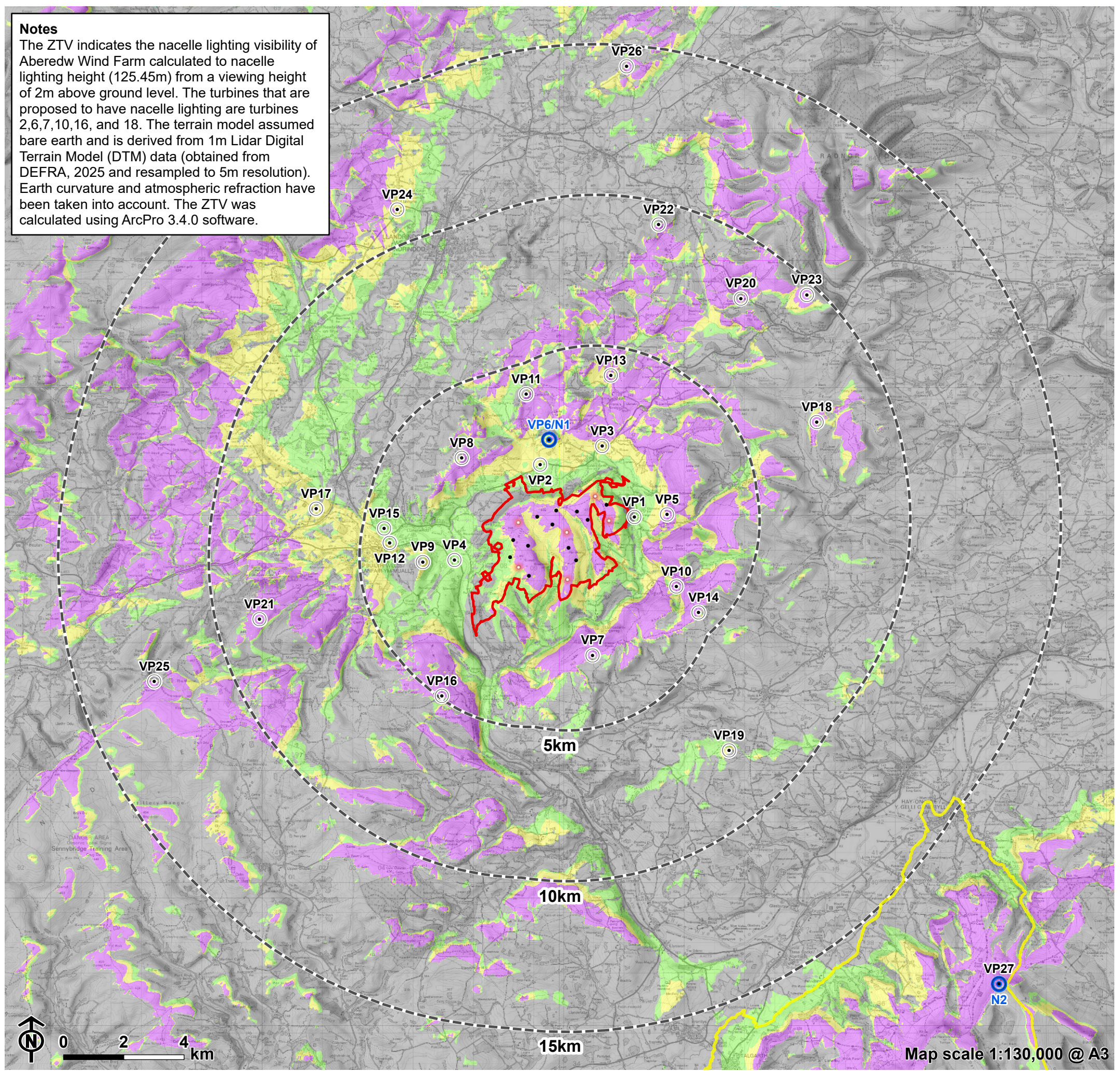
Figure A5.8.1: Visible Aviation Lighting (Turbine Hub Height of Lit Turbines) Zone of Theoretical Visibility within Full Study Area

- LVIA Study Area
 - Application boundary
 - Turbine with nacelle lighting
 - Turbine
 - Turbine buffers - 5km interval
 - Shropshire Hills National Landscape
 - Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)
- Zone of Theoretical Visibility (nacelle lighting)**
- 1 - 2 nacelle lights visible
 - 3 - 4 nacelle lights visible
 - 5 - 6 nacelle lights visible
- Day-time Viewpoint
- | | |
|---|--|
| VP1: St David's Church, Cregrina | VP17: NCN 8 near Cilmeri |
| VP2: A481 at Matts Common | VP18: Llanfihangel Hill |
| VP3: A481 at Hundred House | VP19: The Begwns Roundabout |
| VP4: A470 at Aberduhony | VP20: Bridleway off A44 near Castell Crugerydd |
| VP5: NCN 825 near Cregrina | VP21: Heart of Wales Line Trail at Moelfre |
| VP6: Perthi Common | VP22: Llandeigley Rocks |
| VP7: Twm Tobacco's Grave on Llandeilo Hill | VP23: Open access land on Mynd |
| VP8: Carneddau | VP24: A4081 at Llanyre |
| VP9: Garth Hill | VP25: Promoted viewpoint south of Cwm Graig-ddu |
| VP10: Rhueln, south east of Aberedw | VP26: Elan Valley Way near Cwmwrach |
| VP11: Castle Bank | VP27: Hay Bluff, Bannau Brycheiniog National Park |
| VP12: Wye Bridge, Builth Wells | VP28: Cefn Llechid, Bannau Brycheiniog National Park |
| VP13: Unnamed lane at Bettws | VP29: Pen y Fan, Bannau Brycheiniog National Park |
| VP14: Unnamed lane, north-east of Llanbedr Hill | |
| VP15: Royal Welsh Showground | |
| VP16: Wye Valley Walk near Banc y Celyn | |
- Night-time Viewpoint
- | | |
|-------------------|---|
| N1: Perthi Common | N2: Hay Bluff, Bannau Brycheiniog National Park |
|-------------------|---|

Notes
The study area within the BBNP extends to 33 km so that the summits of Pen y Fan, Corn Du, Cribyn and Fan y Big are considered in the LVIA, as requested by NRW.

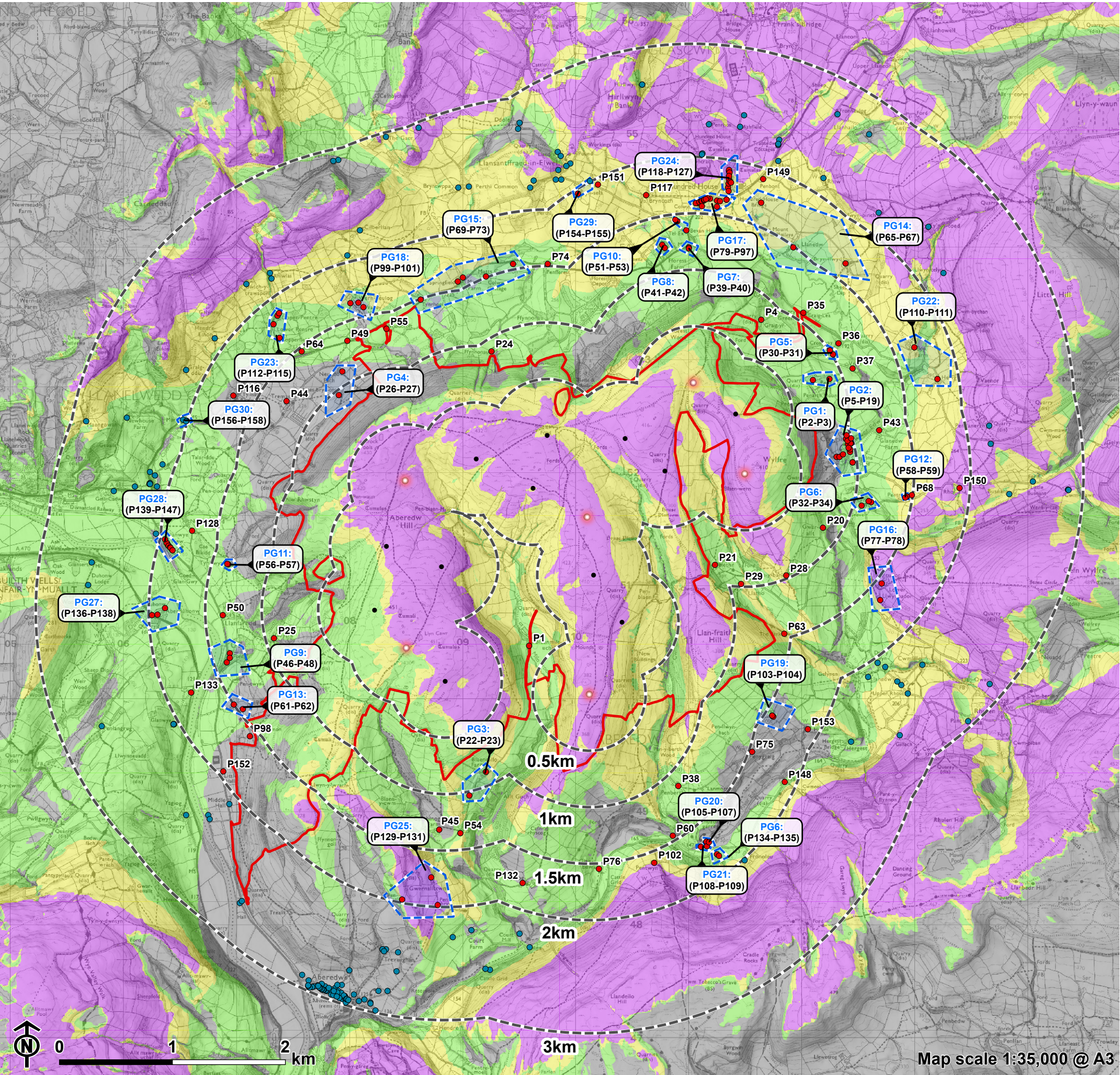
Notes
The ZTV indicates the nacelle lighting visibility of Aberedw Wind Farm calculated to nacelle lighting height (125.45m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 2,6,7,10,16, and 18. The terrain model assumed bare earth and is derived from 1m Lidar Digital Terrain Model (DTM) data (obtained from DEFRA, 2025 and resampled to 5m resolution). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcPro 3.4.0 software.

Figure A5.8.2: Visible Aviation Lighting (Turbine Hub Height of Lit Turbines) Zone of Theoretical Visibility (ZTV) - 15 km



- Application boundary
- Turbine with nacelle lighting
- Turbine
- Turbine buffers - 5km interval
- Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)
- Zone of Theoretical Visibility (nacelle lighting)**
- 1 - 2 nacelle lights visible
- 3 - 4 nacelle lights visible
- 5 - 6 nacelle lights visible
- Day-time Viewpoint
- VP1: St David's Church, Cregrina
- VP2: A481 at Matts Common
- VP3: A481 at Hundred House
- VP4: A470 at Aberduhonw
- VP5: NCN 825 near Cregrina
- VP6: Perthi Common
- VP7: Twm Tobacco's Grave on Llandeilo Hill
- VP8: Carneddau
- VP9: Garth Hill
- VP10: Rhueln, south east of Aberedw
- VP11: Castle Bank
- VP12: Wye Bridge, Builth Wells
- VP13: Unnamed lane at Bettws
- VP14: Unamed lane, north-east of Llanbedr Hill
- VP15: Royal Welsh Showground
- VP16: Wye Valley Walk near Banc y Celyn
- VP17: NCN 8 near Cilmerly
- VP18: Llanfihangel Hill
- VP19: The Begwns Roundabout
- VP20: Bridleway off A44 near Castell Crugerydd
- VP21: Heart of Wales Line Trail at Moelfre
- VP22: Llandegley Rocks
- VP23: Open access land on Mynd
- VP24: A4081 at Llanyre
- VP25: Promoted viewpoint south of Cwm Graig-ddu
- VP26: Elan Valley Way near Cwmwrach
- VP27: Hay Bluff, Bannau Brycheiniog National Park
- Night-time Viewpoint
- N1: Perthi Common
- N2: Hay Bluff, Bannau Brycheiniog National Park

Figure A5.8.3: Visible Aviation Lighting
(Turbine Hub Height of Lit Turbines) Zone
of Theoretical Visibility - 2km



- Application boundary
 - Turbine with nacelle lighting
 - Turbine
 - 500m intervals from outermost turbine
 - 3km from outermost turbines
 - Residential Property within 2km of Turbines
 - Residential Property between 2-3km of Turbines
 - Property Group
- Zone of Theoretical Visibility (nacelle lighting)**
- 1 - 2 nacelle lights visible
 - 3 - 4 nacelle lights visible
 - 5 - 6 nacelle lights visible

Notes:
The ZTV indicates the nacelle lighting visibility of Aberedw Wind Farm calculated to nacelle lighting height (125.45m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 2,6,7,10,16, and 18. The terrain model assumed bare earth and is derived from 1m Lidar Digital Terrain Model (DTM) data (obtained from DEFRA, 2025 and resampled to 5m resolution). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcPro 3.4.0 software.

Notes

The ZTV indicates the nacelle lighting visibility of Aberedw Wind Farm calculated to nacelle lighting height (125.45m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 2,6,7,10,16, and 18. The terrain model assumed bare earth and is derived from 1m Lidar Digital Terrain Model (DTM) data (obtained from DEFRA, 2025 and resampled to 5m resolution). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcPro 3.4.0 software.

The study area within the BBNP extends to 33 km so that the summits of Pen y Fan, Corn Du, Cribyn and Fan y Big are considered in the LVIA, as requested by NRW.

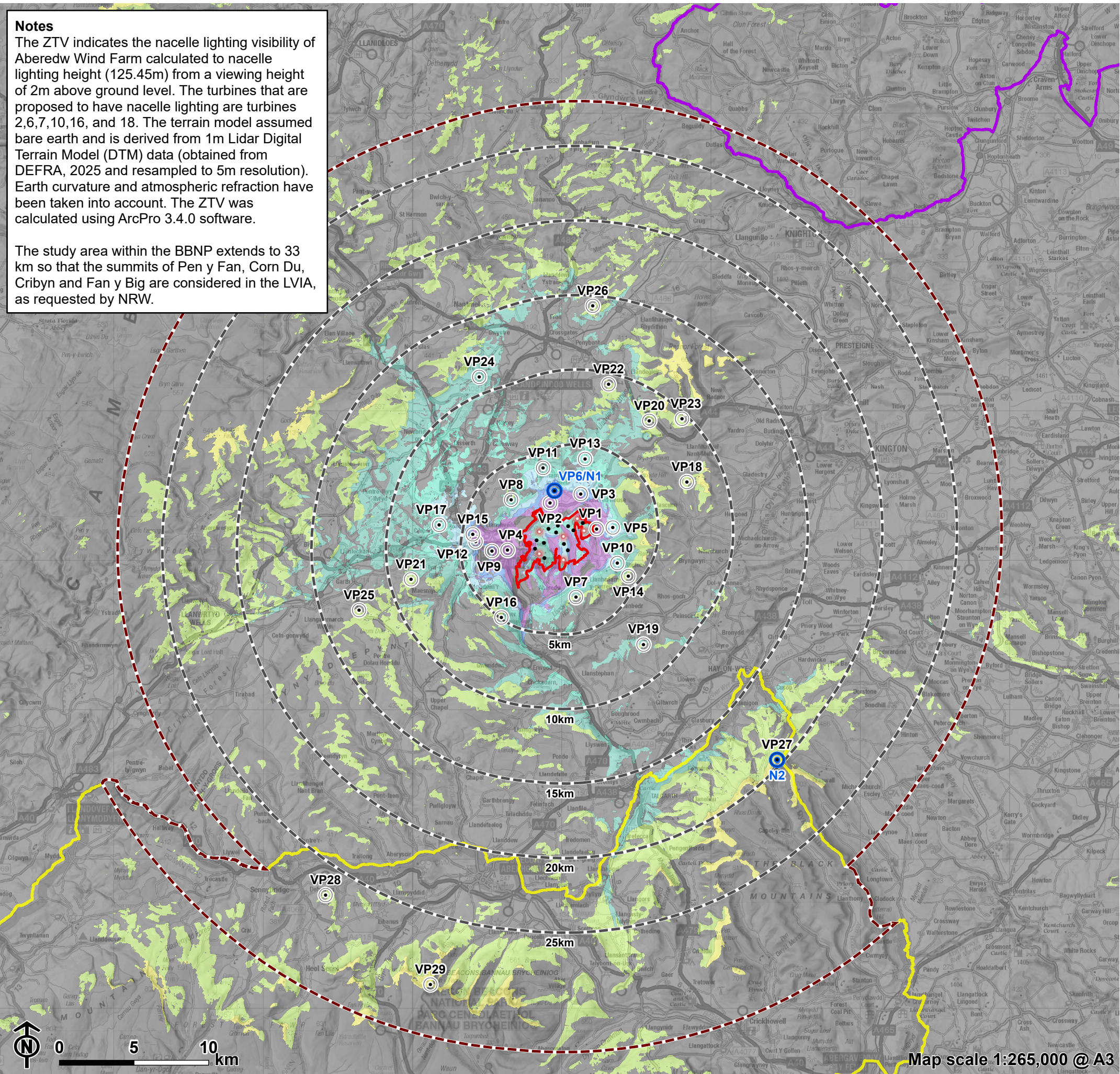


Figure A5.8.4: Visible Aviation Lighting Intensity (Turbine Hub Height of Lit Turbines) Zone of Theoretical Visibility within Full Study Area

- LVIA Study Area

Application boundary

Turbine with nacelle lighting

Turbine

Turbine buffers - 5km interval

Shropshire Hills National Landscape

Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)

Day-time Viewpoint

Night-time Viewpoint

VP1: St David's Church, Cregrina

VP2: A481 at Matts Common

VP3: A481 at Hundred House

VP4: A470 at Aberduhonw

VP5: NCN 825 near Cregrina

VP6: Perthi Common

VP7: Twm Tobacco's Grave on Llandeilo Hill

VP8: Carneddau

VP9: Garth Hill

VP10: Rhueln, south east of Aberedw

VP11: Castle Bank

VP12: Wye Bridge, Builth Wells

VP13: Unnamed lane at Bettws

VP14: Unamed lane, north-east of Llanbedr Hill

VP15: Royal Welsh Showground

VP16: Wye Valley Walk near Banc y Celyn

VP17: NCN 8 near Cilmerly

VP18: Llanfihangel Hill

VP19: The Begwns Roundabout

VP20: Bridleway off A44 near Castell Crugerydd

VP21: Heart of Wales Line Trail at Moelfre

VP22: Llandegley Rocks

VP23: Open access land on Mynd

VP24: A4081 at Llanyre

VP25: Promoted viewpoint south of Cwm Graig-ddu

VP26: Elan Valley Way near Cwmwrach

VP27: Hay Bluff, Bannau Brycheiniog National Park

VP28: Cefn Llechid, Bannau Brycheiniog National Park

VP29: Pen y Fan, Bannau Brycheiniog National Park

N1: Perthi Common

N2: Hay Bluff, Bannau Brycheiniog National Park
- | Vertical Angle of Lighting from Nacelle | Maximum and Minimum Luminous Intensity (Candela/cd.) | 10% of Maximum and Minimum Luminous Intensity (Candela/cd.) |
|---|--|---|
| Above 5° | 147 to 34 | 15 to 3 |
| 4° to 5° | 247 to 134 | 25 to 13 |
| 3° to 4° | 481 to 237 | 48 to 24 |
| 2° to 3° | 1160 to 481 | 116 to 48 |
| 1° to 2° | 2119 to 1170 | 212 to 117 |
| 0° to 1° | 2206 to 1968 | 221 to 197 |
| -1° to 0° | 2036 to 987 | 204 to 99 |
| -2° to -1° | 996 to 383 | 100 to 38 |
| -3° to -2° | 394 to 197 | 39 to 20 |
| -4° to -3° | 199 to 131 | 20 to 13 |
| -5° to -4° | 131 to 92 | 13 to 9 |
| Below -5° | 94 to 38 | 9 to 4 |
- Bute Energy

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12522_EIA_Appendix_5_8/12522_Fig_A5_8_4_r0_AV_Intensity_FSA_A3L 05/06/2025

Notes:
The ZTV indicates the nacelle lighting visibility of Aberedw Wind Farm calculated to nacelle lighting height (125.45m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 2,6,7,10,16, and 18. The terrain model assumed bare earth and is derived from 1m Lidar Digital Terrain Model (DTM) data (obtained from DEFRA, 2025 and resampled to 5m resolution). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcPro 3.4.0 software.

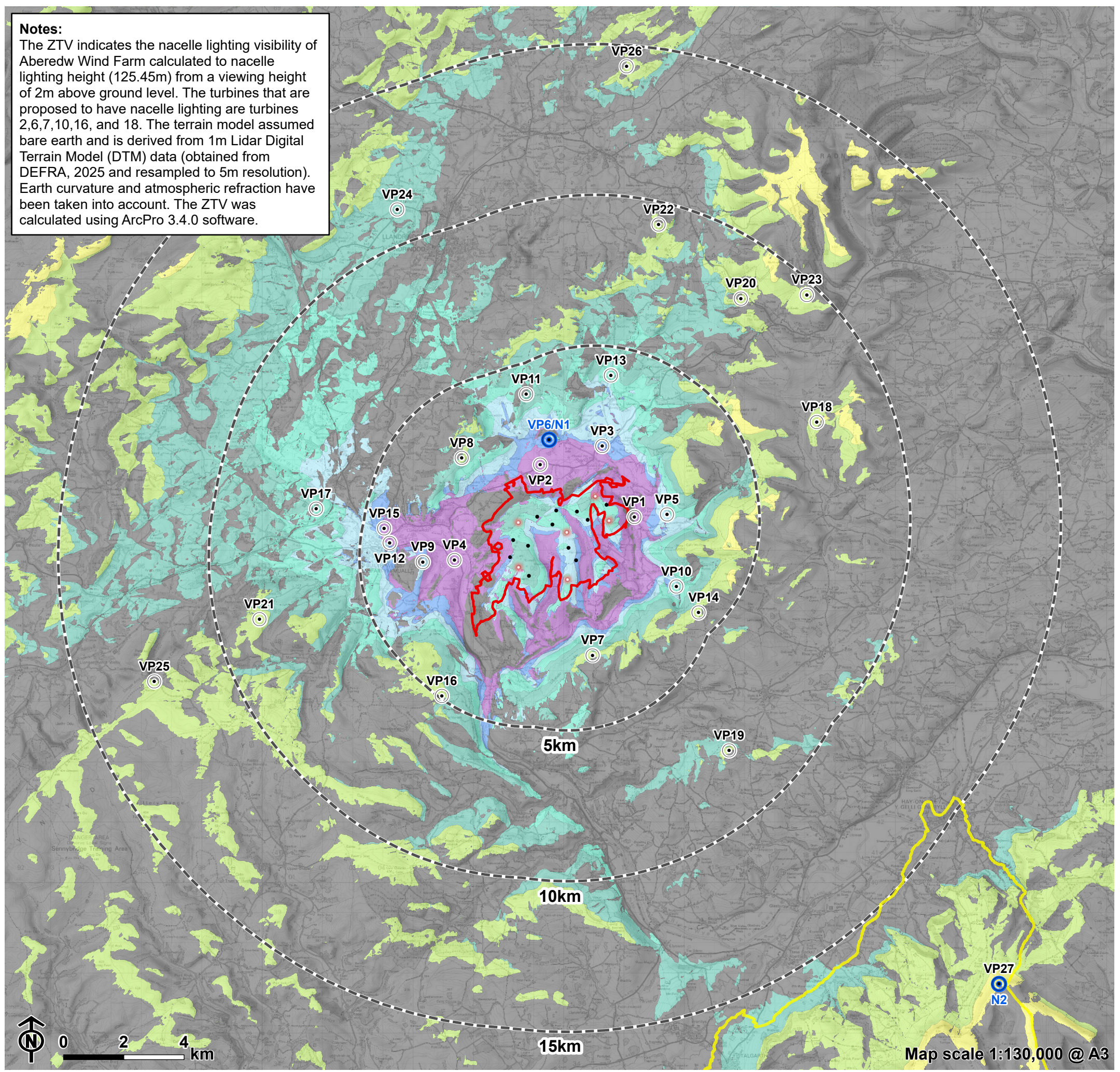


Figure A5.8.5: Visible Aviation Lighting Intensity (Turbine Hub Height of Lit Turbines) Zone of Theoretical Visibility - 15km

- Application boundary

Turbine with nacelle lighting

Turbine

Turbine buffers - 5km interval

Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)

Day-time Viewpoint

Night-time Viewpoint

N1: Perthi Common

N2: Hay Bluff, Bannau Brycheiniog National Park
- VP1: St David's Church, Cregrina

VP2: A481 at Matts Common

VP3: A481 at Hundred House

VP4: A470 at Aberduhonw

VP5: NCN 825 near Cregrina

VP6: Perthi Common

VP7: Twm Tobacco's Grave on Llandeilo Hill

VP8: Carneddau

VP9: Garth Hill

VP10: Rhueln, south east of Aberedw

VP11: Castle Bank

VP12: Wye Bridge, Builth Wells

VP13: Unnamed lane at Bettws

VP14: Unnamed lane, north-east of Llanbedr Hill

VP15: Royal Welsh Showground

VP16: Wye Valley Walk near Banc y Celyn

VP17: NCN 8 near Cilmeri

VP18: Llanfihangel Hill

VP19: The Begwns Roundabout

VP20: Bridleway off A44 near Castell Crugerydd

VP21: Heart of Wales Line Trail at Moelfre

VP22: Llandegley Rocks

VP23: Open access land on Mynd

VP24: A4081 at Llanyre

VP25: Promoted viewpoint south of Cwm Graig-ddu

VP26: Elan Valley Way near Cwmwrach

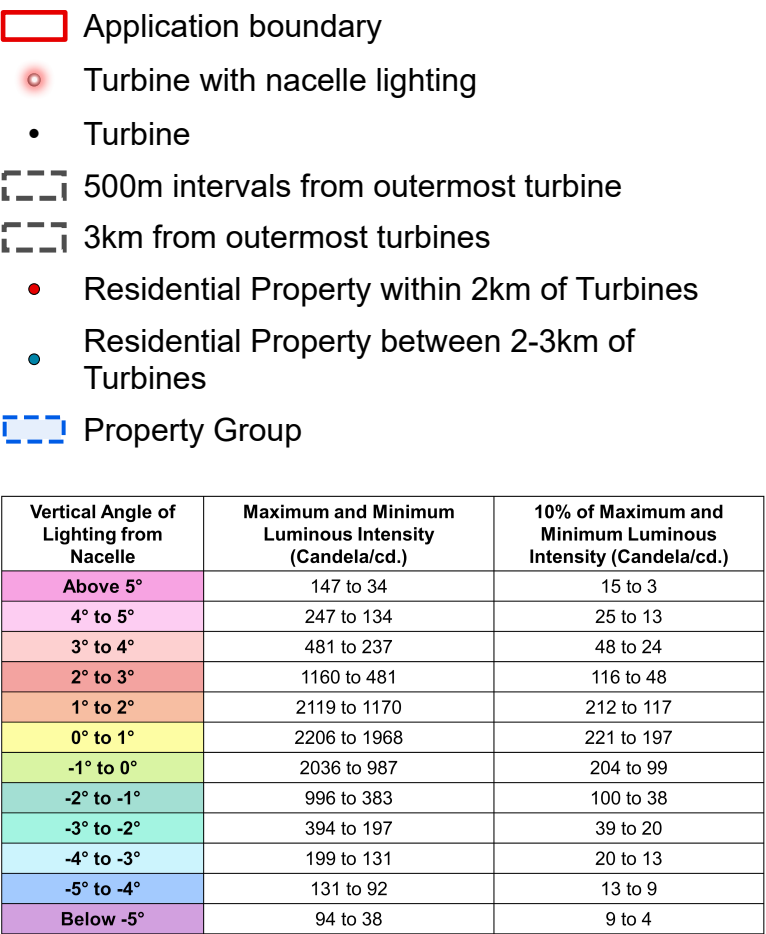
VP27: Hay Bluff, Bannau Brycheiniog National Park

VP28: Cefn Llechid, Bannau Brycheiniog National Park

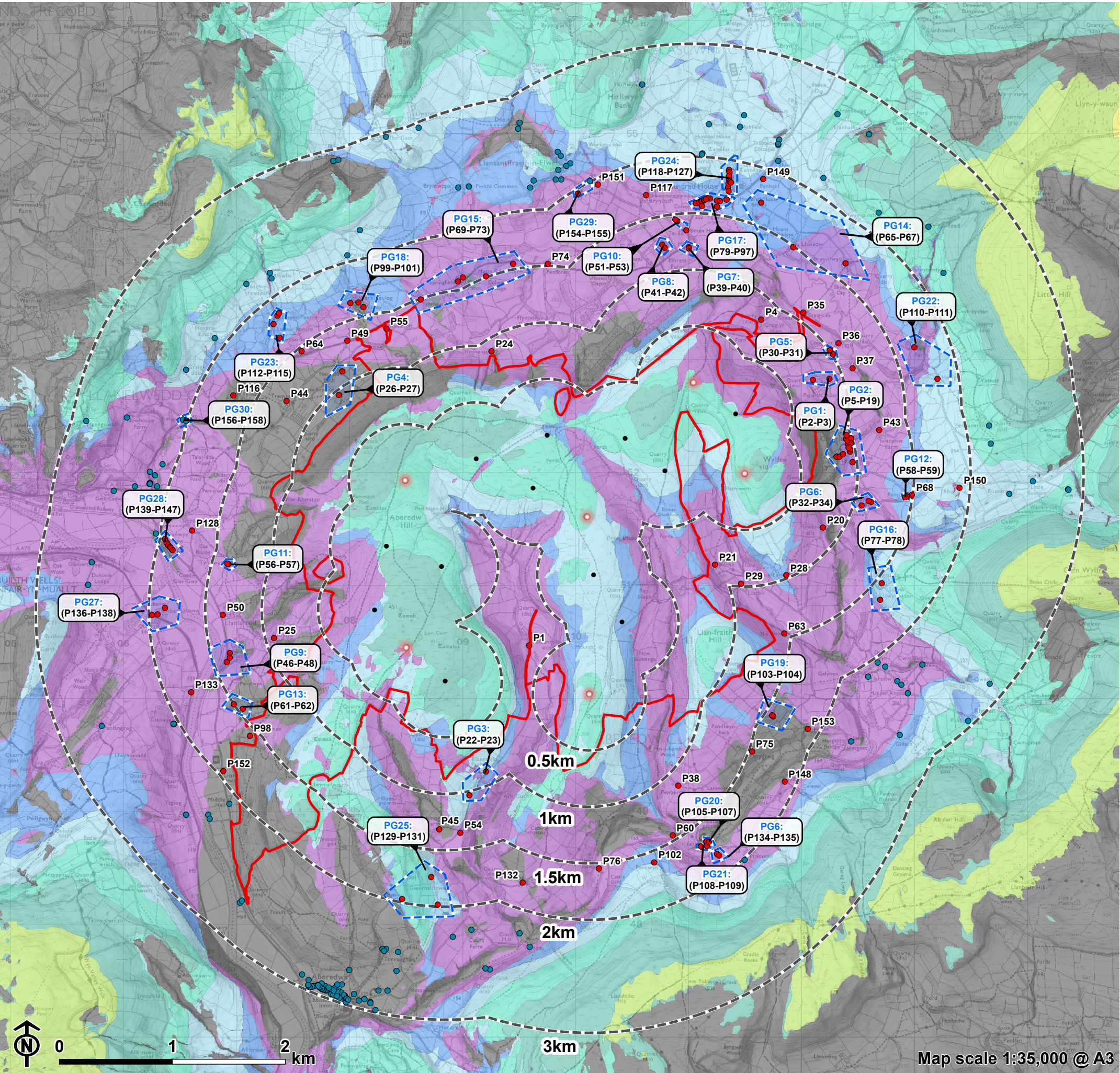
VP29: Pen y Fan, Bannau Brycheiniog National Park

Vertical Angle of Lighting from Nacelle	Maximum and Minimum Luminous Intensity (Candela/cd.)	10% of Maximum and Minimum Luminous Intensity (Candela/cd.)
Above 5°	147 to 34	15 to 3
4° to 5°	247 to 134	25 to 13
3° to 4°	481 to 237	48 to 24
2° to 3°	1160 to 481	116 to 48
1° to 2°	2119 to 1170	212 to 117
0° to 1°	2206 to 1968	221 to 197
-1° to 0°	2036 to 987	204 to 99
-2° to -1°	996 to 383	100 to 38
-3° to -2°	394 to 197	39 to 20
-4° to -3°	199 to 131	20 to 13
-5° to -4°	131 to 92	13 to 9
Below -5°	94 to 38	9 to 4

Figure A5.8.6: Visible Aviation Lighting Intensity (Turbine Hub Height of Lit Turbines)
Zone of Theoretical Visibility - 2km



Notes:
The ZTV indicates the nacelle lighting visibility of Aberedw Wind Farm calculated to nacelle lighting height (125.45m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 2,6,7,10,16, and 18. The terrain model assumed bare earth and is derived from 1m Lidar Digital Terrain Model (DTM) data (obtained from DEFRA, 2025 and resampled to 5m resolution). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcPro 3.4.0 software.



NRW Dark Skies and Light Pollution (Wales), CPRE Night Lights (England)
NanoWatts/cm²/sr

- < 0.5 (Darkest)
- 0.5 - 1
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- 16 - 32
- > 32 (Brightest)

Notes
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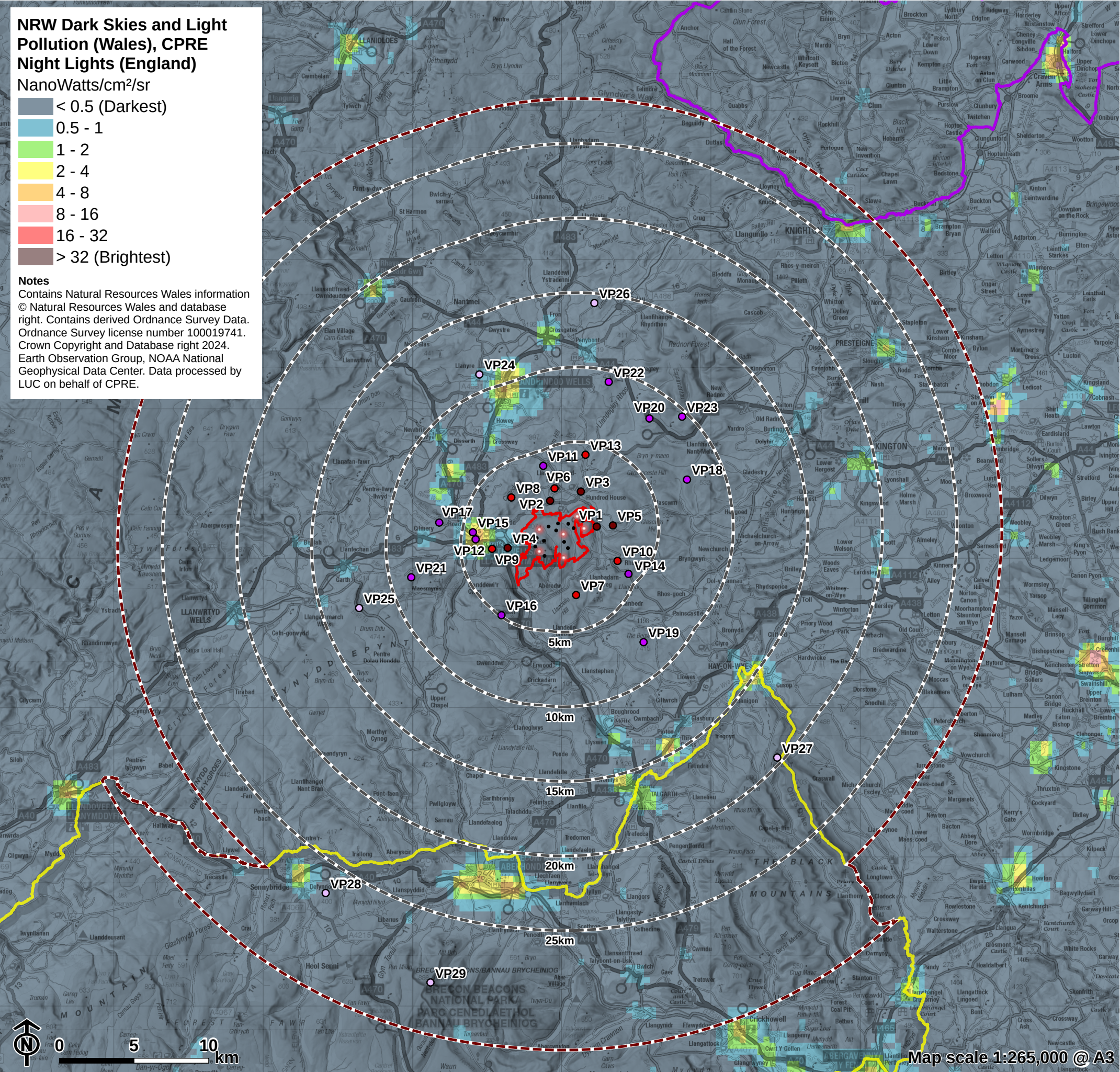


Figure A5.8.7: Visible Aviation Lighting - Illuminance at Viewpoint and Assessment Point Locations

- LVIA Study Area
- Application boundary
- Turbine with nacelle lighting
- Turbine
- Turbine buffers - 5km interval
- Shropshire Hills National Landscape
- Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)

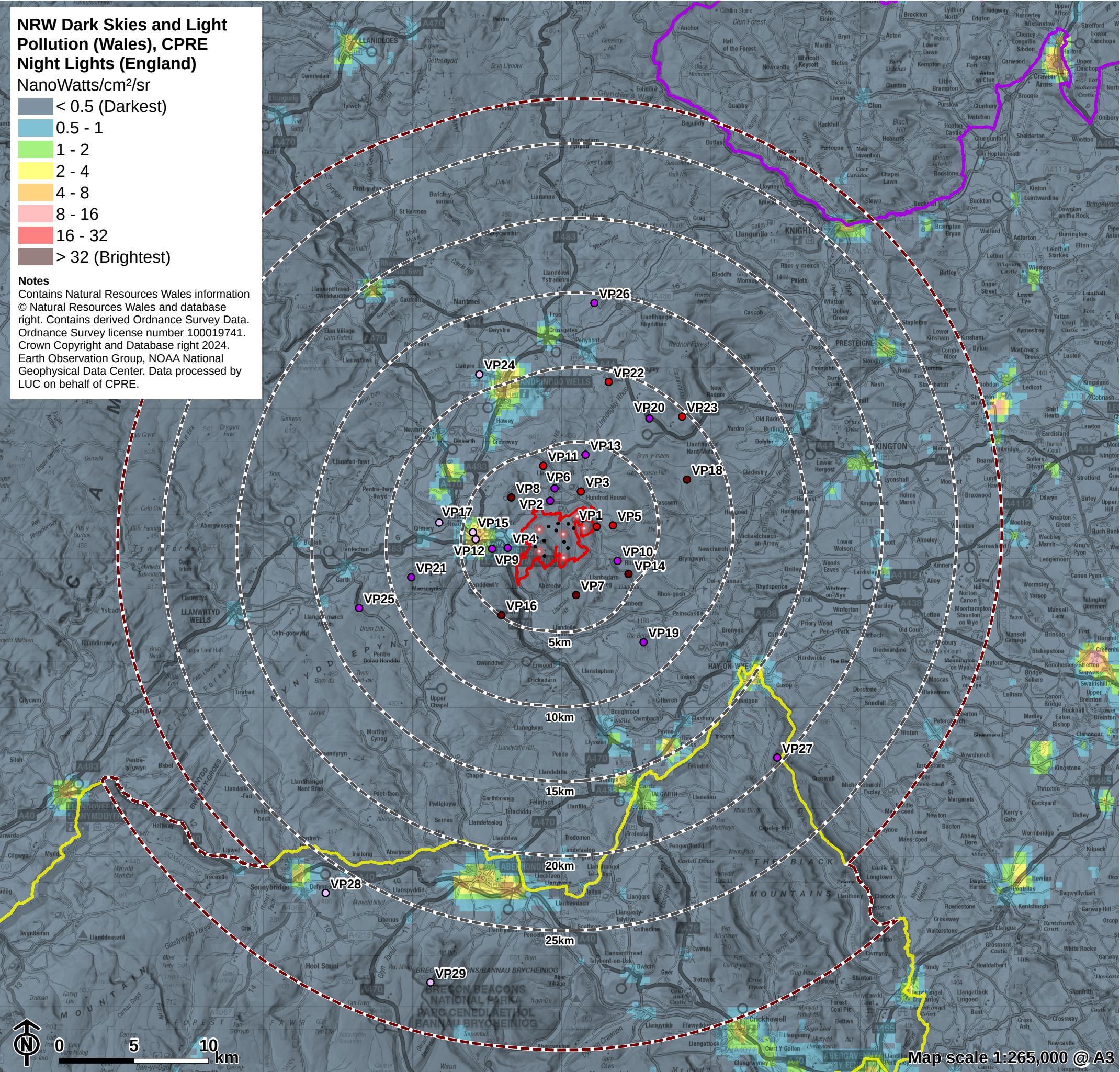
- Illuminance - Maximum Intensity**
- 2 - 16
 - 17 - 33
 - 34 - 120
 - 121 - 342
 - 343 - 926
- Illuminance - 10% of Maximum Intensity**
- 0.00- 1.60
 - 1.61 - 3.30
 - 3.31 - 12.00
 - 12.01 - 34.20
 - 34.21 - 92.60

VP no.	Viewpoint name	Illuminance - Maximum Intensity (microlumens per m2 - µlx)	Illuminance - 10% of Maximum Intensity (microlumens per m2 - µlx)
1	St David's Church, Cregrina	926	92.6
2	A481 at Matts Common	476	47.6
3	A481 at Hundred House	709	70.9
4	A470 at Aberduhonw	437	43.7
5	NCN 825 near Cregrina	531	53.1
6	Perthi Common	342	34.2
7	Twm Tobacco's Grave on Llandeilo Hill	287	28.7
8	Carneddau	248	24.8
9	Garth Hill	198	19.8
10	Rhueln, south east of Aberedw	205	20.5
11	Castle Bank	120	12
12	Wye Bridge, Builth Wells	107	10.7
13	Unnamed lane at Bettws	122	12.2
14	Unnamed lane, north-east of Llanbedr Hill	111	11.1
15	Royal Welsh Showground	101	10.1
16	Wye Valley Walk near Banc y Celyn	81	8.1
17	NCN 8 near Cilmerly	44	4.4
18	Llanfihangel Hill	32	3.2
19	The Begwns Roundabout	33	3.3
20	Bridleway off A44 near Castell Crugerydd	30	3
21	Heart of Wales Line Trail at Moelfre	26	2.6
22	Llandeigley Rocks	23	2.3
23	Open access land on Mynd	21	2.1
24	A4081 at Llanyre	16	1.6
25	Promoted viewpoint south of Cwm Graig-ddu	12	1.2
26	Elan Valley Way near Cwmwrach	10	1
27	Hay Bluff, Bannau Brycheiniog National Park	5	0.5
28	Cefn Llechid, Bannau Brycheiniog National Park	3	0.3
29	Pen y Fan, Bannau Brycheiniog National Park	2	0.2

NRW Dark Skies and Light Pollution (Wales), CPRE Night Lights (England)
NanoWatts/cm²/sr

- < 0.5 (Darkest)
- 0.5 - 1
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- 16 - 32
- > 32 (Brightest)

Notes
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Aberedw Energy Park
Aberedw Energy Park Ltd

Figure A5.8.8: Visible Aviation Lighting - Illuminance at Viewpoint and Assessment Point Locations - accounting for Vertical Directional Intensity Mitigation within Full Study Area

- LVIA Study Area
- Application boundary
- Turbine with nacelle lighting
- Turbine
- Turbine buffers - 5km interval
- Shropshire Hills National Landscape
- Bannau Brycheiniog / Brecon Beacons National Park / International Dark Sky Reserve (IDSR)

Illuminance - Maximum Intensity

- 0.00 - 5.20
- 5.21 - 10.60
- 10.61 - 17.90
- 17.91 - 26.80
- 26.81 - 111.10

Illuminance - 10% of Maximum Intensity

- 0.00 - 0.50
- 0.51 - 1.10
- 1.11 - 1.80
- 1.81 - 2.70
- 2.71 - 11.10

VP no.	Viewpoint name	Illuminance - Maximum Intensity (microlumens per m2 - µlx)	Illuminance - 10% of Maximum Intensity (microlumens per m2 - µlx)
1	St David's Church, Cregina	26.8	2.7
2	A481 at Matts Common	17.9	1.8
3	A481 at Hundred House	26.5	2.6
4	A470 at Aberduhow	16.4	1.6
5	NCN 825 near Cregina	20	2
6	Perthi Common	14.8	1.5
7	Twm Tobacco's Grave on Llandeilo Hill	111.1	11.1
8	Carneddau	55.4	5.5
9	Garth Hill	10.4	1
10	Rhueln, south east of Aberedw	9.8	1
11	Castle Bank	26.8	2.7
12	Wye Bridge, Buith Wells	4.8	0.5
13	Unnamed lane at Bettws	8.1	0.8
14	Unamed lane, north-east of Llanbedr Hill	65.4	6.5
15	Royal Welsh Showground	4.7	0.5
16	Wye Valley Walk near Banc y Celyn	32.8	3.3
17	NCN 8 near Cilmerly	5.2	0.5
18	Llanfihangel Hill	31.8	3.2
19	The Begwns Roundabout	17.8	1.8
20	Bridleway off A44 near Castell Crugenydd	17.8	1.8
21	Heart of Wales Line Trail at Moelfre	12.6	1.3
22	Llandegley Rocks	19.8	2
23	Open access land on Mynd	19.9	2
24	A4081 at Llanyre	4.7	0.5
25	Promoted viewpoint south of Cwm Graig-ddu	10.6	1.1
26	Elan Valley Way near Cwmwrach	5.8	0.6
27	Hay Bluff, Bannau Brycheiniog National Park	5.5	0.6
28	Cefn Llechid, Bannau Brycheiniog National Park	2.5	0.3
29	Pen y Fan, Bannau Brycheiniog National Park	2.4	0.2