Chapter 13

Other Issues

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13 Other Issues

13.1 Introduction

1. This chapter considers the predicted likely significant environmental effects of the Proposed Development on the following aspects, which were scoped into the assessment through the Environmental Impact Assessment (EIA) Scoping consultation:

- forestry and Land Use;
- aviation and Radar;
- carbon Balance;
- telecommunications;
- shadow flicker; and
- cumulative effects interactions

2. The description of other elements of infrastructure of the Proposed Development assessed in this chapter can be found on **Figure 4.1 Site Layout** and **Chapter 4: Development Description**. The aforementioned aspects of the Site selection and design are described in full in **Chapter 3: Site Selection and Design**. **Appendix 4.1 Offsite Access Appraisal** considers the potential aforementioned effects of the proposed offsite access route to the Site, concluding that there would be no potential significant effects likely to occur as a result of the offsite access route upgrade works and as a result, this has not been assessed further within this chapter.

13.2 Forestry and Land Use

13.2.1 Approach

3. An evaluation of the potential effects of the Proposed Development on the woodland resource is provided in **Appendix 13.1 Forestry**.

4. Forestry is not being regarded as a receptor for EIA purposes. Commercial forests are dynamic and their structure continually undergoes change due to normal felling and restocking by the landowner; natural events, such as windblow, pests or diseases; and external factors, such as a windfarm development.

5. **Appendix 13.1 Forestry** therefore describes the plans as a result of the Proposed Development for felling, restocking and forest practices; the process by which these were derived; and the changes to the physical structure of the forest that would occur. It further discusses the issue of forestry waste arising from the Proposed Development.

6. The appendix identifies areas of forest to be removed for the construction and operation of the Proposed Development and outlines the proposed management practices, while identifying the likely restocking proposals and future land management of the remaining forest.

13.2.2 Consultation

7. **Table 13.1** summarises consultation that has taken place during the EIA process.

Consultee	Summary of Consultation
Forestry and Land Scotland (FLS)	FLS have been closely involved in the design evolution of the Proposed Development. Their responses have been integrated into the infrastructure and forestry designs as they progressed throughout the design
Scottish Forestry	All felling and restocking proposals must be compliant with UK Forestry Standard. Noted Annex 1 of Scottish Government's policy on control of woodland removal on the level of information Scottish Forestry expects within an EIAR. Also noted Annex 5 of this guidance which details information on calculating the area of compensatory planting which will be required as a result of the Proposed Development.

Table 13.1 Consultation Responses

13.2.3 Assessment of Effects

8. Approximately 223.48 hectares (ha) of advanced felling would be required for construction of the Proposed Development, with some forestry subsequently being replanted.

9. The species composition of the forest would change as a result of the Proposed Development forestry proposals. In particular, the area of conifer woodland would decrease by 120.69ha and the area of broadleaf woodland would increase by 23.58ha.

10. The area of unplanted ground would increase and as a result, there would be a net loss of woodland area of 97.42ha.

11. In order to comply with the criteria of the Scottish Government's Control of Woodland Removal Policy, offsite compensation planting would be required. The Applicant is committed to providing appropriate compensatory planting. The extent, location and composition of such planting would be agreed with Scottish Forestry and would take into consideration any revision to the felling and restocking plans prior to the commencement of operation of the Proposed Development.

12. Forestry waste would be managed in line with Scottish Environment Protection Agency (SEPA) guidance document WST-G-027 'Management of Forestry Waste' (SEPA, 2013)[1].

13. It is proposed that full consideration and further clarification on this issue would be included in a Forestry Waste Management Plan to form part of the Construction Environmental Management Plan (CEMP).

13.3 Aviation and Radar

13.3.1 Approach

14. Wind turbines are an issue for aviation Primary Surveillance Radars (PSRs), used for civilian and military air traffic control, as the characteristic of a moving wind turbine blade are similar to that of an aircraft. As a general rule, the PSR is unable to differentiate between wanted aircraft targets and clutter targets introduced by the presence of wind turbines.

[1] SEPA (2013): SEPA Guidance Notes WST-G-027 "Management of Forestry Waste". https://www.sepa.org.uk/media/28957/forestry_waste_guidance_note.pdf.

15. The significance of any radar impact depends on airspace usage in the vicinity of the Site and the nature of the Air Traffic Service (ATS) provided in that airspace.

16. An evaluation of the potential effects of the Proposed Development on aviation is provided in **Appendix 13.2 Aviation Impact Assessment.**

17. An Instrument Flight Procedure (IFP) Safeguarding Assessment has been undertaken and is provided in **Appendix 13.3 Instrument Flight Procedure Safeguarding Assessment**.

18. Aviation lighting proposals are detailed in **Chapter 4: Development Description**, with further detail provided in **Appendix 13.4 Indicative Aviation Lighting Landscape and Visual Impact Mitigation Plan (IALLVIMP)**.

13.3.2 Consultation

19. **Table 13.2** summarises consultation that has taken place during the EIA process.

Consultee	Summary of Consultation
Glasgow Prestwick Airport (GPA)	GPA highlighted that the close proximity of the Proposed Development to the existing windfarms at Dersalloch and Hadyard Hill, as well as the proposed Clauchrie Windfarm, needs consideration in relation to cumulative impact and mitigation capacity. GPA sought a better understanding of the impact on the mitigation capacity of its Terma Radar. Additionally, GPA requested that the EIA consider the impact on GPA's Instrument Flight Procedures (IFPs).
Ministry of Defence (MOD)	MOD has no concerns with the Proposed Development but notes that it sits within Tactical Training Area 20 (T), a military low flying area and as such requests that Ministry of Defence (MOD) accredited aviation safety lighting be fitted to the wind turbines.
NATS (En Route) (NERL) Safeguarding	NERL indicated that it would object to the proposal due to wind turbines being visible to its PSR at Lowther Hill. A NATS Technical and Operational Assessment (TOPA) issued for the Proposed Development anticipates an unacceptable technical impact on Lowther Hill radar.
Glasgow Airport (GA)	Proposed Development location outwith consultation zone and as such GA have no comment to make and need not be consulted further.
Civil Aviation Authority (CAA)	No response.

Table 13.2 Consultation Responses

13.3.3 Assessment of Effects

Glasgow Prestwick Airport

20. Initial modelling of the GPA PSRs shows that Radar Line of Sight (RLoS) exists between all of the proposed wind turbines and the S511 and Terma PSRs. The GPA PSRs are likely to detect all of the Proposed Development wind turbines; however, once it has been optimised by a Terma technician the GPA Terma should be capable of detecting the Proposed Development wind turbines and maintaining internal tracks on them (which are not displayed to the controller) whilst simultaneously tracking air targets passing over the Proposed Development. The optimisation process would be a one-off task for the Proposed Development with no requirement for further ongoing mitigation.

21. The potential number of wind turbines in the vicinity of GPA is well within the Terma's concurrent internal track capacity. In other words, the inherent processing capabilities of GPA's Terma should be able to mitigate the impact of the Proposed Development provided a one-off optimisation activity by Terma is undertaken upon the erection of the Proposed Development's wind turbines. If for some reason the Terma PSR becomes unserviceable, then the Radar Control Service would continue using Lowther Hill Secondary Surveillance Radar (SSR) data only, albeit with a minimum traffic separation increase from 5 Nautical Miles (NM) to 10NM.

22. A standalone assessment of the IFPs associated with GPA has been conducted and concludes that the wind turbines associated with the Proposed Development would have no impact on GPA's IFPs as currently published. This is detailed in **Appendix 13.3 Instrument Flight Procedure Safeguarding Assessment**.

NERL

23. Initial modelling of Lowther Hill PSR shows that 9 of the 13 wind turbines are in RLoS. Probability of Detection analysis indicates that wind turbines 1 to 9 would likely be detected and there is a possibility that wind turbine 10 would also be detected. Wind turbines 11, 12 and 13 are unlikely to be detected by Lowther Hill PSR. This confirms the findings of the NATS TOPA. Lowther Hill PSR is being replaced by a more advanced radar facility that is currently undergoing commissioning flight trials. It is assumed that the same wind turbines would be in RLoS and be detected by the new radar.

General

24. There are no significant areas for concerns specifically in relation to airspace or airspace users. The Proposed Development Site lies below a volume of uncontrolled airspace predominantly used by General Aviation and military aircraft. This Class G airspace extends from the surface to 5,500ft Above Mean Sea Level (AMSL) and is the responsibility of NERL. Above this airspace is a Class D portion of the Scottish Terminal Manoeuvring Area (TMA). The Class D airspace (specifically TMA-2) is under the control of Scottish Control (NERL), located at Prestwick Centre and is declared as a Transponder Mandatory Zone. Any aircraft entering this airspace from beneath (i.e. from below 5,500 AMSL) should be carrying and using a serviceable transponder. Any loss of PSR coverage in this area should not impact on the provisions of Air Traffic Services (ATS) within this airspace as there should be sufficient SSR coverage. The Site does fall within the Tactical Training Area within Lower Flying Area 20T within which military aircraft perform low flying as low as 100ft Minimum Separation Distance.

13.3.4 Mitigation and Conclusion

25. Where radar impacts result in an adverse impact on the ATS provided, mitigation may be required.

26. The GPA Terma can be optimised to filter out any clutter generated by the Proposed Development's wind turbines. Individual wind turbine positions would be manually added to the radar's internal map so that plots originating from wind turbines would be identified as static targets and suppressed from the controller's display. The mitigation would be a one-off optimisation task undertaken by a Terma technician.

27. A potential option for mitigating the impact on Lowther Hill PSR is to use an infill radar feed that does not have RLoS of the Proposed Development wind turbines but has adequate coverage over the Proposed Development Site to satisfy NERL Air Traffic Control requirements. It is likely that NERL only control the airspace from 6,000ft above the Proposed Development Site, delegating airspace in the vicinity of GPA from 5,500ft to 6,000ft to GPA.

28. Potential infill PSRs must optimally provide 2,000ft of additional PSR coverage below the base of NERL controlled airspace in the vicinity of the Proposed Development. Great Dun Fell PSR has the lowest base of radar coverage, 3,500ft AMSL, in the vicinity of the Proposed Development. Cumbernauld can provide the required minimum coverage of 4,000ft AMSL. Both of these PSRs are integrated into NERL's Multi-Radar Tracking infrastructure.

29. The replacement Lowther Hill PSR has an in-built capability that allows for filtering out turbine interference. This may provide a further mitigation option if this capability can be applied to the Proposed Development.

13.4 Climate and Carbon Balance

13.4.1 Approach

30. The Scottish Government uses an assessment of the carbon impact of windfarm development to support the process of determining windfarm developments in Scotland. This is particularly relevant in peatland areas where there can be substantial carbon losses due to disturbance to peat, which can in part off-set the benefit of wind energy on carbon emissions.

31. The carbon balance assessment is a desktop assessment comparing the carbon losses of windfarm construction with the ongoing savings of green electricity production to estimate the reduction in carbon emissions expressed as a breakeven or "payback" timescale. It is based on the methodology within Calculating Carbon Savings from Wind Farms on Scottish Peatlands, Nayak *et al* 2008, with subsequent updates. The calculations contain expected values but also upper and lower bound values. Within the parameter set, there are several site-specific options and it is important the appropriate choices are made and can be justified within the supporting report.

32. **Appendix 13.5 Carbon Report** presents details of the carbon balance calculation methodology and results using the Scottish Government on-line Carbon Calculator Tool for the purpose of carbon balance assessment in conjunction with the guidance provided in Scottish Government, NatureScot[2] and SEPA's Peatland Survey – Guidance on Developments on Peatland – 2017 document.

33. The iterative conceptual design has sought to avoid deep peat and minimise peat disturbance, in order to achieve a more favourable carbon balance assessment.

13.4.2 Assessment of Effects

34. Outputs indicate the Proposed Development would pay back the carbon emissions associated with its construction, operation and decommissioning in 3.5 years applying the 'Grid Mix' replacement scenarios. Assuming a maximum of 40 year windfarm life, this equates to an overall carbon saving of 11 times the carbon emitted; however, it should be noted that the windfarm lifespan is likely to be longer. Furthermore, it is considered likely that the actual payback period for this development would be somewhere within the range between the Grid Mix and Fossil Fuel Mix estimates.

35. Based on the expected values input to the calculator, outputs indicate that approximately 33% of the carbon losses are from wind turbine life cycle, 20% of the carbon losses are from the felling of forestry, 29% of the carbon losses are due to the requirements for balancing capacity ('back-up generation' assumed to be predominantly from conventional fossil fuel sources), and 18% due to losses of soil organic matter. Additionally, in compiling carbon data, a conservative approach has been taken; therefore, little allowance has been made for CO_2 gains due to onsite improvements.

13.4.3 Conclusion

36. Although it is possible that some combination of changes could have an impact greater than the sum of their individual effects on payback, the sensitivity analysis embedded within the carbon calculator demonstrates that, even using conservative values for all of the factors contributing to the overall estimation of carbon payback, the carbon savings of the Proposed Development would still be substantially greater than the attributable carbon emissions.

13.5 Telecommunications

13.5.1 Approach

37. Wind turbines, as with any large structure, can potentially interfere with electromagnetic signals; through reflection, shielding or emissions. This can affect fixed radio communications links operated by telecommunication operators.

- reflections - wind turbines are large structures, consisting of a static tower, a nacelle and rotating blades. Radio signals may be reflected from these components, as they are reflected from other structures and terrain. In the case of a wind turbine, these effects are sometimes noticeable due to wind turbine size, the motion of the blades and the combined effects from multiple wind turbines;
- shielding - radio signals can be blocked by terrain and structures. Wind turbine towers can block radio signals. In practice, signals are not blocked entirely but can be weakened due to diffraction effects. This effect can be termed shielding, shadowing or blocking; and
- emissions - most electrical equipment emits radio signals at a range of frequencies. Most equipment is designed to appropriate standards which limit such emissions to negligible levels. Wind turbines are designed to such standards and emissions are consequently negligible.

38. Only electromagnetic interference (EMI) and telecommunications links which travel across the Site and close to the wind turbine locations have the potential to be affected by the Proposed Development and therefore the Study Area comprises the wind turbine locations and the Site.

39. Television (TV) interference is now considered to be a low risk due to analogue TV signals no longer being in use and so this aspect has been scoped out of the assessment.

13.5.2 Consultation

40. Telecommunications operators were consulted and where links were found to be located in, or in close proximity to, the Study Area, further details of the links were requested so they could be taken into consideration in the design of the Proposed Development.

41. Ofcom's Spectrum Information System (SIS) online portal was also checked for transmitters and fixed links within the search area. The portal showed potential links crossing the Site. Therefore, the owners of these links were also consulted to obtain further information regarding the links.

Consultee	Summary of Consultation	Applicant Response
British Telecoms (BT)	No Concerns. The Proposed Development indicated should not cause interference to BT's current and presently planned radio network.	No further action required.
JRC	No Concerns. This Proposed Development cleared with respect to radio link infrastructure operated by: Scottish Power and Scotia Gas Networks.	No further action required.
Met Office	No concerns. The Met Office does not require further consultation.	No further action required.
Mountaineering Scotland	No concerns.	No further action required.
NATS	No concerns were raised regarding the Development's impact to NATS telecommunication infrastructure.	No further action required.
Vodafone	No response received.	N/A
Airwaves solutions	No response received.	N/A
Arqiva	No objection	No further action required.
Atkins	No objection.	No further action required.
Mobile Broadband Network Limited	No response received.	N/A

Table 13.3 Consultation Responses

13.5.3 Assessment of Effects

42. No concerns have been raised by the consultees regarding the windfarm's impact on any communications links.

43. If concerns were raised at a later date, then mitigation measures such as diversion of the telecommunications links would be investigated.

[2] Formerly Scottish Natural Heritage.

13.5.4 Conclusion

44. From the consultation responses received, it is concluded that the Proposed Development would have no effect on any telecommunications links.

13.6 Shadow Flicker

13.6.1 Approach

45. The term "Shadow Flicker" refers to the flickering effect caused when rotating wind turbine blades periodically cast shadows over nearby properties. Shadow flicker can only occur inside a property and under a certain set of conditions including bright sunshine, the wind turbines are operational and when the sun is in a particular location to cast a shadow from the wind turbines across a property.

46. The magnitude of the shadow flicker effect varies both spatially and temporally and depends on a number of environmental conditions coinciding at any particular point in time, including, the position and height of the sun, wind speed, direction, cloud cover and position of the wind turbine to a sensitive receptor.

47. It should be noted that a detailed study was undertaken by Parsons Brinckerhoff on behalf of the Department of Energy and Climate Change (DECC) in 2010 to update the government's evidence base for shadow flicker[2]. This research concluded that *"The frequency of flicker from modern wind turbines is unlikely to cause any health effects and nuisance and is not considered as a significant risk.".*

48. The Scottish Government's "Onshore wind turbines: planning advice"[1] and industry standard guidelines[2] states that shadow flicker is unlikely to be of a significant impact at distances greater than ten rotor diameters from a wind turbine. Additionally, it is important to note that these same industry standard guidelines[2] conclude that shadow flicker can only occur at properties within 130 degrees either side of north. For this application the candidate wind turbine has a rotor diameter of up to 170m which would equate to an area around each of the wind turbine locations of 1.7km. However, the South Ayrshire Council Supplementary Guidance for Wind Energy[4] suggests the Study Area for shadow flicker should be 2.5km around each of the wind turbine locations and so for this assessment the 2.5km Study Area has been used.

49. A search within the Study Area for potential shadow flicker receptors has been undertaken. Shadow flicker only occurs within buildings where the shadow appears through a narrow window opening, according to the Scottish Government's "Onshore wind turbines: planning advice"[1]. Therefore, only buildings with windows (including commercial and residential) were considered as potential shadow flicker receptors.

50. There are a number of factors which influence the potential significance of shadow flicker impacts, these include:

- the location of the relevant building relative to the path of the sun and the wind turbines;
- the distance of wind turbines from such buildings; the size of the window apertures and their location in the building relative to the wind turbines;
- the wind turbine height and rotor diameter;
- the presence of intervening topography, buildings or vegetation;
- the frequency of bright sun and cloudless skies;
- the time of year, and
- the prevailing wind direction and hence usual rotor orientation

51. In addition, the factors which influence the occurrence and duration of shadow flicker include:

- wind speed – would determine its frequency;
- wind direction – must allow the rotor to be perpendicular to the dwelling for a shadow flicker effect to take place; and
- cloud cover – must be sufficiently thin to allow the sun to shine brightly enough for shadow flicker to occur

52. Nordrhein-Westfalen[3] set out criteria for shadow flicker worst case scenario. German guidance sets two limits on the levels of acceptable shadow flicker effect:

- worst case scenario limited to a maximum of 30 hours per year or 30 minutes on the worst affected day; and
- a realistic scenario including meteorological parameters limited to a maximum of eight hours per year.

53. These limits have been widely accepted across Europe and are recommended in guidance such as that undertaken by Predac in European Actions for Renewable Energies.

54. Numerical and qualitative analyses of the impact of shadow flicker at buildings within the Study Area have been undertaken. A computer model (WindPro 3.5) containing the relative position of the sun in the sky, from any point on the earth's surface, and at any time during a day and year, was used. From this model it was possible to accurately quantify the theoretical temporal and spatial shadow flicker effects. The prevalence and impact of such effects is dependent upon a number of other factors, discussed inFactors Considered by Numerical Modelling**Section 13.6.3.3**.

13.6.2 Consultation

55. The methodology for the assessment was consulted on as part of the scoping process. Comments on the methodology were provided by South Ayrshire Council and Crosshill, Straiton and Kirkmichael Community Council and Dailly Community Council. Their comments have been actioned in this assessment as appropriate, as detailed in **Table 13.4.**

Consultee	Summary of Consultation	Applicant Response
South Ayrshire Council – Sept 2020	Pre-Application Response: The potential for shadow flicker should be considered in relation to all residential properties located within 2.5km of any individual wind turbine, unless terrain shielded. The impact on any property assessed as experiencing more than 30 hours of shadow flicker in a year would be considered as unacceptable and would require mitigation.	All residential properties within 2.5km of any wind turbine have been considered as potential receptors. Mitigation is proposed where more than 30 hours of shadow flicker in a year is predicted.
Crosshill, Straiton and Kirkmichael Community Council (CSK CC)	Concern regarding potential unacceptable shadow flicker impact. Suggest that screening is not appropriate mitigation. Request for shadow flicker Study Area to be increased to 6km,	The shadow flicker impact has been assessed. The Study Area of 2.5km is more than that required by national planning policy and modelling shows that the shadow would not be intense enough to cause shadow flicker at further distances. All mitigation options have been considered.
Dailly Community Council (DCC)	Concern regarding potential unacceptable shadow flicker impact. Suggest that hedge creation is not appropriate mitigation. Request for shadow flicker Study Area to be larger than 3km, Concerned regarding impact on human health.	The shadow flicker impact has been assessed. The Study Area of 2.5km is more than that required by national planning policy and modelling shows that the shadow would not be intense enough to cause shadow flicker at further distances. All mitigation options have been considered. The frequency of flicker from modern wind turbines is unlikely to

Consultee	Summary of Consultation	Applicant Response
		cause any health effects and nuisance and is not considered as a significant risk.

Table 13.4 Consultation Responses

13.6.3 Assessment of Effects

13.6.3.1 Construction

56. No shadow flicker would occur during the construction of the Proposed Development.

57. There is potential for shadow flicker to occur during the short commissioning window of the windfarm when the wind turbines would be operational for a short amount of time. Given that the same impacts would be replicated during the operational life of the windfarm then this period is considered to be part of the operational stage of the Proposed Development.

13.6.3.2 Operation

58. WindPro 3.5 was used to model shadow flicker effects on potential receptors within the search area. WindPro calculates how often and in which intervals a specific receptor would be affected by one or more wind turbines. The calculations were based on worst case scenarios.

59. Nordrhein-Westfalen[3] '(worst case)' is the theoretical time when the sun is, during the entire period between sunrise and sunset, passing through a cloudless sky and the rotor surface is perpendicular to the solar radiation, and the wind turbine is in operation.

60. The position of each proposed wind turbine was entered into the WindPro model, along with the indicative hub height (115m) and rotor diameter (170m) dimensions of the proposed wind turbines used in this assessment. The position of each identified potential receptor was also entered into the model. For each receptor it was assumed that a 1m x 1m window is always orientated to directly face each wind turbine; this simulates a worst case scenario. Based on this information the model is able to use spatial data for the position of the sun relative to the wind turbines over the course of a year. The model assumes that the wind turbine rotor is a disc with a shadow occurring when the centre of the sun passes behind any part of the rotor and that it always faces the sun. Any shadow generated by this disc is classed as an impact, however the intensity of any potential flickering was not considered by the model.

13.6.3.3 Factors Considered by Numerical Modelling

61. The following issues were considered by the numerical modelling:

13.6.3.3.1 Site Position

62. One of the key factors relating to shadow flicker is the latitude of a proposed windfarm site. This influences the shape of the potentially affected area, which is characteristically a 'butterfly' or 'kidney' shape centred on each wind turbine.

13.6.3.3.2 Wind Turbine Size and Number

63. A wind turbine's size is broadly defined by its hub height and rotor diameter. For wind turbines with an increased hub height, the same shadow is spread over a larger area, so in the vicinity of the wind turbine, the number of minutes per year when shadows are experienced would actually decrease. Although shadows cast further away from a wind turbine are of less significance, due to the influence of the increased separation distance; shadows cast close to a wind turbine would be more intense and therefore more likely to be of a concern. The rotor diameter determines the size of shadow cast, and the theoretical shadow flicker exposure times close to a wind turbine are proportional to rotor diameter. A larger rotor diameter would increase the area that could have potential impact. The number of wind turbines would not intensify any flicker effects in a cumulative manner. Shadow flicker effects on receptors are relative to individual wind turbines and the position of the sun.

13.6.3.4 Cloud Cover

64. Cloud cover is a key consideration because of the influence on ambient light levels, and therefore the intensity of shadows. The worst case scenario assumes the metrological worst case; clear skies. However, in reality cloud cover would vary daily as well as seasonally. Cloud cover can dramatically reduce the number of shadow hours per year. Therefore, in the realistic calculation cloud cover is taken into account using data available from a meteorological station in a similar location (metrological data from Eskdalemiur) to consider the likelihood of sunshine at different times of year.

13.6.3.4.1 Horizon Diffusion

65. The sunlight's angle varies with the latitude and time of day. The greater the latitude of the Site, the lower the sunlight's angle would be, and so the more important shadow flickering becomes. Moreover, it has been considered that an angle above horizon of less than 3° has no shadow influence. This assumption is considered reasonable due to the significant increase in light diffusion that occurs at low solar altitudes.

13.6.3.4.2 Shielding

66. Another key factor influencing whether or not shadow flicker occurs, is the visibility of a wind turbine's 'rotor disc' (i.e. the area swept by the blades) at a particular receptor location. If only partially visible, or not visible at all, then the impact would be reduced, or eliminated altogether. Shielding can be provided by the topography between the wind turbines and a potential receptor location and also by trees and buildings. The modelling undertaken for the Proposed Development has only considered topography and therefore represents a worst case outcome.

13.6.3.4.3 Wind Speed and Availability

67. The wind speed on a site and availability of wind turbines determines whether or not the wind turbine would operate. If wind speeds are either too low or too high, only static shadows are cast. The worst case scenario used in this study assumes all wind turbines are operational for the duration of the year at all times of the day. The wind turbines were also assumed to be facing directly towards each of the shadow receptors, regardless of the time of day and year which would cause the largest possible shadow to be cast upon the receptor. This again represents a worst case scenario. In the realistic scenario site metrological data was used to simulate the actual amount of time the wind turbine is likely to be rotating (estimated to be 85% of the time) and the direction in which it would be facing.

13.6.3.4.4 Window Size/Viewing Area and Orientation

68. The orientation of the windows of a property is relevant. Unless shadows fall over most of the area of the window(s) providing a light source to a room, the proportion of natural light entering the room would not be reduced sufficiently for shadow flicker effects to be experienced. If the window(s) do(es) not directly face the wind turbines, the potential for shadow flicker would be reduced. However, the model has not considered window orientation and the window is instead modelled to always be facing the wind turbines (referred to as "green house" mode in WindPro). This provides a worst case scenario as the window orientations will not necessarily be orientated towards the wind turbines. The larger a window is, or the more windows there are, to allow natural light into a room, the less significant the potential impact of any moving shadows cast by a wind turbine. For the purpose of the modelling, the size of each shadow receptor has been defined as a 1m x 1m square, at a height of 1m above ground level (AGL) for the lower side.

13.6.3.4.5 Realistic Scenario

69. The worst case assumptions result in a highly conservative assessment for the following reasons:

- it is unlikely to always be sunny when the shadow flicker could theoretically occur;
- the wind turbines would not always face the windows of the receptors;
- the windows of the receptors may be larger than 1m x 1m;
- the wind turbines would not always be turning (for example if the wind speed is too low or high) and so would only cast stationary shadows during these times;
- the receptor property/room may not be occupied at all times; and
- screening may be present

70. Therefore, a realistic scenario has also been presented by incorporating the long term climatic conditions into the model. . These include the probability of sunshine in a given month, the amount of time the wind turbine is likely to be turning and the likely direction the wind turbines would be facing.

13.6.3.5 Results

71. There are seven properties within 2.5km of the Proposed Development that may be affected by shadow flicker. The analysis of these properties has been compiled and is given in **Table 13.5** below.

Receptor ID	Approx. Distance to Nearest Wind Turbine
A	1100m
B	1900m
C	1400m
D	1400m
E	1400m
F	2400m
G	2400m

Table 13.5 Properties Within 2.5km of the Proposed Development

72. A summary of the worst case results of the shadow flicker modelling are included in **Table 13.6** below while a worst case shadow flicker map is shown in **Figure 13.1 Shadow Flicker – Worst Case**.

ID	Shadow Hours Per Year (hour/year)	Max Shadow Minutes Per Day (min/day)
A	127:12	96
B	11:48	22
C	16:03	28
D	15:32	28
E	22:01	28
F	00:00	0
G	00:00	0

Table 13.6 Worst Case Shadow Flicker Modelling Results

73. A summary of the realistic results of the shadow flicker modelling are included in **Table 13.7** below while a realistic case shadow flicker map is shown in **Figure 13.2: Shadow Flicker – Realistic Case**

ID	Realistic shadow hours per year (hour/year)
A	11:43
B	01:59
C	01:58
D	01:54
E	03:05
F	00:00
G	00:00

Table 13.7 Realistic Shadow Flicker Modelling Results

74. Although there is no national planning policy or guidance in Scotland relating to acceptable shadow flicker impacts, it is considered that the levels discussed above of 30 hours a year or 30 minutes a day, based on a worst case scenario; or eight hours per year based on a realistic case, are considered to be acceptable. Based on the best practice limits, receptor A exceeds acceptable levels based on the worst case scenario and on realistic levels. Receptor A would need to be mitigated if the number of shadow hours per year exceeds both 30 hours worst case and eight hours realistic scenario. It should be stated that there does appear to be additional screening between receptor A and the wind turbines which the assessment has not taken into consideration and it is therefore considered that shadow flicker impacts in reality would be significantly lower than modelling results predict. The potential worst case and realistic scenario at the other properties are within acceptable limits.

13.6.4 Mitigation

75. In line with the recommendation by South Ayrshire Council; it is expected that an appropriately worded planning condition would be included to mitigate against any potential effects associated with shadow flicker. The condition would also include measures whereby if shadow flicker was experienced, a complaint would be lodged with the planning authority and investigated by an appropriate expert. If shadow flicker was found to be occurring, then appropriate mitigation would be implemented to reduce the shadow flicker to acceptable levels and control the impact at source.

76. Control at source will prevent shadow flicker from occurring and is considered to be the most effective mitigation measure to mitigate the effects on neighbouring properties. This involves shutting the wind turbine down at times that flicker is likely to occur. These times can be pre-calculated and programmed into the windfarms SCADA system (shutdown calendar) based on actual wind turbine position, actual receptor locations and dimensions and monitored meteorological data. Photocells can also be installed that determine whether ambient light levels are sufficient for distinct shadows (and therefore shadow flicker) to be generated to prevent unnecessary shutdowns.

77. Alternatively, a shadow flicker protection system can be incorporated into the SCADA system. This calculates the locations of shadows in real time, determines whether these coincide with pre-programmed locations and takes into account ambient lighting before triggering a shutdown. These systems provide greater flexibility than shutdown calendars as it allows for new locations to be programmed.

78. The automated approach would allow for real-time shadows to be effectively mitigated. This would only be required at the wind turbines which are predicted to cause the shadow flicker at receptor A which are wind turbines 1, 3, 5, and 6. Due to the short periods of time that the wind turbines are considered to have the potential to have an impact, even based on the worst case scenario, the time that the wind turbines would require to be switched off to completely remove shadow flicker in each year would be less than 0.5% of the time. Based on the realistic scenario this would be less than 0.05% of the time. Application of the above measures, in the event that mitigation is actually required, will ensure that effects are minimised or avoided entirely in the event that they arise.

13.6.5 Cumulative

79. In order to assess the potential for cumulative shadow flicker impact from other windfarms, any windfarms within 2.5km of the identified receptors were identified. The windfarms which would cumulatively affect the same receptors are Craiginmoddie Windfarm (application), to the west of the Proposed Development (approximately 1.8km from the Proposed Development's nearest wind turbine) and Knockcronal Windfarm (currently in scoping and approximately 1km north of the Proposed Development). Craiginmoddie Windfarm has the potential to impact on receptors A and B, whereas Knockcronal Windfarm has the potential to impact all identified receptors (A - G).

80. To assess the potential cumulative impact, we have modelled the worst case shadow flicker assuming both Craiginmoddie Windfarm and Knockcronal Windfarm are operational in addition to the Proposed Development. We have assumed, from information provided by the developer of Craiginmoddie Windfarm, that Craiginmoddie Windfarm would have a hub height of 122.5m and a rotor diameter of 155m and have used the layout provided by the developer for the assessment. Available information for Knockcronal Windfarm has been used with hub height of between 105m and 125m and rotor diameter of 150m.

81. The results of the assessment are presented in **Table 13.8**. It was found that the Proposed Development and cumulative windfarms would potentially cause a cumulative affect at receptor A, B, C, and D. Craiginmoddie Windfarm was found to cause a small increase in the worst case theoretical hours occurring at receptor A, with additional increases at receptor B. Knockcronal Windfarm increased worst case theoretical hours occurring at receptors C and D.

ID	Proposed Development shadow hours per year (hour/year)	Cumulative windfarm shadow hours per year (hour/year)
A	127:12	06:28
B	11:48	47:09
C	16:03	13:22
D	15:32	12:56

Table 13.8 Worst Case Cumulative Shadow Flicker Assessment Results

The theoretical realistic case has also been modelled to include the cumulative impact of the Craiginmoddie Windfarm and Knockcronal Windfarm. The results are presented in **Table 13.9**.

ID	Proposed Development shadow hours per year (hour/year)	Cumulative windfarm shadow hours per year (hour/year)
A	11:43	00:48
B	01:59	07:11
C	01:58	01:38
D	01:54	01:35

Table 13.9 Real Case Cumulative Shadow Flicker Assessment Results

13.6.6 Conclusion

82. The shadow flicker assessment has shown that the Proposed Development has the potential to cause shadow flicker impact on five properties. Out of these five properties, one property, receptor A, could be affected in excess of an acceptable level if the worst case scenario is considered. Based on a worst case scenario, receptor A was found theoretically to experience up to 127:12 hours of shadow flicker per year. The long term metrological conditions of the Site (probability of sunshine and the frequency of the wind direction) were taken into account to assess a realistic scenario. The realistic scenario predicted receptor A to be affected for up to 11:43 hours per year which is above acceptable levels based on industry best practice of up to eight hours per year under a realistic scenario. However, even the realistic scenario does not take all of the factors into account such as existing screening.

83. It is recommended that if shadow flicker is found to occur in practice then mitigation such as automated wind turbine shutdown should be implemented to limit the potential impact of shadow flicker. This would require the Applicant to investigate any shadow flicker complaints and to action appropriate mitigation if the complaints were found to be valid. This would effectively mitigate the impact of shadow flicker without unnecessarily implementing mitigation which might not be required (as the shadow flicker impact is unlikely to be as significant as predicted by the worst case).

84. It should be noted that the shadow flicker predicted as a result of the Proposed Development and cumulative windfarms would occur at different times of the year and at different times of the day. Therefore, if shadow flicker was experienced at a receptor and a complaint needed to be investigated it would be easy to differentiate between shadow flicker occurring due to the Proposed Development and that due to other windfarms. Therefore, effective mitigation of the cumulative impact would be to implement mitigation in line with that suggested.

13.7 Cumulative Effect Interactions

85. Cumulative effect interactions are the combined or synergistic effects caused by the combination of a number of effects on a particular receptor, which may collectively cause a more significant effect than individually.

86. The approach to the assessment of effect interactions considers the changes in baseline conditions at common sensitive receptors (i.e. where there are common receptors with other distinctly different topics and those receptors have been assessed as being potentially impacted) due to the Proposed Development. The assessment is based upon residual effects only (considered to be effects of minor or greater significance i.e. excluding negligible effects).

87. An overall assessment of the cumulative effects on identified common receptors has been made using professional judgement and the technical information provided in **Chapters 5-12**.

88. Based upon the approach to the cumulative effect interactions described above the following technical topics are excluded from this assessment:

- Hydrology, Hydrogeology, Geology and Soils;
- Ecology and Biodiversity;
- Ornithology;
- Archaeology and Cultural Heritage;
- Traffic and Transport; and
- Other Issues (forestry and land use, aviation and radar, climate and carbon balance excluding shadow flicker).

89. Potential effect interactions have been identified for the following receptors groups:

- residential receptors;
- recreational receptors and tourists.

90. Residential dwellings have the potential to be impacted by visual amenity and shadow flicker. The shadow flicker assessment has shown that there is potential for the Proposed Development to impact on five properties, with only one property having the potential to be affected in excess of an acceptable level if the worst case scenario were to occur. Mitigation will be implemented should shadow flicker be found to occur in practice and will therefore not result in any significant effects and will not contribute to effect interactions. Significant effects were assessed at Glenalla, Tairlaw Toll Cottage, Tairlaw Toll House and Tallaminnoch where the proposed visible wind turbines would be close and prominent in views from the property and/or curtilage. However in all cases it is considered that the Residential Amenity Threshold would not be reached due to the separation provided by landform and vegetation, and orientation of the main outlooks from the properties. Given significant residual effects are only predicted for residential amenity and not shadow flicker it is therefore concluded that no significant effect interactions are anticipated for residential receptors. Combined cumulative effects on residential visual amenity have been assessed with the Proposed Development, Craigginmoddie Windfarm and Knockcronal Windfarm. This identified that the level of effect would increase from the assessed for the Proposed Development on its own at Doughty Farm, Glenalla, and Tairlaw Toll Cottage, but for all properties would not reach the Residential Amenity Threshold. It is therefore not considered that there would be no significant effect interactions as a result of the cumulative effects.

91. The Merrick, Galloway Forest Park and recreational paths within the Site have the potential to be impacted both visually and on their recreation use. An assessment on the Merrick WLA was undertaken and identified that the Proposed Development would have significant effects on the naturalness and remoteness attributes within 3km of the northern boundary of the WLA due to existing influences of human artefacts and activity in closer proximity than elsewhere within the WLA. The Proposed Development would have no effects on the secluded and remote interior areas of the WLA. The assessment found there would be no significant effects on the qualities and attributes of the WLA overall. The proposed development would have a minor adverse effect on Merrick as tourism receptor. It is considered that there will be no significant effect interaction because the Proposed Development only has significant effects on the northern 3km of the WLA, which is the least sensitive part of the WLA, and would not affect the full experience of someone appreciating it as a tourist attraction. The Proposed Development would have no effects on the secluded and remote interior of the WLA.

92. Significant effects were assessed on visitors within the northern elevated and open parts of the Galloway Forest Park within 6km of the proposed wind turbines, where the Proposed Development would be an immediately noticeable part of a wider proportion of views. The Proposed Development would have a minor adverse effect on Galloway Forest Park as a tourist receptor. It is considered that there is no significant effect interaction because significant effects were assessed only on the northern elevated and open parts of the Galloway Forest park within

6km of the proposed wind turbines. It is not predicted that the Proposed Development would affect the use of the whole Galloway Forest Park by tourists.

93. Significant effects were assessed on short recreational routes within and in close proximity to the Site where the Proposed Development would change the character of the routes to one which is within or next to a windfarm. This includes Old Road through Straiton Heritage Path, core path SA47 and LPN72, SA49, SA52, SA54, SA55, SA56 (parts of Barr Trails), and Cornish Hill Trail. National Cycle Route 7 (also SA1) lies directly west of the Site but visibility of the proposed wind turbines would only be for a short stretch alongside the Site extents and from limited parts between Maybole and the Site. There would be no visibility along NCN7 south of the Site. Cyclists, as recreational users of the NCN7, would be impacted during construction but effects predicted to occur during the construction period are considered to be temporary it is therefore considered that there would be no significant effect interactions. A minor adverse residual effect is predicted on recreational paths and walkers, cyclists and campers using Loch Bradan during both construction and operation. It is not considered that the minor adverse effects predicted to tourist/recreation receptors would increase the significant effects predicted by landscape and visual assessment.

13.8 References

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