	(Sandercock, 2003). If 22 collisions were to occur per year, it would mean that the losses at the proposed wind farm would increase the estimated annual mortality of the County population (i.e. 4,770 birds, please see Section 7.5.2 for further details) by 1.7%. The predicted collision risk is therefore low in the context of the County population. No significant effects at the International, National or County scale.		

7.10.2.3 Hen Harrier (*All Seasons*)

Table 7-15 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	The Proposed Development site is dominated by mature conifer plantation, is considered sub-optimal for breeding or wintering hen harrier. No breeding or regular roosting sites were recorded within the study area between September 2017 and September 2019. The unfavourable nature of onsite habitats (i.e. dominated by mature forestry) limits the potential for construction activities to result in ecologically significant habitat loss for hen harrier.	The magnitude of the effect is assessed as *low*. The cross tablature of a *High* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Long-term Slight Negative Effect**
Displacement	A recent assessment of the effects of a wind farm on an existing population of breeding hen harriers reported regular flights at close proximity to turbine bases (Madden & Porter 2007). This report also revealed that, although reductions in flight activity around turbines were observed during the construction phase, the activity of bird populations quickly returned to pre-construction levels. Aside from collision risk, turbine avoidance by Hen Harriers observed at one wind farm installation extended to within 250 m of turbines (Pearce-Higgins et al. 2009). This study predicted a 52% reduction in	The magnitude of the effect is assessed as *Low* The cross tablature of a *High* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Short-term Slight Negative Effect**

	breeding population within 500 m of a wind energy array but found no significant modification in flight height near turbines. However, in relation to the current proposal, no territorial and/or breeding behaviours indicative of nesting were recorded at or within the 2km survey radius of the development site boundary. The development site does not form part of the core territory for any known Hen Harrier breeding pair. The species was not found to be dependent on the development site for foraging at any time of the year. Therefore, based on the core dataset there is no potential for significant displacement effects given that hen harrier were not dependent on the habitats within the study area for roosting, foraging or breeding.		
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	In relation to the current proposal, no territorial and/or breeding behaviours indicative of nesting were recorded at or within the 2km survey radius of the development site boundary. The development site does not form part of the core territory for any known Hen Harrier breeding pair. The species was not found to be dependent on the development site for foraging at any time of the year. Therefore, based on the core dataset there is no potential for significant displacement effects given that hen harrier were not dependent on the habitats within the study area for roosting, foraging or breeding.	The magnitude of the effect is assessed as *low*. The cross tablature of a *High* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Long-term Slight Negative Effect**
Collision	The species was recorded flying within the potential collision risk zone during VP surveys. A "Random" collision risk analysis has been undertaken and full details are provided in Appendix 7-6. The collision risk has been calculated at a ratio of 0.002 collisions per year, or one bird every 434 years. The predicted collision risk is insignificant in the context of the county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of a *High* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Imperceptible Negative Effect**

7.10.2.4 Merlin (*All Seasons*)

Table 7-16 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	This species was not recorded utilising habitat within the site boundary for roosting or breeding. Significant effects are not anticipated particularly given the low levels of activity recorded. Extensive areas of suitable foraging habitat will remain post construction and there is an abundance of suitable habitat in the surrounding area. Significant effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Medium* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**
Displacement	No breeding sites were recorded within the study area. Disturbance during construction is unlikely to discourage flight activity or foraging in the vicinity of the Proposed Development particularly given the low levels of activity recorded. Significant displacement effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Medium* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Short-term Slight Negative Effect**
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	Significant effects are not anticipated particularly given the low levels of activity recorded. Extensive areas of suitable foraging habitat will remain post construction and there is an abundance of suitable habitat in the surrounding	The magnitude of the effect is assessed as *negligible*.	**Long-term Slight Negative Effect**

	area. Disturbance during operation is unlikely to discourage flight activity or foraging in the vicinity of the Proposed Development.	The cross tablature of *Medium* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	
Collision	The species was recorded flying within the potential collision risk zone on one occasion during VP surveys. A "Random" collision risk analysis has been undertaken on a precautionary basis and full details are provided in Appendix 7-6. The collision risk has been calculated at a ratio of 0.0009 collisions per year, or approximately one bird every 1,100 years. The predicted collision risk is insignificant in the context of the county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Medium* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Imperceptible Negative Effect**

7.10.2.5 Red Grouse (*All Seasons*)

Table 7-17 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	The development site is dominated by conifer plantation and does not provide significant areas of suitable habitat for red grouse. This species was not recorded utilising habitat within the site boundary for breeding. Extensive areas of suitable breeding and foraging habitat will remain post construction and there is an abundance of suitable habitat in the surrounding area. Significant effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Medium* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Imperceptible Negative Effect**

Displacement	No breeding territories were recorded within the study area with the nearest observations less than 100m from the development site boundary and approximately 400m from the proposed turbine layout. As per McGuinness et al (2015) a zone of sensitivity of 500m applies for breeding red grouse territories. There is potential for temporary displacement of grouse during construction, however, the magnitude of this impacts will be limited as the majority of observations occurred in excess of 500m to the west of the proposed development site and turbine layout. Furthermore, studies of red grouse have found that population densities recover within one year after disturbance caused by construction of wind farms (Pearce-Higgins et al. 2012). Significant effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low*. The cross tablature of *Medium* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Short-term Slight Negative Effect**
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	Red grouse show a high degree of site fidelity in Ireland (Watson and Moss 2008). Disturbance displacement can result in a significant impact if it reduces the availability of resources for red grouse. However, in the case of red grouse, operating turbines are not considered to result in significant levels of displacement (Douglas et.al 2011). In the unlikely event displacement does occur, there are extensive areas of suitable habitat in the wider area, to render this potential impact inconsequential.	The magnitude of the effect is assessed as *low*. The cross tablature of *Medium* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Long-term Slight Negative Effect**

Collision	This species was not recorded flying at the potential collision risk height during the extensive VP survey work undertaken. Collision risk is not likely to significantly impact this species based on available data.	**No Effect**	**No Effect**

7.10.2.6 Woodcock (*Breeding*)

Table 7-18 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	Roding woodcock were recorded on two separate occasions within the development site. These observations indicate that woodcock bred within the development site. The site is dominated by conifer plantation which provides suitable breeding habitat for woodcock. Extensive areas of suitable breeding and foraging habitat will remain post construction and there is an abundance of suitable habitat in the surrounding area. Significant effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low*. The cross tablature of *Medium* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Long-term Slight Negative Effect**
Displacement	Roding woodcock were recorded on two separate occasions within the development site. These observations indicate that woodcock bred within the development site. The site is dominated by conifer plantation which provides suitable breeding habitat for woodcock. Construction in forested areas could potentially cause displacement of breeding woodcock. However, two records of roding woodcock is not considered to be indicative of a site hosting a significant number of breeding woodcock. Should any potential displacement occur, this will be rendered inconsequential given the wider area contains extensive areas of forestry suitable for breeding woodcock.	The magnitude of the effect is assessed as *low*. The cross tablature of *Medium* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Short-term Slight Negative Effect**

Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	The site is dominated by conifer plantation which provides suitable breeding habitat for woodcock. However, roding woodcock were only recorded on two separate occasions within the development site. The number of roding woodcock recorded onsite is considered to be low. There are sufficiently extensive areas of suitable habitat in the wider area, to render any potential displacement effect inconsequential. Significant impacts are not predicted at any geographical scale.	The magnitude of the effect is assessed as *low*. The cross tablature of *Medium* sensitivity species and *Low* Impact corresponds to a ***Low*** effect significance	**Long-term Slight Negative Effect**
Collision	This species was not recorded flying at the potential collision risk height during the extensive VP survey work undertaken. Collision risk is not likely to significantly impact this species based on available data.	**No Effect**	**No Effect**

7.10.2.7 Buzzard (*All Seasons*)

Table 7-19 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	This species was infrequently recorded within the development site during the breeding and winter seasons. No evidence of breeding activity was recorded within the development site or 2km of the same. Significant areas of suitable nesting and foraging habitat will continue to exist within the development site.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low*	**Long-term Slight Negative Effect**

	Substantial areas of undisturbed suitable nesting and foraging habitat will remain beyond the development footprint.	Impact corresponds to a ***Very Low*** effect significance	
Displacement	Construction in forestry areas could potentially cause displacement of breeding Buzzard. There was no evidence of breeding activity within the development site or within 2km of same during either the 2018 or 2019 breeding seasons. Given the availability of potential nesting and foraging habitat in the wider area, no significant effects are anticipated. Overall, disturbance during construction is unlikely to discourage flight activity, foraging or breeding attempts in the vicinity of the Proposed Development. particularly given the low levels of activity recorded. Significant displacement effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low.* The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Short-term Slight Negative Effect**
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	The development footprint is dominated by commercial conifer plantation. Pearce Higgins (2009) describes that buzzard has been found to show significant turbine avoidance extending to at least 500m. However, this species was infrequently recorded within the development site during the breeding and winter seasons. There was no evidence of breeding activity within the development site or 2km of same during either the 2018 or 2019 breeding seasons. Extensive areas of suitable breeding and foraging habitat exist and will remain in the wider area (i.e. outside the 500m buffer zone). Significant displacement effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low.* The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**

Collision	The species was recorded flying within the potential collision risk zone during VP surveys. A "Random" collision risk analysis has been undertaken and full details are provided in Appendix 7-6. The collision risk has been calculated at a ratio of 0.119 collisions per year, or one bird every 8.4 years. The predicted collision risk is insignificant in the context of the county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Low* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**

7.10.2.8 Sparrowhawk (*All Seasons*)

Table 7-20 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	The proposed development area is dominated by mature forestry, this could provide breeding and foraging habitat for sparrowhawk. This species was only observed within the development site on two occasions throughout the extensive 25-month survey period. Both observations occurred during the 2019 breeding season. No evidence of breeding was recorded within the development site. Whilst felling of forestry will occur onsite, significant areas of suitable nesting habitat will continue to exist within the development site. Significant displacement effects are not anticipated, particularly given the low levels of activity recorded.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**
Displacement	No evidence of breeding was recorded within the development site. A possible nest site was identified in June 2019, approximately 750m east of the development site. Construction in forested areas could potentially cause displacement of breeding Sparrowhawk. However, the only nest recorded in	The magnitude of the effect is assessed as *low*.	**Short-term Slight Negative Effect**

	the vicinity of the proposed development is unlikely to be impacted due to the c. 700m separation distance between it and any potential source of disturbance. Furthermore, the wider surroundings contain extensive areas of similar suitable habitat in the unlikely event that any disturbance occurs. Overall, disturbance during construction is unlikely to discourage flight activity, foraging or breeding attempts in the vicinity of the Proposed Development, particularly given the low levels of activity recorded. Significant displacement effects are not anticipated at any geographical scale.	The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	Significant effects are not anticipated particularly given the low levels of activity recorded. Disturbance from operation is unlikely to discourage breeding attempts and the species is expected to habituate to the operation of the development.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**
Collision	The species was recorded flying within the potential collision risk zone during VP surveys. A "Random" collision risk analysis has been undertaken and full details are provided in Appendix 7-6. The collision risk has been calculated at a ratio of 0.009 collisions per year, or one bird every 107 years. The predicted collision risk is insignificant in the context of the county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Low* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Imperceptible Negative Effect**

7.10.2.10 Kestrel (*All Seasons*)

Table 7-21 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	The Proposed Development site is dominated by conifer plantation, with small areas of potential foraging habitat around the margins of the site. Direct loss of breeding and foraging habitat will be minimal. There will be minimal reduction in the distribution and availability of potential nesting sites and minimal loss of potential foraging area. Substantial areas of undisturbed suitable breeding and foraging habitat will remain, both within the development site and the wider area. Significant effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low*. The cross tablature of a *Low* sensitivity species and a *Low* Impact corresponds to a ***Very Low*** effect significance.	**Long-term Slight Negative Effect**
Displacement	Construction in forestry areas could potentially cause displacement of breeding kestrel. However, given the availability of extensive areas of alternative nesting sites in the wider area no significant effects are anticipated. Overall, disturbance during construction is unlikely to discourage flight activity, foraging or breeding attempts in the vicinity of the Proposed Development. Significant displacement effects are not anticipated at any geographical scale.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *low* Impact corresponds to a ***Very Low*** effect significance	**Short-term Slight Negative Effect**
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**

Displacement	Significant effects are not anticipated at any geographical scale. Extensive areas of suitable foraging and breeding habitat will remain post construction. Disturbance from operation is unlikely to discourage breeding attempts and the species is expected to habituate to the operation of the development.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**
Collision	The species was recorded flying within the potential collision risk zone during VP surveys. A "Random" collision risk analysis has been undertaken and full details are provided in Appendix 7-6. The collision risk has been calculated at a ratio of 0.118 collisions per year, equating to one bird every 8.5 years. The predicted collision risk is insignificant in the context of the county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Low* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**

7.10.2.11 Snipe (*All Seasons*)

Table 7-22 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development	Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase		
Direct Habitat Loss	The Proposed Development area is dominated by conifer plantation, this habitat type is not favoured by snipe. Direct loss of breeding and foraging habitat will therefore be minimal. Snipe were regularly recorded during VP surveys, with observations primarily of drumming or calling snipe during the breeding season. There were five breeding territories identified through these observations of calling and	The magnitude of the effect is assessed as *low*. The cross tablature of a *Low* sensitivity species and a *Low* Impact corresponds to a ***Very Low*** effect significance.	**Long-term Slight Negative Effect**

	drumming snipe. Of these five breeding territories, only three were located within 500m of the development site, while only one breeding territory was located within 500m of the proposed turbine layout. There will be minimal reduction in the distribution and availability of potential nesting sites and minimal loss of potential foraging area. Significant impacts are therefore not predicted at any geographical scale.		
Displacement	The Proposed Development site is dominated by conifer plantation, with small areas of open habitat suitable for snipe is present in the margins of the site. There were five breeding territories identified through these observations of calling and drumming snipe. Of these five breeding territories, only three were located within 500m of the development site, while only one breeding territory was located within 500m of the proposed turbine layout. Overall, the numbers recorded were considered to be low and restricted to the margins of the site. Should any potential displacement effects occur, there are extensive areas of suitable habitat in the wider area, to render this potential impact inconsequential.	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Short-term Slight Negative Effect**
Operational Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	Pearce Higgins et. al (2009), found that breeding snipe showed significant avoidance of turbines extending to a distance of 400m. There were five breeding territories identified through these observations of calling and drumming snipe. Of these five breeding territories, only three were located within 500m of the development site, while only one breeding territory was located within 500m of the proposed turbine layout. However, given the overall numbers recorded were low, the distance of the observed breeding territories from the proposed development site and the	The magnitude of the effect is assessed as *low*. The cross tablature of *Low* sensitivity species and *Low* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**

	availability of potential alternative breeding and foraging habitat in the wider area, significant effects are not anticipated at any geographical scale.		
Collision	The species was recorded flying with the potential collision risk zone during VP surveys. A "Random" collision risk analysis has been undertaken and full details are provided in Appendix 7-6. It is acknowledged that Snipe are primarily crepuscular in their flight activity and the vantage point surveys are primarily diurnal. Flight activity has the potential to be under recorded and this has been taken into account in this assessment The collision risk has been calculated at a ratio of 0.097 collisions per year, or one bird every 10.3 years. Even allowing for any potential for under recording of flight activity, the predicted collision risk is insignificant in the context of the local, county, national and international population.	The magnitude of the effect is assessed as *negligible*. The cross tablature of *Low* sensitivity species and *Negligible* Impact corresponds to a ***Very Low*** effect significance	**Long-term Slight Negative Effect**

7.10.3 Effects on Key Ornithological Receptors during Decommissioning

7.10.3.1 All Species

Table 7-23 Impact Characterisation for Ecological Receptors based on Percival (2003) & EPA (2017)).

Analysis of potential effects during construction and operational phases of the Proposed Development		Magnitude and Significance of potential effect (Percival 2003)	Significance of potential effect (EPA 2017)
Construction Phase			
Direct Habitat Loss	Direct or indirect effects are not anticipated	**No Effect**	**No Effect**
Displacement	As above for construction phase for each species listed as a KOR.	As above for construction phase for each KOR	As above for construction phase for each KOR

7.11 Effect Associated with the Grid Connection and Access Road Route

The site of the proposed development is currently accessed, from the R280 to the west, via the local road network. This application includes for the construction of:

- a link road between the R280 in the village of Drumkeeran and the L4282 in the townland of Derryboffin. The road will be constructed through agricultural land and will be left in place and the embankments of the road will be seeded or be allowed to revegetate; and,
- a construction phase access road between the L4282 at Derrycullinan and the same local road at Bargowla. From the proposed construction phase site entrance in the townland of Derrycullinan, the construction access road will comprise a combination of proposed new roads and the upgrade of existing forestry roads.

The cabling routes, assessed as part of this EIAR, will originate at the proposed onsite substation and will run east along the existing site roads and local access roads, within Coillte property, to the existing Garvagh Electricity Substation, located within the site in the townland of Seltan.

The potential for the grid connection and access road route to impact birds is discussed below.

The existing habitats (e.g. existing roads, forestry fire breaks and agricultural land) have the potential to support species of conservation interest in the area. On a precautionary basis it is assumed that some habitat loss and temporary displacement may occur during construction works. However, given the extent of suitable habitat in the wider area; significant habitat loss and displacement effects are not predicted.

As per Percival (2003) the magnitude of the effect on KOR is assessed as ***Negligible***. The cross tablature of a *High* sensitivity species (e.g. hen harrier) and *Negligible* Impact corresponds to a ***Very Low*** effect significance. Hen harrier was used as an example as it is the highest sensitivity species identified as a KOR at this site. The significance of the potential impact is classed as a Long-term slight negative effect following EPA criteria (2017).

7.12 Effects on Designated Areas

The Proposed Development is not located within the boundaries of any European or Nationally designated sites important for nature conservation (Figure 6.X). There will be no direct effects on any designated site as a result of the construction, operation and decommissioning of the Proposed Development.

In relation to European sites, an AA Screening Assessment and Natura Impact Statement have been prepared to provide the competent authorities with the information necessary to complete an Appropriate Assessment for the proposed development in compliance with Article 6(3) of the Habitats Directive.

As per EPA draft Guidance 2017, "a biodiversity section of an EIAR, should not repeat the detailed assessment of potential effects on European sites contained in a Natura Impact Statement" but should "incorporate their key findings as available and appropriate". This section provides a summary of the key assessment findings with regard to Special Protection Areas . A summary of key assessment findings with regard to Special Areas of Conservation is provided in Chapter 6.

The Screening for Appropriate Assessment concluded as follows:

'it cannot be excluded beyond reasonable scientific doubt, in view of best scientific knowledge, on the basis of objective information and in light of the conservation objectives of the relevant European sites, that the proposed development, individually or in combination with other plans and projects, would be likely to have a significant effect on the following sites:

- Lough Gill SAC [001976]
- Cummeen Strand/Drumcliff Bay (Sligo Bay) SAC (000627)
- Cummeen Strand SPA (004035)'

As a result, an Appropriate Assessment of the proposed development is required, and a Natura Impact Statement has been prepared in respect of the proposed development. The Natura Impact Assessment concludes as follows:

For the reasons set out in detail in this NIS, in the light of the best scientific knowledge in the field, all aspects of the proposed development which, by itself, or in combination with other plans or projects, which may affect the relevant European Sites have been considered. The NIS contains information which the competent authority, may consider in making its own complete, precise and definitive findings and conclusions and upon which it is capable of determining that all reasonable scientific doubt has been removed as to the effects of the proposed development on the integrity of the relevant Natura 2000 sites.

In conclusion, in the light of the conclusions of the assessment which it shall conduct on the implications for the European sites concerned, the competent authority is enabled to ascertain that the proposed development will not adversely affect the integrity of any of the European sites concerned.

7.13 Mitigation and Best Practice Measures

This section describes the measures that are in place to mitigate adverse negative effects associated with the Proposed Development on avian receptors. Effects on avian receptors have been addressed in two ways:

- Design of the Proposed Development.
- Management of the development phases.

7.13.1 Mitigation by Design

The project design has followed the basic principles outlined below to eliminate the potential for significant effects on avian receptors:

- Hard standing areas have been designed to the minimum size necessary to accommodate the turbine model that is selected.
- The grid connection route, internal roads and access road has been selected to utilise built infrastructure for the majority of its length (i.e. cables to be laid within public roads). Cables will be laid underground to avoid effects on roadside hedgerows and disturbance to nesting birds.

7.13.2 Mitigation During Construction, Operation and Decommissioning

The following section describe the mitigation measures to be implemented during each phase of the Proposed Development.

7.13.2.1 Construction Phase Mitigation

The following measures are proposed for the construction phase:

- A Construction and Environmental Management Plan (CEMP) has been prepared. The CEMP will be in place prior to the start of the construction phase. Best practice measures which form part of the design of the project are included in Chapter 4 of the EIAR. The CEMP is included as an Appendix to Chapter 4.
- All removal of woody vegetation will be undertaken in accordance with Section 40 of the Wildlife Act 1976 as amended.
- During the construction phase, noise limits, noise control measures, hours of operation (i.e. dusk and dawn is high faunal activity time) and selection of plant items will be considered in relation to disturbance of birds.
- Plant machinery will be turned off when not in use.
- All plant and equipment for use will comply with the Construction Plant and Equipment Permissible Noise Levels Regulations 1996 (SI 359/1996) and other relevant legislation.
- An Ecological Clerk of Works (ECoW) will be appointed. Duties will include:
    - Undertake a pre-construction transect/walkover bird survey to confirm the conditions predicted in this EIAR and ensure that significant effects on breeding birds will be avoided.
    - Inform and educate on-site personnel of the ornithological and ecological sensitivities within the Proposed Development site.
    - Oversee management of ornithological and ecological issues during the construction period and advise on ornithological issues as they arise.
    - Provide guidance to contractors to ensure legal compliance with respect to protected species onsite.
    - Liaise with officers of consenting authorities and other relevant bodies with regular updates in relation to construction progress.

7.13.2.2 Operational Phase Mitigation

No operational phase impacts requiring mitigation were identified.

7.13.2.3 Decommissioning Phase Mitigation

The following measures are proposed for the decommissioning phase:

- During the decommissioning phase, disturbance limitation measures will be as per the construction phase, e.g. commencing works outside the bird nesting season (1st of March to 31st of August inclusive).
- Plant machinery will be turned off when not in use.
- All plant and equipment for use will comply with the Construction Plant and Equipment Permissible Noise Levels Regulations (SI 359/1996).

7.14 Enhancement

It is proposed to provide ecological benefits in the form of a peatland restoration strategy. The plan objective is to pre-maturely fell an area of forestry adjacent, and to the west of turbine T7 and instate restoration measures e.g. drain blocking. This area would otherwise continue to be managed for commercial forestry. In addition to this pre-mature felling, an area of degraded peatland adjacent, and to the north of turbine T7 will be enhanced. Enhancement measures will include drain blocking and removal of self-sown conifer seedlings from adjacent forestry. The proposed enhancement area is

approximately 3.74 hectares. These two areas abut one another and will result in a significant increase in the amount of contiguous open habitat present onsite. Details in full are provided in Appendix 6.4.

This newly created open habitat would be maintained as such for the duration of the operational phase of the wind farm. The proposed peatland and biodiversity restoration area will provide significant benefits to the local avian community.

7.15 Monitoring

7.15.1 Commencement and Pre-Construction Monitoring

Taking a precautionary approach, it is proposed that construction works will commence outside the bird nesting season (1st of March to 31st of August inclusive). Pre-commencement surveys will be undertaken prior to the initiation of works at the wind farm.

A breeding bird survey will be undertaken between April and July. Monitoring will be undertaken by a suitably qualified ornithologist. The survey will include a thorough walkover survey to a 500m radius of the development footprint and/or all works areas, where access allows. If breeding activity of birds of high conservation concern is identified, the nest site will be located, and earmarked for monitoring at the beginning of the first breeding season of the construction phase. If it is found to be active during the construction phase no works shall be undertaken within a 500m buffer (Forestry Commission Scotland 2006; Ruddock & Whitfield 2007) in line with best practise. No works shall be permitted within the buffer until it can be demonstrated that the nest is no longer occupied.

7.15.2 Post Construction Monitoring

A detailed post-construction Bird Monitoring Programme has been prepared for the operational phase of the Proposed Development, please refer to Appendix 7.7 for further details. The programme of works will monitor parameters associated with collision, displacement/barrier effects and habituation and these surveys will be scheduled to coincide with Years 1, 2, 3, 5, 10 & 15 of the life-time of the wind farm. Monitoring measures are broadly based on guidelines issued by the Scottish Natural Heritage (SNH, 2009). The following individual components are proposed for monitoring years:

- Monthly flight activity surveys: vantage point surveys
- Distribution and abundance surveys: breeding wader to a 500m radius of the development area, breeding hen harrier surveys and winter hen harrier roost surveys to a 2km radius of the development area.
- Targeted bird collision surveys (corpse searches) will be undertaken with training dogs. The surveys will include detection and scavenger trials, to correct for these two biases and ensure the resulting data is robust.

7.17 Residual Effects

The following species were identified as KORs and were subject to detailed impact assessment:

- Whooper Swan
- Golden Plover
- Hen Harrier
- Merlin
- Buzzard
- Sparrowhawk
- Kestrel
- Snipe

As per Percival 2003 criteria, effect significance of greater than ***Low*** was not identified for any KOR.

As per EPA 2017 criteria, effect significance of greater than ***Slight*** was not identified for any KOR.

Taking into consideration the effect significance levels identified and the proposed best practice and mitigation; significant residual effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

7.18 Assessment of Cumulative Effects

As per SNH guidance on Assessing the Cumulative Impacts of onshore Wind Energy Developments (2012), cumulative effects arising from two or more developments may be:

- **Additive** (i.e. a multiple independent additive model)
- **Antagonistic** (i.e. the sum of impacts are less that in a multiple independent additive model)
- **Synergistic** (i.e. the cumulative impact is greater than the sum of the multiple individual effects)

7.18.1 Other Plans and Projects

Assessment material for this in combination impact assessment was compiled on the relevant developments within the vicinity of the proposed project. The material was gathered through a search of relevant online Planning Registers, reviews of relevant EIS/EIAR documents, planning application details and planning drawings, and served to identify past and future projects, their activities and their environmental impacts. The projects considered in relation to the potential for in combination effects and for which all relevant data was reviewed (e.g. individual EISs/EIARs, layouts, drawings etc.) include those listed below.

Forestry Practices

The majority of the lands within the site and the surrounding area are planted with commercial forestry. The forestry works (felling/planting) associated with the forestry in the wider surroundings of the proposed development will be subject to relevant licencing and guidance from the Forestry Service. The management and felling of this surrounding commercial forestry was also considered in this assessment.

7.18.2 Plans Considered in the Cumulative Impact Assessment

The following plans were considered in the cumulative impact assessment:

- Leitrim County Development Plan 2015-2021
- Sligo County Development Plan 2017–2023
- National Biodiversity Action Plan 2017-2021

These policies and objectives of these plans have been taken into account in this cumulative assessment.

7.18.3 Projects Considered in the Cumulative Impact Assessment

A review of the Planning Register for Leitrim and Sligo County Council's show that there has been a number of permitted or existing developments within the vicinity of the proposed development area. A full list of the projects considered in relation to cumulative effects are provided in Section 2.4 of Chapter 2 of this EIAR. Planning applications lodged within the wider surroundings of the proposed development area primarily relate to one-off housing or are agricultural in nature. Owing to the nature and scale of these developments significant cumulative or in-combination effects are not anticipated.

There are a number of previous applications for wind farm development and associated infrastructure. The wind farm projects within a 20-kilometre radius of Croagh Wind Farm proposal are provided in Table 7-22 below and are presented in terms of whether the project is permitted/operational or pending/under appeal. A total of 14 wind farms, and 111 existing/permitted turbines fall within a 20-kilometre radius of the proposal as detailed in Table 7-22.

Table 7-22 Wind Farms within 20km of the development site

Wind Farm	Status	No. of Turbines	Distance from development site (km)
Co. Leitrim			
Spion Kop (Ref. 95/12501)*	Constructed	2	3.2
Corrie Mountain (Ref. 96/12794)	Constructed	8	2.3
Black Banks (Ref. 97/13602)	Constructed	12	Partially within
Moneenatieve (Ref. 00/7)	Constructed	6	1.8
Garvagh Glebe (Ref. 03/257, 08/602)	Constructed	13	Partially within
Tullynamoyle (Ref. 03/331)	Constructed	12	7.5
Tullynamoyle Extension (Ref. 15/164)	Permitted	4	7.6

Wind Farm	Status	No. of Turbines	Distance from development site (km)
Tullynamoyle Extension (Ref. 19/26)	Permitted	4	7.6
Carrickheeney (Ref. 12/152)	Constructed	12	19
Co. Sligo			
Carrane Hill (Ref. 98/533)	Constructed	4	0.6
Geevagh (Ref. 98/861)	Constructed	6	1
Derrysallagh (Ref. 12/133)	Constructed	12	3.7
Co. Roscommon			
Altagowlan (Ref. 00/1979)	Constructed	9	3.2
Seltannaveeny (Ref. 02/1094)	Constructed	2	5.7
Garvagh Tullyhaw (Ref. 03/1486)	Constructed	11	4.3
Kilronan (Ref. 94/582)	Constructed	10	7.4
TOTAL EXISTING		107	
TOTAL PROPOSED		111	

**The recent grant of planning permission for the replacement of the two existing Spion Kop turbines with a single turbine (LCC 19/230) has been considered in the cumulative assessment.*

For the purposes of this cumulative assessment wind farms within a 10-kilometre radius of the proposed development area were considered in further detail below. All of the wind farms included in Table 7-22 are located within 10km of the proposed development with the exception of Carrickheeney wind farm. This wind farm was considered to have been too distant from the proposed development to result in cumulative impacts and was therefore not considered further.

Black Banks, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Black Banks wind farm, which is located partially within the site boundary to the south-east, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Black Banks wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Garvagh Glebe, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Garvagh Glebe wind farm, which is located partially within the site boundary to the east, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Garvagh Glebe wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Carrane Hill, Co. Sligo

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Carrane Hill wind farm, which is located 600m from the wind farm site, was considered. The planning file was reviewed on the Sligo County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Carrane Hill wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Geevagh, Co. Sligo

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Geevagh wind farm, which is located 1km from the wind farm site, was considered. The planning file was reviewed on the Sligo County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Geevagh wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Moneenatieve, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Moneenatieve wind farm, which is located 1.8km from the wind farm site, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Moneenatieve wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed

Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Corrie Mountain, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Corrie Mountain wind farm, which is located 2.3km from the wind farm site, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Corrie Mountain wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Spion Kop, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Spion Kop wind farm, which is located 3.2km from the wind farm site, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Spion Kop wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Altagowlan, Co. Roscommon

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Altagowlan wind farm, which is located 3.2km from the wind farm site, was considered. The planning file was reviewed on the **Roscommon** County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Altagowlan wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Derrysallagh, Co. Sligo

Derrysallagh is the next closest wind farm to the proposed development, located approximately 3.7km to the south. The EIS was consulted to determine whether cumulative impacts are likely to result. The EIS identifies the following Key receptors on site: golden plover, hen harrier, merlin and red grouse. The EIS concluded that "no likely collision impacts have been identified and it is not considered that the presence of other turbines in the general area will contribute to any significant cumulative effect in this regard." This assessment did not identify any likely significant displacement effect on birds of the proposed wind farm, given the existence of large areas of suitable habitat at alternative locations in the vicinity of the study area, for example, for migratory and/or wintering flocks of golden plover. It was concluded that whilst a cumulative displacement effect on non-breeding golden plover or other species from upland areas in the vicinity of these wind farms may occur, it is not considered that this is of significance.

No significant residual effects on avian receptors were identified. Based on the information available in the EIS, significant cumulative impacts are not anticipated.

Garvagh Tullyhaw, Co. Roscommon

Garvagh Tullyhaw is the next closest wind farm to the proposed development, located approximately 4.3km to the south-east. The EIS was consulted to determine whether cumulative impacts are likely to result. The EIS concluded that "taking into account the location of the windfarm, the extent of lands involved, the size of the development, research undertaken elsewhere, available information on bird populations in the area and site visits, there is no strong evidence to indicate that the development will have anything other than a minimal impact on birds."

No significant residual effects on avian receptors were identified.

Based on the information available in the Garvagh Tullyhaw EIS, significant cumulative impacts are not anticipated.

Seltannaveeny, Co. Sligo

Seltannaveeny is the next closest wind farm to the proposed development, located approximately 5.7km to the south-east. A compilation of a formal EIS was not mandatory as the proposed development was below the statutory threshold (5 turbines or 5MW). However, given the location of the Seltannaveeny wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Kilronan, Co. Roscommon

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Kilronan wind farm, which is located 7.4km from the wind farm site, was considered. The planning file was reviewed on the **Roscommon** County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Kilronan wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Tullynamoyle, Co. Leitrim

The potential for the proposed development to result in significant cumulative or in combination effects when assessed alongside Tullynamoyle wind farm, which is located 7.5km from the wind farm site, was considered. The planning file was reviewed on the Leitrim County Council Planning Register and no information regarding potential effects on bird species was available. However, given the location of the Tullynamoyle wind farm, the nature of the habitats on that site (as reviewed on publicly available aerial photography) and the lack of significant residual impacts on bird species associated with the proposed Croagh Wind Farm when considered on its own, significant cumulative or in-combination effects are not anticipated.

Taking into consideration the effect significance levels identified for the proposed Croagh Wind Farm (i.e. no effect significance of greater than ***Low*** (Percival 2003) or ***Slight Negative*** (EPA 2017)), significant cumulative effects on KORs with regard to direct habitat loss, displacement or collision mortality are not anticipated.

Tullynamoyle Extension (Ref. 15/164), Co Leitrim

Tullynamoyle Extension is located approximately 7.6km to the north-east of the proposed development area. The EIS was consulted to determine whether cumulative impacts are likely to result. The EIS stated that "sensitive species known to occur or recorded in the area include red grouse, golden plover, merlin, hen harrier and common gull." However, the EIS concluded that "the proposed development is not likely to result in significant impacts to these species due to the sub-optimal nature of the habitats occurring within the site for these species and their flight behaviour, which has not been recorded in association with the proposed site and which is unlikely to bring these species into contact with turbine blades."

No significant residual effects on avian receptors were identified. Based on the information available in the Tullynamoyle Extension EIS, significant cumulative impacts are not anticipated.

Tullynamoyle Extension (Ref. 19/26), Co Leitrim

The 2019 Tullynamoyle Extension application is located approximately 7.6km to the north-east of the proposed development area. The EIS was consulted to determine whether cumulative impacts are likely to result. The EIS identifies the following Key receptors on site: hen harrier, kestrel, buzzard, golden plover, red grouse, common snipe, meadow pipit and skylark. This assessment identified only low significant displacement effects on the avian population of the proposed wind farm. Collision risk was identified as being of low significance, or lower, at the proposed wind farm site.

No significant residual effects on avian receptors were identified. Based on the information available in the EIS, significant cumulative impacts are not anticipated.

7.18.3.1 Existing Habitats and Land Uses

The potential for the proposed development to result in a cumulative loss or deterioration of habitats for birds was considered in relation to the existing land uses in the area.

The wind farm is primarily located in forestry habitats, which generally provide low value habitats for bird species. The proposed development will not result in any significant loss of valuable habitats for birds e.g. upland peatland or grassland. The minor loss of peatland habitat that will be affected, will be fully mitigated through habitat enhancement and restoration proposed as part of this development. The

wind farm will not contribute to any overall loss of high value bird habitat, it has been deliberately designed to be located on habitats of low value for bird species.

7.18.3.2 Cumulative Impact Assessment Conclusion

Important migratory routes for any species were not identified in any of the assessments undertaken and no significant short term or daily migrations over the site were identified. There is no potential for the proposed development to result in significant cumulative barrier effect when considered on its own. It cannot therefore contribute to any cumulative barrier effect.

No potentially significant disturbance, displacement or habitat loss effects on any of the KORs has been identified with regard to the development proposal on its own. It cannot therefore contribute to any cumulative disturbance, displacement or habitat loss.

The proposed development does not have the potential to result in significant collision risk on any KOR species when considered on its own. It cannot therefore contribute to any cumulative collision risk when considered in combination with any other development.

No cumulative residual additive, antagonistic or synergistic effects have been identified with regard to habitat loss, displacement or collision mortality for any KOR.

7.19 Conclusion

Following consideration of the residual effects (post mitigation) it is concluded that the Proposed Development will not result in any significant effects on any of the identified KORs. No significant effects on receptors of International, National or County Importance were identified.

Provided that the Proposed Development is constructed, operated and decommissioned in accordance with the design, best practice and mitigation that is described within this application, significant individual or cumulative effects on ornithology are not anticipated at the international, national or county scales or on any of the identified KORs.

8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential impacts of a proposed 10 no. turbine wind farm including its grid connection at Croagh, Drumkeeran, Co. Leitrim (the 'Proposed Development') on the land, soil and geological environment.

This report provides a baseline assessment of the environmental setting of the proposed development and all other associated works, as described in Chapter 4 of the EIAR, in terms of land, soils and geology and discusses the potential likely significant, direct,indirect and cumulative effects that the construction, operation and decommissioning of the proposed development will have. Where required, appropriate mitigation measures to avoid any identified effectsto land, soils and geology are recommended and the residual effects of the proposed development post-mitigation are assessed.

8.1.2 Statement of Authority

HES are a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience includes soils, subsoils and geology. We routinely complete impact assessments for land soils and geology, hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by Michael Gill and David Broderick.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. In addition, he has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, Carrownagown WF (SID) and Meenbog WF (SID).

David Broderick (BSc, H Dip Env Eng, MSc) is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on many wind farm EIAR projects, including Cloncreen WF, Oweninny WF (SID), and Meenbog WF (SID).

Michael and David have worked on over 120 wind farm related projects across Ireland and Northern Ireland over the last 12 years.

8.1.3 Relevant Guidance

The land, soils and geology chapter of this EIAR was prepared having regard, where relevant, to the legislation and guidance outlined in Chapter 1: Introduction and the following documents:

- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes; and,
- University College Dublin (2012) BOGLAND – Protocol for Sustainable Peatland Management in Ireland.

8.2 Schedule of Works

8.2.1 Desk Study

A desk study of the site and the surrounding area was completed in advance of undertaking the walkover survey and site investigations. This involved collecting all relevant geological data for the site and surrounding area. This included consultation of the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 7 (Geology of Sligo - Leitrim). Geological Survey of Ireland (GSI, 1996);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets; and,
- General Soil Map of Ireland 2nd edition (www.epa.ie);

8.2.2 Baseline Monitoring and Site Investigations

Detailed walkover surveys, geological mapping and peat/soil augering was undertaken by HES on 3rd and 4th April 2018 with follow up visits carried out on 4th and 11th November 2018, 6th September 2019 and 13th March 2020.

Trial pit investigations (40 no. trial pits over 3 phases – 2017, 2019 and 2020) and bedrock investigation drilling in 2019 was completed by Fehily Timoney and Company - FT formally called AGEC Ltd). Trial pits Phase 1 and Phase 2 were carried out along the internal site access roads and Phase 3 was carried out along the proposed construction access road The trial pits were strategically placed to get an understanding of the soil and bedrock conditions across the proposed development site.

The objectives of the intrusive site investigations included mapping the distribution and depth of blanket peat at the site along with assessing the mineral subsoil / bedrock interface beneath the peat at key development locations (i.e. proposed turbines & met mast, substation, temporary construction compounds, existing and proposed access roads, peat and spoil repository areas and borrow pit location). These thorough investigations allowed the development of an accurate geological conceptual model of the site.

In summary, site investigations to address the land, soil and geology section of the EIAR included the following:

- A total of over 850 no. peat probe depths were carried out by HES, MKO and FT, between 2013 and 2020, to determine the depth and geomorphology of the blanket peat at the site;

- Gouge soil cores were undertaken at each turbine location to investigate peat and mineral subsoil lithology;
- A geotechnical assessment of peat stability by FT (March 2020);
- Logging and supervision of 40no. trial pits across the site (2017, 2019 and 2020 investigations) and laboratory testing of bulk samples from trial pits;
- Drilling of 4 no. bedrock boreholes at the site to investigate potential borrow pit locations and laboratory testing of rock samples from boreholes;
- Logging of bedrock outcrops and subsoil exposures; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

The Peat Stability Assessment report prepared by FT is included as Appendix 8-1 of this EIAR.

8.2.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.6 of this EIAR. Certain issues and concerns highlighted with respect land, soils and geology are summarised in Table 8-1 below.

Table 8-1 Summary of Scoping Responses Relating to Land, Soils and Geology

Degree/Nature	Description	Addressed in Chapter Section
Health Services Executive (HSE)	• HSE welcomes detailed studies and proposed mitigation measures in relation to peat stability particularly at construction but also at other later stages of the life of the site.	Sections 8.3.8 & 8.5.3.4
Inland Fisheries Ireland (IFI)	• IFI is seriously concerned over the potential for landslides in this area, based on the occurrence of two landslides in close proximity to this site which resulted in significant damage to the fisheries resource and water quality in the Owengar River. The Geological Survey of Ireland have also identified numerous landslides in this area, indicating significant risks from activities involving large scale earth works such as windfarms.	Sections 8.3.8 & 8.5.3.4 Refer also the Water Chapter (Chapter 8) with regard the Owengar River and potential impacts
Irish Peatland Conservation Council (IPCC)	• There is a risk landslide events may occur within the locality of the proposed wind farm. Landsides are disastrous for wildlife (aquatic and terrestrial) . • Most of the footprint of the proposed windfarm is situated on peat soils. Peat is very sensitive to development and will require extra stringent planning procedures	Sections 8.3.8, 8.3.2 & 8.5.3.4

Degree/Nature	Description	Addressed in Chapter Section
	• Planning and construction in, or within close proximity to peatland habitat should adhere to the Environmental Protection Agency funded project BOGLAND (www.ucd.ie/bogland). This project recommends the best practice guidelines to ensure no damage from development occurs on, or affects peat soils and peatlands of conservation/biodiversity value.	
Department of Culture Heritage and Gaeltacht	• In order to assess impacts it may be necessary to obtain hydrological and/or geological data. Any impact on water table levels or groundwater flows may impact on wetland sites some distance away. The EIAR should assess cumulative impacts with other plans or projects if applicable. Where negative impacts are identified suitable mitigation measures should be detailed as appropriate	Section 8.3.2 Refer to Chapter 9 (Hydrology/Hydrogeology)

8.2.4 Impact Assessment Methodology

Using information from the desk study and data from the site investigation, an estimation of the importance of the land, soil and geological environment within the study area is assessed using the criteria set out in Table 8-2 (NRA, 2008).

Table 8-2-Estimation of Importance of Soil and Geology Criteria (NRA, 2008).

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying attributeis significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and/or soft organic soil underlying site is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site). Well drained and/or highly fertility soils. Moderately sized existing quarry or pit Marginally economic extractable mineral resource.
Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and/or soft organic soil underlying site is moderate on a local scale.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed Wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit. Sub-economic extractable mineral Resource.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and/or soft organic soil underlying site is small on a local scale.	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral Resource.

The guideline criteria (EPA, 2017) for the assessment of impacts require that likely impacts are described with respect to their extent, magnitude, complexity, probability, duration, frequency, reversibility and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment are those set out in EPA (2017) Glossary of Impacts as shown in Chapter 1 of this EIAR. In addition, the two

impact characteristics proximity and probability are described for each impact and these are defined in Table 8-3.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of impacts are related to examples of potential impacts on the hydrology and morphology[1] of the existing environment, as listed in Table 8-4.

Table 8-3: Additional Impact Characteristics.

Impact Characteristic	Degree/ Nature	Description
Proximity	Direct	An impact which occurs within the area of the proposed project, as a direct result of the proposed project.
	Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Low	A low likelihood of occurrence of the impact.
	Medium	A medium likelihood of occurrence of the impact.
	High	A high likelihood of occurrence of the impact.

Table 8-4: Impact descriptors related to the receiving environment.

Impact Characteristics		Potential Geological, Hydrogeological and Hydrological Impacts
Quality	Significance	
Negative only	Profound	Widespread, permanent impact on: › The extent or morphology of a cSAC. › Regionally important aquifers. › Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread, time dependent impacts on: › The extent or morphology of a cSAC / ecologically important area. › A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). › Extent of floodplains. Widespread permanent impacts on the extent or morphology of an NHA/ecologically important area. Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.

[1] *Geological Form or Structure*

Impact Characteristics		Potential Geological, Hydrogeological and Hydrological Impacts
Quality	Significance	
Positive or Negative	Moderate	Local, time dependent impacts on: › The extent or morphology of a cSAC / NHA / ecologically important area. › A minor hydrogeological feature. › Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local, perceptible, time dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.3 Existing Environment

8.3.1 Site Description and Topography

The core of the Proposed Development site (EIAR Site Boundary) is located approximately 5 kilometres west of Drumkeeran, Co. Leitrim, however a portion of the construction access road extends out to the village itself. The total study area is approximately 670 ha (~6.7km^2). The site setting is forested upland blanket bog which is owned by Coillte(forestry currently covers approximately 86% of the site). The site is accessible via a network of existing forestry tracks.

Current main access to the site is via a small local road (L4282) which runs from Drumkeeran towards the site. This road then turns south towards Boleymaguire and the southern tip of the site, where access can be gained at various forestry barriers.

The proposed construction access road for the wind farm commences from the R280 at Drumkeeran, approximately 5km to the east of the main site area and traverses private land, public roads and Coillte property (with some short sections in third party lands) before emerging onto the local road where itapproaches the core wind farm site.

The overall elevation of the site ranges between approximately 70m to 330m OD (Ordnance Datum) with the northern section of the site sloping in a northerly direction and the southern section of the site sloping to the southwest.

There is 1 no. proposed grid route, along with 1 no. proposed substation. The proposed substation is located approximately 330 metres east of Turbine No. 4 along an existing access road. From here, the proposed underground grid connection cabling route runs southeast along existing forestry roads for approximately 4.1 km before turning north and following the public road for approximately 1.9km and connecting with the existing Garvagh Glebe 110kV substation.

8.3.2 Soils and Subsoils

The published soils map (www.epa.ie) for the area is attached as Figure 8-1. Blanket peat is the dominant soil type at the site with areas of poorly drained mineral soils with peaty topsoil derived from mainly acidic parent materials (AminPDPT) being present in areas of outcropping bedrock on the northern section of the site and in areas towards the southern and eastern edges of the site. A small area of shallow reasonably drained mineral soil derived from mainly acidic parent materials (AminSRPT) is mapped also. The dominant soil type along the site entrance/turbine delivery road is poorly draining mineral soil (AminPD).

A map of the local subsoil cover is attached as Figure 8-1 (www.gsi.ie). This shows the mapped distribution of subsoil deposits around the site. The map also shows bedrock outcropping on a small area towards the south of the site.

The majority (>80%) of the site is mapped as Blanket peat. An area of the site is mapped as Tills derived from Namurian sandstones and shales (TNSSs), this is mainly along the site construction access road from the R280 and around the banks of the Killanummery Stream and Cashel Stream at the north of the site. A localised area of bedrock outcrop or subcrop is mapped at the very southern end of the site.

A total of over 850 no. peat probes were undertaken by HES, FT and MKO within the Proposed Development footprint area (summary peat depth maps are shown as Figure 8-2 and Figure 8-3).

Peat depths recorded within the proposed infrastructure envelope ranged from 0 to 6.0m with an average of 2.1m. Peat depths recorded at the turbine locations varied from 0.3 to 4.5m with an average depth of 2.0m.

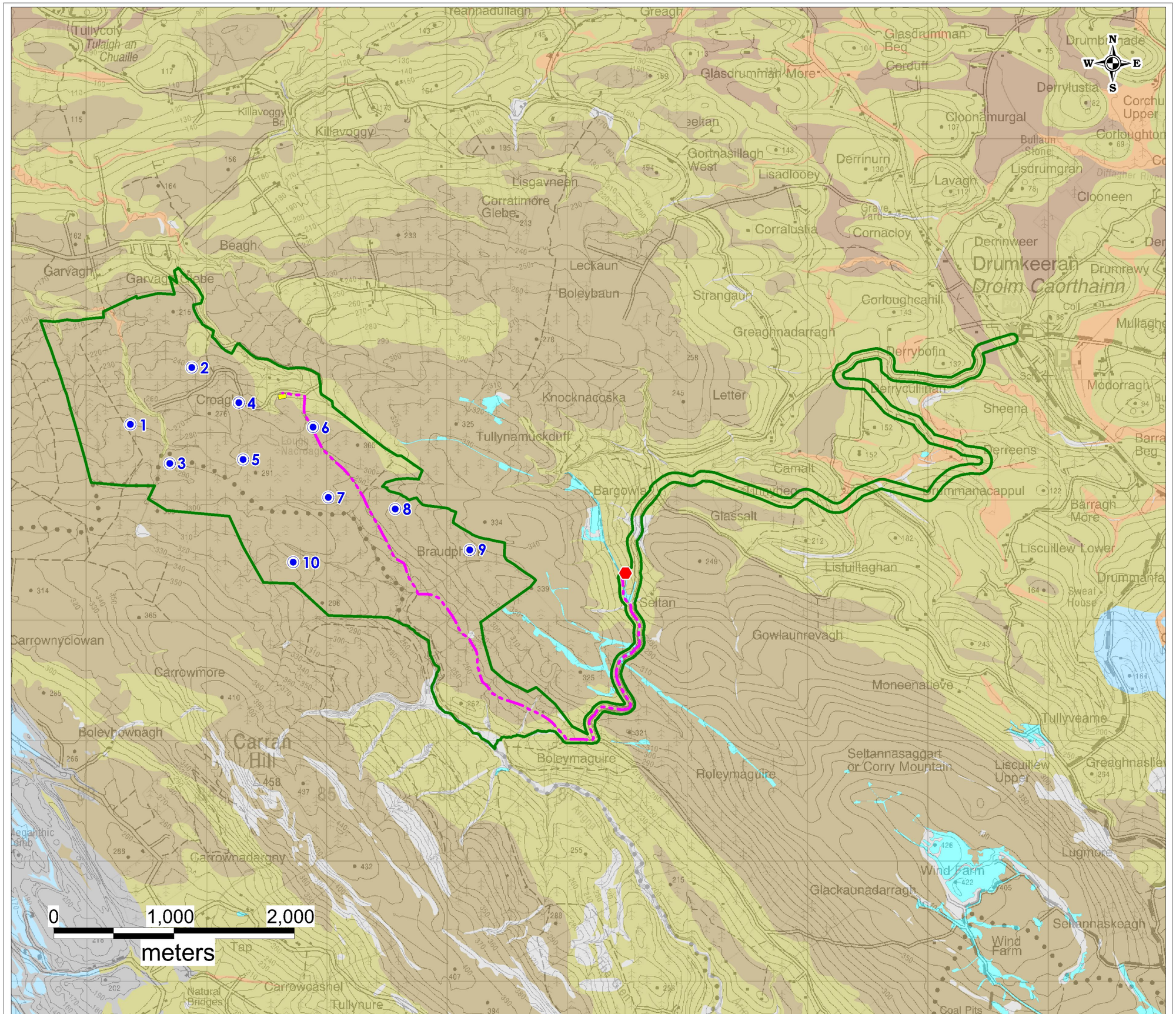
With respect to the existing and proposed access roads, peat depths are typically less than 3m with localised depths of up to 5m. Approximately 10km of existing access roads are present across the site and based on Coillte records have been in operation for a number of years.

Along the proposed construction access road (as described in Section 4.4 of this EIAR), no peat was recorded.

To assess the geological and geotechnical conditions at the turbine locations and other key areas (i.e. substations, construction compounds, met mast, borrow pit and site access roads) a combination of trial pits (were accessible) and soil gouge cores were carried out. A summary of the investigation results are shown in below in Table 8-5.

Table 8-5: Summary of trial pit logs at Key Development Locations

Infrastructure Ref.	Peat Depth (m)	Investigation Location ID	Subsoil Lithology
T1	1.8 – 2.2	TP24A	Firm, locally soft, SILT/CLAY to 2.7m overlying stiff, locally firm, SILT/CLAY
T2	1.8 – 2.8	GC_T2	Soft, dark grey SILT/CLAY
T3	1.9 - 2.8	TP2A	Soft SILT/CLAY in excess of 4.4m
T4	0.5 – 1.0	TP4A	Soft SILT/CLAY to 0.8m overlying firm SILT/CLAY to 1.9m overlying stiff SILT/CLAY to 3.1m overlying very stiff SILT/CLAY



Legend

- EIAR Site Boundary
- Proposed Turbine
- Proposed Substation
- Garvagh Substation
- Proposed Underground Grid Connection Route
- Alluvium
- Blanket Peat
- Made ground
- Kartsified bedrock outcrop or subcrop
- Bedrock outcrop or subcrop
- Till derived from limestones
- Till derived from Namurian sandstones and shales

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Client: MKO	
Job: Croagh WF, Co. Leitrim	
Title: Local Subsoils Map	
Figure No: 8.1	
Drawing No: P1459-0-0620-A3-801-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

Infrastructure Ref.	Peat Depth (m)	Investigation Location ID	Subsoil Lithology
T5	0.3 – 1.3	TP25A	Soft SILT/CLAY to 1.1m overlying firm, locally stiff, SILT/CLAY to 2.1m overlying very stiff SILT/CLAY
T6	1.8 - 2.4	TP26A	Soft SILT/CLAY to 1.9m overlying firm, locally stiff, SILT/CLAY to 2.9m overlying stiff SILT/CLAY
T7	2.0 – 2.8	TP12A	Soft SILT/CLAY to 2.8m overlying firm and stiff SILT/CLAY to 3.7m overlying stiff SILT/CLAY
T8	3.3 – 3.9	TP14A	Peat and soft SILT/CLAY to 2.4m overlying firm, locally stiff, SILT/CLAY
T9	2.1 – 4.5	TP16A	Firm SILT/CLAY to 1.9m overlying stiff, locally very stiff, SILT/CLAY
T10	0.8 – 1.0	TP27A	Very soft and soft SILT/CLAY to 1.2m overlying firm SILT/CLAY to 2.0m overlying stiff SILT/CLAY. Material at base of trial pit recovered as residual soil/extremely weathered shale (assumed top of weathered rock)
Substation	0	TP20A	Firm, locally stiff, very gravelly SILT/CLAY to 2.0m overlying Gravels, Cobbles and Boulders with a sandy silt matrix
Compound 1	0.9	TP05A	Very soft to soft sandy clayey SILT to 1.3m over firm to stiff, sandy gravelly Silt/Clay with occasional cobbles to 4.1m
Compound 2	0.4	TP10A	Soft sandy clayey SILT to 0.6m over firm to stiff sandy very gravelly SILT/CLAY to 4.1m
Site construction access road	0	TP-AR1 to TP-AR6	Brown firm CLAY over Stiff dark blue / grey SILT/CLAY, becoming very stiff with depth
Borrow Pit	0.35	TP11	Soft clayey SILT over very gravelly SILT/CLAY. Bedrock met at 2.2m
Peat and Spoil Repository 1	1.0 – 1.5	TP MKO3	Grey sandy clayey SILT to 0.85 over firm blue/grey slightly sandy very gravelly SILT/CLAY to 2.9 over weathered shale at 2.9m
Peat and Spoil Repository 2	0.9 – 1.5	TP3	Soft light grey/brown sandy clayey Silt to 0.7m over firm and stiff grey slightly sandy very gravelly SILT/CLAY with ocaasional cobbles to 2.1m over Stiff grey slightly sandy SILT/CLAY with frequent cobbles to 3.2m

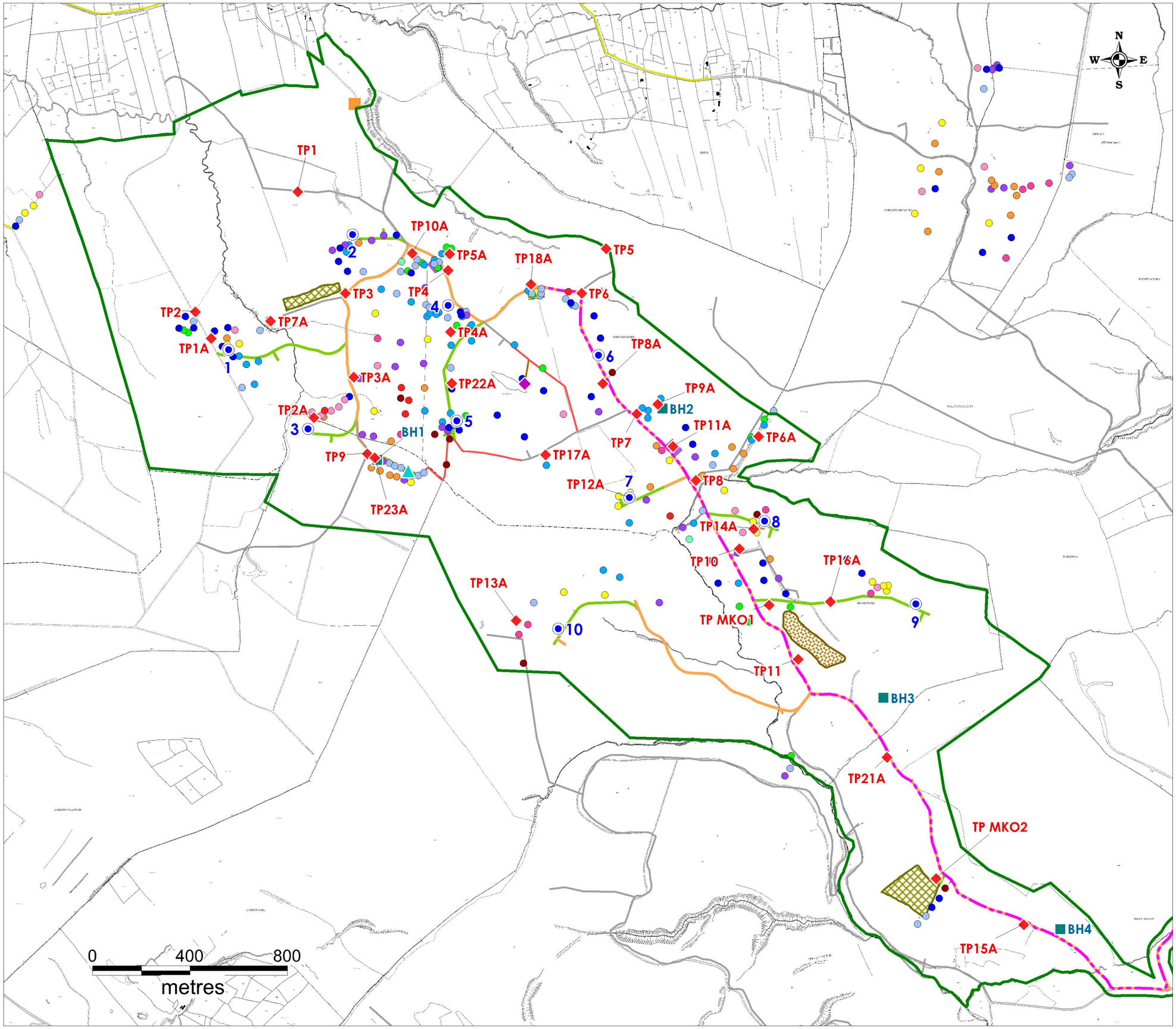
In total 40no. trial pits were undertaken across the overall site. The trial pits typically encountered brown/black amorphous PEAT which was generally spongy and fibrous. Directly underlying the peat there is typically a very soft layer of SILT which is generally less than 0.5m in thickness. Below the SILT, sandy gravelly SILT/CLAY with frequent cobbles and boulders were encountered.

Bedrock at the borrow pit location was met at 2.2m when weathered SHALE was encountered during trial pitting undertaken in September 2019. Bedrock was encountered in 2 no. trial pits)TP9A and TP27A which were undertaken along proposed access roads), where weathered SHALE was encountered at a depth of 3.8 and 3m respectively.

The locations of the trial pits and boreholes are shown on Figure 8-2 and Figure 8-3.

8.3.3 Bedrock Geology

The underlying bedrock at the Proposed Development site is mapped by the GSI as being broadly Namurian shales. The Dergvone Formation encompasses the majority of the site, consisting of four main



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Met Mast
- Proposed Substation
- Proposed Construction Compound
- Proposed Borrow Pit
- Proposed Peat Repository
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Visitor Car Park
- Viewing Platform
- Existing Road Proposed for Upgrade
- Proposed New Road
- Existing Forestry Roads
- Amenity Walkways
- Amenity Boardwalk
- Local Roads
- Trial Pit Locations
- Borehole Locations

Peat Depth Legend

0 - 0.5m	3.0 - 3.5m
0.5 - 1.0m	3.5 - 4.0m
1.0 - 1.5m	4.0 - 4.5m
1.5 - 2.0m	4.5 - 5.0m
2.0 - 2.5m	5.0 - 5.5m
2.5 - 3.0m	5.5 - 6.0m

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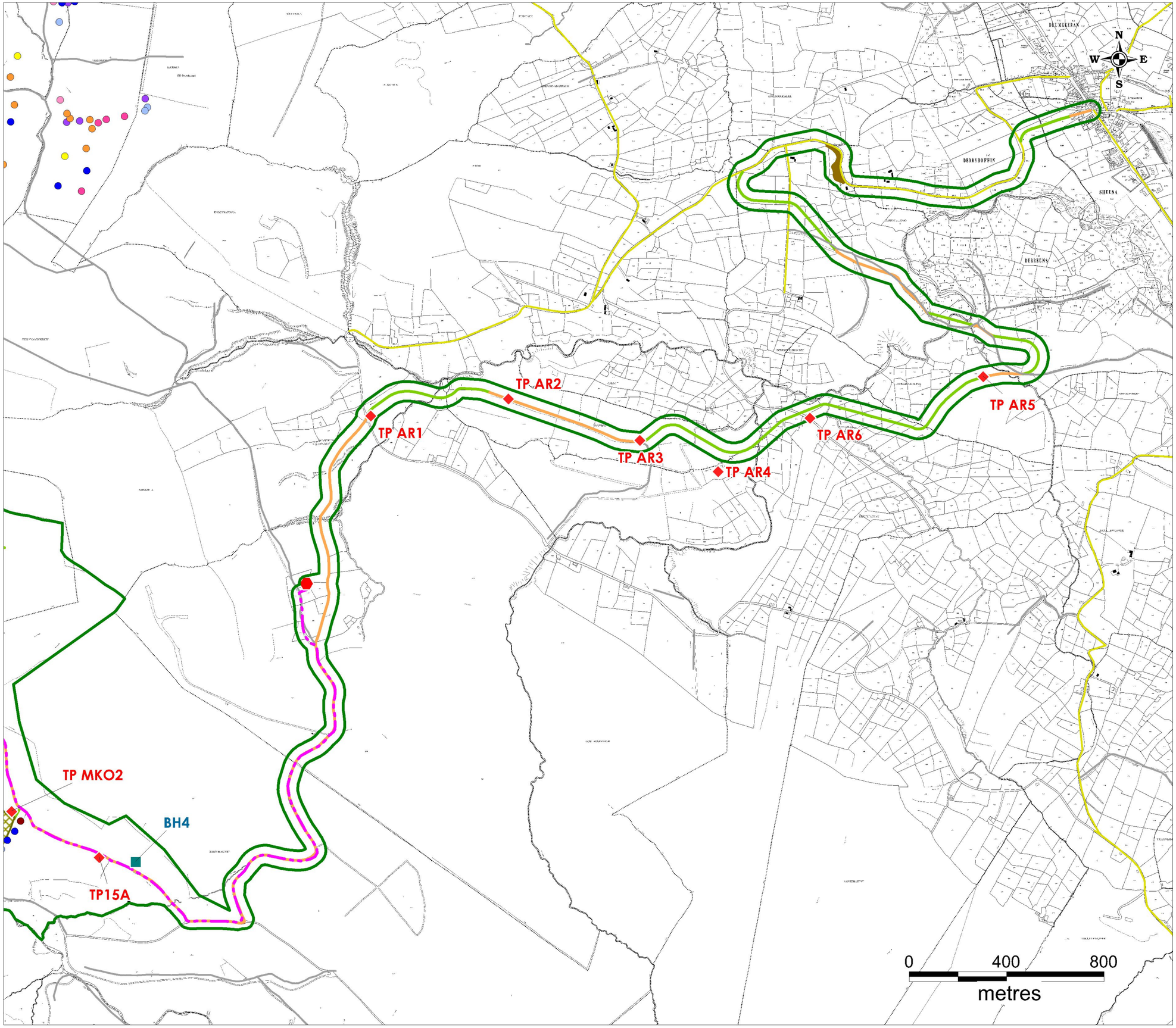
Client: MKO	
Job: Croagh WF, Leitrim	
Title: Peat Depths Map	
Figure No: 8.2	
Drawing No: P1459-0-0620-A3-802-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:15,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Met Mast
- Proposed Substation
- Proposed Construction Compound
- Proposed Borrow Pit
- Proposed Peat Repository
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Visitor Car Park
- Viewing Platform
- Existing Road Proposed for Upgrade
- Proposed New Road
- Existing Forestry Roads
- Amenity Walkways
- Amenity Boardwalk
- Local Roads
- Road Widening Works Area
- Trial Pit Location
- Borehole Locations

Peat Depth Legend

0 - 0.5m	3.0 - 3.5m
0.5 - 1.0m	3.5 - 4.0m
1.0 - 1.5m	4.0 - 4.5m
1.5 - 2.0m	4.5 - 5.0m
2.0 - 2.5m	5.0 - 5.5m
2.5 - 3.0m	5.5 - 6.0m

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Title: Peat Depths Map

Figure No: 8.3

Drawing No: P1459-0-0620-A3-803-0A

Sheet Size: A3	Project No: P1459-0
Scale: 1:15,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

shale facies S1-S4. S1 is a generally dark pyritic, sometimes calcareous shale which is often fossiliferous, S2 is similar to S1 but generally not fossiliferous. S3 is pyritic and unfossiliferous with sideritic mudstone and nodules. S4 is a micaceous and silty shale with thin beds of ironstone and flaggy sandstone.

The northwestern end of the site is underlain by rocks which are Dinantian in age. They are part of the Carraun Shale Formation consisting of grey to black fossiliferous shales and mudstones with thin subordinate limestones and dolomites.

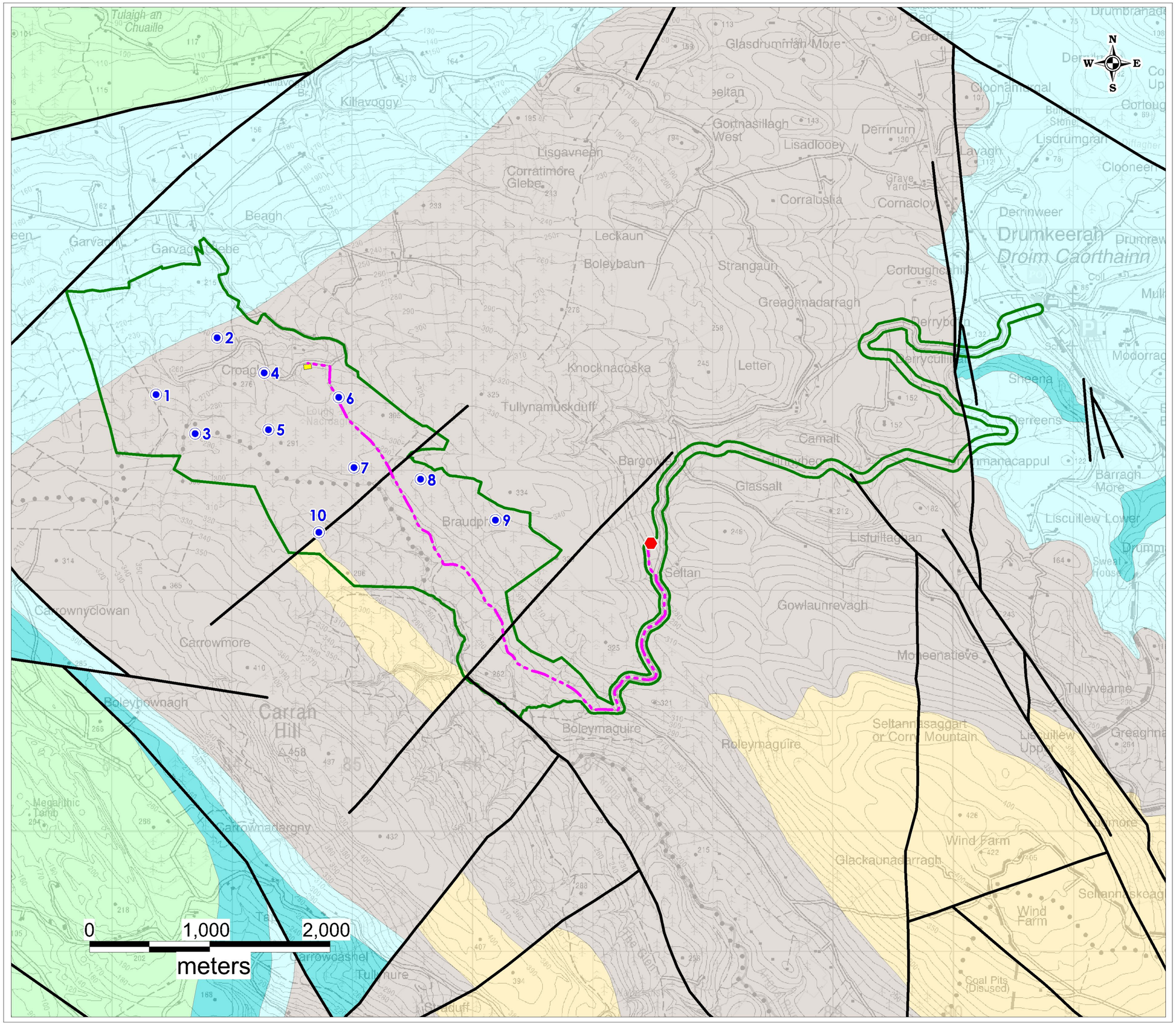
There are numerous mapped faults in the area, which generally trend northeast-southwest or at 90° to this trend. Two northeast-southwest trending faults are mapped within the proposed development site, mapped near the upper reaches of the Arigna River, and further south approximately 0.5km north of the southern tip of the proposed development site. These faults are mapped over a relatively short distance and it is unlikely that there is considerable displacement along them.

A bedrock geology map is shown as Figure 8-4.

Rotary core drilling was undertaken at locations across the site to assess depth of overburden and bedrock lithology/type. A summary of the drillers logs are shown in Table 8-6 below.

Table 8-6: Summary of Borehole Logs

BH no.	Depth (mbgl)	Summary Information (mbgl)
1	30.3	0-4.2 mbgl: No recovery
		4.2–17.4 mbgl: Very stiff dark grey slightly sandy gravelly silty CLAY with cobbles and boulders
		17.4-30.3 mbgl: Medium strong thinly laminated dark blackish grey slightly bioclastic silty fine-grained LIMESTONE
2	30.3	0-4.2 mbgl: No recovery
		4.2-4.8 mbgl: Stiff dark greenish brown SILT
		4.8-30.3 mbgl: Medium strong thinly laminated dark blackish grey slightly bioclastic silty fine-grained LIMESTONE.
3	30.2	0-4.4 mbgl: No recovery
		4.4-10.7 mbgl: Very stiff dark grey slightly sandy gravelly silty CLAY with cobbles.
		10.7–14.9 mbgl: Weathered SILTSTONE rock.
		14.9–30.2 mbgl: Medium strong thinly laminated dark blackish grey calcareous fine-grained SILTSTONE.
4	30.2	0-3.0 mbgl: No recovery
		3.0-6.2 mbgl: Very stiff dark grey slightly sandy gravelly silty CLAY with cobbles
		6.2-9.8 mbgl: Weathered SILTSTONE rock.
		9.8–30.2 mbgl: Medium strong thinly laminated dark blackish grey fissile calcareous fine-grained SILTSTONE



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Mapped Faults
- Dinantian Mixed Sandstones, Shales and Limestones
- Dinantian Pure Bedded Limestones
- Dinantian Shales and Limestones
- Namurian Sandstones
- Namurian Shales

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Client: MKO	
Job: Croagh WF, Co. Leitrim	
Title: Local Bedrock Geology Map	
Figure No: 8.4	
Drawing No: P1459-0-0620-A3-804-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

BH1 and BH2 encountered dark blackish grey bioclastic, silty LIMESTONE below sandy gravelly silty CLAY and greenish brown SILT respectively.

BH3 and BH4 encountered dark blackish grey fissile SILTSTONE, below weathered siltstone and sandy gravelly silty CLAY. This bedrock type is in line with the bedrock mapped at the site by the GSI and is typical of the Dervgone and Gowlaun Shale Formations.

8.3.4 Geological Resource Importance

There are several ironstone mineral localities mapped in the vicinity of the proposed development site, although no active or inactive quarries have been mapped. This is classified as "Low" importance as it is not likely to economically viable.

The blanket bog and mineral soil at the site are classified as "Low" importance as they are not statutorily designated in this area and are significantly degraded in most places at the site as a result of forestry related drainage and rill ploughing.

Refer to Table 8-1 for criteria.

8.3.5 Geological Heritage and Designated Sites

There are no recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) within 5km of the proposed development area.

The Proposed Development site is not located within any designated site. However, Corry Mountain Bog NHA runs adjacent to the south-eastern boundary of the site. Also close to the proposed site is Carrane Hill Bog NHA which is located approximately 300m to the southwest of the site. Designated sites further downstream of the site include the Unshin River SAC. Designated sites are assessed in the Water Chapter (Chapter 9) with respect hydrological and hydrogeological impacts.No direct or indirect effects on these designated sites with regard to land, soils or geology are anticipated.

8.3.6 Soil Contamination

There are no known areas of soil contamination on the site of the Proposed Development. During the site walkovers, no areas of contamination concern were identified.

According to the EPA online mapping (http://gis.epa.ie/Envision), there are no licensed waste facilities on or within the immediate environs of the site of the Proposed Development.

There are no historic mines at or in the immediate vicinity of the site of the Proposed Development that could potentially have contaminated tailings.

8.3.7 Economic Geology

The GSI online Aggregate Potential Mapping Database shows that the Proposed Development site is located within an area mapped as being typically Very Low to Low in terms of crushed rock aggregate potential and with no potential for granular aggregate potential (i.e. potential for gravel reserves).

8.3.8 Peat Stability Assessment

8.3.8.1 Peat Stability Assessment Methodology

This section summarises the report on assessment of peat stability undertaken by Fehily Timoney and Company (FT). The peat stability assessment report is included as Appendix 8-1of this EIAR.

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions.

An adverse combination of factors could potentially result in peat sliding. An adverse condition of one of the above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding (See Table 8-7 below). This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes present on-site where development is proposed.

- The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.
- The drained loading condition applies in the long-term. The condition examines the effect of, in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Table 8-7: Probability Scale for Factor of Safety.

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.19 to 1.11	Probable
5	<1.0	Very Likely

8.3.8.2 Peat Stability Assessment Results

Undrained analysis results are presented inTable 8-8. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

Table 8-8 Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition[2]	
			Condition (1)	Condition (2)
T1	583322	823639	5.22	3.59
T2	583831	824112	6.14	4.53
T3	583648	823314	6.14	4.53
T4	584223	823820	2.95	1.48
T5	584259	823347	13.23	7.48
T6	584841	823616	7.17	5.06
T7	584968	823032	11.16	8.23
T8	585523	822935	2.39	1.9
T9	586144	822595	2.55	2.09
T10	584676	822493	5.77	2.89
Substation	584584	823867	13.69	5.13
Temporary Construction Compound 1	584170	823980	3.84	1.92
Temporary Construction Compound 2	585150	823232	3.87	2.19
Met Mast	583166	823847	20.78	7.79

Drained analysis results are presented in Table 8-9. As outlined above, the drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Table 8-9: Factor of Safety Results (drained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	583322	823639	3.48	5.17

[2] *For the stability analysis two load conditions were examined, namely*

Condition (1): *no surcharge loading*
Condition (2): *surcharge of 10 kPa, equivalent to 1 m of stockpiled peat assumed as a worst case.*

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T2	583831	824112	4.1	6.53
T3	583648	823314	4.1	6.53
T4	584223	823820	1.97	2.08
T5	584259	823347	8.82	10.79
T6	584841	823616	4.78	7.3
T7	584968	823032	7.44	11.88
T8	585523	822935	1.59	2.74
T9	586144	822595	1.69	2.99
T10	584676	822493	3.85	4.14
Substation	584584	823867	9.13	7.39
Temporary Construction Compound 1	584170	823980	2.56	2.74
Temporary Construction Compound 2	585150	823232	2.58	3.13
Met Mast	583166	823847	16.63	13.49

The findings of the peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development. The findings include recommendations and specific control measures (Section 13 of Appendix 8-1 of this EIAR) for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

An analysis of peat stability was carried out at the turbine locations, roads, substation compound, construction compounds and met mast for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the proposed? peat slopes during construction and operation?.

An undrained analysis was carried out, which applies in the short-term during construction. For the undrained condition, the calculated FoS for load conditions (1) & (2)[3] for the locations analysed, show that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

[3] *For the stability analysis two load conditions were examined, namely*

Condition (1): *no surcharge loading*
Condition (2): *surcharge of 10 kPa, equivalent to 1 m of stockpiled peat assumed as a worst case.*

In addition, an analysis of peat stability was carried out at each infrastructure location (including existing and proposed roads) on site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes. The findings of the analyses, which involved analysis of 324 no. locations, showed that the site generally has an acceptable margin of safety.

For both the undrained and drained condition, all 324 no. locations showed an acceptable FoS of greater than 1.3 except for 8 no. marginally low FoS's. The locations of the marginally low FoS's are highlighted on the construction and buffer zone plan (Figure 4-3 of Appendix 8-1) and are typically located alongside existing access roads on site which have been in operation for a number of decades for transportation and management of the timber crop through to the second rotation and hence are not considered areas at risk of peat instability. In addition, 2 no. marginally low FoS's are located along the new proposed access road to turbine T9 and coincides with a deeper pocket of peat. This area has an elevated construction risk and is also highlighted on the construction buffer zone plan (Figure 4-3 of Appendix 8-1). This location is subject to additional control and mitigation measures as per the adjacent turbine T9 (these measures are detailed in the peat stability assessment report). The remainder of the locations analysed had acceptable FoS's of greater than 1.3, indicating a low risk of peat instability.

The peat stability risk assessment at each infrastructure location (as listed above) identified a number of specific mitigation/control measures to reduce the potential risk of peat failure. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

In summary, the findings of the peat assessment showed that the proposed Croagh wind farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is at low risk of peat failure. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

8.4 Characteristics of the Proposed Development

The Proposed Development will involve removal of peat, subsoil and bedrock for hardstanding emplacement. Crushed rock for construction will be sourced from 1 no. proposed borrow pit. It is proposed that this borrow pit will be reinstated with peat and spoil excavated as part of the construction phase of the Proposed Development. Excess peat will be stored at 2 no. proposed repository areas.

Estimated volumes of peat, subsoil and bedrock to be removed are shown in Table 8-10 and Table 8-11 respectively. Not all of the peat and soil excavated will be sent to the borrow pit and repository areas for reinstatement, the remaining portion will be cast to one side and used for reinstatement and landscaping works around the site. Any bedrock excavated during cut and fill works will be used for filling along the development footprint. Further details are provided in the Peat and Spoil Management Plan for the works which is included as Appendix 4-2 of this EIAR.

Table 8-10: Estimated Peat and Mineral Soil Excavation Volumes

Development Component	Peat (m^3)	Mineral Soil (m^3)
10 No. Turbines & Hardstands	65,925	48,635
All Access Roads	103,500	93,550
Borrow Pit (1 no.)	14,820	34,580
Repository Areas (2 no.)	15,000[Note]	3,000

Development Component	Peat (m^3)	Mineral Soil (m^3)
Substation	2,810	17,095
Meteorological Mast	425	
Temporary Construction Compounds	7,490	
Totals (m3)	**209,970**	**196,860**
Total Peat and Spoil Volumes (m3)	**406,830**	

Note: Peat is removed from the peat repository areas to reach a founding area for the perimeter stone buttresses.

Table 8-11: Estimated Borrow Pit Rock Resource Volumes

Borrow Pit No.	Volume (m3)
1	372,600

Table 8-12: Peat Storage Locations and Volumes

Location	Volume (m3)
Borrow Pit	298,000
Repository Area 1	82,000
Repository Area 2	18,000
Landscaping	10,000
Total	408,000

8.5 Likely Significant Effects and Associated Mitigation Measures

8.5.1 Do Nothing Scenario

An alternative land-use option to the development of a renewable energy project at the proposed development site would be to leave the site as it is, with no changes made to existing land-use practices. Commercial forestry operations would continue at the site.

Surface water drainage carried out in areas of existing access road and coniferous plantations will continue to function and may be extended in the case of coniferous plantation. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with more coniferous trees is likely to occur. Plantations will be reploughed where necessary to facilitate afforestation.

The land, soils and geology would remain largely unaltered as a result of the Do-Nothing Scenario.

8.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

The likely impacts of the proposed development and mitigation measures that will be put in place to eliminate or reduce them are shown below.

8.5.2.1 Peat, Subsoil Excavation and Bedrock Excavation

Excavation of peat, subsoil and bedrock will be required for site levelling and for the installation of infrastructure and foundations for the access roads and turbines. This will result in a permanent removal of peat, subsoil and bedrock at excavation locations. There is no loss of peat or subsoil, it will just be relocated within the site. Estimated volumes of peat and bedrock to be removed are shown in Table 8-10 and Table 8-11 above.

Mechanism: Extraction/excavation.

Receptor: Peat, subsoil and bedrock

Pre-MitigationPotential Impact: Negative, slight/moderate, direct, likely, permanent impact on peat, subsoil and bedrock due to relocation within the site.

Mitigation Measures:

- Placement of turbines and associated infrastructure in areas with shallow peat during the design phase;
- Use of the existing road network to reduce peat excavation and borrow pit volumes;
- Use of floating roads (where acceptable to do so) to reduce peat excavation volumes;
- The peat and subsoil which will be removed during the construction phase will be localised to the Proposed Development infrastructure;
- No turbines or related infrastructure will be constructed near or on any designated sites such as NHAs or SACs;
- A minimal volume of peat and subsoil will be removed to allow for infrastructural work to take place in comparison to the total volume present on the site due to optimisation of the layout by mitigation by design;
- The bedrock at the site is classified as "Medium" importance; and,
- The peat deposits and mineral soil at the site is classified as "Low" importance as the blanket bog is already degraded by forestry works and drainage.

Residual Effect Assessment: The granular soil and peat deposits at the site are classified as of "Low" importance as they are already degraded by forestry and drainage. The overall site area is extensive while the proposed development footprint is approximately 86% of the overall site area. The impact is the disturbance and relocation of c 405,705m^3 of soil and subsoil during construction. All work will be in accordance with the Biodiversity Management Plan. The design measures incorporated into the project as described above in particular the avoidance of deeper peat areas combined with the 'low' importance of the deposits means that the residual effect is- negative, slight, direct, high probability, permanent effect on peat and subsoils due to disturbance and relocation within the site.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock are anticipated.

8.5.2.2 Contamination of Soil by Leakages and Spillages and Alteration of Peat/Soil Geochemistry

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk. The accumulation of small spills of fuels and lubricants during routine plant use can also be a significant pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. Large spills or leaks have the potential to result in significant effects (i.e. contamination of peat, subsoils and pollution of the underlying aquifer) on the geological and water environment.

Pathway: Peat, subsoil and underlying bedrock pore space.

Receptor: Peat, subsoil and bedrock.

Pre-Mitigation Potential Impact: Negative, direct, slight, short term, unlikely impact on peat, subsoil and bedrock.

Proposed Mitigation Measures

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station;
- On site re-fuelling will be undertaken using a double skinned bowser with spill kits on the ready for accidental leakages or spillages;
- On site re-fuelling will be undertaken by suitably trained personnel only under a permit to refuel system;
- Fuels stored on site will be minimised. Storage areas located at the temporary compounds where required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The electrical substation will be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- All waste tar material arising from the chipping and resurfacing of the public road portion of the temporary construction access road will be removed off-site and taken to licenced waste facility;
- An emergency plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (Appendix 4-4 of this EIAR). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Effect Assessment: The use and storage of hydrocarbons and small volumes of chemicals is a standard risk associated with all construction sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect is considered to be - Negative, imperceptible, direct, short-term, low probability effect on peat and subsoils and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock are anticipated.

8.5.2.3 Erosion of Exposed Subsoils and Peat During Tree Felling and Construction Work

There is a high likelihood of erosion of peat and spoil during its excavation and during landscaping works. The main impacts associated with this aspect is to the water environment, and therefore this aspect is further assessed in detail in Chapter 9.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

Pre-Mitigation Potential Impact: Negative, slight, direct, short-term, high probability effect on peat and subsoils by erosion and wind action.

Proposed Mitigation Measures:

Peat removed from turbine locations and access roads will be used for landscaping, placed alongside designated access roads, used to reinstate the 1 no. proposed borrow pits or placed in 2 no. repositories. Where possible, the acrotelm shall be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored peat within the borrow pits. Re-seeding and spreading/planting of heather and moss cuttings will also be carried out in these areas. These measures will prevent erosion of stored peat in the long term. A full Peat and Spoil Management Plan for the development is included as Appendix 4-2.

Any excess temporary mounded peat in storage for long periods will be sealed using the back of an excavator bucket. This will prevent erosion of soil. Silt fences will be installed around stockpiles to limit movement of entrained sediment in surface water runoff. The use of bunds around earthworks and mounds will prevent egress of water from the works.

In order to minimize erosion of mineral subsoils stripping of peat will not take place during extremely wet periods as defined in the Chapter 9 of this EIAR (to prevent increased silt rich runoff). Temporary drainage systems will be required to limit runoff impacts during the construction phase.

During tree felling, brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.

Residual Effect Assessment: Peat soils and spoil can be eroded by vehicle movements, wind action and by water movement. To prevent this all excavation works will be completed in accordance with the detailed Peat and Spoil Management Plan, material will be moved the least possible distance, and reseeding and planting will be completed to bind landscaped peat and spoil together. Following implementation of these measures the residual effected is considered - Negative, slight, direct, short-term, medium probability effect on peat and subsoils by erosion and wind action.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock are anticipated.

8.5.2.4 Peat Instability and Failure

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on the Proposed Development, proposed construction access road and the surrounding environment. Peat failure excludes localised movement of peat that could occur below an access road, creep movement or erosion type events. The consequence of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of access tracks;
- Drainage disrupted;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by soil particulates;
- Degradation of the environment.

Mechanism: Vehicle movement and excavations.

Receptor: Peat subsoils.

Pre-Mitigation Potential Impact: Negative, significant, direct, low probability permanent effect on peat and subsoils. The findings of the peat stability assessment showed that the proposed Croagh wind farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at low risk of peat failure. The findings include recommendations and control measures which will be implemented for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

Mitigation Measures:

Based on the recommendations and control measures given in the FT Peat Stability Assessment (Appendix 8-1) report being strictly adhered to during construction and the detailed stability assessment carried out for the peat slopes which showed that the site has an acceptable margin of safety, there is a low risk of peat instability/failure at the Proposed Development site.

The risk assessment at each turbine location identified a number of control measures to reduce further? the potential risk of peat failure. Access roads to turbines will be subject to the same relevant control measures that apply to the nearest turbine as detailed in the FT Peat Stability Assessment Report.

The following measures which will be implemented during the construction phase of the project will assist in the management of the risks for this site.

- Appointment of experienced and competent contractors;
- The site will be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a peat movement);
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground as detailed in the peat stability assessment report;
- Set up, maintain and report findings from monitoring systems;
- Ensure construction method statements are followed or where agreed modified/ developed; and,
- Revise and amend the Geotechnical Risk Register as construction progresses.

Please refer to Appendix 8-1 for proposed turbine specific and road section mitigation measures.

Residual Effects Assessment: A detailed Geotechnical and Peat Stability Assessment has been completed for the development proposal. The findings of that assessment have demonstrated that there is a low risk of peat failure, at the site as a result of the proposed development. With the implementation of the control measures outlined above the residual effect is - Negative, imperceptible, direct, low probability, permanent effect on peat and subsoils.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock are anticipated.

8.5.2.5 Proposed Amenity and Recreation Infrastructure

The recreation and amenity proposals include the construction of 1.1km of new amenity walkways (3m wide, floating road construction), 100m of wooden board walk leading to a proposed viewing area next to Lough Nacroagh and a proposed visitor car park located adjacent to an existing access road approximately 540m north of T2. It is proposed that amenity traffic will access the site from the north and that no upgrade is required to the existing junction or access road leading to the car park.

The proposed construction methodology for the amenity walkways is by floating road construction, with no requirement for additional excavation or spoil generation. Walkways and the car park will be created on the existing ground surface by adding crushed stone.

Pathway: Extraction/excavation of peat and soil/subsoils (spoil).

Receptor: Peat and underlying subsoil.

Pre-Mitigation Potential Impact: Negative, slight, direct, high probability, permanent effect on peat and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section **Error! Reference source not found.**.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section **Error! Reference source not found.** above and measures dealing with soil erosion are dealt with in Section **Error! Reference source not found.**. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section **Error! Reference source not found.**.

Residual Effect Assessment: It is proposed to place amenity pathways and car park on top of existing ground. Ground disturbance and peat and spoil relocation during these works will be minimal. As such the residual effects of these works are considered - Negative, imperceptible, direct, high probability, permanent effect on peat and subsoils by covering with 3m wide pathway.

Significance of Effects: For the reasons outlined above, no significant effects on soils and subsoils are anticipated.

8.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

Very few potential direct impacts are envisaged during the operational phase of the Proposed Development. These may include:

- Some construction vehicles or plant necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil; and,
- The transformer in the substation and transformers in each turbine are oil cooled. There is potential for spills / leaks of oils from this equipment resulting in contamination of soils and groundwater.

In relation to indirect impacts a small amount of granular material will be required to maintain access tracks during operation which will place intermittent minor demand on local quarries. Please note the on-site borrow pit will have been reinstated with excavated peat and spoil following the construction stage and will not be available to source aggregate during the operational phase.

Mitigation measures for soils and geology during the operational stage include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/peat and subsoils and groundwater or surface water quality. The substation transformer, and oil storage tanks will be in a concrete bunded capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks would be contained within the turbine. These mitigation measures are sufficient to reduce risk to ground/peat/soils and subsoils, and groundwater and surface water quality.

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the proposed development will be similar to those associated with construction but of reduced magnitude.

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas, and the substation. This will be done by covering hard surfaces with peatland vegetation/scraw or poorly humified peat from the site to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude due to the reduced scale of the works. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

> *"best practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm".*

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant. Some of the impacts will be avoided by leaving elements of the proposed development in place including turbine bases which will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant impacts on the soils and geology environment are envisaged during the decommissioning stage of the proposed development.

8.5.5 Cumulative Effects

The geological impact assessment undertaken above in this chapter outlines that significant effects are unlikely due to the localised nature of the construction works. Impacts on land soil and geology will not extend beyond the immediate vicinity of the Proposed Development Site and certainly not beyond the site development boundary. Tree felling has a negligible effects on soils and geology as no significant excavation are required and therefore the surrounding commercial forestry or proposed replanting sites are not expected to contribute to cumulative effects.

Therefore, no cumulative impacts between the Proposed Development, the proposed construction access road and other existing, permitted or proposed projects, listed in Section 2.5 of this EIAR, on land soils and geology are anticipated.

8.5.6 Post Construction Monitoring

None proposed.

8.5.7 Assessment of Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. A wind farm is not a recognized source of pollution and so the potential for effects during the operational phase are negligible. Hydrocarbons will be used onsite during construction however the volumes will be small in the context of the scale of the Proposed Development and will be handled and stored in accordance with best practice mitigation measures. The potential residual impacts associated with soil or ground contamination and subsequent health effects are negligible.

9. WATER

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to undertake an assessment of the potential direct, indirect and cumulative effects of the proposed 10 no. turbine, Croagh Wind Farm development (the 'proposed development') on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are to:

- Produce a baseline study of the existing water environment (surface water and groundwater) in the area of the proposed wind farm development and associated works;
- Identify likely significant effects of the proposed development on surface water and groundwater during construction, operational and decommissioning phases of the development;
- Identify mitigation measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects; and
- Assess cumulative effects of the proposed development and other local developments.

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience include upland hydrology and windfarm drainage design. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by Michael Gill, David Broderick and Adam Keegan.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 100 other wind farm-related projects.

David Broderick is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has worked on the EIS for Oweninny WF, Meenbog WF, Glenmore WF, Yellow River WF, and over 80 other wind farm-related projects.

Adam Keegan is a hydrogeologist with two years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR

projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.6 of this EIAR. Issues and concerns highlighted with respect to the water environment are summarised in

Table 9-1 below.

Table 9-1:Summary of Water Environment Related Scoping Responses

Degree/Nature	Description	Addressed in Section
Inland Fisheries Ireland (IFI)	• IFI is seriously concerned over the potential for landslides in this area, based on the occurrence of two landslides in close proximity to this site which resulted in significant damage to the fisheries resource and water quality in the Owengar River.	Refer to Land, Soils and Geology Chapter (Chapter 8) for a peat stability risk assessment
Geological Survey of Ireland (GSI)	• The Geological Survey of Ireland have also identified numerous landslides in this area, indicating significant risks from activities involving large scale earth works such as windfarms.	
Irish Peatland Conservation Council (IPCC)	• There is a risk landslide events may occur within the locality of the proposed wind farm. Landsides are disastrous for wildlife (aquatic and terrestrial). • Most of the footprint of the proposed windfarm is situated on peat soils. Peat is very sensitive to development and will require extra stringent planning procedures	Refer to Land, Soils and Geology Chapter (Chapter 8) for a peat stability risk assessment and a peat management plan
Department of Culture Heritage and Gaeltacht	• In order to assess impacts it may be necessary to obtain hydrological and/or geological data. Any impact on water table levels or groundwater flows may impact on wetland sites some distance away. The EIAR should assess cumulative impacts with other plans or projects if applicable. Where negative impacts are identified suitable mitigation measures should be detailed as appropriate	Sections: 9.3.4, 9.3.7, 9.3.12 and 9.4.3.9

Degree/Nature	Description	Addressed in Section
Health Services Executive (HSE)	• HSE have particular interest in environmental impact studies, methodologies and proposed mitigation measures in the areas of ground and surface water quality and protection, at construction, operational and decommissioning phases. • Recommendation made that all surface waters and private wells affected be identified and that qualitative analysis of both surface and groundwaters be as current as possible.	Sections: 9.3.17 and 9.4.3
Department of Agriculture, Food and the Marine	• The interaction of these proposed works with the environment locally and more widely, in addition to potential direct and indirect impacts on designated sites and water, is assessed	Sections: 9.3.4, 9.3.7, 9.3.12 and 9.4.3.9
OPW	• The OPW has no records of flooding in this area. • It will be a requirement of the applicant to apply for Section 50 consent for all new and upgraded culverts and bridges	Sections: 9.4.3.8

9.1.4 Relevant Legislation

This chapter of the EIAR is prepared in accordance with the requirements of the Environmental Impact Assessment legislation outlined in Chapter 1: Introduction.

The requirements of the following legislation are complied with:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1994, S.I. No. 101 of 1996, S.I. No. 351 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001, S.I. 134 of 2013 and the Minerals Development Act 2017), the Planning and Development Act 2000 (as amended), and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 2011/92/EU and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) establishing a framework for the Community action in the field of

water policy and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC) on the protection of groundwater against pollution and deterioration. Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council Directive 2013/64/EU; and Commission Directive 2014/101/EU ("WFD"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003);

- S.I. No. 684 of 2007: Waste Water Discharge (Authorisation) Regulations 2017, resulting from EU Directive 2000/60/EC on the protection of water; S.I. No. 106 of 2007: European Communities (Drinking Water) Regulations 2007and S.I. No. 122 of 2014: European Communities (Drinking Water) Regulations 2014, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the "Drinking Water Directive") and EU Directive 2000/60/EC;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended by S.I. No. 389/2011; S.I. No. 149/2012; S.I. No. 366/2016; the Radiological Protection (Miscellaneous Provisions) Act 2014; and S.I. No. 366/2016); and,
- S.I. No. 296 of 2009: The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (as amended by S.I. No. 355 of 2018).

9.1.5 Relevant Guidance

The Hydrology and Hydrogeology chapter of the EIAR has been completed in accordance with guidance outlined in Chapter 1: Introduction and the guidance contained in the following:

The water section of the EIAR is also carried out in accordance with guidance contained in the following:

- Environmental Protection Agency (2006): Environmental Management in the Extractive Industry;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements) where relevant;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);

- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,

9.2 Methodology

9.2.1 Desk Study & Preliminary Hydrological Assessment

A desk study and preliminary hydrological assessment of the EIAR Site Boundary and the surrounding area was completed in advance of the site investigations. This involved collection of all relevant geological, hydrological, hydrogeological and meteorological data for the study area. This included consultation and review of the following data sources:

- Coillte databases on forestry and drainage;
- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 7 (Geology of Sligo-Leitrim). Geological Survey of Ireland (GSI, 1996);
- Geological Survey of Ireland (2004) – Lough Allen Groundwater Body Initial Characterization Report;
- OPW Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM flood risk mapping (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.2 Site Investigations

Detailed walkover surveys, geological mapping and peat/soil augering was undertaken by HES on 3rd and 4th April 2018 with follow up visits carried out on 14th and 20th November 2018, 6th September 2019 and 19th March 2020. Water sampling within local streams was carried out on the 14th and 20th of November 2018, as well as the 6th September 2019 and19th March 2020. Trial pit investigations (3 phases – 2017, 2019 and 2020) and bedrock investigation drilling in 2019 was completed by Fehily Timoney & Company (FT, formally AGEC Ltd).

In summary, site investigations to address the Water Section of the EIAR included the following:

- A total of over 850 no. peat probe depths were carried out by HES, MKO and FT, between 2013 and 2020, to determine the depth and geomorphology of the blanket peat at the site;
- Walkover surveys and drainage mapping of the site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin and nature of surface water flows;
- Surface water sampling (4 rounds) were undertaken to determine the baseline water quality of the primary surface waters originating from the site and along the grid connection route;
- Surface water flow monitoring of the primary streams passing through the site and along the grid connection route;
- Drilling of 4 no. bedrock boreholes to assess hydrogeological conditions at the proposed borrow pit locations;
- Assessment of bedrock permeability at the proposed borrow pit locations; and,

- Excavation of 40 no. trial pits across the site (2017, 2019 and 2020 investigations) to assess subsoil lithology and depth.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, August 2017) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental assessment are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR.

In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are then used to assess the potential effect that the Proposed Development may have on them.

Table 9-2: Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

Sensitivity of Receptor	
Not sensitive	Receptor is of low environmental importance (e.g. surface water quality classified by EPA as A3 waters or seriously polluted), fish sporadically present or restricted). Heavily engineered or artificially modified and may dry up during summer months. Environmental equilibrium is stable and is resilient to changes which are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability "Low" – "Medium" classification and "Poor" aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. Surface water quality classified by EPA as A2. Salmonid species may be present and may be locally important for fisheries. Abstractions for private water supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability "High" classification and "Locally" important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value i.e. NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

9.3 Receiving Environment

9.3.1 General Site Description

The Proposed Development site (EIAR Site Boundary) is located approximately 1.3 kilometres northeast of Drumkeeran, Co. Leitrim, at its closest point. The total study area is approximately 670 ha (~6.7km^2). The site setting is forested upland blanket bog which is owned by Coillte. The site is accessible from public roads via a network of existing forestry tracks.

The proposed construction access road for the wind farm commences from the R280 at Drumkeeran village, approximately 6km to the east of the main site area and traverses private land, a public road and Coillte property before emerging onto the local road that approaches the core wind farm site.

The overall elevation of the site ranges between approximately 90m to 330m OD (Ordnance Datum) with the northern section of the site sloping in a northerly direction and the southern section of the site sloping to the southwest.

There is 1 no. proposed grid route, along with 1 no. proposed substation. The proposed substation is located approximately 330 metres east of Turbine No. 4 along an existing access road. From here, the proposed underground grid connection cabling route runs southeast along existing forestry roads for ~ 4.1 km before turning north and following the public road for ~ 1.9km and connecting with the existing Garvagh Glebe 110kV substation.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (1981 - 2010) recorded at Dromahair (Market St), approximately 4 kilometres east of the site, are presented in

Table 9-3. The is the nearest and most appropriate station with respect to topography and elevation.

Table 9-3: Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Dromahair		180600		331500		27		1960		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
125	87	99	66	79	86	89	108	113	129	125	127	1231

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 80 kilometres southeast of the site. The long-term average PE for this station is 446mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 423mm/yr (which is 0.95 × PE).

The effective rainfall (ER) represents the water available for runoff and groundwater recharge. The ER for the site is calculated as follows:

$$\text{Effective rainfall (ER)} = \text{AAR} - \text{AE}$$

$$= 1{,}231\text{mm/yr} - 423\text{mm/yr}$$

$$\text{ER} = 808\text{mm/yr}$$

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 5% recharge is taken for the site as an overall average. This value is for "Peat" with a "High" vulnerability rating. Areas where peat is absent may have slightly higher recharge rates, but on this site, these areas are generally on sloping ground. The high stream density in the area would also suggest that recharge rates are very low.

[1] Meteorological station at which observations are made for synoptic meteorology and at the standard synoptic hours of 00:00, 06:00, 12:00, and 18:00.

The lowest value in the available range was chosen to reflect the large coverage of blanket peat and high drainage density. Therefore, annual recharge and runoff rates for the site are estimated to be 40mm/yr and 768mm/yr respectively.

Table 9-4 presents return period rainfall depths for the centre of the Croagh wind farm site. This data is taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year). These extreme rainfall data will be used for wind farm drainage design and not the long-term averages.

Table 9-4: Return Period Rainfall Depths for Croagh site

Duration	10-year Return Period	50-Year Return Period	100-Year Return Period
15-min	14.2	22.0	26.4
1-hour	22.7	32.6	38.3
6-hour	39.7	54.4	62
12-hour	49.7	66.3	74.8
24-hour	62.3	80.9	90.1
48-hour	77.2	97.7	107.7

9.3.3 Regional and Local Hydrology

With respect to regional hydrology, the Proposed Development is located in 2 no. river basins and 3 no. regional surface water catchments. The southern half of the wind farm site is located in the Shannon River surface water catchment within the Shannon International River Basin District (SHIRBD). The northern half of the wind farm site is located in the Garvogue River surface water catchment. Both the Garvogue River and the Ballysadare River are located within the North Western International River Basin District (NWIRBD).

In terms of turbine distribution, 4 no. are located in the Shannon River surface water catchment and 6 no. are located in the Garvogue River surface water catchment.

The Garvagh grid connection route, which runs to the southeast of the site, passes through the Shannon River surface water catchment (for 6.4km) and the Garvogue River surface water catchment (for 0.7km). Approximately 8.5km of the construction access road is in the Shannon River catchment.

In terms of local hydrology, the southern half of the windfarm site is located in the Arigna River surface water catchment. The Arigna River flows into Lough Allen approximately 16km downstream of the site. The north half of the windfarm site is located in the Bonet River surface water catchment. The Bonet River flows into Lough Gill approximately 15km downstream of the site. Approximately 6km of the construction access road drains directly to Lough Allen via the Owengar River.

A regional hydrology map is attached as Figure 9-1.

Belhavel Lough

Killanummery River

Owengar River

Douglas River

Arigna River

Lough Allen

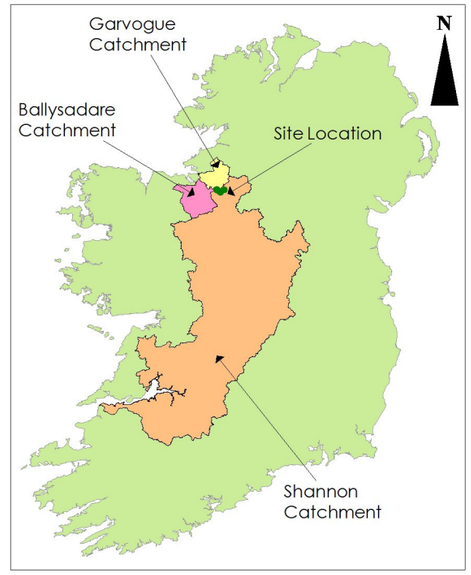
0 1,500 3,000

meters

Legend

- EIAR Site boundary
- Proposed Underground Grid Connection Route
- Rivers
- River Flow Direction
- Lakes
- Ballysadare Catchment
- Garvogue Catchment
- Shannon Catchment

KEY PLAN



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Client: MKO	
Job: Croagh WF, Leitrim	
Title: Regional Hydrology Map	
Figure No: 9.1	
Drawing No: P1459-0-0620-A3-901-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:50,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

9.3.4 Local & Site Drainage

There are four main rivers which drain the Proposed Development site, namely the upper reaches of the Killanummery River (IE_WE_35K030600) which drains the north-western section of the site. The Killanummery River continues to flow northwest, before meeting the River Bonet just south of Dromahair, approximately 7.5 km north of the site. The smaller Tullynascreen Stream (IE_WE_35K030600) runs parallel to this river, and flows northwest, meeting the Killanummery River approximately 2 km north of the site. The Tullynascreen Stream emanates from Lough Nacroagh, a small lake with an area of ~0.01 km^2.

The Cashel Stream drains the north-eastern section of the proposed site. The Cashel Stream is fed from several smaller streams which converge near Kilavoggy Bridge ~1.5km north of the site. The stream then flows north/northeast, meeting the River Bonet approximately 1 km southeast of Dromahair.

The southern section of the proposed site is drained by the Arigna River. The Arigna River runs south through the site and delineates much of the southwestern boundary of the site. It flows through a steep valley between Carrane Hill and Corry Mountain, and the drainage network suggest it is fed primarily from surface waters draining from the peaked ridge of Carrane Hill, which runs parallel to the river, approximately 1 km southwest of the river. The Arigna River continues to flow south before discharging into the southern tip of Lough Allen, some 3km northwest of Drumshanbo.

The site access road is drained by several headwater streams that flow easterly to form the Owengar River which flows into Lough Allen which is located 2km east of the site entrance.

A local hydrology map is shown as Figure 9-2 and a site drainage map is shown as Figure 9-3.

A summary of the sub-catchments along with relevant Proposed Development infrastructure and significant existing drainage features/routes are shown in

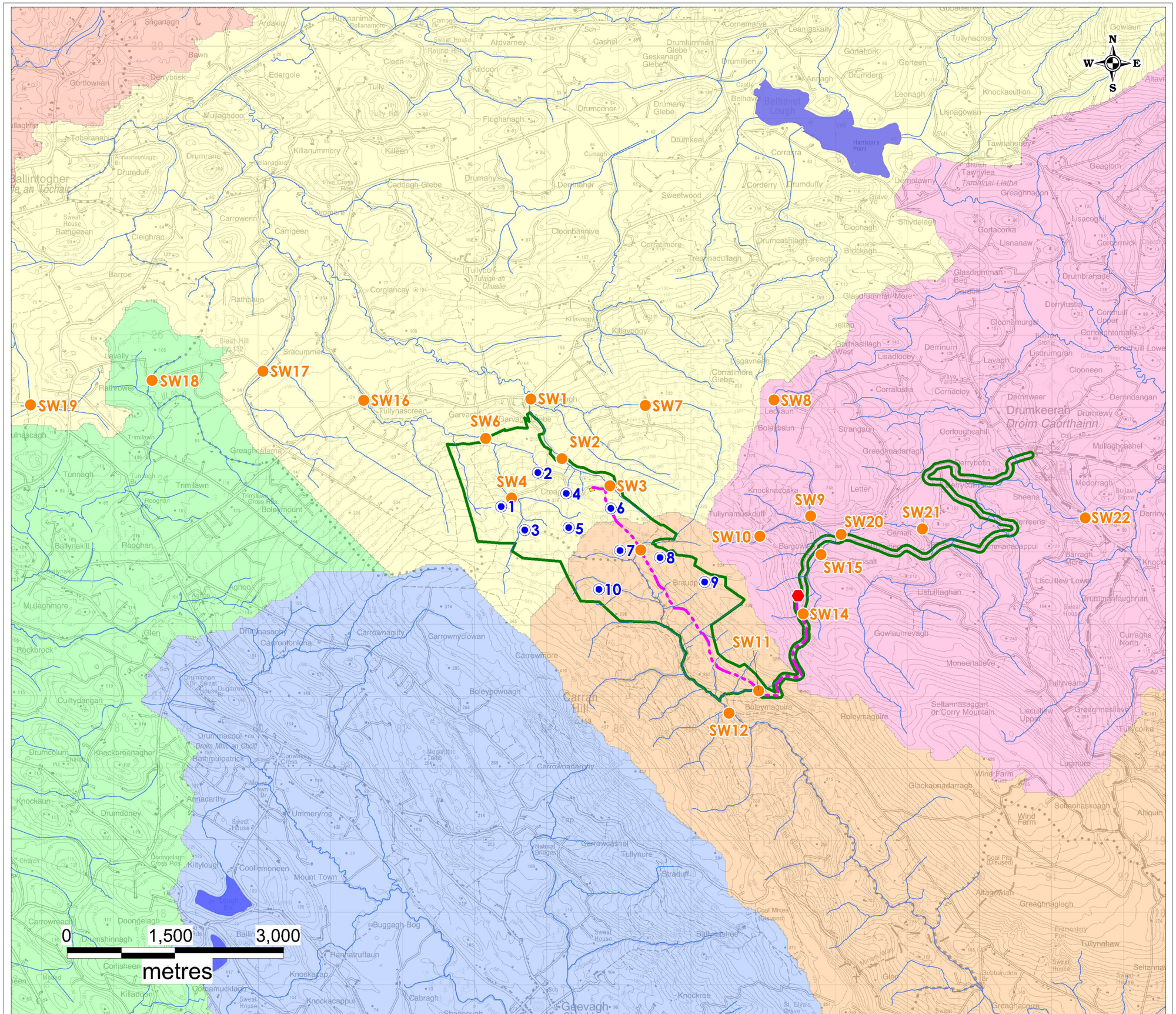
Table 9-5.

Within the Proposed Development site there are numerous manmade drains that are in place predominately to drain the forestry plantations. The current internal forestry drainage pattern is influenced by the topography, peat subsoils, layout of the forest plantation and by the existing road network. The forest plantations, which cover the majority of the site (where clearfelling has occurred forest drains still exist as before, and replanting has generally taken place) are generally drained by a network of mound drains or ploughed ribbons, which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation.

Mound drains and ploughed ribbon drains are generally spaced approximately every 15m and 2m respectively. As illustrated in Plate 9-1, interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of forestry access roads. Culverts are generally located at stream crossings and at low points under access roads which drain runoff onto down-gradient forest plantations. A schematic of a typical standard forestry drainage network and one which is representative of the site drainage network is shown as Plate 9-1.

The forestry drains are the primary drainage routes towards the natural streams on the development site, but the flows in these drains are generally very low. The integration of the existing main drains with the proposed wind farm drainage is a key component of the drainage design which is discussed further in Sections 9.4.1 and 9.4.2 below.

Monitoring of stream discharge in the main streams passing through the site, along the grid connection and the construction access road was undertaken in April and November 2018, as well as low flow monitoring in September 2019 and this data is presented in Table 9-6 below. The flows are typical for upland high energy watercourses.



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Garvagh Grid Connection
- Garvagh Substation
- Rivers
- Lakes
- SW Sampling Location

- Arigna[Roscommon]_SC_010
- Bonet_SC_020
- Feorish[Ballyfarnon]_SC_010
- Owengar[Leitrim]_SC_010
- Unshin_SC_010

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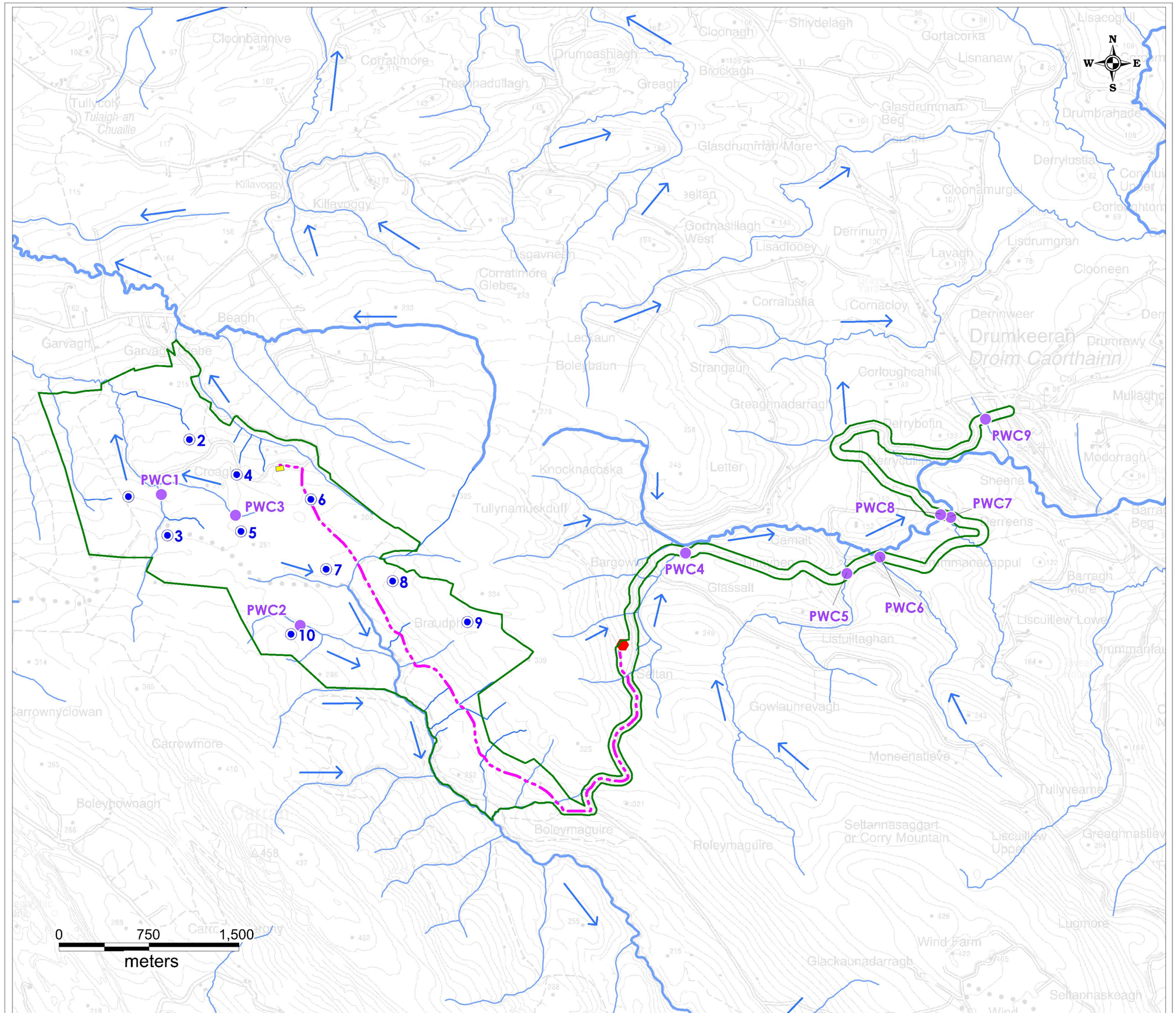
Client: MKO	
Job: Croagh WF, Leitrim	
Title: Local Hydrology Map	
Figure No: 9.2	
Drawing No: P1459-0-0620-A3-902-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:40,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG



Legend

- EIAR Site boundary
- Proposed Turbine
- Proposed Substation
- Proposed Underground Grid Connection Route
- Garvagh Substation
- Rivers
- River Flow Direction
- Proposed WC Crossing (PWC)

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Client: MKO	
Job: Croagh WF, Leitrim	
Title: Site Drainage Map	
Figure No: 9.3	
Drawing No: P1459-0-0620-A3-903-0A	
Sheet Size: A3	Project No: P1459-0
Scale: 1:30,000	Drawn By: GD
Date: 25/06/2020	Checked By: MG

Flow duration curves, generated by the EPA HydroTool website, are presented in Plate 9-2 below, and these represent likely volumetric flow variations between dry and wet weather.

The locations of the monitoring points are shown in Figure 9-2.

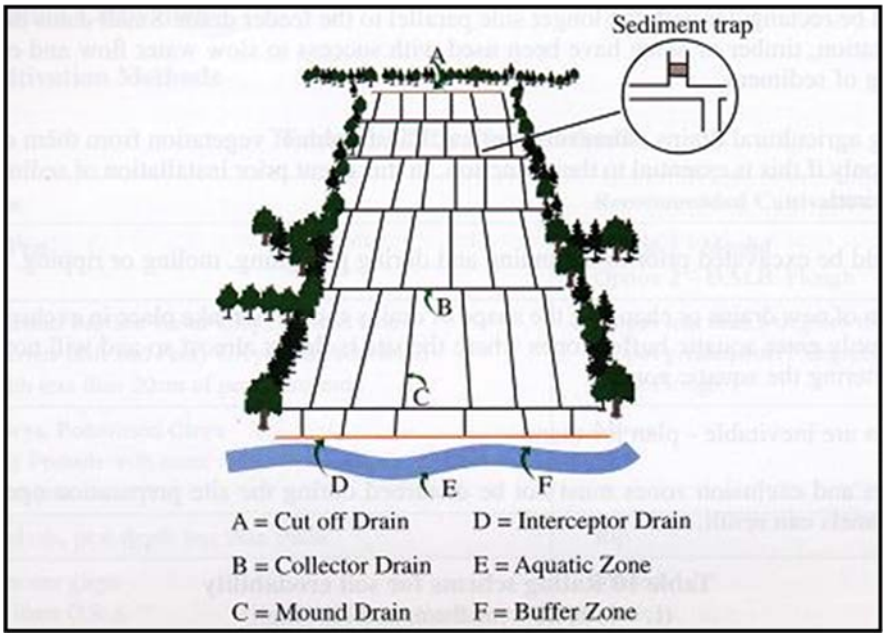

Plate 9-1: Standard forestry drainage network

Table 9-5: Summary of Regional/Local hydrology & Proposed Windfarm Infrastructure

Regional Catchments	Sub-catchment	Main Development Infrastructure	Primary Drainage Features
Shannon	Arigna	4 no. turbines, 1 no. borrow pit, 1 no. peat and spoil repository area,1 no. construction compound and 1.4km of the grid connection route and boardwalk	Arigna River
	Owengar	3.95km of the grid connection route and 8.5km of the construction access road	Owengar River
Garvogue	Bonet	6 no. turbines, substation, 1 no. peat and spoil repository area, 1 no. construction compound, 0.6km of the Garvagh grid connection route and met mast	Killanummery River

Table 9-6: Surface Water Flow Monitoring Data

Location	04/04/2018	14/11/2018	20/11/2018	06/09/2019
	Flow (litres/sec)	**Flow (litres/sec)**	**Flow (litres/sec)**	**Flow (litres/sec)**

Location	04/04/2018	14/11/2018	20/11/2018	06/09/2019
SW1	15	200	20	15
SW2	10	40	10	6
SW3	12	200	15	10
SW4	<10	30	<10	5
SW5	<10	30	<10	5
SW6	22	250	30	15
SW7	<10	100	<10	5
SW8	15	120	20	10
SW9	12	50	15	10
SW10	<10	30	<10	5
SW11	<10	30	<10	5
SW12	90	800	100	80

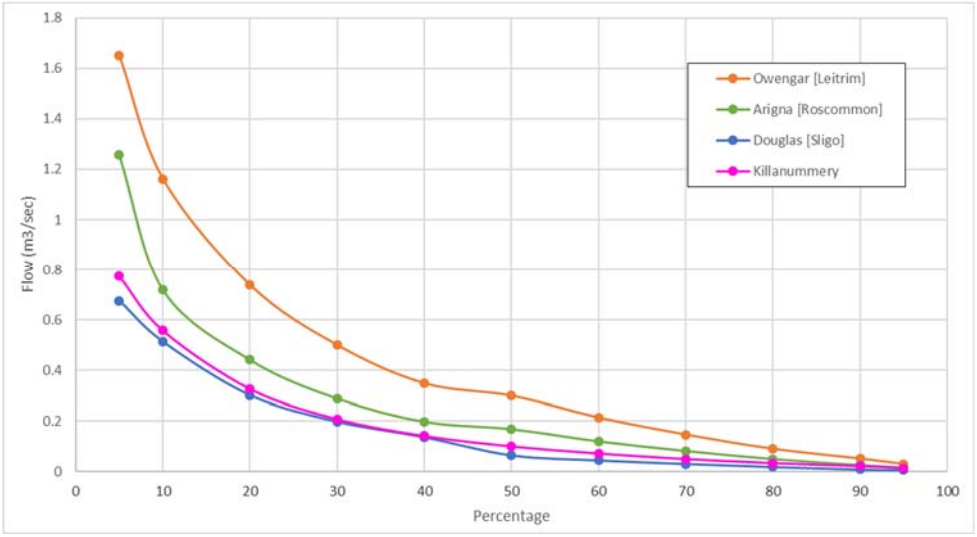

Plate 9-2: Flow Duration Curves for Local Rivers downstream of proposed development [2]

9.3.5 Baseline assessment of site runoff

This section undertakes a long-term water balance assessment and surface water runoff assessment for the baseline conditions at the proposed development site.

[2] http://watermaps.wfdireland.ie/HydroTool/Authentication/Login.aspx?ReturnUrl=%2fHydroTool%2fDefault.aspx

The rainfall depths used in this water balance, long term averages, are not used in the design of the sustainable drainage system for the wind farm. The 100-year rainfall depth will be used for the purpose of drainage design.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-7). It represents, therefore, the long-term, average, wettest monthly scenario in terms of volumes of surface water runoff from the site pre-wind farm development. The worst case surface water runoff co-efficient for the site is estimated to be 96% based on the predominant peat coverage (refer to Section 9.3.2).

The highest long-term average monthly rainfall recorded at Dromahair over the period 1987 – present occurred in December, at 128mm. The average monthly evapotranspiration for the synoptic station at Mullingar over the period 1961-1990, for the month of December, was 0mm. The calculation is carried out for the entire study area. The balance indicates that a conservative estimate of surface water runoff for the study area during the highest rainfall month is 814,720m^3/month, which equates to an average of 26,281m^3/day, as outlined in Table 9-8.

Table 9-7: Water Balance and Baseline Runoff Estimates for Wettest Month (December)

Water Balance Component	Depth (m)
Average December Rainfall (R)	0.128
Average December Potential Evapotranspiration (PE)	0
Average December Actual Evapotranspiration (AE = PE x 0.95)	0
Effective Rainfall December (ER = R - AE)	0.128
Recharge co-efficient (5% of ER)	0.0064
Runoff (95% of ER)	0.1216

Table 9-8: Baseline Runoff for the Study Area

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
670	814,720	26,281

9.3.6 Flood Risk Identification

OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), Department of Environment, Community and Local Government on-line planning mapping (www.myplan.ie) and historical mapping (i.e. 6" & 25" base maps) were consulted to identify those areas as being at risk of flooding.

A site specific Flood Risk Assessment was completed for the Proposed Development and this is attached as Appendix 9-1 of the EIAR. A summary of the FRA is provided in this section.

No recurring flood incidents within the EIAR site boundary were identified from OPW's indicative river and coastal flood map. A recurring flooding incident is mapped downstream of the site at the southern tip of Lough Allen, where the Arigna and Owengar Rivers discharge.

The PFRA mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (i.e. river) and pluvial (i.e. rainfall) flood events. The 100-year fluvial flood zones mapped within the site

boundary generally occur in close proximity to the stream channel itself. All proposed turbine locations, substation, construction compounds, met mast, borrow pit, peat repository areas and access roads (with the exception of stream crossings and road upgrades) are located at least 50m away from streams and are therefore outside of the fluvial indicative 100-year flood zone.

The Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie.) has areas indicated as "fluvial flooding" in the close proximity of streams which pass through the site.

There is no text on local available historical 6" or 25" mapping for the proposed site that identify areas that are "prone to flooding" within the study area or benefitting lands (lands benefitting from the OPW arterial drainage scheme).

It is a key mitigation of the proposed wind farm development to ensure all surface water runoff is treated (water quality control) and attenuated (water quantity control) prior to diffuse discharge at pre-existing Greenfield rates. As such the mechanism by which downstream flooding is prevented and controlled is through avoidance by design. These proposed drainage attenuation measures are outlined in the impact assessment section below.

9.3.7 Surface Water Hydrochemistry

9.3.7.1 Proposed Wind Farm Site

Q-rating data for EPA monitoring points on Arigna River are available from a location approximately 3.5km south of the southern site boundary, referred to as Altagowlan School. Most recent data (2004 to present) show that the river has a Q-4 rating (Good Status). A Q-rating point is also located approximately 2.5 km southeast of the Altagowlan school monitoring point. This monitoring point also has a Q-4 rating.

Q ratings are also available along the Owengar river. The river achieved a Q-4 rating at a monitoring point approximately 2 km east of the eastern boundary of the site.

Q ratings for the River Bonet are also available from a monitoring point approximately 3 km north of the site at a bridge along the L4275. The last Q rating at this point was a Q4-5. Q ratings for the Killanummery River are available from a monitoring location at a bridge north of Garvagh Glebe. A Q-4 rating is assigned to the river at this point. A Q rating was also available from the small Cashel Stream which originates at Lough Nacroagh. The monitoring point is located approximately 1km west of the Killanummery River monitoring point. A Q4 rating is reported at this point. These are latest values available from the EPA, please refer to the aquatic section (Chapter 6 of the EIAR) for more contemporary values for the area of the Proposed Development.

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and temperature (C°) were taken at locations across the site within surface water courses on 14th and 20th November 2018 and 6th September 2019. The results are listed in Table 9-9 below.

Electrical conductivity (EC) values for surface waters at the site area ranged between 38 and 116µS/cm. This indicates that surface water is derived mainly from rainfall input. Measurement in lower-flow conditions (lower water levels in late summertime) may indicate a higher groundwater flow component (i.e. baseflow - typically signified by 'higher' EC values) contributing to discharge in the Bonet, Owengar and Arigna Rivers.

The pH values, which ranged between 4.7 and 7.2, had an overall average value of 6.32. Slightly acidic values were observed, especially at SW4 and SW6 where values <5 were recorded. This is most likely due to discharge from the small lake Lough Nacroagh, where waters may become relatively acidic due to the residence time within the bog lake.

Slightly acidic pH values of surface waters would be typical of peatland environments due to the decomposition of peat. In addition, the shale bedrock (and related till subsoils) which underlie the area would have slightly acidic groundwater characteristics which would have some effect on surface water chemistry specifically during dryer periods when baseflow is likely to be more prevalent.

Table 9-9: Summary of Surface Water Chemistry Measurements

Location	EC (µS/cm)			pH			Dissolved Oxygen (mg/L)		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
SW1	58.1	57	57.9	5.93	6.16	6.9	10.82	11.06	10.51
SW2	76.3	67	-	6.33	6.5	-	10.74	10.78	-
SW3	82.7	106	-	6.92	6.81	-	10.72	11.01	-
SW4	37.7	54	-	4.95	6.14	-	10.04	10.38	-
SW5	40.9	39	34.3	5.02	7.11	6.6	10.42	10.84	10.3
SW6	65.6	51	-	4.71	5.85	-	10.71	11.1	-
SW7	54.9	48	54.1	5.88	6.36	6.79	10.48	11.17	10.43
SW8	47.3	54	46.3	5.82	6.85	6.55	10.7	11.09	10.62
SW9	58.1	116	94.9	6.82	7.22	7.39	10.79	10.97	10.48
SW10	51.3	42	-	6.09	6.83	-	10.8	11.34	-
SW11	59.6	72	-	6.84	7.13	-	10.69	11.37	-
SW12	57.4	60	-	6.22	7.21	-	10.62	11.42	-

R1 (Round 1) – 14/11/2018, R1 (Round 2) – 20/11/2018, R3 (Round 3) – 06/09/2019

Two rounds of surface water sampling were completed on 6 no. of the wind farm downstream monitoring locations (See Table 9-10 and (+) *S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations*
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9-11 below for the locations sampled) on the 14th November and 20th November 2018. These 6 no. sampling locations are situated downstream of the key proposed infrastructure locations.

Sampling was carried out along the grid connection option on 3rd and 4th April 2019 (refer to

Table 9-14 and (+) *S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations*
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9-15). Further sampling was carried out at points within the proposed wind farm site boundary and along the grid route (Table 9-12) on the 6th September 2019. The sampling results for the wind farm and grid route are discussed separately below.

Results of analysis are shown alongside relevant water quality regulations. In addition, relevant Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) threshold values are shown in Table 9-13 below. Laboratory reports are shown as Appendix 9-2.

Table 9-10: Analytical Results of Surface Water Samples (Wind farm Round 1)

Parameter	EQS	Sample ID					
		SW1	SW3	SW6	SW8	SW10	SW12
Total Suspended Solids (mg/L)	25(+)	17	17	27	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.04	0.04	0.05	0.02	0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	0.14	0.1	0.1	<0.1	<0.1	<0.1
Chloride (mg/L)	-	11	12.6	12.6	9	9.6	10.4
BOD	≤ 1.3 to ≤ 1.5(*)	<2	5	<2	<2	<2	2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9-11: Analytical Results of Surface Water Samples (Wind farm Round 2)

Parameter	EQS	Sample ID					
		SW1	SW3	SW6	SW8	SW10	SW12
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.03	0.03	0.08	0.02	0.03	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	0.03	0.02	0.04	0.02	0.03	0.03
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	5.7	7.6	5.5	7.2	2.2	4.1
Phosphorus (mg/L)	-	<0.1	<0.1	0.11	<0.1	<0.1	0.11
Chloride (mg/L)	-	9.8	12.1	12.9	9.9	9.7	9.8
BOD	≤ 1.3 to ≤ 1.5(*)	2	<2	2	<2	3	2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9-12: Analytical Results of Surface Water Samples (Wind Farm/Grid Route(s) Round 3)

Parameter	EQS	Sample ID									
		SW1	SW5	SW6	SW7	SW8	SW9	SW11	SW12	SW16	SW17
Total Suspended Solids (mg/L)	25(+)	8	8	<5	<5	<5	<5	<5	6	<5	6
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	<0.02	0.03	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	0.02	<0.02	0.04	0.02	<0.02	0.02	0.02	0.03	0.02	0.03
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	1.3	1.1	1.7	1.4	2.7	1.0	1.0	1.5	1.5	2.0
Phosphorus (mg/L)	-	0.11	<0.1	0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1	0.1
Chloride (mg/L)	-	8.8	5.1	10.0	8.8	8.5	8.2	5.8	7.9	9.3	12.3
BOD	≤ 1.3 to ≤ 1.5(*)	2	<2	2	2	2	<2	2	2	2	2

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

*Table 9-13: Chemical Conditions Supporting Biological Elements**

Parameter	Threshold Values (mg/L)
BOD	High status ≤ 1.3 (mean)
	Good status ≤ 1.5 mean
Ammonia-N	High status ≤ 0.04 (mean)
	Good status ≤0.065 (mean)
Ortho-phosphate	High status ≤0.025 (mean)
	Good status ≤0.035 (mean)

* European Communities Environmental Objectives Surface Water Regulations (S.I. 272 of 2009)

Round 1 of Sampling (Windfarm)

Total suspended solids at all sampling locations were generally less than 25mg/l, the threshold value contained within the European Communities (Quality of Salmonid Waters) Regulations (S.I. No. 293 of 1988). 1 no. sample at SW6 exceeded this value at 27 mg/l. This is likely due to the very high rainfall in the days prior to sampling, leading to excess runoff and the associated increase in suspended solids. This high TSS is also likely linked to the low pH value observed at this sampling location, with peaty solids leading to a temporary increase in acidity of the surface waters. Nitrite and nitrate values were below or equal to the laboratory detection limit of 0.05 and 5.0 mg/L respectively.

Ortho-phosphate was below the laboratory detection limit of 0.02mg/L in 5 of 6 locations, with the sample at SW6 returning a value of 0.04mg/l.

In comparison to the European Communities Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 5 of 6 results for ammonia N were below the "Good Status" threshold, and below the "High Status" threshold. One sample from SW6 exceeded the Good status threshold with a result of 0.05 mg/l.

In relation to ortho-phosphate, again, 5 of 6 were within the "Good Status" and "High status range while SW6 exceeded the "High Status" threshold values.

BOD was below the detection limit of 2 mg/l for 4 of 6 samples, however it exceeded both the "Good status" and "High status" threshold in the remaining two samples.

The results of round 1 sampling are presented in Table 9-10.

Round 2 of Sampling (Windfarm)

Total suspended solids at all sampling locations during round 2 (20/11/2018) were <5mg/L and nitrite and nitrate values were below or equal to the laboratory detection limits.

Ortho-phosphate ranged between <0.03 and 0.04mg/L, while phosphorus was generally below detection limit of 0.1 mg/l, but rose to 0.11 mg/l on two occasions at SW6 and SW12. Ammonia values ranged between <0.02 and 0.08mg/L.

In comparison to the European Communities Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 5 of 6 sample results for ammonia N were below the "good" and "High Status" threshold while all results 2 of 6 no. samples were below the detection limit for BOD, with the remaining 4 exceeding both the "Good" and "High" status.

The results of round 2 sampling are presented in Table 9-11.

Round 3 of Sampling (Windfarm/ Grid route(s))

Total suspended solids at all sampling locations during round 3 (06/09/2018) ranged from <5mg/L to 6 mg/L. Nitrite and Nitrate values were below or equal to the laboratory detection limits.

Ortho-phosphate ranged between <0.02 and 0.04mg/L, while phosphorus was generally at or below the detection limit of 0.1 mg/. Ammonia values ranged between <0.02 and 0.04mg/L which is within the "High Status threshold" as outlined in Table 9-13.

BOD ranged from <2 to 2 mg/l in all samples.

The results of round 2 sampling are presented in Table 9-12.

Round 1 of Sampling (Grid Connection)

6 no. additional sampling locations were used for the grid connection baseline monitoring. These locations are downstream on the main watercourses intercepted by the proposed route.

Total suspended solids at all sampling locations were generally at or below the limit of detection (5mg/l), considerably below the threshold value of 25 mg/l. SW16 was above the limit of detection at 7 mg/l. Nitrite and nitrate values were below or equal to the laboratory detection limit of 0.05 and 5.0 mg/L respectively within all samples.

Ortho-phosphate was below the laboratory detection limit of 0.02mg/L in all 6 locations.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), 5 of 6 results for ammonia N were below the "Good Status" threshold, and below the "High Status" threshold. One sample from SW18 exceeded the Good status threshold with a result of 0.05 mg/l.

In relation to ortho-phosphate, all 6 samples were within the "Good Status" and "High Status" range.

BOD was below the detection limit of 5 mg/l

Table 9-14: Analytical results of Grid route samples (Round 1)

Parameter	EQS	Sample ID					
		SW14	SW15	SW16	SW17	SW18	SW19
Total Suspended Solids (mg/L)	25(+)	<5	<5	9	5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	<0.02	<0.02	0.03	0.02	0.03	0.03
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	8	8.8	5.1	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride (mg/L)	-	13.4	12.9	17.1	17.9	17.5	16.6
BOD	≤ 1.3 to ≤ 1.5(*)	<5	<5	<5	<5	<5	<5

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Table 9-15: Analytical results of Grid route samples (Round 2)

Parameter	EQS	Sample ID					
		SW14	SW15	SW16	SW17	SW18	SW19
Total Suspended Solids (mg/L)	25(+)	<5	<5	7	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	0.02	0.03	0.02	0.05	0.03
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrogen (mg/L)	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phosphorus (mg/L)	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride (mg/L)	-	13.4	12.7	16.7	18	17.9	16.8
BOD	≤ 1.3 to ≤ 1.5(*)	<5	<5	8	<5	<5	<5

(+) S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).