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ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED DERRYNADARRAGH WIND FARM, CO. KILDARE & CO. OFFALY

Volume 2 - Main EIAR

Chapter 18 – Interactions of the Foregoing

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18. INTERACTIONS OF THE FOREGOING

18.1 Introduction

The requirement for the identification of interactions between the various aspects of the environment as detailed throughout the EIAR is set out in Article 3(1) of the amended EIA Directive 2011/92/EU as amended by the Directive 2014/52/EU, which states the following:

"*The environmental impact assessment shall identify, describe and assess in an appropriate manner, in the light of each individual case, the direct and indirect significant effects of a project on the following factors:*

a) population and human health;
b) biodiversity, with particular attention to species and habitats protect under Directive 92/43/EEC and Directive 2009/147/EC;
c) land, soil, water, air and climate;
d) material assets, cultural heritage and the landscape
e) the interaction between the factors referred to in points (a) to (d)."

This chapter adheres to guidance in the Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact interactions (European Commission, 1999)[1], the EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports 2022[2], and the European Commission's Guidance on the Preparation of the Environmental Impact Assessment Report (2017)[3]

This Chapter assesses the potential for interactions and inter-relationships between one aspect of the environment and another which can result in an impact being either positive or negative, as well as having varying significance. The chapter considers potential significant environmental effects that may occur in terms of the interaction and inter-relationships of Air Quality & Climate; Noise & Vibration; Biodiversity; Ornithology; Soils, Geology and Hydrogeology; Hydrology & Water Quality and Flood Risk Assessment (FRA); Population and Human Health; Shadow Flicker; Traffic and Transportation; Archaeology, Architectural & Cultural Heritage; Landscape & Visual Impact; Material Assets, Telecommunications & Aviation as a result of the Proposed Development as described in Chapter 2 of this EIAR.

Direct, indirect, cumulative, and interactive effects were considered during the siting of the proposed turbines and associated infrastructure in order to minimise effects on the environmental aspects mentioned above. The interactions and inter-relationships of the potential impact as set out throughout this EIAR are detailed in this Chapter.

The Proposed Development is made up of the following elements as defined in Chapter 2, and referred to throughout this Chapter as follows:

- The 'Proposed Wind Farm' (also referred to in this EIAR as the 'Site');
- The 'Proposed Grid Connection' (also referred to in this EIAR as the 'GC');
- The 'Turbine Delivery Route' (also referred to in this EIAR as the 'TDR');

[1] European Commission (1999), Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions. Office for Official Publications of the European Communities, May 1999
[2] EPA Guidelines on the information to be contained in Environmental Impact Assessment Reports (2022)
[3] European Commission (2017), Environmental Impact Assessment of Projects: Guidance on the preparation of the Environmental Impact Assessment Report. Publications Office of the European Union.

- The 'Biodiversity Enhancement Management Plan Lands' (also referred to in this EIAR as the 'BEMP Lands').
- For further detail on the Proposed Development please refer to Chapter 2 of the EIAR.

18.2 Effect Interactions

Where any potential negative effects have been identified during the assessment process, these effects have been avoided by embedded design mitigation or at a minimum, reduced by the proposed mitigation measures.

18.3 Summary of Mitigation Measures

This Chapter summarises mitigation measures proposed elsewhere in the EIAR. Chapter 2 to 17 of the EIAR outlines the findings of the assessment of the predicted effects of the Development on a topic-by-topic basis. The significance of these effects has been assessed using criteria defined in the topic chapters. In the context of The EPA Guidelines (2022), the significance of likely effects is categorised from imperceptible through to not significant, significant and profound with varying sub-categories.

18.3.1 Embedded Mitigation

Embedded mitigation includes design changes that were made to reduce or eliminate adverse effects, as well as normal good practice measures; these have avoided most of the potentially significant effects.

The process of applying the embedded mitigation is set out in *Chapter 3: Site Selection & Alternatives* . The key design aspects comprising embedded mitigation include:

- Avoiding inconsistent turbine spacing, outliers and excessive turbine overlapping to minimise visual clutter and ensure a balanced/compact array of key views has allowed for a reduction in adverse effects from a landscape and visual effect perspective.
- Evaluating both the landscape and planning policy objectives set out in the Offaly Development Plan 2021 – 2027, Kildare County Development Plan 2023-2029, and Laois County Development Plan 2021-2027, has influenced an appropriate scale of turbine, taking account of the landscape context of the local area.
- Respecting and understanding the ground conditions and site topography, including minimising effects on active peat where possible, and incorporating a biodiversity management and enhancement plan (Appendix 2.2 BEMP). Maximising the separation from residential dwellings to avoid or reduce visual, noise, and shadow flicker effects on residential dwellings.
- Respecting other environmental and ecological constraints, and associated buffer separations.

This chapter draws on the findings of each technical chapter of the EIAR to identify where interactions between environmental topics may occur, and how the embedded mitigation set out across the EIAR contributes to avoiding or minimising potential cumulative or cross-disciplinary impacts.

18.3.2 Specific Mitigation Measures

In addition to mitigation proposed to address significant adverse effects, some Chapters have also proposed further measures to reduce effects, and to provide betterment for example along the Cushina River, that were assessed as 'Not Significant' before mitigation.

Technical assessments have assessed pathways, both direct and indirect that could potentially magnify effects through the interaction or cumulative effects; these have been cross-referenced between Chapters. Also, Table 18-1, below, provides a matrix detailing the key interactions and inter-relationships between the key environmental aspects of the Proposed Development.

Table 18-2 provides further details and examples of the diverse range of interaction and inter-relationships between the key environmental aspects. Each individual chapter of the EIAR has assessed the applicable interactions between different potential effects. For example, Hydrology and Water Quality and FRA has assessed the potential effects on Biodiversity, Ornithology, Land, and Soils and Geology.

Table 18-1: Matrix of Interaction Between key Environmental Aspects

	Air Quality & Climate	Noise & Vibration	Biodiversity & Ornithology	Soils, Geology and Hydrogeology	Hydrology and Water Quality & FRA	Population and Human Health	Shadow Flicker	Traffic & Transportation	Archaeological, Architectural & Cultural Heritage	Landscape & Visual Impact	Material Assets, Telecommunications and Aviation
Air Quality & Climate											
Noise & Vibration											
Biodiversity & Ornithology											
Soils, Geology and Hydrogeology											
Hydrology and Water Quality & FRA											
Population and Human Health											
Shadow Flicker											
Traffic & Transportation											
Archaeological, Architectural & Cultural Heritage											
Landscape & Visual Impact											
Material Assets, Telecommunications and Aviation											

Table 18-2: Descriptions of interactions and inter-relationships between Key Environmental Aspects of the proposed development

Interaction	Description
• **Air Quality and Climate;** • **Noise & Vibration;** • **Biodiversity** • **Ornithology;** • **Soils, Geology and Hydrogeology;** • **Traffic and Transportation;** • **Population and Human Health.**	**Air Quality and Climate**: During the construction phase of the Proposed Development, there is potential for adverse effects to air quality and associated human health arising from dust emissions and construction-related activities. Dust will be generated through earthworks, excavation, vegetation clearance, vehicle movements along the internal site access tracks and turbine delivery route (TDR), and handling and storage of aggregates and excavated materials. These dust-generating activities may cause the temporary elevation of particulate matter (PM10 and PM2.5), which can result in short-term adverse effects on air quality and potentially affect nearby sensitive receptors. These effects interact closely with Chapter 8: Noise & Vibration due to construction plant operations and vehicle movements which contribute both to airborne dust and elevated noise levels, particularly in proximity to sensitive residential receptors. The interaction with Chapter 9: Biodiversity is also significant, as dust deposition can affect vegetation and terrestrial habitats, with potential indirect effects on flora and fauna from habitat degradation or sedimentation. Such dust emissions are particularly relevant along the turbine delivery route (TDR), with the potential for soiling effects up to 25 m from vegetation and up to 100 m from aquatic environments. Chapter 11: Soils, Geology and Hydrogeology outlines how felling machinery resulting in soil erosion could potentially affect hydrological regimes and groundwater quality, which in turn may impact ecological receptors. Traffic movements contribute further to air quality concerns, as noted in Chapter 14: Traffic & Transportation, particularly along local roads used for turbine delivery. Increased vehicular activity leads to additional airborne dust and may also exacerbate road surface degradation, contributing to the spread of material and fine particles onto adjacent lands. The interaction between air quality and population & human health, as addressed in Chapter 6: Population and Human Health, is of particular concern given that particulate matter has recognised health implications. However, based on baseline assessments and the significant setback of the construction site from sensitive dwellings, exposure is expected to be limited and temporary. Nonetheless, some sensitive receptors located closer to access routes, turbine delivery nodes, or working areas may experience dust soiling in the absence of mitigation. To address these potential interactions, comprehensive mitigation measures have been developed and will be implemented in full. These include: • The use of graded aggregates on internal access tracks. • Deployment of a water bowser to dampen surfaces and suppress dust.

Interaction	Description
	• Strict implementation of a Dust Control Plan as part of the CEMP (Appendix 2.1). • Covering of all loads likely to cause dust nuisance during transport. • Re-vegetation of exposed soils and stockpiles to reduce wind-blown dust. • Installation of wheel-washing facilities at the site access points. • Restricting vehicle access and egress to designated haul routes only. • Use of speed limits and construction phasing to minimise dust dispersion. • Road sweeping along affected road segments to maintain cleanliness and reduce material spread. The CEMP also outlines protocols for construction traffic, including minimising idling times and rerouting heavy vehicles where feasible to avoid sensitive areas. These traffic controls are coordinated with measures outlined in Chapter 14: Traffic & Transportation to ensure alignment between environmental and logistical planning. In addition, a 50 m buffer has been applied around all watercourses to prevent dust and sediment runoff from impacting sensitive aquatic habitats, including habitats supporting Qualifying Interests of downstream Natura 2000 sites, as detailed in Chapter 9. In combination, the proposed mitigation measures and development design features will effectively reduce any short-term interactions between air quality and other environmental receptors as detailed in Chapters 6, 8, 9, 10, 11 and 14, ensuring that the residual effects remain imperceptible to slight and reversible in nature. In accordance with the EIA Directive (Directive 2011/92/EU as amended by Directive 2014/52/EU), a thorough assessment of the Proposed Development has been undertaken. Based on the nature, scale, and location of the project, as well as the mitigation measures proposed, it is concluded that the development will not result in any likely significant effects on the environment. The design and implementation of the project will adhere to all relevant environmental protection standards and legislative requirements, ensuring that potential impacts are avoided or minimised to an acceptable level.

Interaction	Description
• **Noise & Vibration;** • **Air Quality & Climate;** • **Biodiversity** • **Ornithology;** • **Population & Human Health;** • **Traffic & Transportation;** • **Landscape & Visual Impact;** • **Material Assets, Telecomms and Aviation**	**Noise and vibration** effects during all stages of the Proposed Development have the potential to interact with multiple environmental receptors. These interactions are primarily associated with construction plant operations, ground excavation, rock breaking, turbine assembly/ decommissioning, and increased vehicular movements to and from the site, particularly along the turbine delivery route (TDR). As outlined in Chapter 8: Noise & Vibration, noise levels generated during the construction phase are predicted to be below the recommended thresholds at the nearest noise-sensitive receptors. Nonetheless, these activities are a key source of disturbance and interact directly with Chapter 7: Air Quality & Climate due to the dual effect of construction activities in generating both noise and dust. The operation of heavy machinery contributes to airborne particulate levels while also generating continuous or intermittent noise and low-level vibration. In terms of biodiversity (Chapter 9) and ornithology (Chapter 10), noise disturbance can disrupt fauna, particularly avian species and terrestrial mammals, by displacing individuals from foraging or nesting areas. Vibration from machinery can also cause temporary displacement or behavioural changes in sensitive species. These effects are exacerbated in areas where vegetation clearance or habitat removal takes place, linking noise and vibration closely with biodiversity sensitivities. Chapter 6: Population and Human Health notes that noise and vibration can adversely affect human wellbeing, especially for nearby receptors. Although separation distances have been maximised through careful siting of turbines and associated infrastructure, some residential receptors within proximity to the TDR may still experience perceptible levels of construction noise. However, these effects are expected to be temporary, and appropriate mitigation measures have been outlined. In relation to noise, the predicted operational wind farm noise levels meet the daytime and night-time noise limits derived using the Wind Energy Development Guidelines 2006 at all noise sensitive locations. As detailed in Chapter 6: Population and Human, this is considered to be a current best practice approach. The predicted noise levels from the proposed substation are below the noise limits at all noise sensitive locations. Operational phase employees tend to be specialist contractors who move between developments and generally do not take up residence close to operating wind farms for the purpose of wind farm maintenance. Furthermore, as previously described elsewhere in the Chapter 6: Population and Human, there are no residential receptors within the Site and the Proposed Development has been designed to minimise potential effects on residential receptors. In line with the appropriate legislation and guidelines, a minimum set back distance of a 4 times turbine tip height to the closest residential receptor is achieved, meaning that operational effects on receptors are aimed to be minimised.

Interaction	Description
	From a traffic perspective (Chapter 14: Traffic & Transportation), noise emissions from construction-related traffic and turbine delivery vehicles are another source of potential disturbance, particularly along rural local roads and within local settlements. Haul routes and the TDR have been chosen to minimise disruption and avoid dense residential areas. In terms of visual and landscape effects (Chapter 16: Landscape & Visual Impact), construction noise may influence perceptions of tranquillity, particularly within medium sensitivity landscapes or scenic areas. While these effects are considered temporary and not significant in the long term, they represent an important interaction between audible and visual experience. Interactions also occur with Chapter 17: Material Assets, Telecommunications and Aviation. Vibrations during excavation, have the potential to impact nearby infrastructure and built assets. Due to the embedded design of the development, including a minimum 740 m setback between turbines and the nearest residential dwellings, no piling activity will occur within close proximity to sensitive receptors. Although no critical infrastructure is located in immediate proximity to the main construction areas, protective measures have been included in the design and CEMP to ensure no inadvertent effects arise. Mitigation measures to address the potential adverse effects of noise and vibration are discussed in Chapter 8, including: • Adherence to best practice construction noise limits and hours of work (e.g., 07:00–19:00 Monday to Friday). • Use of silencers and noise suppression equipment on plant and machinery. • Locating stationary plant away from sensitive receptors and using acoustic barriers where required. • Phased construction planning to avoid prolonged disturbance at any single location. • Restricting delivery and heavy haulage operations to designated hours. • Monitoring of noise at key sensitive locations during peak construction activities and responding promptly to any increased levels. Collectively, the mitigation measures proposed in Chapters 6, 7, 8, 9, 10, 14 and 16 ensure that potential noise and vibration interactions are controlled, with residual effects expected to be temporary, localised, and not significant as per EIA Directive.

Interaction	Description
• **Biodiversity** • **Ornithology;** • **Air Quality & Climate;** • **Noise & Vibration;** • **Soils, Geology and Hydrogeology;** • **Hydrology and Water Quality & FRA;** • **Population & Human Health;** • **Traffic & Transportation**	**Biodiversity:** The construction and operational phases of the proposed development in Derrynadarragh has the potential for several environmental factors to interact with biodiversity, primarily through disturbance to species and habitats as a result of site clearance, vegetation removal, excavation, noise, dust generation, and changes to the water environment. There is potential for direct and indirect effects on biodiversity through interactions with Chapter 7: *Air Quality & Climate*, where dust generation during construction may result in vegetation soiling and reduced photosynthetic efficiency. Deposition of dust from traffic movements and machinery operation could impact the quality of habitats, particularly in dry weather conditions. Mitigation measures outlined in Chapter 7, including a Dust Management Plan (Appendix 2.1 of CEMP) and best practice construction controls such as water bowser spraying and covering of stockpiles, aim to minimise dust-related effects on vegetation and habitats. To prevent any adverse effects on sensitive aquatic habitats and downstream Natura 2000 sites, as stated in Chapter 9 – Biodiversity, the volume and source of water used for dust suppression will be carefully managed. The management of same is documented in the CEMP. Runoff from dust suppression will be directed through appropriate treatment measures, such as settlement ponds or vegetated buffers, to prevent sediment or pollutant loading of surface waters, as outlined in Chapter 12: Hydrology and Water Quality. Chapter 8: *Noise and Vibration* highlight the potential for noise during construction to disturb wildlife, particularly avifauna and other fauna, in proximity to turbine locations and haul routes. Noise arising from tree felling, vegetation clearance, machinery operation, and increased traffic movements has potential to cause short-term displacement of mobile species. As outlined in Chapter 9, invasive or disruptive works such as tree felling will be undertaken outside of sensitive ecological periods, including the bird nesting season (March to August). As part of mitigation, noise-generating activities will be time-restricted and machinery will be fitted with effective silencers, as per best practice guidance. In addition, operational noise effects from wind turbines and the substation transformer have been assessed in Chapter 8 (Section 8.6.3), with predicted levels shown to comply with regulatory limits at all sensitive locations. These measures will ensure that both construction and operational noise are appropriately managed to minimise impacts on ecological receptors throughout the project lifecycle. Interactions with Chapter 11: *Soils, Geology and Hydrogeology* such as vegetation removal and earthworks have the potential to increase soil erosion, leading to sedimentation of nearby habitats and aquatic systems. This sediment transfer may alter habitat conditions, degrade riparian zones, and affect sensitive aquatic species. Implementation of erosion control measures, buffer zones, and proper soil storage—as outlined in Chapter 9 Biodiversity and Chapter 12 Hydrology and Water Quality and FRA—will reduce these potential effects.

Interaction	Description
	From Chapter 11: *Hydrology and Water Quality & FRA*, it is noted that changes to surface water hydrology and potential contamination through construction activities could have indirect adverse effects on habitats and species dependent on wetland or watercourse environments. Surface water runoff and accidental spillages may affect water quality, altering ecological conditions. Mitigation includes the installation of silt fencing, settlement ponds, and adherence to a Surface Water Management Plan and Emergency Erosion and Silt Control Response Plan to prevent the risk of adverse water-related effects. In addition, a 50 m buffer around all watercourses will be maintained throughout construction to protect aquatic habitats and their associated Qualifying Interests. These buffers will be physically demarcated and fenced off to prevent inadvertent encroachment, as outlined in Chapter 9 and detailed further in Appendix 9.1 (BEMP).). Chapter 6: *Population and Human Health* intersects with biodiversity primarily in relation to human-wildlife co-existence and the indirect effects of biodiversity loss on ecosystem services. The loss or fragmentation of habitats may diminish the recreational and natural value of the landscape, with indirect implications for public health and wellbeing. However, significant setbacks from residences and protected areas reduce the likelihood of such conflicts. Finally, interactions with Chapter 14: *Traffic and Transportation* include increased vehicle movements during construction, which may lead to direct mortality of fauna (e.g., amphibians, mammals) and fragmentation of habitat connectivity. Furthermore, heavy construction traffic can contribute to dust and noise, indirectly impacting biodiversity. There is also a risk of hydrocarbon or fuel spills from construction vehicles, which could contaminate nearby habitats and watercourses, affecting sensitive ecological receptors. Mitigation includes speed restrictions, designated haul routes, and minimising unnecessary traffic movements near sensitive ecological areas. These measures are reinforced in Chapter 9: Biodiversity, which highlights the vulnerability of aquatic and terrestrial habitats to such pollutants and describes embedded protections such as the 50 m watercourse buffer, pollution control measures, and sensitive timing of works to reduce ecological risk. Operational effects such as potential bat and bird strikes (including potential bat mortality due to barotrauma) have also been assessed, with specific mitigation and enhancement measures outlined in Chapter 9 and detailed further in Appendix 9.1 – BEMP. These include turbine siting and operational curtailment measures to reduce collision risk, as well as habitat management strategies to support local biodiversity. The overall effect of the BEMP after implementation and over time will be a positive benefit on the water quality, native woodland cover and aquatic habitat cover. It is expected that there will be a corresponding increase in biodiversity. Although the Proposed Development will result in some habitat loss of Key Ecological Receptors (KERS), the BEMP will result in a greater amount of corresponding habitat creation. In addition, through the removal of the Third Schedule Invasive species, Giant Hogweed, the ecological integrity of the habitats in the vicinity will be improved and protected.

Interaction	Description
	In summary, potential interactions between biodiversity and air quality, noise, soil, water, human health, and transportation have been considered in detail across the relevant chapters of the EIAR. A suite of mitigation measures, many embedded in Appendix 2.1, the Proposed Development's Construction Environmental Management Plan (CEMP), aim to avoid or reduce these effects, resulting in overall slight to non-significant effects as per EIA Directive on biodiversity during the lifecycle of the Proposed Development.
• **Soils, Geology and Hydrogeology;** • **Air Quality & Climate;** • **Noise & Vibration;** • **Biodiversity** • **Ornithology;** • **Hydrology and Water Quality & FRA;** • **Population & Human Health;** • **Traffic & Transportation;** • **Archaeology, Architectural & Cultural Heritage;** • **Material Assets, Telecomms and Aviation**	**Soils, Geology and Hydrogeology**: Construction activities associated with the Proposed Development have the potential to result in the erosion of soil which can lead to hydrocarbons, sediment, and nutrient concentrations being released in surface water run-off that could potentially have adverse effects on the watercourses within the Site and/or those hydrologically connected downstream (see Chapter 9 Biodiversity; Chapter 12 Hydrology; Appendix 12.1 SWMP.) Soil infiltration to groundwater and soil erosion may represent a potential impact to the underlying locally important aquifer identified beneath the site, which is characterised by moderate to high vulnerability in certain areas due to the presence of peat and glacial till deposits. Erosion or degradation of soil from increased vehicular movements associated with construction traffic may lead to the carrying of suspended solids by surface water run-off, which could disrupt established drainage networks and increase sedimentation in downstream watercourses. The proposal also has the potential to create new pathways for runoff, causing erosion of soils and construction materials and the entrainment of solids during rainfall events. Construction activities such as tree-felling, vegetation clearance, and operation of machinery may lead to habitat disturbance, noise, and water quality deterioration. Secondary habitat degradation could occur from suspended solids and nutrient loading due to surface water runoff. Hydrocarbons from machinery and concrete leachate may further degrade water quality. Potential effects include effects on aquatic habitats, and fauna displacement from noise and vibration, though vibration levels are predicted to be below perceptible thresholds. There is also potential for adverse effects on road infrastructure and traffic safety due to increased HGV movements associated with delivery of turbine or substation components, or related construction logistics. As noted in Chapter 14: Traffic and Transportation, a designated haul route and Traffic Management Plan (TMP) will be implemented to reduce risks of sediment transport and road damage. In conjunction with the TMP, the Surface Water Management Plan (SWMP) (Appendix 11.1) sets out additional measures to control sediment runoff from construction areas and haul roads, particularly during wet weather conditions. Temporary road signage, condition surveys, and use of road sweepers will mitigate traffic-related effects.

Interaction	Description
	In addition, site clearance and groundworks have potential to uncover or disturb sub-surface archaeological features. Chapter 15: Archaeology, Architectural & Cultural Heritage outlines measures including archaeological monitoring during groundworks and buffer zones around known cultural heritage features to avoid damage. Material assets such as roads, electricity cables, gas and water mains have been considered in Chapter 17: Material Assets, Telecommunications and Aviation. Appropriate siting of infrastructure will ensure setbacks from utilities, and consultation with statutory providers (e.g., Irish Water, telecom operators) has informed design to avoid interference. No significant effects on telecommunications or aviation are expected. Mitigation measures set out in Chapter 9: Biodiversity, Chapter 11: Soils, Geology and Hydrogeology, Chapter 12: Hydrology and Water Quality & FRA, Chapter 14: Traffic and Transportation, Chapter 15: Archaeology, Architectural & Cultural Heritage, and Chapter 17: Material Assets, Telecommunications and Aviation will be implemented. These include: • Locating infrastructure in lower sensitivity areas (please refer to Chapter 9: Biodiversity) and ensuring appropriate setback distances from hydrological features, with a 50 m watercourse buffer zone applied along Cushina River and Daingean River (where practicable to protect water quality and riparian corridors), in accordance with the measures set out in Appendix 9.1 – Biodiversity Enhancement Management Plan (BEMP), including the associated ecological monitoring programme to ensure compliance and effectiveness. Please refer to Section 3.3.7 of the CEMP documented in Appendix 2.1, Volume 3 of the EIAR for clear span bridge details and construction methodologies. • Implementation of a Surface Water Management Plan (Appendix 12.1 SWMP), incorporating drainage measures such as silt fences, settlement ponds, swales, and check dams to collect surface water run-off and reduce sediment and nutrient loads before diffuse discharge to the environment. As outlined in Appendix 2.1 CEMP and Appendix 9.5 BEMP, an Environmental Clerk of Works (ECoW) will monitor the site to prevent adverse effects on hydrology, while monthly water quality grab samples and daily visual monitoring of the surface water network will be undertaken to check for visible signs of construction effects. Appropriate records will be maintained, in addition to regular reporting to agreed authorities. • Excavations associated with the construction compound, on site substations, and cable trenches will be controlled to ensure they do not extend unnecessarily into the underlying bedrock aquifer. • Traffic mitigation via the TMP, road cleaning, and condition surveys (Appendix 14.1). • Archaeological oversight by a competent professional will ensure heritage assets are protected.

Interaction	Description
	• Coordination with utility providers and aviation authorities to safeguard material assets. Following mitigation, potential adverse effects are expected to be temporary and not significant as per the EIA Directive within the local context. In addition, positive effects are anticipated as a result of the aquatic habitat enhancement measures set out in Appendix 9.1 (BEMP).
• **Hydrology and Water Quality & FRA;** • **Soils, Geology and Hydrogeology;** • **Biodiversity** • **Ornithology;** • **Traffic & Transportation**	**Hydrology and Water Quality & FRA**: The Proposed Development, as described in Chapter 2, comprises a wind farm, grid connection (including substation infrastructure), turbine delivery route, BEMP, and associated works collectively referred to as "the Site." During the construction phase of the Proposed Development, there is potential for adverse negative effects on water quality, aquatic biodiversity, ornithology and habitats as a result of excavation, tree felling and construction activities. This can result in the deterioration of water quality due to the release of suspended solids, sediments and nutrients to watercourses, within or hydrologically connected to the Site and Turbine Delivery Route (TDR). Furthermore, there is potential for spillage of hydrocarbons from refuelling activities and plant use, or from malfunctioning machinery, which has potential to impact on water quality and aquatic biodiversity in aquatic environments/watercourses. Excavation works, inappropriate management of excavated material and overland flow during rainfall events may result in suspended solids reaching watercourses, increasing turbidity and potentially impacting water quality and aquatic ecology, including sensitive receptors such as the Natura sites downstream and the related Qualifying Interests (QI's). Suspended solids can also be transported to watercourses by being carried from the construction site to the public road on the wheels of construction traffic. Additionally, the use and subsequent release of cement-based products during excavation dewatering, cable trenching, and the installation of turbine foundations can lead to increased pH levels in receiving waters, which may cause adverse ecological effects. The Potential release of hydrocarbons from plant and machinery, particularly during tree felling and construction of watercourse crossings, may also affect water quality. The potential for surface water runoff and increased flows from the site may result in temporary increases in peak runoff to receiving waters, but this was assessed as being relatively low due to the small infrastructure footprint and use of permeable construction methods. See Appendix 2.1 CEMP, Chapter 12 Hydrology & water quality; Appendix 12.1 SWMP; Chapter 9 Biodiversity and related appendices. Each EIAR Chapter has specific mitigation measures including Chapter 9: Biodiversity, Chapter 11: Soils, Geology and Hydrogeology, Chapter 11: Hydrology and Water Quality & FRA, and Chapter 13: Traffic and Transportation to reduce potential effects on watercourses and biodiversity. These include, inter alia, the items set out in turn below:

Interaction	Description
	• Mitigation by design includes the implementation of a Biodiversity Enhancement Management Plan (Appendix 9.1 BMEP), which provides for native hedgerow and tree planting, habitat enhancement, and long-term biodiversity management, monitoring and reporting, to enhance local habitats, fauna and pollinators while enhancing the resilience of the receiving environment. • Management Plans: the implementation of Appendix 2.1 CEMP, Appendix 11.1 the Surface Water Management Plan (SWMP, and Appendix 9.1 BEMP, all of which provide integrated solutions for mitigation to prevent or minimise potential adverse effects. For example, incorporating the use of silt fencing, sediment traps, settlement ponds, and swales to manage suspended solids, as well as SUDS or other good practice pollution prevention measures. • Refuelling will only take place within designated bunded areas at the temporary compound(s), with spill kits available on site and regular training for all site staff. Precast concrete structures will be utilised where possible, and cement leachates will be contained and tankered off site for treatment/disposal, to prevent release to watercourses. • A minimum of a 50 m watercourse buffer zone has been applied for construction activities throughout the site. There are two exceptions to this, the first being a clear span bridge crossing the Cushina River within the Wind Farm site, and the clear span bridge crossing the Daingean River along TDR. • Construction activities will be undertaken in dry weather conditions where possible to reduce the potential for runoff. • Measures for controlling sediment and hydrocarbon runoff, as well as control of concrete leachate, will be implemented to protect water quality. • A road sweeper will be used to maintain road cleanliness, reducing the potential for sediments to enter drainage systems from the TDR. The Traffic Management Plan (Appendix 14.1) includes commitments to undertaking road condition surveys and road cleanliness measures for the GC and TDR. These measures will ensure the protection of sensitive aquatic and terrestrial habitats, maintaining water quality within the Cushina River and Daingean River and downstream Natura sites, with potential residual effects assessed to be not significant as per the EIA Directive following implementation of the mitigation measures outlined.

Interaction	Description
• **Population & Human Health;** • **Air Quality & Climate;** • **Noise & Vibration;** • **Biodiversity** • **Ornithology;** • **Soils, Geology and Hydrogeology;** • **Shadow Flicker;** • **Traffic & Transportation;** • **Archaeology, Architectural & Cultural Heritage;** • **Landscape & Visual Impact;** • **Material Assets, Telecomms and Aviation**	**Population & Human Health:** The operational phase of the Proposed Wind Farm has the potential to have effects on the landscape and cultural heritage, which may influence local amenity and tourism. As outlined in Chapter 15: Archaeology, Architectural & Cultural Heritage, the operational phase may result in a range of indirect visual effects on the wider settings of recorded archaeological sites within 2km of the site, with effects ranging from imperceptible to slight in significance. Chapter 15: Landscape & Visual Impact concludes that while the turbines will be visible across portions of the study area, including the uplands and localised elevated vantage points, no significant indirect effects on cultural heritage assets with notable visual or amenity sensitivities are expected during the operational phase. Potential effects on landscape character are assessed as High-Medium within the landscape associated with the Grand Canal and River Barrow and its immediate environs (up to 5km), reducing to Medium-low within the central study area, and Low to Negligible at increasing distances, as the proposed development integrates into the wider landscape fabric. The operational phase is considered to result in substantial to moderate, long-term, adverse landscape effects within and immediately around the site, reducing to moderate-slight at greater distances, in line with the landscape's capacity to absorb the development. Cumulative effects with other existing and permitted developments are assessed as Low, with a Medium cumulative effect when combined with other wind energy developments within the study area, as noted in Chapter 15. The Route Screening Assessment (RSA), included in the revised Chapter 15, confirms that visibility along the Turbine Delivery Route (TDR) is largely limited due to screening by hedgerows and local topography. As a result, cumulative visual impacts along the TDR are not considered significant. There are tourism and amenity features in proximity to the proposed development, including walking routes and scenic viewpoints, as identified in Chapter 6: Population and Human Health. However, the operational phase is not expected to significantly impact tourism, given the level of landscape integration, the scale of the development relative to the receiving environment, and the distance from key tourism assets. In relation to Chapter 17: Material Assets, Telecommunications and Aviation, the operational phase will not result in significant effects on utility infrastructure, telecommunications, or aviation. Engagement with stakeholders, including EirGrid and the Irish Aviation Authority, has confirmed no significant operational interference with telecommunications or aviation safety. The operational phase will not result in any significant effects on material assets within the study area. Interactions also arise with Chapter 13: Shadow Flicker, which considers the impact of rotating turbine blades on nearby receptors. While a number of receptors were identified as potentially subject to shadow flicker, mitigation measures including turbine curtailment have been proposed where necessary to ensure effects remain within acceptable limits. These measures help protect human health and amenity, and are relevant for minimising cumulative effects on residential settings.

Interaction	Description
	Air Quality and Climate (Chapter 7) and Noise and Vibration (Chapter 8) also contribute to the overall amenity experience. While construction effects are temporary, operational noise from turbines has been assessed and found to be below applicable day-time and night-time noise limits, with Chapter 8 concluding a long-term, slight to moderate significance of effect for the closest receptors. The predicted noise levels from on-site activity from the general construction works associated with the proposed project are below the noise criteria in BS 5228-1:2009+A1:2014 and are not expected to result in significant negative effects. Nonetheless, several mitigation measures will be employed, as good practice, to minimise any potential impacts from the proposed project. In the unlikely event of an exceedance, mitigation measures will be implemented to ensure compliance with the noise limits is achieved at all noise sensitive locations. In the event of an exceedance, noise mitigation will be provided by running the relevant turbine(s) in noise reduced modes of operation. The noise emissions can be lessened by reducing the rotational speed of the turbines, with a resultant loss of electrical energy production. Please refer to the full mitigation measures as outlined in Chapter 8 of this EIAR. Chapter 9: Biodiversity highlights indirect benefits from habitat management and enhancement measures, which include improved connectivity and quality of retained habitats (Appendix 9.5 BEMP, Appendix 9.6 AHMEP. These measures may also support local community amenity and nature-based wellbeing, which are increasingly relevant in health-related planning considerations. From a geological and hydrological perspective (Chapter 11, and Appendix 11.1 SWMP), careful siting and drainage management have been incorporated into the design to avoid slope instability, prevent water pollution, and reduce risk to local population health. These measures are critical for maintaining the integrity of drinking water sources and ground conditions that could otherwise pose a risk to public health. Traffic effects are considered in Chapter 14: Traffic and Transportation, where increases in traffic volumes during construction and decommissioning have the potential to cause temporary nuisance. However, the use of haul routes, traffic scheduling and road safety measures reduce the risk of accidents or prolonged disruption, with no long-term health risks expected. Mitigation measures include avoidance by design, ensuring the majority of the turbines are located within low sensitivity landscape character areas (as set out in Chapter 16: Landscape and Visual Impact, with the exception of Turbine 03 which falls on the edge between low and medium sensitive areas) to reduce prominence and buffer distances to sensitive receptors, as well as biodiversity enhancement measures such as hedgerow and tree planting to improve visual screening, contributing positively to local landscape structure. These measures are set out in Chapter 16: Landscape and Visual Impact and Chapter 15: Archaeology, Architectural and Cultural Heritage and will assist in reducing visual effects, supporting landscape integration, and protecting the settings of cultural heritage assets.

Interaction	Description
	Following implementation of these mitigation measures, the potential operational phase effects on landscape, cultural heritage, telecommunications, material assets, and human health are considered to be long-term, not significant to slight in significance as per the EIA Directive, and acceptable within the receiving environment.
• **Shadow Flicker;** • **Material Assets, Telecomms and Aviation;** • **Landscape & Visual Impact;** • **Population & Human Health**	**Shadow Flicker**: The Proposed Development has potential to impact on residential amenity and human health as a result of a combination of visual effects and the effects of shadow flicker. These effects have been considered in Chapter 6: Population and Human Health, Chapter 13: Shadow Flicker, Chapter 16: Landscape and Visual Impact, and Chapter 17: Material Assets, Telecommunications and Aviation. In total, 52 no. properties have been identified within 10 rotor diameters (1,620 m) of the turbines, and are therefore considered potential shadow flicker receptors. No receptors are located within 500 m of any turbine, and the closest receptor (SFAL16) is situated at 740 m. As outlined in Chapter 13: Shadow Flicker, a worst-case and realistic-case assessment was undertaken using WindPro modelling software. Where predicted shadow flicker exceeds guideline thresholds, mitigation will be implemented via automated turbine control systems, which temporarily shut down turbine operation when shadow flicker conditions are met. This ensures compliance with national and international guidelines, and helps maintain the residential amenity of nearby dwellings. In line with Chapter 6: Population and Human Health, no significant health effects are anticipated, and the residual shadow flicker impacts are considered to be slight to negligible, with no effects occurring under most conditions following mitigation. In accordance with the EIA Directive (Directive 2011/92/EU as amended by Directive 2014/52/EU), a thorough assessment of the Proposed Development has been undertaken. Based on the nature, scale, and location of the project, as well as the mitigation measures proposed, it is concluded that the development will not result in any likely significant effects on the environment. The design and implementation of the project will adhere to all relevant environmental protection standards and legislative requirements, ensuring that potential impacts are avoided or minimised to an acceptable level. Chapter 13: Shadow Flicker confirms that all receptors will experience zero shadow flicker through the implementation of curtailment controls, and therefore no significant effects are expected. These measures also contribute positively to human health and amenity by reducing visual disturbances associated with turbine operation.

Interaction	Description
	In terms of Chapter 16: Landscape and Visual Impact, the operational turbines will be visible from parts of the surrounding area. However, they have been strategically sited to reflect the underlying landform, to reduce prominence, with significant setback distances from dwellings. Landscape character effects range from High-Medium within the landscape associated with the Grand Canal and River Barrow and its immediate environs (up to 5km), reducing to Medium-low within the central study area, and Low to Negligible at increasing distances, as the proposed development integrates into the wider landscape fabric. Material Assets, Telecommunications and Aviation (Chapter 17) outlines that the proposed development will not interfere with telecommunication links or aviation safety. Stakeholder consultation with EirGrid, the Irish Aviation Authority, and telecommunications providers has confirmed that the turbines will not give rise to signal interference or require aviation warning lighting. The impact assessment determined there is no expected impact on material assets such as utilities or public infrastructure during the operational phase. These considerations ensure that the proposed development will not significantly affect nearby residences or critical infrastructure during its operational phase. The implementation of control software to eliminate shadow flicker, the appropriate siting of turbines, and the inclusion of visual and material asset protections collectively support the protection of population and human health, amenity, and infrastructure in the surrounding area. Following implementation of these mitigation measures, the potential operational phase effects in relation to shadow flicker, landscape and visual impact, material assets, telecommunications, and human health are long-term, not significant to slight in significance as per the EIA Directive, and acceptable within the receiving environment.
• **Traffic & Transportation;** • **Air Quality & Climate;** • **Noise & Vibration;** • **Biodiversity** • **Ornithology;** • **Soils, Geology and Hydrogeology;** • **Hydrology and Water Quality & FRA; Population & Human Health**	**Traffic & Transportation**: The Proposed development will require temporary traffic management measures during the construction phase, which could give rise to short-term effects on the local road network and its users. These are assessed in Chapter 14: Traffic and Transportation, which outlines the proposed Turbine Delivery Route (TDR), and the associated accommodation works required to facilitate safe and efficient turbine component delivery. The movement of construction vehicles, plant and equipment has the potential to interact with other environmental topics, particularly air quality and noise. As outlined in Chapter 7: Air Quality & Climate, construction traffic can contribute to localised dust and emissions, particularly through haulage activities and transportation of materials along the TDR. Mitigation measures such as wheel washing, dust suppression via water bowsers, and the implementation of a Dust Management Plan (Appendix 2.1 CEMP) are included to reduce effects.

Interaction	Description
	In terms of Chapter 8: Noise and Vibration, construction traffic has been assessed as a contributor to temporary noise effects along the route, especially during delivery of Grid Connection or turbine components. However, predicted construction noise levels remain below the thresholds outlined in British Standard 5228:2009+A1:2014, and deliveries will be restricted to standard working hours to minimise disturbance to nearby receptors. Potential effects on biodiversity are outlined in Chapter 9: Biodiversity, where the movement of vehicles along the TDR is recognised as a source of disturbance to local fauna and potential contributor to vegetation soiling due to dust deposition. Temporary disturbances to bat and bird species, may also occur due to noise, vibration, and increased human activity during construction. However, mitigation measures such as speed controls, defined haul routes, and good practice site management are proposed to limit these interactions. Additional species-specific mitigation, including timing of works and avoidance buffers, is outlined in Chapter 10 – Ornithology, to reduce risks to sensitive bird species during the breeding season and to protect known bat roosts from significant disturbance. From a ground conditions perspective, Chapter 11: Soils, Geology and Hydrogeology identifies the risk of sediment transport from construction areas to adjacent watercourses via construction vehicle movement. This risk is mitigated through the use of surface water management infrastructure, buffer zones, and careful storage of excavated material. Chapter 12: Hydrology and Water Quality & FRA further notes that runoff from the TDR could potentially carry sediments or pollutants into watercourses. To address this, measures such as silt fencing, settlement ponds, and the use of existing roads where feasible have been adopted to minimise hydrological impact (Appendix 11.1 SWMP). In terms of Chapter 6: Population and Human Health, temporary disruption to residents, including noise, dust and temporary road diversions, has been assessed. However, mitigation by design—such as using existing routes, restricting HGV movements to daytime hours, and carrying out road condition surveys before and after use—ensures that these effects remain short-term and not significant. Additional site controls such as wheel-washing facilities and active dust suppression (e.g. use of water bowsers and covered stockpiles) will also be implemented to prevent dust nuisance and reduce potential impacts on air quality and residential amenity. Cumulatively, traffic associated with the Derrynadarragh Wind Farm is expected to result in temporary, short-term and not significant effects across environmental topics when appropriate mitigation measures are fully implemented. The use of existing infrastructure and designated delivery schedules further ensures that the proposed development will be safely accommodated within the local road network, with minimal disruption to human health, biodiversity, soils, water, and air quality.

Interaction	Description
• **Archaeology, Architectural & Cultural Heritage;** • **Soils, Geology and Hydrogeology;** • **Hydrology and Water Quality & FRA;** • **Population & Human Health;** • **Landscape & Visual Impact;** • **Material Assets, Telecomms and Aviation**	**Archaeology, Architectural & Cultural Heritage**: The proposed development has potential to result in both direct and indirect effects on cultural heritage, particularly during the construction and operational phases. As outlined in Chapter 15: Archaeology, Architectural & Cultural Heritage, no recorded monuments lie within the development footprint, but several are located within a 2 km study area. While no direct effects are expected, slight to imperceptible indirect visual effects may arise on their wider settings. Potential interactions are also identified in Chapter 11: Soils, Geology and Hydrogeology, where groundworks could uncover previously unrecorded archaeological material. All excavation works will be archaeologically monitored to mitigate this risk. Hydrological effects are considered in Chapter 12: Hydrology and Water Quality & FRA, with mitigation measures such as buffer zones, surface water management, and erosion control reducing any potential effects on heritage features from runoff or altered drainage. Cultural heritage is an important part of the local identity, as noted in Chapter 6: Population and Human Health, and the proposed development has been designed to avoid negative effects on community setting and amenity. As outlined in Chapter 16: Landscape & Visual Impact, the turbines have been sited to minimise intrusion on sensitive views. Chapter 17: Material Assets, Telecommunications and Aviation confirms that no protected structures or heritage buildings are affected by the proposed works, and appropriate buffers have been maintained between infrastructure and cultural features. Following mitigation, residual effects on archaeology, architecture and cultural heritage are predicted to be not significant as per the EIA Directive.
• **Landscape & Visual Impact;** • **Noise & Vibration;** • **Shadow Flicker;** • **Population & Human Health;** • **Archaeology, Architectural & Cultural Heritage;** • **Material Assets, Telecomms and Aviation**	The **landscape and visual effects** of the proposed development have been assessed in Chapter 16: Landscape and Visual Impact. The turbines are well-spaced, allowing for a high degree of visual permeability between the turbines. Their regular spacing corresponds with the scale and simple form of the receiving landscape type. The Proposed Development has an organic layout which responds to the meandering form of the River Cushina which flows centrally through the scheme. The are considered to be visually appropriate within the context of this broad peatland setting. The proposed turbines are consistent in height resulting in an even profile which similarly is appropriate for this lowland setting. Within 1 km of the site, landscape effects are assessed as substantial to moderate, reducing to moderate to slight with distance as visibility decreases. Visual mitigation has been embedded in the project through careful siting and design, avoiding skylining where possible and aligning the turbine layout with the landscape's character. No additional physical screening measures such as hedgerow or tree planting have been proposed specifically for visual impact mitigation.

Interaction	Description
	Chapter 13: Shadow Flicker identifies 52 no. properties within 10 rotor diameters (1,620 m) of the proposed turbines that are considered potential shadow flicker receptors. However, no receptors are located within 500 m, with the closest property situated at 740 m. Using predictive modelling, shadow flicker was assessed under both worst-case and realistic-case scenarios. To mitigate potential effects, automated turbine control systems will be implemented to temporarily shut down turbines during conditions when shadow flicker is predicted to occur. This approach ensures compliance with relevant guidelines, protects local residential amenity, and supports overall wellbeing in nearby communities. In Chapter 6: Population and Human Health, the visual and shadow flicker effects are considered in relation to residential amenity and human health. Setback distances and curtailment measures reduce the potential for disturbance, resulting in no significant health effects. Chapter 15: Archaeology, Architectural & Cultural Heritage assesses potential indirect visual effects on recorded archaeological sites within 2 km. These are evaluated as ranging from imperceptible to slight, with no direct effects on built or cultural heritage features. As outlined in Chapter 17: Material Assets, Telecommunications and Aviation, turbine placement ensures no interference with telecommunications or aviation infrastructure. Consultation with relevant bodies has confirmed no requirement for aviation lighting and no impact on signal transmission. Collectively, the design and mitigation measures ensure that operational effects on landscape, shadow flicker, cultural heritage, telecommunications, and human health are considered not significant to slight and acceptable within the receiving environment.
• **Material Assets, Telecomms and Aviation;** • **Shadow Flicker;** • **Archaeology, Architectural & Cultural Heritage;** • **Landscape & Visual Impact**	**Material Assets, Telecommunications and Aviation**: The Proposed development has the potential to impact nearby receptors through a combination of visual changes, shadow flicker, and interactions with material assets and telecommunications infrastructure. Chapter 17: Material Assets, Telecommunications and Aviation confirms that the development will not result in adverse effects on telecommunications, aviation, or utilities. Stakeholder consultation with the Irish Aviation Authority and service providers confirmed no risk of signal interference or requirement for aviation lighting.

Interaction	Description
	Certain temporary accommodation works will be required at construction phase associated with the TDR and the provision of passing opportunities along the local road network are subject to this EIA but for which planning consent is not being sought within the current application. These works to facilitate the delivery of turbine components and haulage to the Site are detailed further in Table 2.4 ' Turbine Delivery Route Accommodation Works' and include hedge or tree trimming, temporary relocation of powerlines/poles, lampposts, signage and temporary local road widening. For these locations, works have been identified and assessed in the EIAR, however, these works will be carried out under a Road Opening Licence to be sought from Offaly County Council. However, no material assets, such as overhead powerlines, roads, or water infrastructure, will be affected during the operational phase. As outlined in Chapter 12: Shadow Flicker, 52 properties fall within 10 rotor diameters of the turbines. No dwellings are located within 500 m of the turbines. Turbine curtailment software will be implemented to temporarily shut down turbines when conditions for shadow flicker are met, ensuring compliance with relevant guidelines and protecting residential amenity, as also considered in Chapter 6: Population and Human Health. Visual and cultural heritage effects are considered in Chapter 16: Landscape and Visual Impact and Chapter 15: Archaeology, Architectural & Cultural Heritage, respectively. While the turbines will be visible from parts of the surrounding area, especially upland views, the layout has been designed to follow the landform and minimise visual prominence, with substantial buffer distances from residential receptors. Mitigation is embedded in the layout and siting strategy, rather than through additional visual screening. Effects on recorded archaeological sites within 2 km are assessed as ranging from imperceptible to slight and not significant. Following the implementation of embedded and additional mitigation, the residual effects in relation to shadow flicker, visual impact, telecommunications, aviation, and cultural heritage are considered not significant to slight and are acceptable within the context of the receiving environment as per the EIA Directive.

18.4 Conclusion

The Proposed Development has potential to impact on various environmental aspects as detailed throughout this EIAR. As outlined in this Chapter, there are interactions and inter-relationships between these aspects as described above. The EIAR has considered these interactions and inter-relationships throughout the assessment, firstly through the design of the Proposed Development, to avoid effects where possible and also in the definition of suitable mitigation measures to minimise potential effects. Any significant effect associated with the interactions of environmental effects outlined in this chapter will be avoided due to the implementation of mitigation measures as detailed throughout the EIAR.

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