Technical Appendix 4.6: Aviation Lighting Assessment

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1.1 Introduction

1.1.1 This Technical Appendix (TA) sets out an evaluation of the effects of the aviation lights of the Proposed Development on the visual amenity of the local area during times when the turbines are lit. The assessment is supported by:

- Volume 2: Main Report;
- Volume 3a: Figures;
- Volume 3b: Visualisations;
- Volume 4: Technical Appendices:
  - TA4.1: Landscape and Visual Impact Assessment Methodology;
  - TA4.2: Landscape Character Assessment;
  - TA4.4: Cumulative Assessment;
  - TA4.5: Implications for Designated Landscapes;
  - TA4.6: Aviation Lighting Assessment; and
  - TA4.7: Residential Visual Amenity Assessment.

Regulations and Guidance

1.1.2 As the proposed turbines would be over 150 m to blade tip, they are above the threshold for Civil Aviation Authority (CAA) regulations for lighting[1]. The CAA has accepted an application for a reduced lighting scheme that includes:

- *"medium intensity steady red (2000 candela) lights on the nacelles of turbines T01, T04 and T05;*
- *a second 2000 candela light on the nacelles of the above turbines to act as alternates in the event of a failure of the main light (note that both lights should not be lit at the same time);*
- *the lights on these turbines to be capable of being dimmed to 10% of peak intensity when the lowest visibility as measured at suitable points around the wind farm by visibility measuring devices exceeds 5km;"*
- *infra-red lights to MoD specification installed on the nacelles of turbines T01, T02, T03, T04, T05 and T06 (note that dimming permission is applicable only to visible lights, not infra-red lighting).*

Intermediate level 32 candela lights are not required to be fitted on the turbine towers." [2]

1.1.3 Infrared lighting as required by the Ministry of Defence (MOD) is not visible to the naked eye and is therefore not considered further.

Guidance on Assessment of Lighting Effects

1.1.4 The *Guidelines for Landscape and Visual Impact Assessment, Third Edition* (referred to hereafter as GLVIA3) (Landscape Institute, Institute of Environmental Management and Assessment, 2013)[3] recognises that sometimes there is a need for assessment of lighting effects for development (not solely wind farms) and includes the following guidance: *"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.*[4]*"*

1.1.5 NatureScot guidance on the preparation of visualisations for wind farms relating to dark photomontages states: *"It is difficult to illustrate turbine lighting well in visualisations, although some recent examples which use photographs taken in low light conditions (just before or after sunrise / sunset) have been more useful."* And *"Where an illustration of lighting is required, a basic visualisation showing the existing view alongside an approximation of how the wind farm might look at night with aviation lighting may be useful.*[5]*"*

1.1.6 Regarding the selection of viewpoints for illustration of night time lighting, NatureScot state that illustration *"is only likely to be required in particular situations where the wind farm is likely to be regularly viewed at night (e.g. from a settlement, transport route) or where there is a particular sensitivity to lighting (e.g. in or near a Dark Sky Park or Wild Land Area). Not all viewpoints will need to be illustrated in this way."*

1.1.7 Advising on the preparation of images: *"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. It is only necessary to illustrate visible lighting, not infrared or other alternative lighting requirements. We have found that [photography taken at] approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image. It is important that the photographs represent the levels of darkness as seen by the naked eye at the time and the camera exposure does not make the image appear artificially brighter than it is in reality. It can also be helpful to note the intensity of other lights in the area to enable comparison (e.g. television transmitters) as this can aid the assessment process."*

1.1.8 NatureScot, at a seminar on aviation lighting in November 2019, advised a proportionate and pragmatic approach to lighting assessments. NatureScot's view is that lengthy and detailed debate about the exact brightness of lights is not very helpful, and it is better to discuss relative brightness, and to focus on where they will be visible, and how they will change the baseline night view. However, it is considered that the perceived brightness of the lights that will be observed from each viewpoint is important to understand, including an understanding of atmospheric dispersal, attenuation by distance, and angle of view relative to the focus of the light, and darkness adaptation, in order to be able to make a meaningful assessment of visual effects.

Examples of Lighting

1.1.9 The intensity of light emitted is measured in candela, but the apparent brightness of light received from low intensity lights by the human eye is measured in microlux (microlumens per m^2). These units can be difficult to use without translation into examples that may be familiar to viewers. Some examples include:

- Planet Venus: 140 microlux;

[1] CAA publications CAP 764 Policy Guidelines on Wind Turbines, and CAP 393 Air Navigation Order 2016.

[2] CAA letter dated 12 December 2023

[3] Landscape Institute., Institute of Environmental Management and Assessment. (2013) *Guidelines for Landscape and Visual Impact Assessment, Third Edition*. London. Routledge.

[4] Landscape Institute and the Institute of Environmental Assessment (2013) Guidelines for Landscape and Visual Impact Assessment. Third Edition. Page 103, paragraph 6.12.

[5] Scottish Natural Heritage (2017) Visual Representation of Wind Farms. Version 2.2.

- Orion constellation, upper left and lower right stars: 1.5-2 microlux;
- Orion constellation, 'belt' stars: 0.3 microlux;
- Faintest light visible to a 'typical' person: 0.01 microlux; and
- Car rear brake lights, although they vary, are in the order of 70-80 candela (ca), and at 1 km may appear as 100 microlux.

1.1.10 NatureScot advise that quantitative analysis is '*less useful'* for the assessment of effects on the night time experience of the lights than qualitative comparisons with existing lights that people may be familiar with. However, it is clear from the science of lighting and as set out in this TA that understanding the calculated light intensities and brightness of lights (quantitative) is important to be able to carry out an assessment, even in a relative (qualitative) way. It is important to note that specifications for existing lights in the landscape are not available, such that comparisons cannot be quantitative.

1.1.11 The apparent brightness of the light (received by the human eye) depends not only on how much light is emitted (intensity), but also on intervening atmospheric conditions (rain, fog, dust, haze, etc) that cause atmospheric dispersal of light; the lit environment of the viewer (standing in a well-lit area or a dark place); and the distance from the light source. The apparent brightness reduces with distance (attenuation) in clear weather as well as when there are poorer viewing conditions. Brightness reduces with the square of the distance (x=1/distance2), such that a light observed from a distance of 10 km would have an apparent brightness only 1% of that of the same light observed from a distance of 1 km.

1.1.12 This TA sets out that the lights wouldl be close to the limit of the human eye's ability to see them at about 20 km (with at 200 cd emitted at source, at -1° view angle, and in good visibility). This assessment therefore assumes that over approximately 20 km, the lights are likely to go unnoticed.

1.1.13 When lights are designed to give a horizontal beam with reduced upward and downward spill of light, the brightness of the light is decreased for viewers close to the turbines viewing them from below.

1.1.14 An important factor for perception of light is the different ways that cameras and human eyes perceive light. Cameras are governed by lenses and settings, human eyes adapt to different light environments (for example it can seem very dark when lights are first switched off, until one's eyes become accustomed to the dark). Dark adaptation of the human eye is related to the 'rods' and 'cones', light detecting cells in the back of the eye that have different roles in low light levels, with rods taking over from cones when it is dark. Cones detect colour and are used in the light (being less sensitive in low light levels), while rods are not as good with colour but can pick up faint lights (they switch off in bright light). Dark adaptation is when the rods can fully activate and can make out faint lights in a dark environment, but as soon as a light is switched on, even briefly, cones take over again and it takes time for the rods to reactivate. Lights clearly visible to dark-adapted eyes may be imperceptible when other lights are first switched off (before dark adaptation can occur), or when in a bright place such as under street lights or from within a dark vehicle when much of the attention is on the pool of light from the headlights. In these environments dark adaptation cannot occur in full as the rods in our eyes cannot fully take over. It is noted that most people would be close to lights after dark, either in lit houses/properties, or in vehicles with headlights on. This makes the perception of other lights more difficult.

1.1.15 In contrast, cameras do not have any adaptation, but light capture depends on exposure and camera settings (modern cameras may have auto-adjust or 'night mode', but this is not adaptation in the same way as the human eye). This means that images can be very different to what we experience. An issue for photographic capture and rendition of lights is that existing lights shown in photographs can appear larger and more blurred than those seen by the naked eye in the field. The term used in photography to describe this effect is 'bokeh' which has been defined as 'the way the lens renders out of focus points of light'. This is difficult to avoid when taking photographs of lights (particularly moving lights such as vehicle headlights). To best model the lights as if they were existing, this effect has been added to the hub lights in the viewpoint illustrations.

1.1.16 It is not possible to accurately model the exact brightness of the lights, given variations in not only light specifications and camera settings, but also weather and atmospheric conditions at the time of photography, as well as the resolution and colour calibration of a computer screen, ambient light when viewing images on screen, and finally printer resolution and paper quality. However, the lights illustrated on the figures have been 'calibrated' as much as possible using comparison with images of other lights in the views, and other examples of existing potentially equivalent lighting observed in South Lanarkshire, and other lights on wind farms in other parts of Scotland.

1.1.17 The duration of effects of the lights depends on when the lights are switched on and off. Sunset occurs when the sun disappears below the horizon, sunrise is the time at which the sun first appears on the horizon in the morning. The exact times of sunset and sunrise vary throughout the year. Although it is not visible, the sun still illuminates the sky with diffused light for a period of time after sunset and before sunrise, known as twilight. There are different stages of twilight:

- Civil twilight, which begins once the sun has disappeared below the horizon and continues until it descends to 6 degrees below the horizon. This translates in duration as from sunset to about half an hour after sunset, or for half an hour before sunrise. As noted in this TA, civil twilight is still bright, such that the aviation lights are unlikely to be visible against the bright sky. Aviation lights would be stitched on half an hour after sunset (and off half an hour before sunrise) because of this;
- Nautical twilight, when the sun is between 6 and 12 degrees below the horizon, which is for approximately half an hour after civil twilight in the evening, or before civil twilight in the morning (landforms are still visible while the stars start to appear and so it is a valuable time for navigators at sea). During this phase the aviation lights would be on, and would become more visible as the daylight diminishes; and
- Astronomical twilight, when the sun is between 12 and 18 degrees below the horizon. Below 18 degrees below the horizon, the sun no longer illuminates the sky.

1.1.18 It is noted that it does not necessarily get completely dark, with lingering light on short summer nights, moonlight, or the glow from settlement lights, and light reflected off clouds. In these conditions, the turbines may be partially visible over short distances at different times of night, and the apparent brightness of the lights may be affected by other lights, e.g. when seen against the late sun-lit clouds in views towards the west or seen from well-lit areas. Conversely there would be evenings and mornings that are darker due to weather conditions such as thick cloud cover.

1.2 Methodology and Approach

Assessment Methodology

1.2.1 The methodology and approach to the assessment of significance of lighting effects are based on the methodology of the LVIA, which is based on GLVIA3 as set out in Technical Appendix A4.1 (EIAR Volume 4). Key aspects relevant to the visual assessment of aviation lighting include:

- Identification of baseline lighting at night, including existing lights of local properties and existing wind farms or other structures visible, as well as areas of darkness;
- Information about likely brightness of lighting seen from viewpoints;
- Description of lighting relative to the existing lights; and
- Assessment of effect on the night time view as a result of the introduced lights.

1.2.2 In considering sensitivity of receptors and magnitude of change to arrive at a judgement of significance of effects, it is noted that:

- Sensitivity is generally considered in guidance to relate to day time views, and night time sensitivity is very different. At night, viewpoints that of high value and susceptibility may be of low sensitivity at night because people do not go there to see the dark. Locations within Dark Skies Parks are an exception to this as people go to experience the dark and observe the stars, but for most places' sensitivity is low as people move through or between lit spaces (turning lights on or using headlights as necessary) and usually view darker landscapes from better lit locations. However, consideration of night time sensitivity also needs to include how many people would be at that location to see the night time view (many on main commuter roads in winter, to none on mountain tops) and who would see the view (residents who may go out of their homes to see the night sky, or road users who would be focussed on the road ahead lit by headlights); and
- The change to night views includes consideration of baseline lighting in the view and the proposed lights, including intensity and position in the view in relation to existing lights, as well as colour, nature (steady or flashing) and duration.

1.2.3 Changes to night time viewing experiences are considered briefly for all viewpoints, with those where the lights are more noticeable discussed in more detail.

1.2.4 The likely brightness of the lights seen from each viewpoint is a function of emitted light and angle of view (reduced downward light spill from a horizontal beam design), as well as distance attenuation and atmospheric conditions. The assessment below considers potential brightness of the lights in clear conditions.

Fieldwork

1.2.5 Field visits undertaken for the LVIA between March 2024 and July 2024 included observations made after dark. Fieldwork and photography specific to the night time lighting assessment was undertaken in August 2024.

ZTV modelling

1.2.6 ZTV mapping has been carried out to identify the theoretical visibility of the hub lights. It is noted that the ZTV uses a bare ground model and does not account for local screening by woodlands or buildings. The ZTV in Figure TA4.6.1, (EIAR Volume 4) is calculated to show visibility of all hubs to 25 km. Figures TA4.6.2 – TA4.6.8, EIAR Volume 4) shows the visibility of the aviation lights, calculated to hub height for the lit turbines only, and is coloured to illustrate the downward angle of view (from the light to the viewer) and therefore represents the brightness emitted at that angle. It does not include attenuation by distance, nor does it take account of variations in atmospheric conditions.

Production of visualisations

1.2.7 Photography for night-time photomontages to illustrate potential effects of aviation lighting was carried out in the evening. A set of photographs was taken prior to sunset to ensure that the camera was correctly set up, and to allow cross reference between lights caught on dark photographs and buildings caught on day time photographs. A series of photograph sets were taken over a period of about an hour and a half from sunset into nautical twilight. This enabled the photographer to take multiple sets as the sky darkened, with varied camera settings. Downloaded sets were then reviewed to select a set that best matched NatureScot advice on having the sky relatively dark and other lights in the landscape on, but the form of the landscape still visible.

1.2.8 Photomontages prepared for night-time views using photography taken during twilight were produced using the same method as for daylight photomontages (methodology as set out in Technical Appendix 4.1, EIAR Volume 4), with turbines rendered in black as silhouettes. Images of aviation lights are provided for indicative illustration only and have been modelled on the basis of approximately 200 cd for viewpoints.

Scope of the Assessment

1.2.9 The assessment of effects of aviation lighting at night briefly considers each of the viewpoints used in the LVIA briefly, with additional information and illustrative dark photomontages for 3 viewpoints:

- VP3: B7078 Carlisle Road (Figure 4.16, EIAR Volume 3a);
- VP5: Abington Services (Figures 4.18, EIAR Volume 3a); and
- VP10: B7055 Greenhill (Figures 4.23, EIAR Volume 3a).

1.2.10 Settlements are places where people are most likely to be at night but are also where there is abundant lighting. From well-lit areas, faint lights are more difficult to see. With lights nearby, although the lights of the Proposed Development may be visible from settlements, there would be no likelihood of significant effects. Settlements are therefore not considered further.

1.2.11 Routes can pass through dark areas between settlements, and although drivers' and passengers' attention is most likely to be on the road ahead corresponding with the area lit by the vehicle headlights, other lights in the landscape are also noticeable. Routes can be considered using representative viewpoints and knowledge of roadside screening by vegetation and buildings.

1.2.12 During the times when the lights would be on, the perception of the character of the landscape is reduced to nothing in darkness, such that whilst the lighting may be seen in views when the outlines of landforms and horizons would still be visible, the likelihood of significant effects on the perception of landscape character decreases rapidly with the onset of darkness. As such, an assessment of effects of aviation lighting on landscape character has been scoped out.

1.3 Baseline Lighting

1.3.1 Artificial light within the Site comes from the front and rear lights of vehicles travelling along the M74 motorway and B7078 road. No other lights were recorded in the Site.

1.3.2 Within the wider landscape there are several light sources including the street and building lights of the settlements of Abington and Crawfordjohn which as well as providing a direct light source, also result in sky glow, as well as the populated central belt of Scotland further to the north. Other light sources include a series of scattered properties and farms, and vehicle lights travelling along the network of roads in nearby valleys.

1.3.3 Away from roads, the landscape has limited development and areas of moorland and forestry have a degree of darkness which increases with remoteness.

1.3.4 There are no existing wind farms with lit turbines within the study area.

1.3.5 No ready comparison can be made between the lights that would be installed at the Proposed Development and the lights noted above because their technical specifications are not known. The perceived brightness of a light at any given distance depends fundamentally on this specification. Additionally, the specifications of lights of the type required for wind farms are developing in response to the issues which may arise for visual amenity and may be different by the time any permission is implemented.

1.4 Assessment of Visual Effects of Aviation Lighting

1.4.1 As stated above, it is assumed that 8 turbines would be lit (T1, 3, 4,9 16, 17, 19 and 22) with medium intensity 2000/200 cd steady red lights on the top of the hub (a second light on each hub would be installed as backup but would not be lit when the primary light is functional). The lights would come

on at half an hour after sunset and would be switched off at half an hour before sunrise (to be on during nautical twilight).

1.4.2 Mitigation includes the reduction of intensity of the lights during conditions of clearer visibility, such that the lights would only operate at full intensity of 2000 cd when visibility is less than 5km. At other times they would be at 10%, i.e. 200 cd. Met Office meteorological data for the local area suggests that the 2000cd lights would be at 2000cd for 7-10% of the time and at 200cd for 90-93% of the time.

1.4.3 Candidate lights are designed to give a horizontal beam with reduced upward and downward spill of light, such that the brightness of the light is decreased for viewers close to the turbines viewing them from below. Below -4° the lights should not be visible, although from nearby locations the reflection of light on the passing blades would be visible. Angles discussed below and shown on Figures TA4.6.1 – TA4.6.8 (EIAR Volume 4) are angles emitted from the bulb.

Analysis of ZTV

1.4.4 The combined aviation lighting ZTV on Figure TA4.6.1, (EIAR Volume 4) was modelled for T1, T3, T4, T9, T16, T17, T19 and T22, as per the reduced lighting schedule. The ZTV is calculated to show the minimum vertical viewing angle for the lights visible at each point, i.e. the angle closest to the horizontal for the brightest light - which is not necessarily the closest turbine or the same turbine at each point. Whilst the ZTV does not indicate which turbine would be the brightest, it indicates the least amount of downward reduction in intensity. The ZTV illustrates that there would be greater downward angles of view when closer to the proposed turbines, and lesser downward angles when seen from higher ground to the north and west. It should be noted that the ZTV in Figures TA4.6.1 – TA4.6.8 (EIAR Volume 4) does not illustrate the brightness of light that may be received in any one place, which needs to take account of distance attenuation, weather conditions and the technical specifications for a candidate light unit. Calculations for apparent brightness have been provided for the 3 viewpoint locations considered.

Assessment of Visibility of Lights from Viewpoints

1.4.5 Table TA4.6.1 below sets out the likely visibility and effects of turbine lights from viewpoints.

Table TA4.6.1: Visibility of Aviation Lights from Viewpoints

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
VP1: Devonburn Road T1: 0 to -1 degrees T4: 0 to -1 degrees T17: 0 to -1 degrees T19: 0 to -1 degrees T22: 0 to -1 degrees	Road users on a minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes but barely perceptible at 12.8 km. A total of 5 aviation lights are predicted to be visible from this location with a reduction of downward angle (-1°), seen against traffic travelling along the M74 motorway in the foreground including front and rear vehicle lights which would be brighter than the aviation lights mounted on turbines. Given the distance to the Site, and elevated location of the viewpoint, viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).

Table TA4.6.1: Visibility of Aviation Lights from Viewpoints

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
VP2: B7078 Carlisle Road T1: 0 to -1 degrees T4: 0 to -1 degrees T22: 0 to -1 degrees	Road users on a minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes but barely perceptible at 11.8 km. A total of 3 aviation lights are predicted to be visible from this location with a reduction of downward angle (-1°), seen against traffic travelling along both the B7078 road and the M74 motorway in the foreground including front and rear vehicle lights which would be brighter than the aviation lights mounted on turbines. Given the distance to the Site, viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP3: M74 Southbound, B7078 near Parkhead T1: -2 to -3 degrees T3: -1 to -2 degrees T4: -2 to -3 degrees T22: 0 to -1 degrees	Road users on a minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes in front of the Southern Uplands. A total of 4 aviation lights are predicted to be visible from this location with a reduction of downward angle (0 to -3°) due to proximity to the lit turbines. Views of aviation lights would be within the context of traffic travelling on both the B7078 road and M74 motorway including front and rear vehicle lights. Viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP4: M74 within Site T1: -4 and below degrees T3: -4 and below degrees T4: -4 and below degrees T9: -3 to -3 degrees T16: -3 to -4 degrees T17: -2 to -3 degrees T19: -4 and below degrees T22: -4 and below degrees	Road users on the minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, all 8 of the lit turbines would be seen successfully and turbines would be seen as dark structures or silhouettes. A total of 8 aviation lights are predicted to be visible from this location with a reduction of downward angle (-2 to -4°) due to proximity to the lit turbines within the Site. Views of aviation lights would be within the context of traffic travelling on both the B7078 road and M74 motorway including front and rear vehicle lights. Viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP5: Abington Services T1: -1 to -2 degrees	Road users on the minor road. Value is typically low as people are not in that location	A total of 6 lit turbines would be seen alongside the dark structures or silhouettes of the remaining turbines.

Table TA4.6.1: Visibility of Aviation Lights from Viewpoints

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
T3: -2 to -3 degrees T4: 2 to -3 degrees T9: 2 to -3 degrees T16: 2 to -3 degrees T22: 2 to -3 degrees	to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	There would be a reduction in intensity with the downward angle (-1 to -3°) due to proximity to the lit turbines within the Site. Views of aviation lights would be within the context of lights around the Service Station and hotel, and traffic travelling to the north on the B7078 road and M74 motorway including front and rear vehicle lights. Viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP6: Castle Hill T1: 0 to 3 degrees T3: 0 to 3 degrees T4: 0 to 3 degrees T9: 0 to 3 degrees T16: 0 to 3 degrees T17: 0 to 3 degrees T19: 0 to 3 degrees T22: 0 to 3 degrees	Walkers at a summit. Value is typically medium as people do visit this location to experience the view albeit in low numbers and levels of darkness would be seen in the context of nearby Abington and vehicles travelling on the M74 motorway and A702 road; susceptibility medium as people are likely to have some appreciation of the dark skies. Overall, night-time sensitivity is Medium.	A total of 8 lit turbines would be seen and the remaining turbines would be seen as dark structures or silhouettes. Due to the higher elevation, the aviation lights would be viewed at their strongest intensity and at approximately 5.2 km between 0 to 3 degrees. Views of aviation lights would be within the context of lights from foreground Abington, and vehicles travelling on the M74 motorway, and A702 road. Viewers would have some dark adaptation. Magnitude of change would be Medium and the overall effect significant (Moderate).
VP7: Crawfordjohn T1: -1 to -2 degrees T3: -1 to -2 degrees T4: -2 to -3 degrees T16: -1 to -2 degrees T19: -1 to -2 degrees T22: 0 to -1 degrees	Residents and road users. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit. Overall, night-time sensitivity is Low.	A total of 6 lit turbines would be seen to the east beyond the ridgeline and the remaining turbines would be seen as dark structures or silhouettes against the sky. This would be seen within the context of street lighting within Crawfordjohn and sky glow from Abington. There would be a reduction of downward angle (0 to -2°). Viewers would have limited dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP8: B740 Spango None	Road users on the minor road. Value is typically low as people are not in that location to see the night time	No lights would be visible from this location due to screening by intervening landform.

Table TA4.6.1: Visibility of Aviation Lights from Viewpoints

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
	view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	
VP9: A702 near Hartside T3: -1 to -2 degrees T9: - 1 to -2 degrees	Road users on the minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes at 5.4 km. A total of 2 aviation lights are predicted to be visible from this location with a reduction of downward angle (-1 to -2°), seen against traffic travelling along the A702 road including front and rear vehicle lights. Viewers on the road would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP10: B7055 Greenhill T1: -1 to -2 degrees T3: 0 to -1 degrees T4: -1 to -2 degrees T9: 0 to -1 degrees	Road users on the minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes at 5.9 km. A total of 4 aviation lights are predicted to be visible from this location with a reduction of downward angle (0 to -2°), seen against traffic travelling along the B7055 road including front and rear vehicle lights. However, intervening forestry would screen views towards the lights. Viewers on the road would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Minor).
VP11: Tinto Hill T1: 0 to 3 degrees T3: 0 to 3 degrees T4: 0 to 3 degrees T9: 0 to 3 degrees T16: 0 to 3 degrees T17: 0 to 3 degrees T19: 0 to 3 degrees T22: 0 to 3 degrees	Walkers at a summit. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be seen as dark structures or silhouettes at 8.5 km to the south west. A total of 8 aviation lights are predicted to be visible from this location at an angle of 0 to 3 degrees and at the highest intensity of 200 cd. However, at the distances involved the intensity would be reduced and would not be as bright as a car brake light. Viewers would have dark adaptation, however, given the distance to the Site, and elevated location of the viewpoint, magnitude of change would be Low and the overall effect not significant (Minor).

Table TA4.6.1: Visibility of Aviation Lights from Viewpoints

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
VP12: Cairn Table T1: 0 to 3 degrees T3: 0 to 3 degrees T4: 0 to 3 degrees T9: 0 to 3 degrees T16: 0 to 3 degrees T17: 0 to 3 degrees T19: 0 to 3 degrees T22: 0 to 3 degrees	Walkers at a summit. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be barely perceptible at 15.2 km to the east and viewed through two other wind farms in front. A total of 8 aviation lights are predicted to be visible from this location at an angle of 0 to 3 degrees and at the highest intensity of 200 cd. However, at the distances involved the intensity would be reduced and filtered by intervening wind turbines. Viewers would have dark adaptation, however, given the distance to the Site, and elevated location of the viewpoint, magnitude of change would be Low and the overall effect not significant (Minor).
VP13: Lowther Hill T1: 0 to 3 degrees T3: 0 to 3 degrees T4: 0 to 3 degrees T9: 0 to 3 degrees T16: 0 to 3 degrees T17: 0 to 3 degrees T19: 0 to 3 degrees T22: 0 to 3 degrees	Walkers at a summit. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be barely perceptible at 15.5 km to the north and viewed within the context of lights in the foreground at Green Lowther radar station. A total of 8 aviation lights are predicted to be visible from this location at an angle of 0 to 3 degrees and at the highest intensity of 200 cd. However, at the distances involved the intensity would be reduced. Viewers would have dark adaptation, however, given the distance to the Site, and elevated location of the viewpoint, magnitude of change would be Low and the overall effect not significant (Minor).
VP14: Culter Fell T1: 0 to 3 degrees T3: 0 to 3 degrees T4: 0 to 3 degrees T9: 0 to 3 degrees T16: 0 to 3 degrees T17: 0 to 3 degrees	Walkers at a summit. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be barely perceptible at 14.4 km to the east and viewed through two other wind farms in front. A total of 8 aviation lights are predicted to be visible from this location at an angle of 0 to 3 degrees and at the highest intensity of 200 cd. However, at the distances involved the intensity would be reduced. Viewers would have dark adaptation, however, given the distance to the Site, and elevated location of the viewpoint, magnitude of change would be Low and the overall effect not significant (Minor).
T19: 0 to 3 degrees T22: 0 to 3 degrees		
VP15: B7016 east of Biggar T16: 0 to -1 degrees T22: 0 to -1 degrees	Road users on a minor road. Value is typically low as people are not in that location to see the night time view; susceptibility is also low as people are usually focussing on the road ahead or on the area lit by headlights. Overall, night-time sensitivity is Low.	At night, turbines would be seen as dark structures or silhouettes but barely perceptible at 18.6 km. A total of 2 aviation lights are predicted to be visible from this location with a reduction of downward angle (0 to -1°), seen against traffic travelling along the B7016 in the foreground including front and rear vehicle lights which would be brighter than the aviation lights mounted on turbines. Given the distance to the Site, viewers would not have dark adaptation. Magnitude of change would be Low and the overall effect not significant (Negligible).

1.5 Assessment of Visibility of Lights from Routes

1.5.1 Given the findings of Technical Appendix 4.3 (EIAR Volume 4) and for the viewpoints in the table above, there are unlikely to be significant effects on routes around the study area. Observations relative to routes are set out below. It is noted that route users have low night-time sensitivity, and do not have dark-adapted vision, with lights in vehicles and of other vehicles. People are likely to be focussed on the road ahead or on features within the pool of light created by headlights. Lights are most likely to be noticeable when ahead but lightly oblique to the main headlight direction. Therefore, no roads or railway lines have been considered further in the assessment which focusses on the two walking routes in Table TA4.6.2.

Table TA4.6.2: Visibility of Aviation Lights from Route Receptors

Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
SHT 57: Roberton to Douglas	Walkers. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be seen as dark structures or silhouettes in front of the Southern Uplands. A total of 8 aviation lights are predicted to be visible from this location between -4 and 3. This would typically occur over a short section on Bodinglee Moor. Views of aviation lights would be within the context of traffic travelling on M74 motorway including front and rear vehicle

Table TA4.6.2: Visibility of Aviation Lights from Route Receptors		
Location and Distance from nearest lit turbine	Receptors, Night-time Sensitivity and Baseline Lighting	Assessment of Effects of Visibility of Aviation Lighting
		lights, but the section of the footpath affected would be further away and experience darker skies. Viewers would have dark adaptation. Magnitude of change would be Medium and the overall effect significant (Major).
SHT 58: Douglas to Wanlockhead	Walkers. Value is typically high as people do visit this location to experience the dark sky in low numbers; susceptibility high as people would be focussing on the surrounding landscape and experience of darkness. Overall, night-time sensitivity is High.	At night, turbines would be seen as dark structures or silhouettes in front of the Southern Uplands. A total of 8 aviation lights are predicted to be visible from this location between -4 and 3. This would typically occur over a short section on Pagie Hill. Views of aviation lights would be within the context of traffic travelling on M74 motorway including front and rear vehicle lights, but the section of the footpath affected would be further away and experience darker skies. Viewers would have dark adaptation. Magnitude of change would be Medium and the overall effect significant (Major).

1.6 Summary

1.6.1 The findings of the above assessments of visual effects are set out in Table 4.6.2.

Table TA4.6.2: Summary of Visual Effects from Aviation Lights	
Visual Receptor	Effect
Viewpoints	
VP1: Devonburn Road	Not significant (Minor)
VP2: B7078 Carlisle Road	Not significant (Minor)
VP3: M74 Southbound, B7078 near Parkhead	Not significant (Minor)
VP4: M74 within Site	Not significant (Minor)
VP5: Abington Services	Not significant (Minor)
VP6: Castle Hill	Significant (Moderate)
VP7: Crawfordjohn	Not significant (Minor)
VP8: B740 Spango	No view of aviation lights
VP9: A702 near Hartside	Not significant (Minor)
VP10: B7055 Greenhill	Not significant (Minor)
VP11: Tinto Hill	Not significant (Minor)
VP12: Cairn Table	Not significant (Minor)
VP13: Lowther Hill	Not significant (Minor)
VP14: Culter Fell	Not significant (Minor)
VP15: B7016 east of Biggar	Not significant (Negligible)
Routes	
SHT 57: Roberton to Douglas	Significant (Major)
SHT 58: Douglas to Wanlockhead	Significant (Major)

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Distance from turbines (5km intervals)
- Site boundary
- Turbines 1, 3, 4, 9, 16, 17, 19 & 22

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated using the maximum aggregate value of vertical angles derived from T1, T3, T4, T9, T16, T17, T19 & T22 at hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

1 0 1 2 3 4 5 km

Figure Title

Figure TA4.6.1: Theoretical Visibility of Aviation Lighting by Intensity to 20km - All Lit Turbines

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.1
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

M74 West Ltd

MVGLA Landscape Architecture RAMBOLL

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-114-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 1
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.2: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 1

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.2
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

M74 West Ltd

MVGLA Landscape Architecture RAMBOLL

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 3
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.3: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 3

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.3
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

M74 West Ltd

MVGLA Landscape Architecture RAMBOLL

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 4
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

1 0 1 2 3 4 5 km

Figure Title

Figure TA4.6.4: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 4

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.4
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

M74 West Ltd

MVGLA Landscape Architecture RAMBOLL

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 9
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.5: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 9

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.5
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

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1 0 1 2 3 4 5 km

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 16
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.6: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 16

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.6
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

Client

M74 West Ltd

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1 0 1 2 3 4 5 km

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1

270000 280000 290000 300000 310000

640000 630000 620000 610000

Legend

- Turbine 17
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.7: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 17

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.7
Date	Prepared by
29/08/2024	AS
Scale	Issue
Scale @ A3: 1:160,000	r1

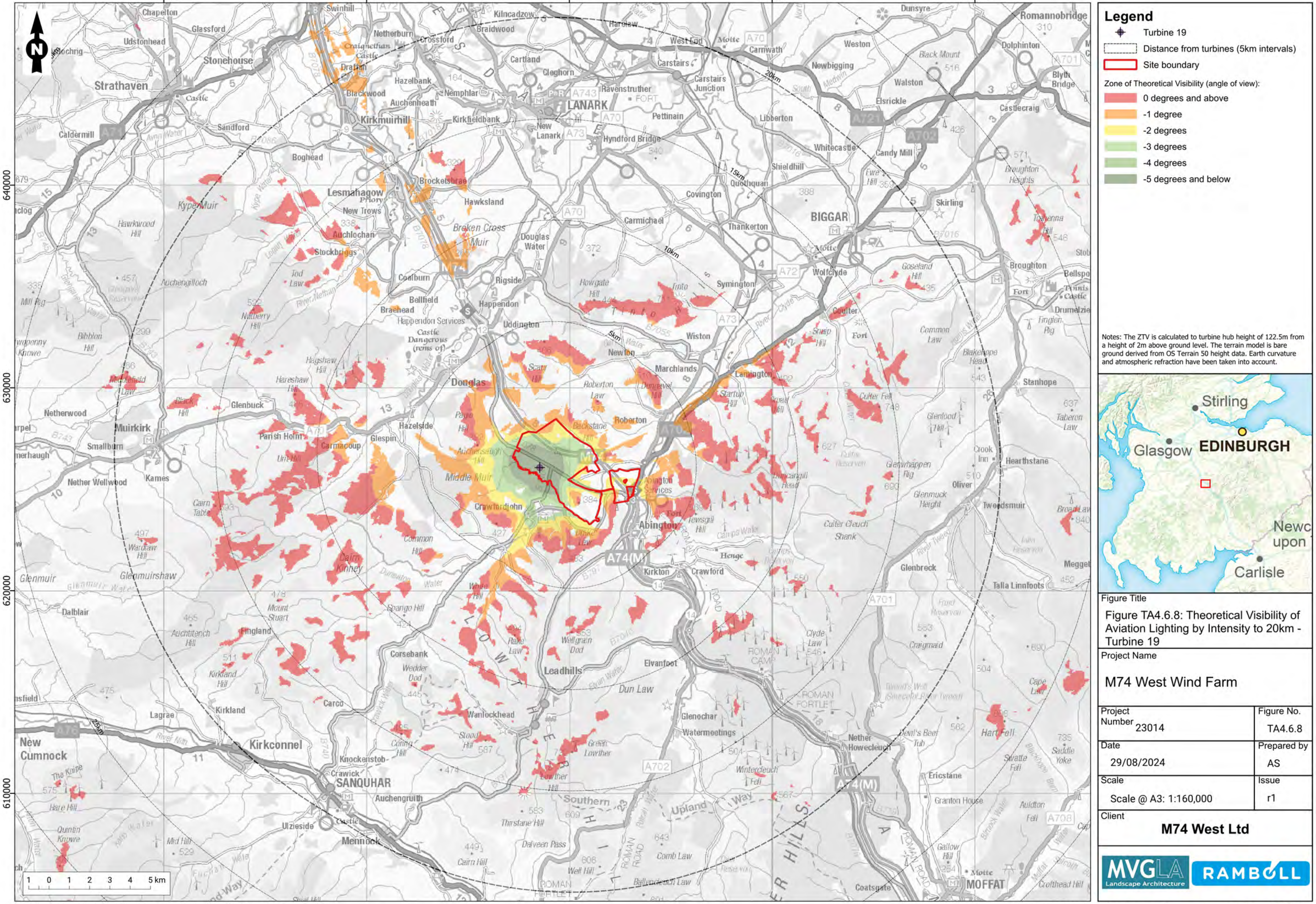
Client

M74 West Ltd

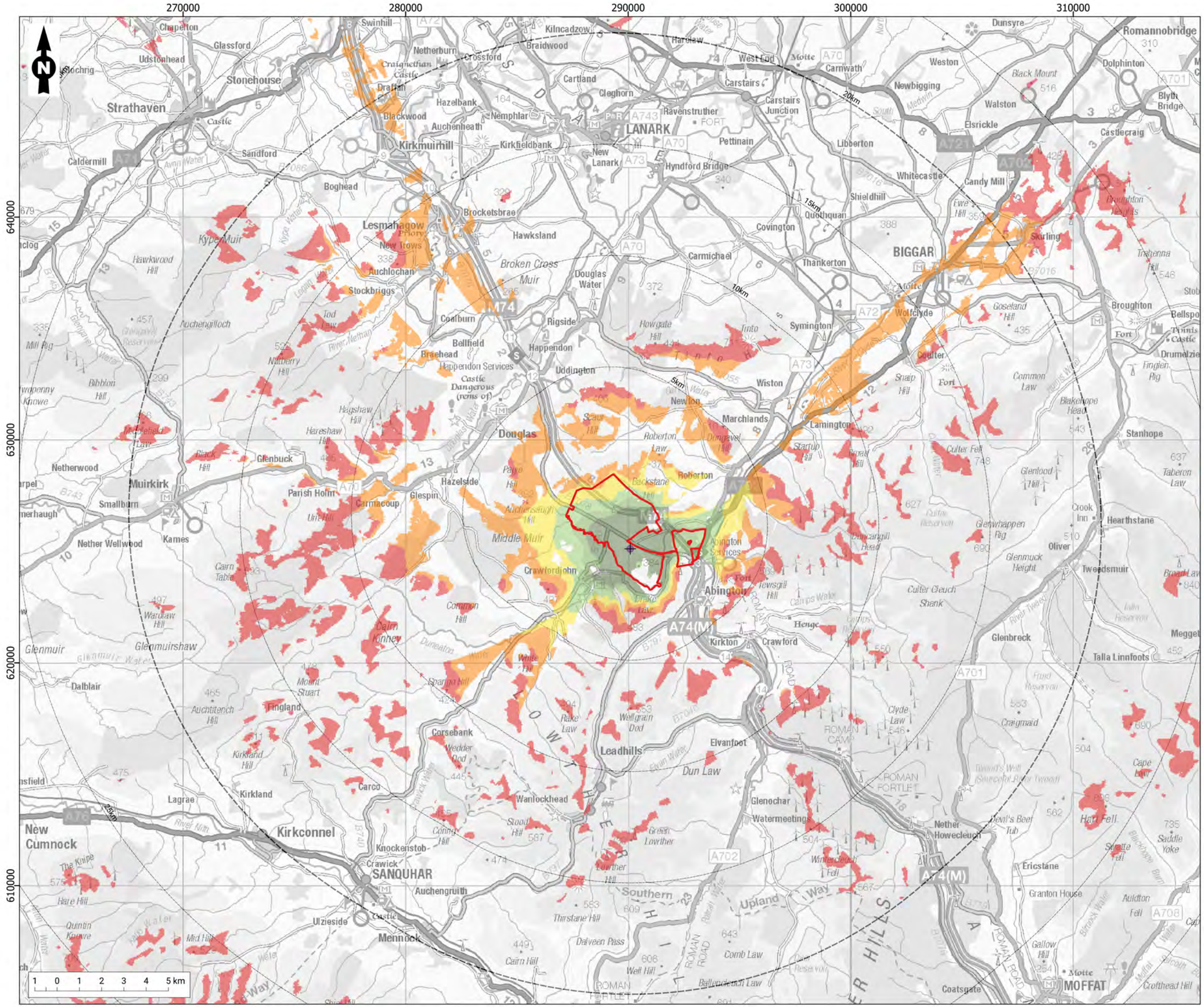
MVGLA Landscape Architecture RAMBOLL

Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1



Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936
Ref: 23014-115-r1



Legend

- Turbine 22
- Distance from turbines (5km intervals)
- Site boundary

Zone of Theoretical Visibility (angle of view):

- 0 degrees and above
- -1 degree
- -2 degrees
- -3 degrees
- -4 degrees
- -5 degrees and below

Notes: The ZTV is calculated to turbine hub height of 122.5m from a height of 2m above ground level. The terrain model is bare ground derived from OS Terrain 50 height data. Earth curvature and atmospheric refraction have been taken into account.

Figure Title

Figure TA4.6.9: Theoretical Visibility of Aviation Lighting by Intensity to 20km - Turbine 22

Project Name

M74 West Wind Farm

Project Number	Figure No.
23014	TA4.6.9
Date	**Prepared by**
29/08/2024	AS
Scale	**Issue**
Scale @ A3: 1:160,000	r1

Client

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Coordinate System: British National Grid: Projection: Transverse mercator. Datum: OSGB 1936

Ref: 23014-115-r1