9 WATER

9.1 Introduction

9.1.1 Background & Objectives

Hydro-Environmental Services (HES) was engaged by McCarthy Keville & O'Sullivan (MKO) to undertake an assessment of the potential impacts of the proposed development comprising up to 19 no. turbine wind farm and grid connection route as associated infrastructure at Meenbog, Co. Donegal (the Proposed Development) on water aspects (hydrology and hydrogeology) of the receiving environment:

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater including connectivity with local designated sites) in the area of the Proposed Development and forestry replacement (replanting) sites;
- Identify likely negative impacts of the Proposed Development on surface water and groundwater during construction and operational phases of the development;
- Identify mitigation measures to avoid, remediate or reduce significant negative impacts and,
- Assess significant residual impacts and cumulative impacts of the Proposed Development and determine the significance of potential effects.

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 and David Broderick.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer with over 15 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. In addition, he has substantial experience in surface water drainage design and SUDs design, and surface water/groundwater interactions.

David Broderick (BSc, H.Dip Env Eng, MSc) is a hydrogeologist with over 12 years' experience in both the public and private sectors. 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 EIAs for a range of commercial developments.

9.1.3 Trans-border Hydrological Impacts

The site of the Proposed Development is located close to the Northern Ireland border and is proposed within a river catchment (Mourne Beg River) that drains into Northern Ireland. The following impact assessment therefore considers both trans-border hydrological and hydrogeological impacts, with the former generally being potentially more significant.

The potential cumulative impacts of other wind farm developments located in Northern Ireland are also assessed where required. Consultation letters were also issued to relevant Northern Ireland agencies regarding the Proposed Development and their responses are summarised in Section 9.1.3 below.

9.1.4 Consultation Responses

A number of consultation letters were issued to agencies in both Ireland and Northern Ireland in relation to the planning application and EIAR for the Proposed Development The responses relevant to the hydrological and hydrogeological environments are summarised below. The relevant sections of this chapter (Hydrology and Hydrogeology) that address these concerns are also shown.

Northern Ireland Bodies:

Northern Ireland Environment Agency – WMU (response date 2nd June 2014)	
Original Consultation Response Summary:	Addressed at Section
Potential Groundwater Impacts: • The impact of dewatering on any groundwater dependent receptors, *i.e.* domestic/industrial/ commercial abstractions, waterways, boreholes, wetlands etc, within or outside of the proposed site; • The potential mobilisation of contaminated groundwater within the site or onto the site as a result of dewatering, thereby creating a contaminated discharge; • How will dewatered water be treated prior to discharge and where will it be discharged; and, • The potential impact from the spillage of oils/fuels/cement/chemicals or other pollutants entering groundwater.	9.4.2.3 9.4.2.9 9.4.2.4 9.4.2.4 9.4.2.5
Potential Surface Water Impacts: • The mobilisation of sediments due to storm water runoff from excavated/cleared areas or soil stockpiles; • Spillages of oils/fuels/cement/chemicals or other pollutants;	9.4.2.1 9.4.2.2 9.4.2.5 9.4.2.4

• Discharge of contaminated groundwater into surface waters; • The disposal of sewage from the site both during the construction and operational phases; and, • The disposal of storm water from the site both during the construction and operational phases.	9.4.2.6 9.4.2.2 9.4.3.1
Potential Hydro-morphological Impacts: • The permanent or temporary diversion of watercourses; • New, or alterations to existing, crossing structures such as culverts and bridges; • New or altered structures impacting on a waterway *e.g.* Jetties, piers, outfall structures, bank reinforcements; and, • Loss of river continuity.	 9.4.2.8 9.4.2.8 n/a n/a

Loughs Agency (response dated 23rd June 2014)	
Original Consultation Response Summary:	Addressed at Section
• The potential for deleterious matter to enter watercourses is of primary concern; • Oil and fuel should be stored (in a bunded area providing at least 110% capacity of the largest stored unit) 100m from watercourses; • It is essential that silt traps and settlement ponds are used and that they are inspected regularly and maintained accordingly; and, • Any stocking piling of material will require careful management to ensure slippage of collapse to any watercourses will not occur.	9.4.2.1 9.4.2.2 9.4.2.5 9.4.2.1 9.4.2.2 9.4.2.2

Loughs Agency (response dated 19th March 2017)	
Original Consultation Response Summary:	Addressed at Section
• The Lough Agency has no objection to the principle of the proposed development • The potential for deleterious matter to enter watercourses is of primary concern • The applicant should demonstrate best environmental practice when working close to watercourses	 9.4.2.1/ 9.4.2.2

DARD (response dated 5th June 2014)	
Original Consultation Response Summary:	Addressed at Section
• Any water discharge from works should be consented by the Water Management Unit; (NIEA) under the Water (NI) Order 1999;	n/a
• All works near watercourses to be carried out in line with guidance as described in the Pollution Prevention Guidelines 5 (Works In, Near or Liable to Affect Watercourses);	9.4.2.8
• The developer must be sure that no pollutants, including sediment are allowed to enter the river during construction operations; and,	9.4.2.2
• A description of the mitigatory measures proposed to prevent, reduce or offset adverse impacts on fisheries.	9.4.2.2/ 9.4.2.8

n/a – not applicable

Rivers Agency (response dated 27th January 2017)	
Original Consultation Response Summary:	Addressed at Section
• Paragraph 5.8 of PPS 15 requires that flood risk and drainage assessment are addressed in the EIAR;	9.3.6

9.1.5 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. We have also addressed certain issues raised by 3rd parties relating to the 2015 wind farm application (under ABP Ref: PA0040).

9.1.6 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU

Regard has also been taken of the requirements of the following legislation (where Relevant):

- Planning and Development Acts 2000-2017;
- Planning and Development Regulations, 2001 (as amended);

- S.I. No. 94 of 1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293 of 1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;
- S.I. No. 41 of 1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249 of 1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);
- S.I. No. 439 of 2000: Quality of Water intended for Human Consumption Regulations and S.I. No. 278 of 2007 European Communities (Drinking Water No. 2) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010; and,
- S.I. No. 296 of 2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

Relevant Northern Irish legislation were also reviewed and considered during the assessment of trans-border hydrological impacts.

9.1.7 Relevant Guidance

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

- Environmental Protection Agency (2017): Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation on Environmental Impact Statements) where relevant;

- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements where relevant;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation on Environmental Impact Statements) where relevant;
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in 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;
- Wind Farm Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- 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;
- Eastern Regional Fisheries Board (not dated): Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites;
- 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); and,
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006.

9.2 Methodology

9.2.1 Desk Study

A desk study of the study area of the Proposed Development including the wind farm site and grid connection route was largely completed prior to the undertaking of field mapping and walkover assessments. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation with the following:

Republic of Ireland Information Sources:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- 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);
- Water Framework Directive Map Viewer (www.catchments.ie);

- Bedrock Geology 1:100,000 Scale Map Series, Sheet 3 (Geology of South Donegal). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

Northern Ireland Information Sources:

- Northern Ireland Environment Agency- "River Basin Plan Map Viewer" (www.ni-environment.gov.uk);
- Northern Ireland Environment Agency (www.ni-environment.gov.uk);
- British Geological Survey (www.bgs.ac.uk);
- Geological Survey of Northern Ireland- "Geoindex" (www.bgs.ac.uk/gsni);
- Department of Agricultural and Rural Development – Strategic Flood Map (www.dardni.gov.uk/riversagency/index/strategic-flood-maps.htm);
- Northern Ireland Met office (www.metoffice.gov.uk/weather/uk/ni); and,
- Strabane District Council – Local Biodiversity Action Plan

9.2.2 Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring was initially undertaken by HES during October 2014, and additional site surveys and intrusive investigations were undertaken between 26th and 28th July 2017.

The objectives of the intrusive site investigations (refer to Chapter 8 – Soils and Geology for details), which accumulated to over 350 hours of site work (man hours), 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 turbine, substation, compound and borrow pit locations. The surveying of several existing borrow pits at the site (not forming part of the development) confirmed the findings of the investigations and allowed the development of an accurate hydrogeological conceptual model of the site.

The duration of time spent on site, and the accumulation of data from several site visits demonstrates that this work was not rushed or inadequate, and is in fact robust and comprehensive.

The hydrological walkover survey involved:

- Walkover surveys and hydrological mapping of the proposed site, grid connection route and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- An assessment of the hydraulic capacity/adequacy of existing stream culverts (those being altered by construction) and design specifications for proposed stream culverts;
- A preliminary flood risk assessment for the proposed development footprint area;
- Over 500 no. peat probes were undertaken by HES, AGEC Ltd and MKO to determine the thickness and geomorphology of the blanket peat overlying the site;

- Gouge cores (+30 no.) and window sampling (1 no. location)[1] was undertaken to investigate peat and mineral subsoil lithology along with depth to bedrock;
- A Peat Stability Assessment was undertaken by AGEC Ltd (October, 2017);
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows;
- A total of 3 no. surface water samples were undertaken to assess the contemporary baseline water quality of the primary surface waters originating from the proposed site (the status of the local watercourses has already determined as part of the Water Framework Directive mapping); and,
- Measurement of surface water flows from streams draining the proposed development footprint.

9.2.3 Impact Assessment Methodology

Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology (EPA, 2107 and 2002, 2003, 2015 (where relevant)). 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 9.1 are then used to assess the potential effect that the Proposed Development may have on them.

Table 9.1 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

[1] We intended to complete 8 no. window sample drill holes on the site of the Proposed Development to assess groundwater levels/inflows in the underlying mineral subsoils, but in general peat overlies bedrock, weathered bedrock or very thin subsoils, and as such window sampling to assess groundwater conditions in the mineral subsoil was not needed, as none existed. This is explained further below.

9.3 Receiving Environment

9.3.1 Site Description & Topography

The site of the Proposed Development site is located approximately 8km to the southwest of the towns of Ballybofey and Stranorlar, Co. Donegal.

The total study area is approximately 990ha (9.9km^2) in area. The eastern and southern boundaries of the development study area are defined by the Northern Ireland border. The closest town to the site, in Northern Ireland, is Castlederg which is located approximately 17km to the southeast of the site.

The site is dominated by commercial forestry plantations that have been planted over peat. The elevation of the site ranges between approximately 180 and 300mOD (metres above Ordnance Datum) with the majority of the site sloping in a northwesterly direction towards the Bunadaowen River which flows northerly through the site. The southern section of the site slopes to the southeast towards Northern Ireland border and drains towards the Glendergan River.

The site is generally bordered on all sides by forestry plantations with the eastern and southern boundaries also being defined by the Northern Ireland border. Land use is almost exclusively commercial forestry in the areas proposed for development with the exception of 2 turbines (T16 and T19) which are located on open upland intact blanket bog.

There is a network of existing forestry roads providing access in and around the site. The site is covered by blanket bog with very few natural mineral subsoil or bedrock exposures visible at the site. However, there are number of existing borrow pits where the subsoil and bedrock profile can be observed but these borrow pits do not form part of this application. The observations from the exposures are consistent with the finding of the intrusive site investigations (as detailed in Chapter 8) which show that the peat directly overlies bedrock, weathered bedrock or very thin pockets of subsoils.

The grid connection route connects the proposed Meenbog Windfarm substation to the permitted Clogher substation at Cullionbuoy which exists approximately 6.2km to the southwest of the site. The current application seeks permission for underground cabling to link with the underground grid connection cabling from the Drumnahough substation currently proposed under Pl. Ref 17/505/43 & ABP Ref. PL05E.248796. This will be done via a link with the underground grid connection cabling from the Drumnahough substation, currently proposed under Pl. Ref 17/50543, ABP Ref. PL05E.248796 ("the Drumnahough Cable"). The proposed underground cable route follows the Meenbog Windfarm wind farm access road that leads towards the site entrance on the N15 for approximately 1.5km. The route then goes off road to the south of the windfarm access road for approximately 320m before passing under the N15. Directional drilling will be undertaken to run the cable below the N15 and also below a stream that flows on the eastern side of the N15. The route will then run for approximately 225m, off-road, on the western side of the N15 before connecting into the Drumanhough Cable route. The grid connection cabling arrangement is described, in detail, in Section 4.3.7 of this EIAR.

The replacement replanting of felled forestry can occur anywhere in the State subject to licence. Five potential replanting areas have been identified for assessment purposes, with a combined availability of 46.1 hectares. These lands have been granted Forest Service Technical Approval for afforestation, and these or similarly approved lands will be used for replanting should the proposed wind farm receive planning permission. A description of the proposed replanting lands and an assessment of the potential impacts including cumulative impacts associated with afforestation at this location are provided in Appendix 4.3 of this EIAR.

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 Ballybofey (Lough Mourne), 2km northwest of the site, are presented in Table 9.2. This is the closest station which is most similar to the elevation of the site of the Proposed Development. (*Please note that these rainfall data are used for baseline characterisation purposes only and are not used for assessing runoff volumes pre/post development or for drainage design*).

Table 9.2 Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Lough Mourne		110700		235200		101		1963		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
214	152	170	113	101	107	122	154	162	211	204	221	1931

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Malin Head, approximately 74km northeast of the site. The long-term average PE for this station is 555mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 527mm/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:

Effective rainfall (ER) = AAR – AE
= 1,931mm/yr – 527mm/yr
ER = 1,404mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate of 51 – 100mm/year average annual recharge is given for the study area. This means that the hydrology of the study area is characterised by high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the site are estimated to be 51mm/yr and 1,353mm/yr respectively. The large coverage of low permeability blanket peat means recharge rates are likely to be towards the lower end of the GSI range.

9.3.3 Regional & Local Hydrology

Regionally the site of the Proposed Development is located in the Mourne River surface water catchment. The proposed grid connection route is located in the Mourne River surface water catchment (6 of the 14.8km) and the Lough Eske surface water catchment (8.8 of the 14.8km).

The Mourne River, which originates within the Republic of Ireland as the Mourne Beg River (tributary of the Mourne River), flows in a northerly direction approximately 12km to the northeast of the site. The downstream Mourne River / River Derg, which flow to the south of the site (within Northern Ireland), merge with the Strule River approximately 15km east of the proposed site to the form the Mourne River. The Mourne River exists within the regional River Foyle catchment.

The Lough Eske catchment, in which an 8.8km section of the grid connection route exists, is located in the North Western River Basin District, within the Republic of Ireland. A regional hydrology map is shown as Figure 9.1.

In terms of local hydrology the site of the Proposed Development is situated within the Bunadaowen River and the Glendergan River catchments. Both catchments exist with the Mourne River catchment.

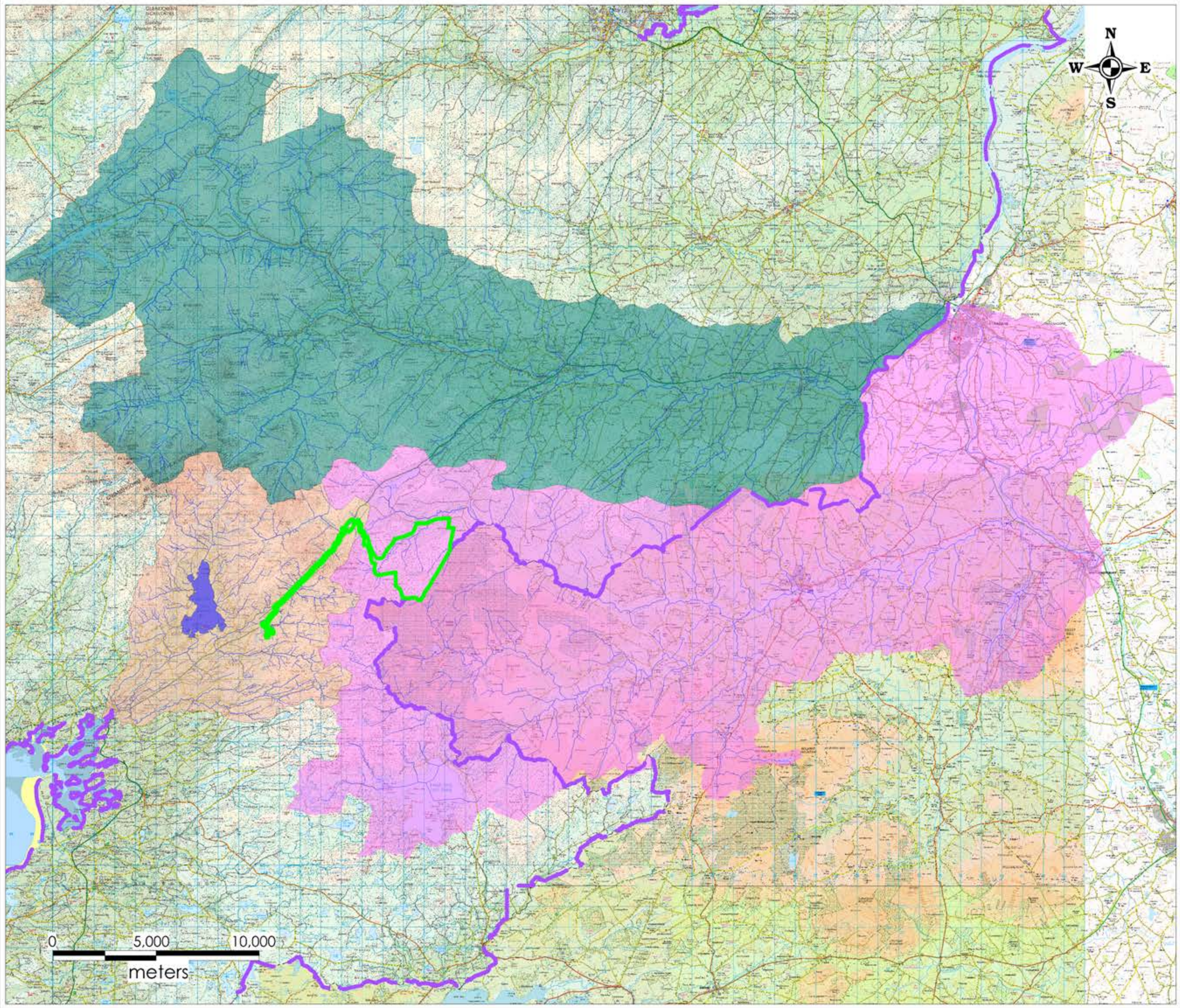
The grid connection route passes through the Mourne Beg River catchment and Lowerymore River catchment with the latter being a sub-catchment to Lough Eske. A local hydrology map is shown as Figure 9.2.

9.3.4 Forestry Drainage Background

Within the site of the Proposed Development here are numerous manmade drains that are in place predominately to drain the existing forestry plantations. The current internal forestry drainage pattern is influenced by the local topography, peat cover, layout of the forest plantation and by the existing road network. The forestry plantations, which cover the majority of the site are generally drained by a network of mound drains 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 (refer to Figure 9A below for existing forestry drainage layout schematic).

Mound drains and ploughed ribbon drains are generally spaced approximately every 15-20m and 2m respectively. Interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of existing forestry access roads. Culverts are located on existing access roads at stream and drain crossings and at low points under access roads which drain runoff onto down-gradient forest plantations.

The site drainage surveys, which were undertaken during October 2014, January 2015 and July/September 2017, were carried out during relatively wet periods and therefore the drains and streams at the site were observed during wet conditions. Every effort was made during the surveys to map the main important drains in the vicinity of the proposed development footprint but due to the dense forestry coverage it was not feasible to map every single drain. However, it is not necessary to map or have knowledge of every single forestry drain, as the typical standard forestry drainage layout (as shown in Plate 9.1 was applied when designing the wind farm drainage and runoff control measures for the protection of surface water quality. The integration of the existing forestry drains with the Proposed Development drainage is a key component of the drainage design and the same integration approach (which is outlined in Section 9.4.2.2 below) will be applied to all forestry drainage during the construction and operation of the Proposed Development.



Legend:

- EIAR Site Boundary
- River Finn Catchment
- Mourne River Catchment
- Lough Eske Catchment
- Northern Ireland Border
- Rivers/Streams

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Title: Regional Hydrology Map

Client: McCarthy Keville O'Sullivan

Job: Meenbog WF, Co. Donegal

Project No: P1249-2

Figure No: 9.1

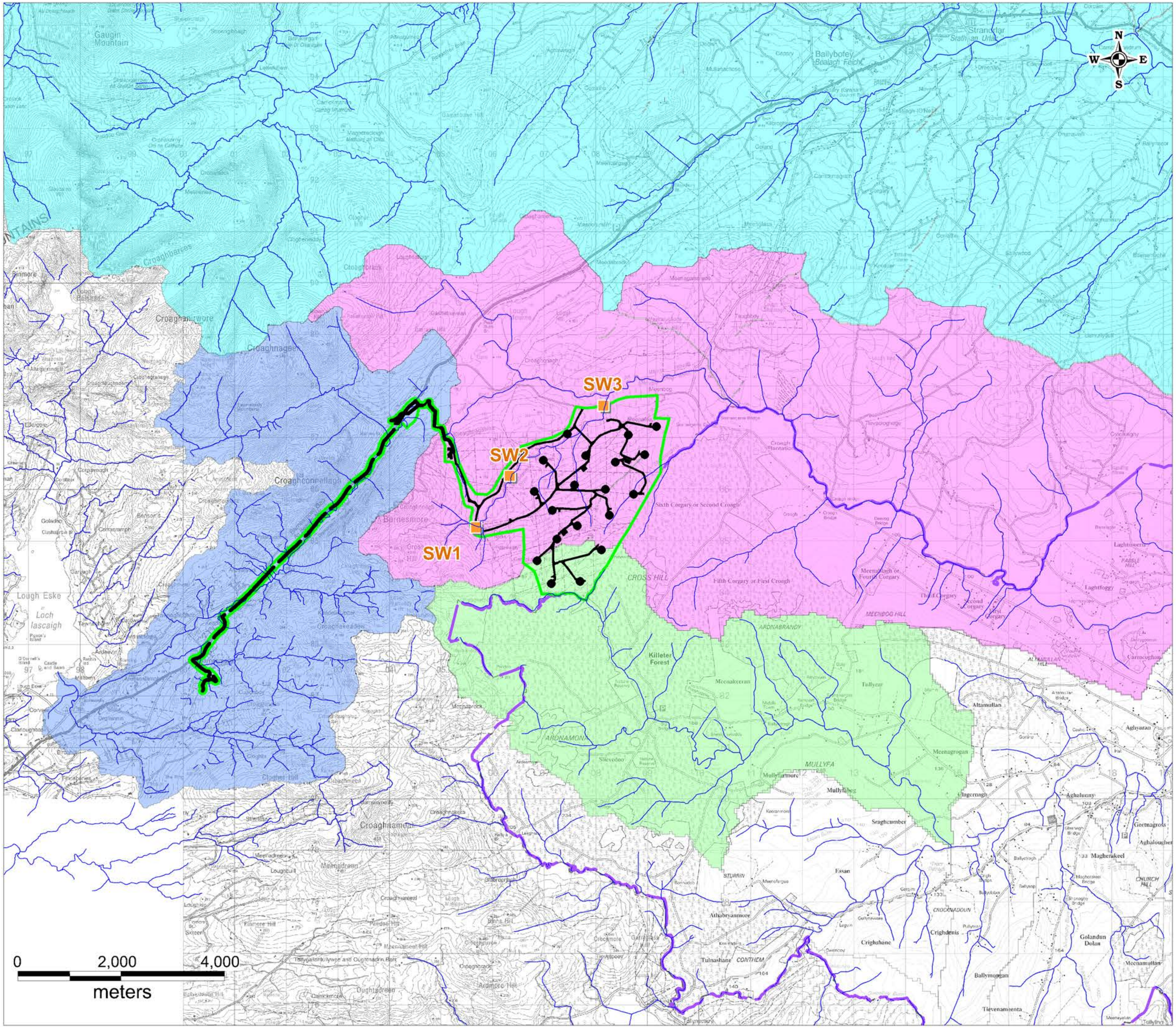
Sheet Size: A4

Drawing No: P1249-2-1217-A4-901-0A

Date: 12/12/2017

Scale: 1:250,000

Drawn By: GD | Checked By: MG



LEGEND:

- EIAR Site Boundary
- Glendergan River Catchment
- River Finn Catchment
- Mourne Beg River Catchment
- Lowerymore River Catchment
- Proposed Turbine & Development Footprint Layout
- Grid Connection Cable Route
- Surface Water Sample Location
- Northern Ireland Border
- Rivers/Streams

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Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Local Hydrology Map	
Figure No: 9.2	
Drawing No: P1249-2-1217-A3-902-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:100,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG

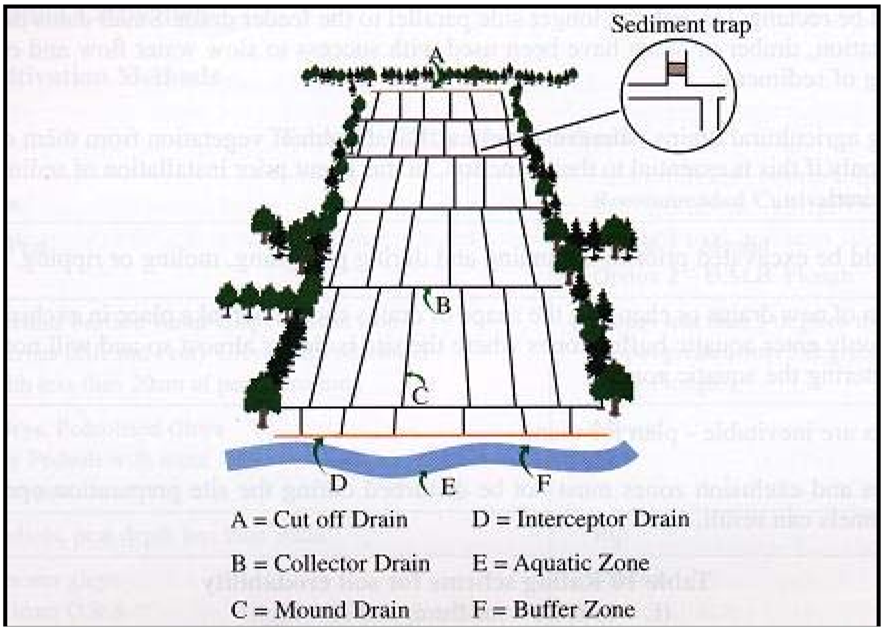


Plate 9.1: Standard Forestry Drainage (Forestry Schemes Manual, Forest Service, August 2004)

9.3.5 Site Drainage

For the purpose of describing the existing site drainage the site of the Proposed Development site is divided into the four main sub-catchments as described below.

A site sub-catchment map is shown as Figure 9.3 and a site drainage map is shown as Figure 9.4.

9.3.5.1 Bunadaowen River

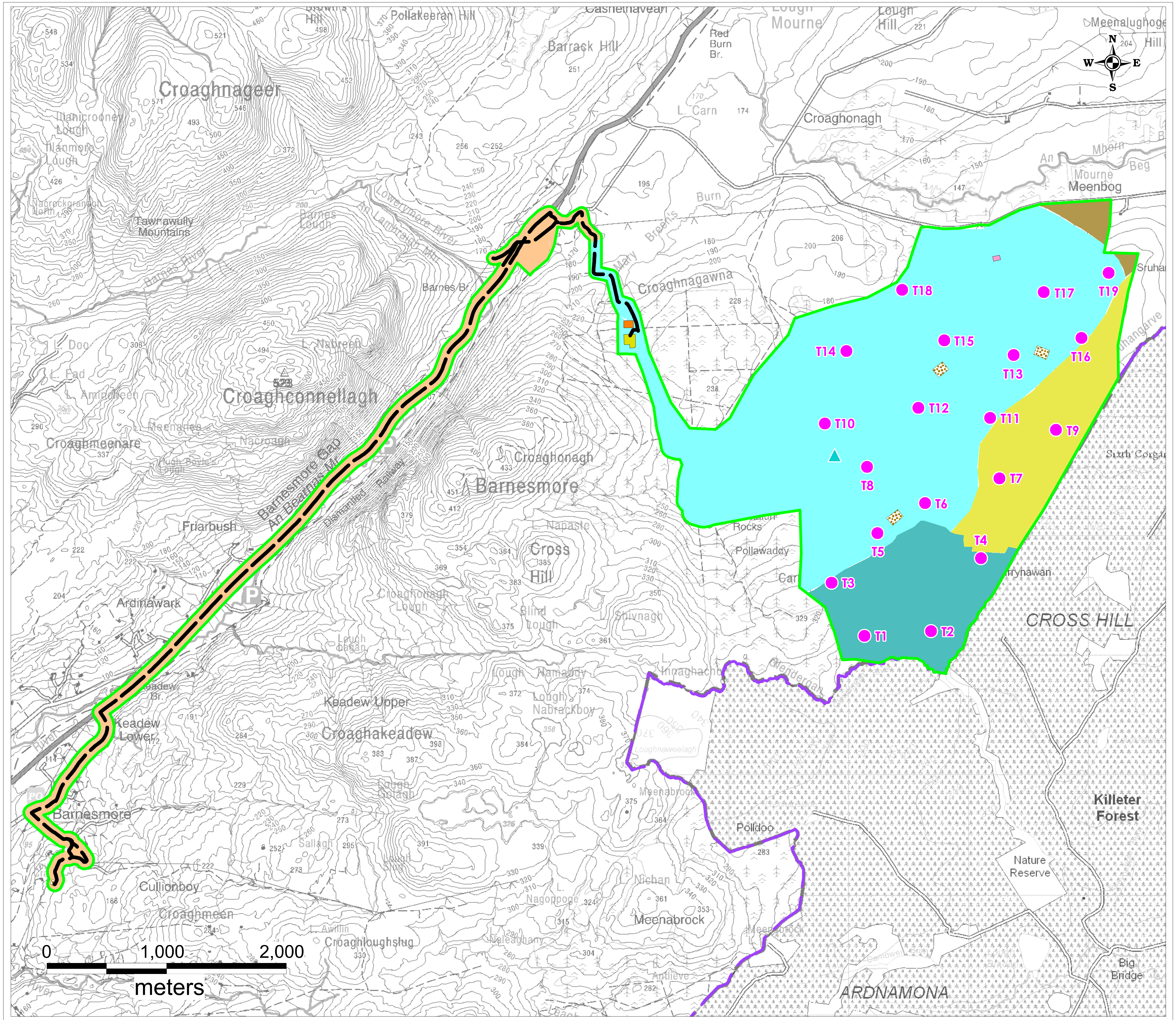
The majority of the site of the Proposed Development drains directly to the Bunadaowen River which flows in a northeasterly direction through the northwestern section of the site. The Bunadaowen River merges with the Mourne Beg River approximately 0.3km to the north of the development study area. Within the Bunadaowen River catchment area the site area is also drained by several first order tributary streams which flow in a general northwesterly direction towards the Bunadaowen River. The streams are typically deeply incised, narrow eroding streams with a width of between 0.5 and 1m. The existing and proposed access roads intersect these streams at several locations within the proposed development area. An assessment of existing and proposed stream crossing culverts is undertaken in Section 9.3.20 below. Flow measurements were also undertaken in these tributary streams and these data are shown further below.

9.3.5.2 Glendergan River

The most southern section of the site drains to the Glendergan River which flows along the southern study area boundary. In addition there are two first order tributary streams which flow in a southerly direction through the development site towards the Glendergan River.

9.3.5.3 Shruhangarve Stream

The eastern section of the site drains to the Shruhangarve Stream which flows in a northerly direction towards the Mourne Beg River which exists approximately 2.4km downstream of the site of the Proposed Development.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Grid Connection Cable Route
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Proposed Construction Compound / Amenity Area
- Northern Ireland Border

Mourne Beg Subcatchments

- Glendergan River Catchment
- Shruhangarve Stream Catchment
- Mourne Beg Direct Catchment
- Bunadaowen River Catchment

Lough Eske Subcatchments

- Lowerymore River Catchment

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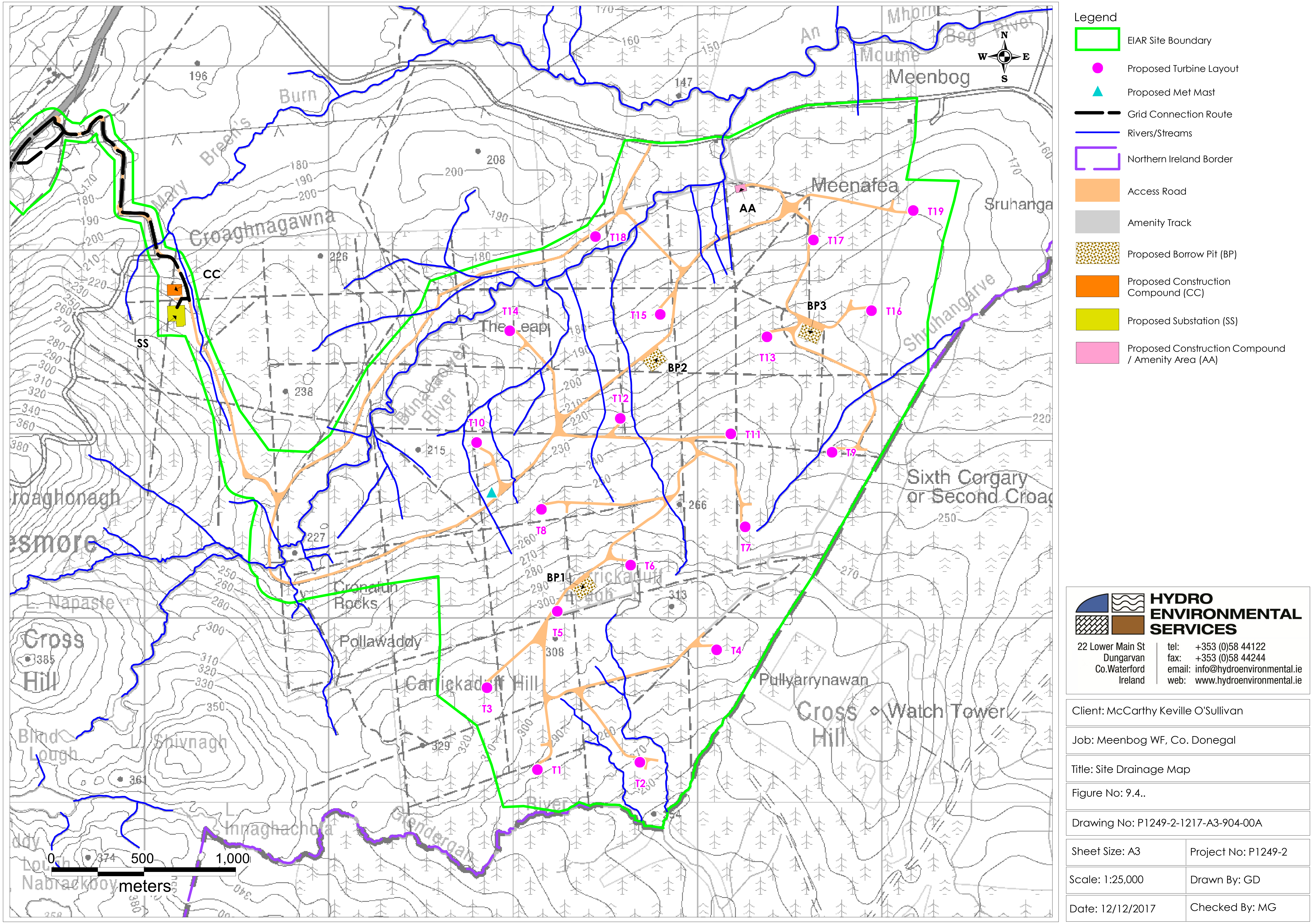
Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Site Subcatchment Map	
Figure No: 9.3	
Drawing No: P1249-2-1217-A3-903-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:42,500	Drawn By: GD
Date: 12/12/2017	Checked By: MG



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Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Site Drainage Map	
Figure No: 9.4..	
Drawing No: P1249-2-1217-A3-904-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:25,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG

9.3.5.4 Lowerymore River

The western section of the grid connection route adjacent to the N15 exists within the Lowerymore River catchment. The Lowerymore River flows adjacent to the N15 for most of its stretch upstream of Lough Easke. The Lowerymore River also passes beneath the N15 at two locations upstream of Lough Eske. The off-road section of the proposed grid connection route crosses a tributary stream of the Lowerymore River. It is proposed that this stream will be negotiated by directional drilling beneath the watercourse.

A summary of the main infrastructure within each of the sub-catchments is shown in Table 9.3 below.

Table 9.3 Summary of Site Sub-Catchments & Proposed Infrastructure

Regional Catchment Area	Sub Catchment	Proposed main Infrastructure
Mourne	Bunadaowen	11 no. turbines, 2 no. compounds, 1 no. substation, 3 no. borrow pits andmet mast
Mourne	Glendergan	4 no. turbines
Mourne	Shruhangarve	4 no. turbines
Mourne	Mourne Beg Direct (Mary Breen's Burn)	1 no. substation, 1 no. borrow pit and 0.6km section of grid connection route
Eske	Lowerymore	8.9km Section of grid connection route

9.3.5.5 Surface Water Flow Monitoring

Surface water flows measured at the site on 20th September 2017 are shown in Table 9.4 below. The watercourses monitored are typical of the headwater streams that drain towards the Bunadaowen River within the windfarm site.

Table 9.4 Surface Water Flow Monitoring (20/09/2017)

Location	Easting / Northing	Channel Width (m)	Water Depth (m)	Discharge (m^3/s)
FM1	E208130 N387062	1.1	0.35	0.033
FM2	E206135 N385190	0.5	0.09	0.013
FM3	E205791 N385190	1.1	0.15	0.080
FM4	E206593 N386681	0.4	0.09	0.011

9.3.6 Flood Risk Identification

To identify those areas as being at risk of flooding in the Republic of Ireland, 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" and 25" base maps) were consulted. For watercourses down-gradient of the development within Northern Ireland, the Department of Agriculture and Rural Development (DARD)/Rivers Agency "Strategic Flood Map" (www.dardni.gov.uk) was consulted.

No recurring flood incidents within the study area boundary or immediately downstream of it were identified from OPW's indicative river and coastal flood map.

The PFRA map no. 394 (www.cfram.ie) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (*i.e.* river) and pluvial (*i.e.* rainfall) flood events. The 1 in 100 year fluvial flood zones mapped within the study area generally occur in close proximity to the stream channel itself. All proposed turbine locations and the majority of access roads are located (with the exception of watercourse crossings) at least 50m away from streams and are outside of the fluvial indicative 1 in 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. This means flooding is a result of surface water flooding from local streams/rivers.

There is no identifiable map text on local available historical 6" or 25" mapping for the study area that identify lands that are "prone to flooding".

There are no areas within the study area mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

Downstream of the study area within Northern Ireland, the Strategic Flood Map shows the 1 in 100 year flood zone incorporates significant land area surrounding the Mourne Beg River and Derg River. Flood zones in the areas of local streams and burns generally occur in close proximity to the stream channels and may affect local roads in places.

It is a key mitigation of the Proposed Development to ensure all surface water runoff is treated (water quality control) and attenuated (water quantity/flood management 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

Within the Republic of Ireland Q-rating status data for EPA monitoring points on the Bunadaowen River and the Mourne Beg River are shown on Table 9.5 below. Most recent data available (2004 to present) show that the Q-rating for the Bunadaowen River and the Mourne Beg River is Poor Status in the vicinity of the study area.

Table 9.5 EPA Water Quality Monitoring Q-Rating Values

Water body	EPA Location Description	Easting	Northing	EPA Q-Rating Status
Bunadaowen	Bridge u/s Mourne beg	208141	387602	Q2-3 Poor
Mourne Beg	Red Burn Bridge	205770	389360	Q2-3 Poor
Mourne Beg	Bridge SW of Tonreagh	209910	388300	Q2-3 Poor

Field hydrochemistry measurements of electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken within surface watercourses at the study area on 20th September 2017.

The monitoring was undertaken during a period of relatively wet weather and as a result streams and drains were observed in medium flow conditions. The results are listed (along with the surface water feature type) in Table 9.6.
Electrical conductivity (EC) values for drains and natural surface waters at the site area ranged between 39 and 45µS/cm. This indicates that surface water flow was derived predominantly from rainfall input / runoff during the monitoring period. Measurement in lower-flow conditions (lower water levels in late summer time) may indicate a higher groundwater flow component (*i.e.* baseflow - typically signified by 'higher' EC values) contributing to discharge in the primary rivers streams.

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

Table 9.6: Summary of Surface Water Chemistry Measurements.

Location ID	Easting	Northing	EC (µS/cm)	pH	Temp °C	Drainage Feature
SW1	205686	385269	45	5.7	10.5	Bunadaowen River
SW2	206336	386266	39	5.6	10.2	Bunadaowen River
SW3	208156	387628	42	5.6	10.8	Bunadaowen River

Surface water samples were taken from the Bunadaowen River on 20th September 2017. Please note that this sampling was only undertaken to compliment the WFD water quality status (which is based long term monitoring results) which is assumed to be the baseline in terms of water quality. This sampling has no major significance in terms of our interpretation or understanding of the existing hydrological environment.

Refer to Figure 9.2 for sampling locations. SW1 is upstream of the proposed development and SW3 is the furthest downstream. SW2 is the intermediate downstream location and it was taken at the proposed Lough Mourne Public Water Supply abstraction location which exists within the wind farm site (refer to Section 9.3.15 below).

Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 9.7. In addition, Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) are shown in Table 9.8. Original laboratory reports are attached as Appendix 9.1.

Table 9.7 Analytical Results of Surface Water Samples

Parameter	EC DIRECTIVES			Sample ID		
	2006/44/EC		EC DW Regs 2007	SW1	SW2	SW3
	Salmonid	Cyprinid				
Total Suspended Solids (mg/L)	≤ 25 (O)	≤ 25 (O)	-	<10	<10	<10
Ammonia N (mg/L)	≤0.04	≤0.02	0.3	<0.03	<0.03	<0.03
Nitrite NO_2 (mg/L)	≤ 0.01	≤ 0.03	0.5	<0.03	<0.03	<0.03
Ortho-Phosphate – PO_4 (mg/L)	-	-	-	<0.03	0.03	0.05
Nitrate - NO_3 (mg/L)	-	-	50	<0.2	<0.2	<0.2
Phosphorus (mg/L)	-	-		0.027	0.039	0.045
Chloride (mg/L)	-	-	250	6.6	7.6	8.1
BOD	≤ 3	≤ 6	-	<1	<1	<1

Total suspended solids were <10mg/L, which is significantly below the Freshwater Fish Directive (2006/44/EC) for both Salmonid and Cyprinid waters.

Ammonia N was below the laboratory detection limit of 0.03mg/L, which is less than the Freshwater Fish Directive (2006/44/EC) for Salmonid waters.

BOD was less than 1mg/L in all samples, which is below the Freshwater Fish Directive (2006/44/EC) for both Salmonid and Cyprinid waters.

Nitrite was below the laboratory detection limit of 0.03mg/L in samples which is the same as the Freshwater Fish Directive (2006/44/EC) limit for Cyprinid waters.

Nitrate was also below the laboratory detection limit of 0.2mg/L in all samples and phosphorus ranged between 0.027 and 0.045mg/L which would be considered low. The low levels of nutrients reported in the samples would be typical of surface water quality from a peatland environment.

Chloride which ranged between 6.6 and 8.1mg/L is typical of surface waters in a non-coastal setting such as the proposed development study area.

Table 9.8 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)
	High status ≤0.025 (mean) Good status ≤0.035 (mean)

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

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), all results for ammonia N and BOD were within the "High Status" range. Ortho-phosphate in SW1 and SW2 was below the "Good Status" but it exceeded the limit in SW3.

9.3.8 Hydrogeology

The Precambrian quartzites, gneisses and schists, which are mapped to underlie the proposed development site and the grid connection route are classified by the GSI (www.gsi.ie) as a Poor Aquifer, having bedrock which is generally unproductive except for local zones (Pl).

The Precambrian rocks generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 150m (GSI, 2004). Based on observations from the bedrock exposures at the existing borrow pits (which were noted to be largely competent and massive) limited groundwater flow will be restricted to the top of the rock or within a very thin weathered zone (0.2 – 03m). Also, the pockets of mineral subsoil (where present) are not expected to act as preferential groundwater flowpaths due to their silty composition, limited thickness and disconnected lateral distribution. Therefore, the overall potential for groundwater flow at the base of the peat is anticipated to be insignificant. As stated in the water balance section above, it expected that over 90% of effective rainfall landing on the site will leave the site as runoff.

No significant groundwater flow is expected either in the deeper bulk of bedrock as any jointing or fractures visible at the exposures were noted to be very tight. Some of the existing borrow pits have depths of up to 5 - 6m below the local ground surface and no groundwater seepage (or evidence of past or intermittent seepage) was noted.

As stated above, installing piezometers (for groundwater level monitoring) within the underlying mineral subsoil was attempted by means of window sampling. However, the peat was found to overlie rock or thin pockets of mineral subsoil and therefore this was not possible.

Groundwater flowpaths (where present) are likely to be short (30-300m), with groundwater discharging to nearby streams and small springs. Groundwater flow directions are expected to follow topography and therefore groundwater directions within the site are expected to be towards the primary streams draining the site (GSI, 2004).

Based on observations at the site, groundwater baseflow contribution to local streams is expected to be very low all year round. Overall, the hydrology of the site will be dominated by surface water runoff on the bog surface and within the existing drainage channels.

Local groundwater flow directions will mimic topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at local streams (GSI, 2004).

9.3.9 Groundwater Vulnerability

The vulnerability rating of the aquifer within the overall site ranges between "Moderate to High" and this reflects the varying depth of local subsoils and peat. In areas where subsoil is shallow or absent and where bedrock is outcropping, an Extreme vulnerability rating is given.

However, due to the low permeability nature of the Precambrian bedrock aquifer underlying the site, groundwater flowpaths are likely to be short (30 – 300m), with recharge emerging close by at seeps and surface streams. This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore surface water bodies such as drains and streams are more vulnerable than groundwater at this site.

9.3.10 Groundwater Hydrochemistry

There are no groundwater quality data for the proposed wind farm site and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality impacts would not be anticipated. There are also no proposed discharges to ground. The WFD status for the local groundwater body in terms of water quality is Good and therefore this is assumed to be the baseline condition for groundwater in the area of the proposed development.

Based on data from GSI publication Calcareous/Non-calcareous classification of bedrock in the Republic of Ireland (WFD,2004), alkalinity for this bedrock type generally ranges from 14 – 400mg/L while electrical conductivity and hardness were reported to have mean values of 446µS/cm and 200mg/L respectively.

9.3.11 Water Framework Directive Water Body Status & Objectives

For the Republic of Ireland, Local Groundwater Body and Surface water Body status and risk result are available from (www.catchments.ie) and for Northern Ireland these can be found at (www.daera-ni.gov.uk/RiverBasinViewer).

Within the Republic of Ireland, the site of the Proposed Development site is located in the Bunadaowen River Water Body (Bunadaowen_010) and the Lowerymore River Waterbody (Lowerymore_020) within the WFD North Western River Basin District. The River water quality status (2010 – 2015) for the Bunadaowen and the Lowerymore at the location of the Proposed Development is Poor and High respectively. Both River Waterbodies are reported to have a risk result of "At Risk".

Within Northern Ireland the site of the Proposed Development is located in the Mourne Beg River Water Body (UKGBNI1NW010102066) and the Glendergan River Water Body (UKGBNI1NW010102067) within the WFD North Eastern River Basin District. The River water quality status (2010 – 2015) for the Mourne Beg River and the Glendergan River at the location of the proposed site is Moderate. Both River Waterbodies are reported to have a risk result of "At Risk".

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) status information are available (www.catchments.ie). Refer to Figure 9.5 for the locations of local groundwater bodies.

The Castlederg GWB (IEGBNI_NW_G_005) underlies the site of the Proposed Development . The Donegal South GWB (IE_NW_G_047) underlies the section of the grid connection route which runs adjacent to the N15 National Road.

All the above mentioned GWBs are assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

9.3.13 Designated Sites & Habitats

With the Republic of Ireland designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). Within Northern Ireland designates sites include Special Areas of Conservation (SACs), Areas of Special Scientific Interest (ASSIs), Local Nature Reserves (LNRs) and National Natures Reserves (NNRs).The footprint of the Proposed Development footprint is not located within any designated conservation site, however there are designated sites within the development site boundary as outlined below. Republic of Ireland and Northern Ireland designated sites in proximity to the Proposed Development study area are show in Figure 9.6

Small sections of Croaghonagh Bog SAC/NHA and Cashelnavean Bog NHA are located within site boundary along the proposed grid connection route. The proposed route runs adjacent to the boundary of these designated sites along existing tracks and roads. The proposed route of the grid connection is along an existing track through these sections and therefore hydrological impacts on Croaghonagh Bog or Cashelnavean Bog NHA are not expected.

The site of the Proposed Development drains to the Mourne Beg River and the Derg River (within Northern Ireland) which also forms part of the River Foyle and Tributaries ASSI and SAC designated site.

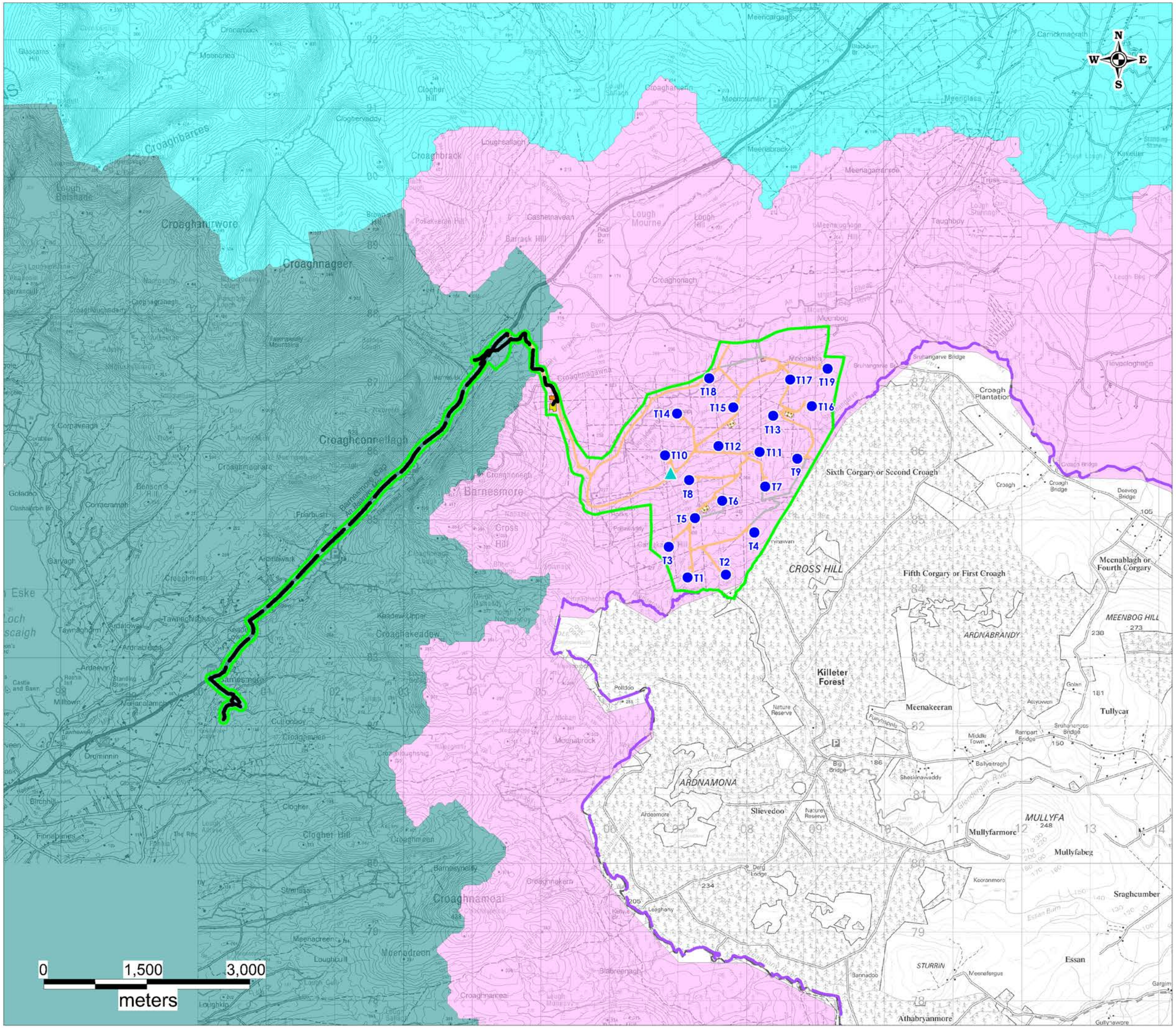
The section of the grid connection route within the Lowerymore River catchment drains to Lough Eske which is a designated SAC within the Republic of Ireland. The SAC runs adjacent to the N15 at the southern end of the grid connection route and a very small section of the SAC is within the study area boundary. A watercourse crossing under a tributary stream of the Lowerymore River, via directional drilling, is required upstream of the SAC.

The potential impacts on Lough Eske SAC are assessed further below.

9.3.14 Water Resources

There are no groundwater protection zones mapped within the site of the Proposed Development or study area. Private well locations (accuracy of 1 – 50m) obtained from the GSI well database (www.gsi.ie) are shown on Figure 9.7. Only private well locations with a mapped accuracy of 1 – 50m are shown on this map.

To overcome the poor accuracy problem of other GSI mapped wells it is assumed that every private dwelling in the area has a well supply and this impact assessment approach is described further below. Potential wells at private dwellings in both Ireland and Northern Ireland were identified.



LEGEND:

- EIAR Site Boundary
- Northern Ireland Border
- Grid Connection Cable Route
- Donegal South GWB
- Castlederg GWB
- Ballybofey GWB
- Proposed Turbine Layout
- Proposed Met Mast
- Access Road
- Amenity Track
- Proposed Borrow Pit
- Proposed Construction Compound
- Proposed Substation
- Proposed Construction Compound / Amenity Area

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Client: McCarthy Keville O'Sullivan

Job: Meenbog WF, Co. Donegal

Title: WFD Groundwater Bodies

Figure No: 9.5

Drawing No: P1249-2-11217-A3-905-00A

Sheet Size: A3	Project No: P1249-2
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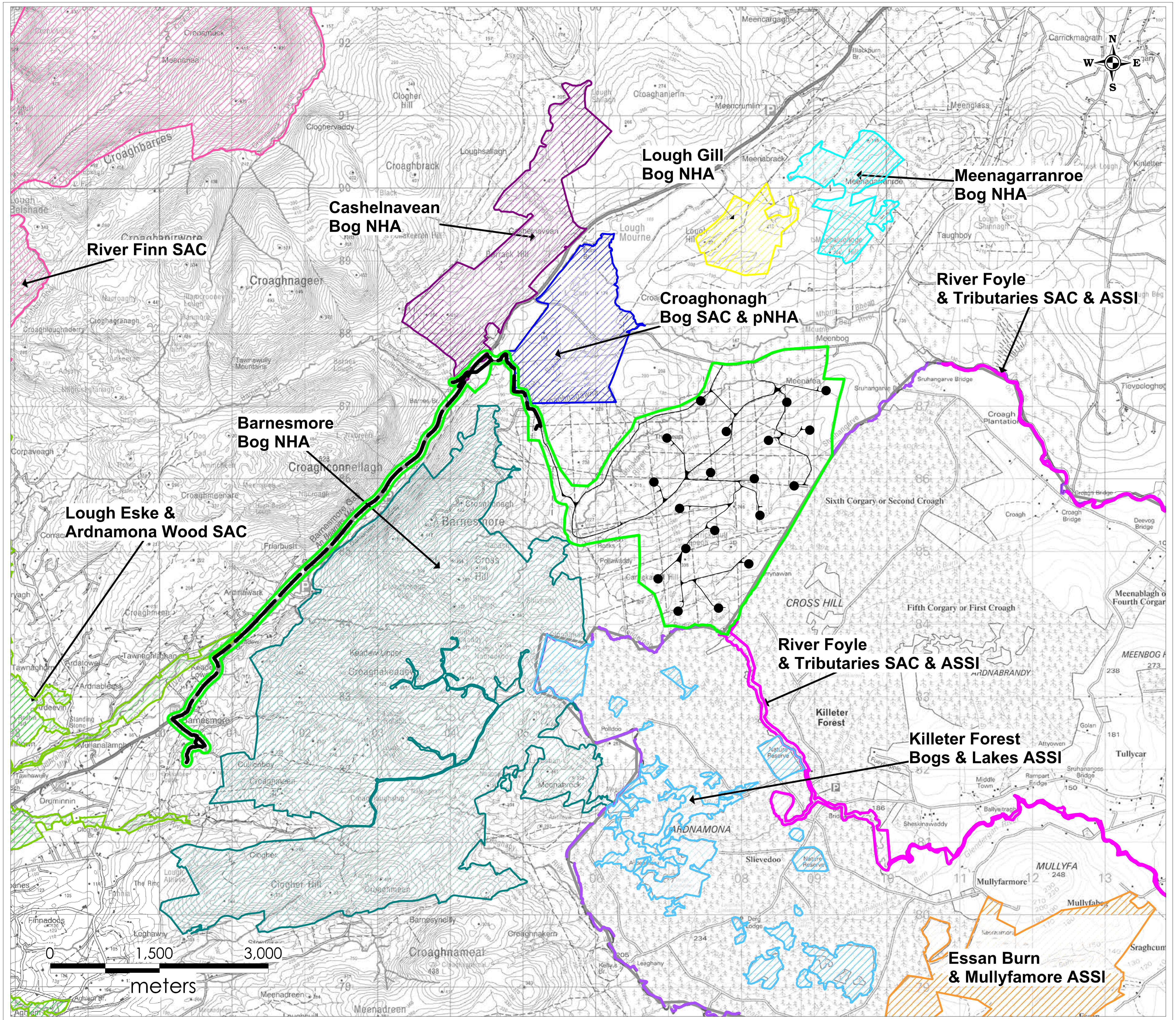

LEGEND:

- EIAR Site Boundary
- Proposed Turbine & Access Road Layout
- Grid Connection Cable Route
- Northern Ireland Border

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Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Designated Site Map (IRL & N. IRL)	
Figure No: 9.6	
Drawing No: P1249-2-1217-A3-906-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:70,000	Drawn By: GB
Date: 12/12/2017	Checked By: MG

The private well assessment undertaken below also assumes the groundwater flow direction in the aquifer underlying the site mimics topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at streams and rivers. Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the footprint of the Proposed Development footprint are identified and an impact assessment for these actual and potential well locations is undertaken if required.

Based on the GSI well database there are no mapped wells within 2.3km of the site of the Proposed Development (refer to Figure 9.7) with the closest mapped well being 2.3km to the northwest of the development site footprint. There is a cluster of private wells located along the western end of the grid connection route at Barnesmore on the N15. However, due to the shallow nature of the cable trench (~1.2m), the excavation of the trench within the road carriageway and the unsaturated nature of the ground to be excavated no impacts on groundwater levels or flows or water quality are anticipated from the grid connection construction works.

As the GSI well database is not exhaustive in terms of the locations of all private wells in the area (as the database relies on the submission of data by drillers and the public etc) and to overcome the poor accuracy problem (accuracy >50m) it is assumed that every private dwelling in the vicinity of the Proposed Development has a water supply well associated well with it (this is unlikely to be the case).

Shown on Figure 9.7 also are the locations of private dwellings in the vicinity of the development study area. There are no private dwelling houses located down-gradient of the Proposed Pevelopment and therefore there is no potential to impact on groundwater supplies.

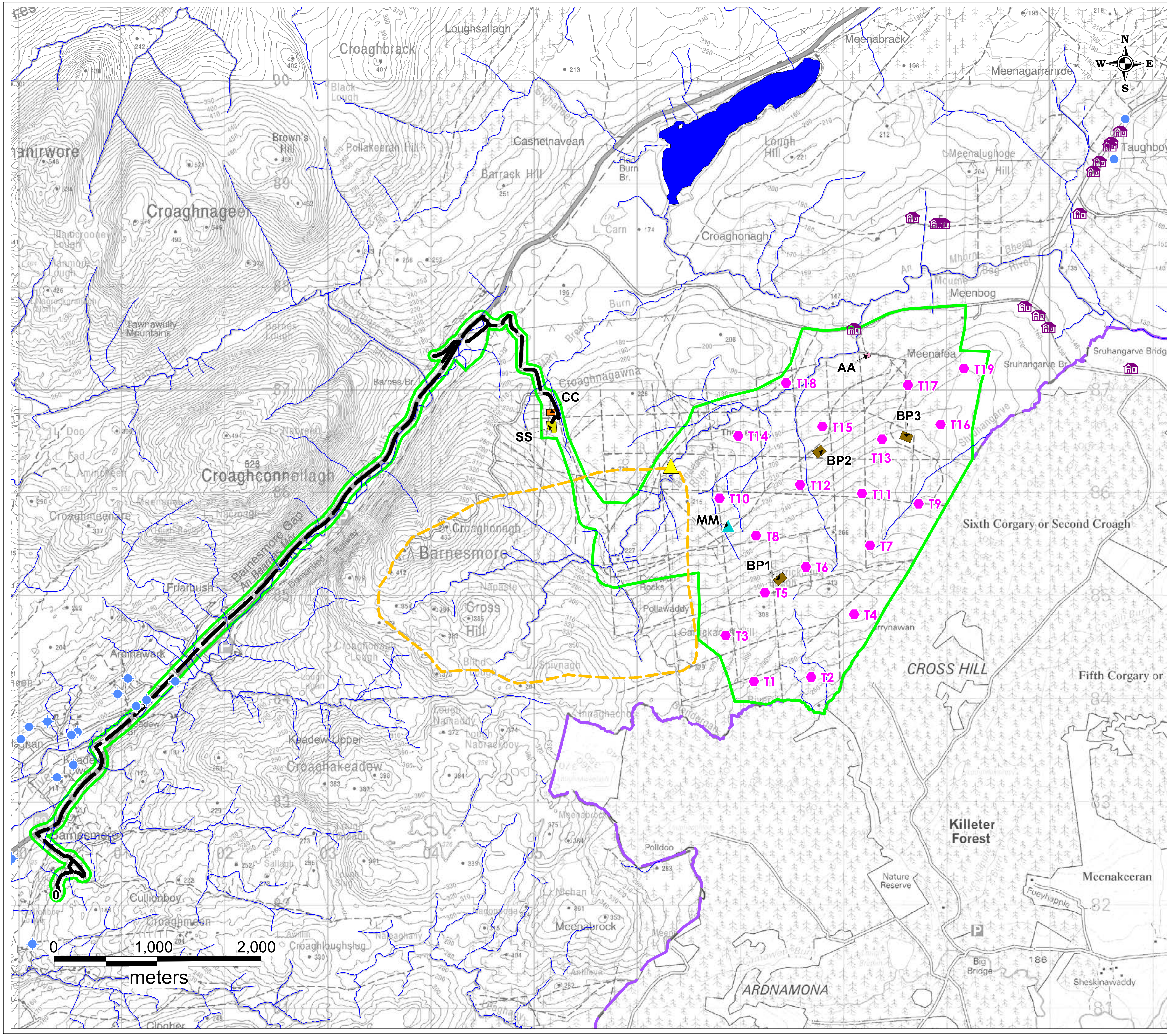
Donegal County Council is proposing to abstract surface water from the Bunadaowen River within the site of the Proposed Development and pump it to Lough Mourne Reservoir which exists approximately 1.7km to the north of the windfarm site. The surface water catchment to the proposed abstraction point is also shown on Figure 9.7.

Due to the carefully designed layout of the Proposed Development, proposed infrastructure within the surface water catchment to the source is limited to a ~2km stretch of existing foresty track (to be upgraded as part of the windfarm) and also internal cabling which will be placed within the upgraded road. The potential impacts on the proposed water supply during the construction and operational phase of the Proposed Development is assessed in Section 9.4.3.2 below.

9.3.15 Receptor Sensitivity

Due to the nature of wind farm developments, being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the site of the Proposed Development would be from cementitious materials, hydrocarbon spillage and leakages. These are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources are to be carefully managed at the site during the construction and operational phases of the Proposed Development and mitigation measures are proposed below to deal with these potential minor impacts.

Based on criteria set out in Table 9.1 above, the Poor Aquifers (*i.e.* Precambrian quartzites, geisses and schists) at the site can be classed as Not Sensitive to pollution. The majority of the site of the Proposed Development is also covered in blanket peat



LEGEND:

- EIAR Site Boundary
- Lough Mourne (Reservoir)
- Rivers/Streams
- Private Dwelling House
- Proposed Turbine Location
- GSI Database well (accuracy 1 - 5
- Proposed Borrow Pit (BP)
- Proposed Construction Compound (CC)
- Proposed Substation (SS)
- Proposed Met Mast (MM)
- Proposed Construction Compound / Amenity Area (AA)
- Grid Connection Cable Route
- Northern Ireland Border
- Proposed Lough Mourne Reservoir Supplementary Intake Location
- Proposed Lough Mourne Reservoir Supplementary Intake Catchment

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Title: Local Water Supplies Map

Figure No: 9.7

Drawing No: P1249-2-1217-A3-907-00A

Sheet Size: A3	Project No: P1249-2
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which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff.

Surface waters such as the Bunadaowen, Lowerymore River, Lough Eske, Mourne Beg River, Derg River and local streams are very sensitive to potential contamination. These rivers and streams are known to be of trout potential and are important locally for fishing (see Flora & Fauna. Biodiversity Chapter, Chapter 6). The Bunadaowen River is also a proposed new source for the Lough Mourne Public Water Supply Scheme.

Within the Republic of Ireland, the only designated site that is hydrologically connected to the site of the Proposed Development is Lough Eske which is a designated SAC. Within Northern Ireland, the Proposed Development drains to the Mourne Beg River / Derg River catchments which form part of the River Foyle and Tributaries ASSI and SAC designated site.

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downstream receiving waters. Mitigation measures will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the site will mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the site.

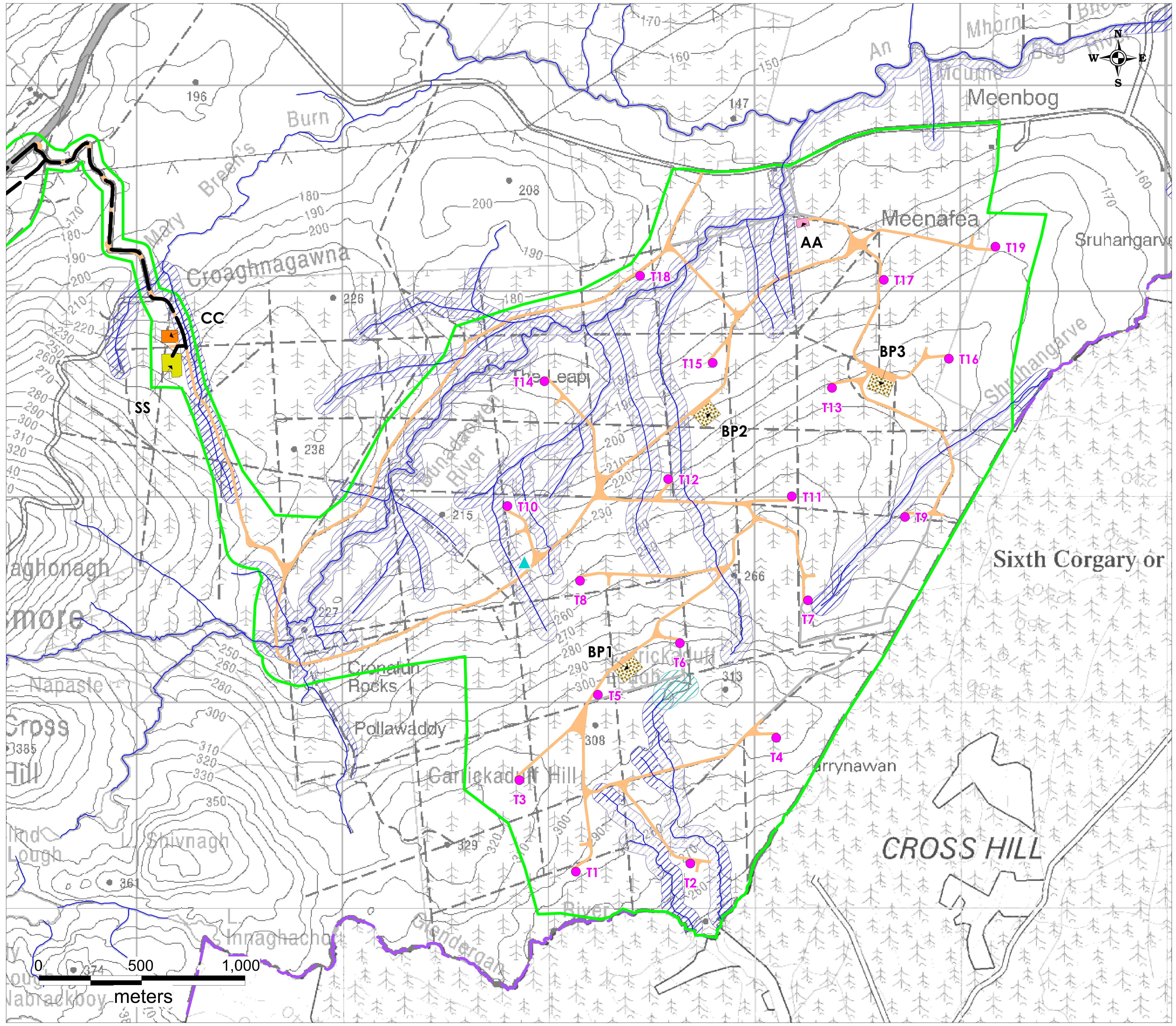
A hydrological constraints map for the site of the Proposed Development is shown as Figure 9.8. The vast majority of the Proposed Development (including of the turbines, borrow pits, substation and compounds) is more than 50m from a watercourse (with the exception of watercourse crossings and other minor elements of infrastructure). A 50m buffer is typically used for surface water quality protection relating to wind farm developments. This significantly exceeds the Forest Service maximum recommended buffer of 25m for steeply sloping sites which is the only published document relevant to the proposed development works.

Apart from the upgrade of existing roads and stream crossings and minor sections of infrastructure most of the Proposed Development areas are generally away from areas on the site that have been determined to be hydrologically sensitive. The large setback distance from sensitive hydrological features means they will not be impacted on by excavations/drains or any general construction works. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features within sub-catchments. This will allow attenuation of surface runoff to be more effective. Where there is a requirement for works within the 50m buffer zone, additional surface water quality mitigation will be put in place as outlined below in the impacts and mitigation section.

9.3.16 Assessment of Changes in Site Runoff Volumes

The water balance undertaken in this section is for baseline characterisation purposes along with an assessment of potential runoff changes as a result of the footprint of the Proposed Development. *The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the wind farm. As outlined in Section 9.4.2.2 below a 1 in 100 year 6 hour return period will be used for drainage design purposes.*

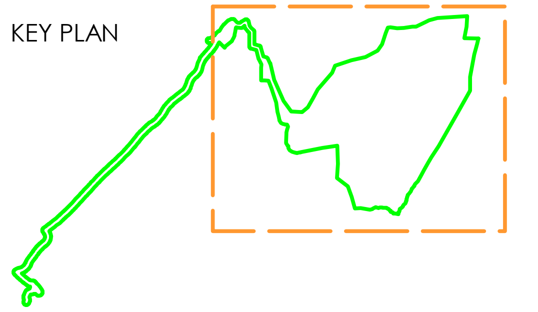
The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9.9). It represents therefore, the long-term average wettest monthly scenario in



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Grid Connection Cable Route
- Rivers/Streams
- 50m Rivers/Streams Buffer
- Northern Ireland Boundary
- Access Road
- Amenity Track
- Proposed Borrow Pit (BP)
- Proposed Construction Compound (CC)
- Proposed Substation (SS)
- Proposed Construction Compound / Amenity Area (AA)

KEY PLAN



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Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Hydro-Constraints Map	
Figure No: 9.8.	
Drawing No: P1249-2-1217-A3-908-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:25,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG

terms of volumes of surface water runoff from the study area pre-development. The surface water runoff co-efficient for the area is estimated to be 95% based on the predominant peat coverage at the site. However, to account for potential increased peat drainage as a result of the forestry cover and subsequent peat damage (*i.e.* from root damage) a lower runoff coefficient of 80% is used.

The highest long-term average monthly rainfall recorded at Lough Mourne over the period 1987 - present occurred in December, at 221mm. The average monthly evapotranspiration for the synoptic station at Malin Head over the same period in December was 15mm. The water balance indicates that a conservative estimate of surface water runoff for the study area during the highest rainfall month is 1,643,400m^3/month / 53,013m^3/day for the site as outlined in Table 9.10.

Table 9.9 Water Balance and Baseline Runoff Estimates for Wettest Month (December)

Water Balance Component	Depth (m)
Average December Rainfall (R)	0.221
Average December Potential Evapotranspiration (PE)	0.015
Average December Actual Evapotranspiration (AE = PE x 0.95)	0.0143
Effective Rainfall December (ER = R - AE)	0.207
Recharge co-efficient (20% of ER)	0.041
Runoff (80% of ER)	0.166

Table 9.10 Baseline Runoff for the Study Area

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
990	1,643,400	53,013

Table 9.11 Water Balance and Estimated Development Runoff Volumes

Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 80% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)	% Increase from Baseline Conditions (m3)
1,643,400	53,013	284,440	58,879	47,217	11,662	376.2	0.71

The emplacement of the proposed permanent development footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of 11,662m^3/month or 376m^3/day (Table 9.11). This represents a potential increase of less than 1% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the study area being developed, the proposed total permanent development footprint being approximately 28.45ha, representing 2.8% of the total study area of 990ha.

Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate). The increase in runoff from the site will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

9.3.17 Development Interaction with the Existing Forestry Drainage Network

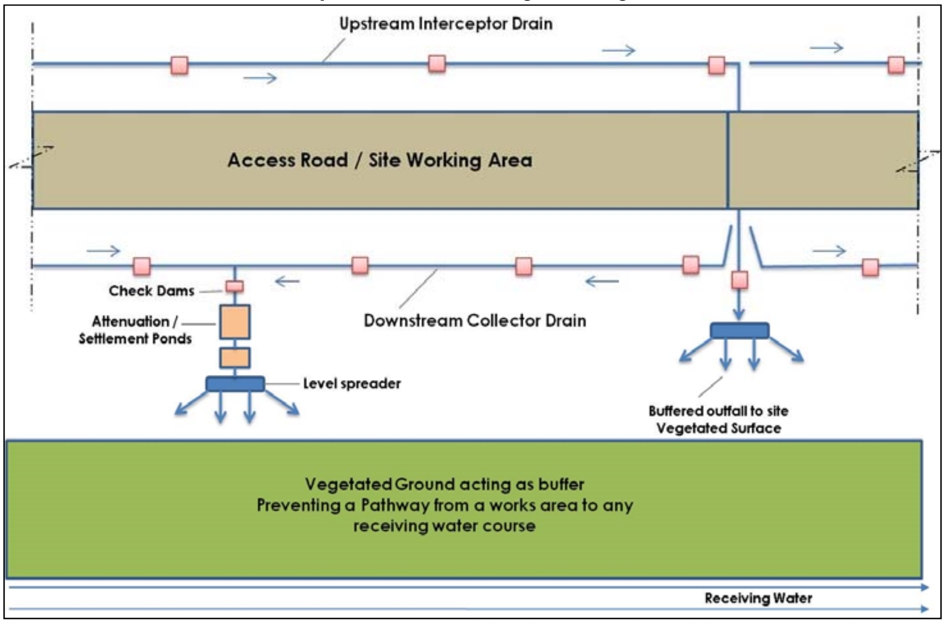
In relation to hydrological constraints, a self-imposed buffer zone of approximately 50m has been put in place for on-site streams. A 50m buffer is typically used for surface water quality protection relating to wind farm developments. This significantly exceeds the Forest Service maximum recommended buffer of 25m for steeply sloping sites which is the only published document relevant to the proposed development works. Manmade forestry drains at the site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.

The general design approach to wind farm layouts in existing forestry is to utilize and integrate with the existing forestry infrastructure where possible, whether it be existing access roads or the existing forestry drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing forestry drains have no major ecological or hydrological value, and can be readily integrated into the Proposed Development drainage scheme using the methods outlined below (Section 9.4.2.2).

9.3.18 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Development. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards settlement ponds (or stilling ponds) prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas (*i.e.* dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as Plate 9.2 below. A detailed drainage plan showing the layout of the proposed drainage design elements as shown in Plate 9.2 is shown in Appendix 4.1 of the EIAR.

Plate 9.2: Schematic of Proposed Site Drainage Management



9.3.19 Existing and Proposed Culvert Assessment

A survey of all existing stream culverts and proposed stream crossings along existing roads (for upgrade) and proposed access roads was undertaken as part of the drainage mapping. The channel dimensions of proposed stream crossings along with culvert type and dimensions at existing crossings were recorded and this information is shown in Appendix 9.2. There are a total of 19 no. existing watercourse crossings and 5 no. proposed new watercourse crossings. The locations of existing and proposed crossings are shown on Figure 9.9.

The 1 in 100 year flood flow at each existing and proposed crossing location was then estimated using the Institute of Hydrology (Report 124) along with the relevant growth factor (1.9) for this return event.

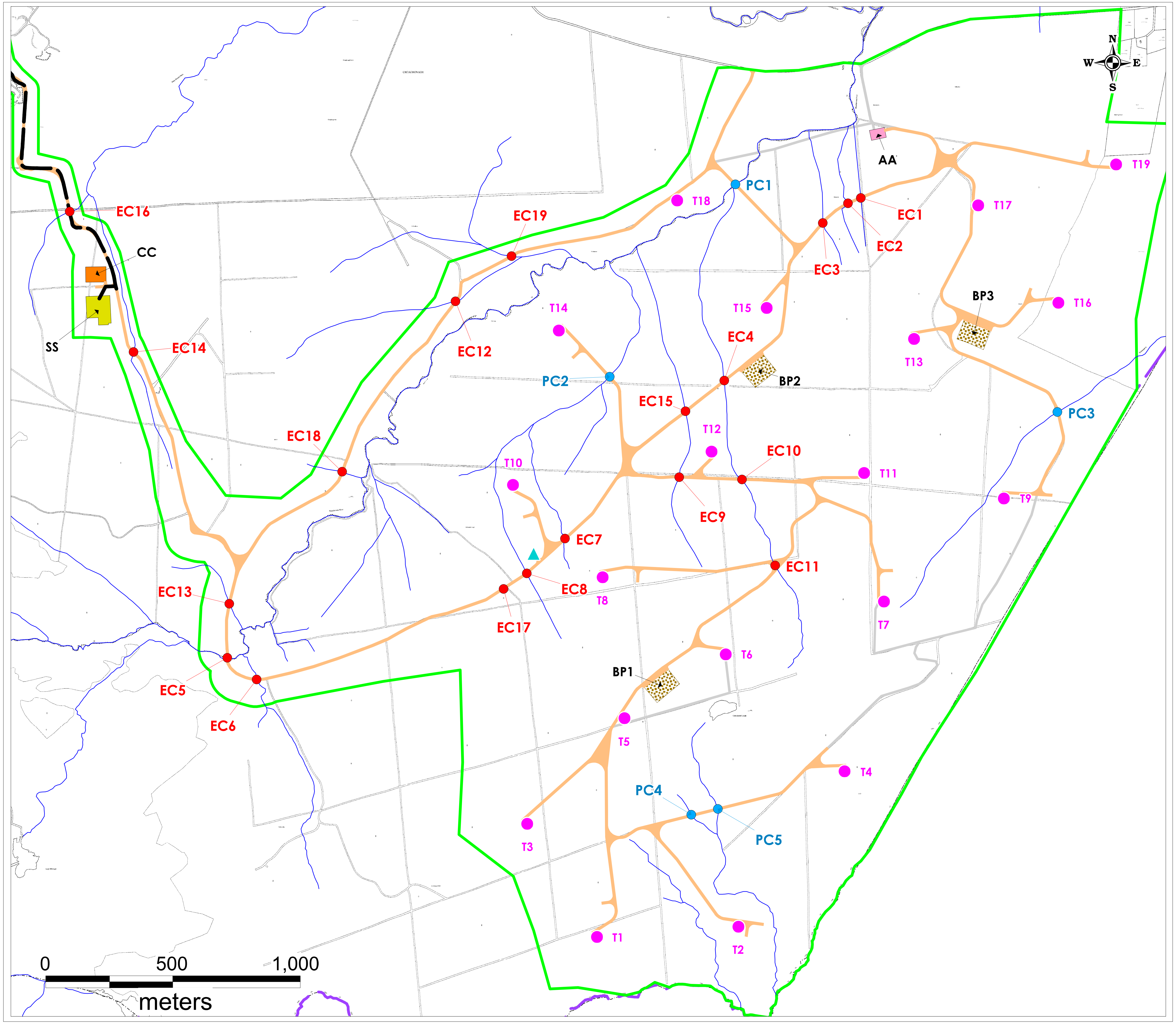
Based on the estimated 1 in 100 year flood flow at each crossing location, the adequacy of existing culverts and the minimum required dimension of proposed culverts were assessed and determined. Information relating to the hydraulic assessment including flood estimation calculations, hydraulic adequacy of existing culverts and minimum required culvert dimensions of proposed culverts are shown in Appendix 9.2. All new stream culvert crossings and upgrades will be subject to a Section 50 application (Arterial Drainage Act, 1945) and the data provided in Appendix 9.2 will be included with those applications.

A survey of all the culvert crossings along the proposed grid connection route was also undertaken. The majority of these culvert crossings are along the N15. There are no culvert upgrade requirements along the proposed grid connection route. The culvert survey for the grid connection is shown in Appendix 4.6.

9.4 Potential Impacts and Mitigation Measures

9.4.1 Overview of Impact Assessment Process

The conventional source-pathway-target model (see below, top) was applied to assess potential impacts on downstream environmental receptors (see below, bottom as an example) as a result of the Proposed Development.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Existing Culvert Locations
- Proposed Culvert Locations
- Grid Connection Route
- Rivers/Streams
- Northern Ireland Border
- Access Road
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- Proposed Borrow Pit (BP)
- Proposed Construction Compound (CC)
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- Proposed Construction Compound / Amenity Area (AA)

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Client: McCarthy Keville O'Sullivan

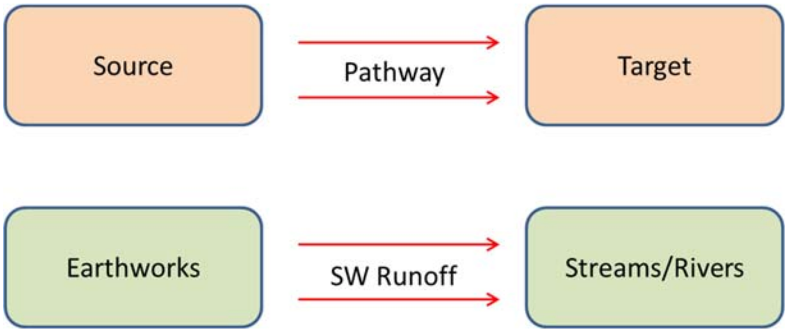
Job: Meenbog WF, Co. Donegal

Title: Existing and Proposed Culvert Locations Map

Figure No: 9.9.

Drawing No: P1249-2-1217-A3-909-00A

Sheet Size: A3	Project No: P1249-2
Scale: 1:20,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG



Where potential impacts are identified, the classification of impacts in the assessment follows the descriptors provided in the Glossary of Impacts contained in the following guidance documents produced by the Environmental Protection Agency (EPA):

- Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2017);
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003);
- Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 2002).

The description process clearly and consistently identifies the key aspects of any potential impact source, namely its character, magnitude, duration, likelihood and whether it is of a direct or indirect nature.

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.4.2 and 9.4.3), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

Using this defined approach, this impact assessment process is then applied to all wind farm construction and operation activities which have the potential to generate a source of significant adverse impact on the geological and hydrological/ hydrogeological (including water quality) environments.

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	**Pathway / Mechanism:**	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of wind farm developments, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical

		mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, *e.g.* human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to wind farm developments, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

9.4.2 Construction Phase Potential Impacts

9.4.2.1 Clear Felling of Coniferous Plantation

It is estimated that 73.6ha (hectares) in total of existing plantation forestry will be felled to allow for development of the proposed wind farm infrastructure. This includes 43ha that will be permanently felled and 30.6ha that will be felled for turbulence purposes.

The total amount to be felled accounts for 6.3% of the forestry coverage at the site.

Potential impacts during tree felling occur mainly from:

- Exposure of soil and subsoils due to vehicle tracking, and skidding or forwarding extraction methods resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses;
- Entrainment of suspended sediment in watercourses due to vehicle tracking through watercourses;
- Damage to roads resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses;
- Release of sediment attached to timber in stacking areas; and,
- Nutrient release.

Pathways: Drainage and surface water discharge routes.
Receptors: Surface waters and associated dependant ecosystems.

Pre Mitigation Impact

Indirect, negative, moderate, temporary, high probability impact.

Proposed Mitigation Measures

Best practice methods related to water incorporated into the forestry management and mitigation measures have been derived from:

- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations and Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Forest Service (Draft): Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures; and,
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.

Mitigation by Avoidance:
There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "*Forestry and Water Quality Guidelines*" are shown in Table 9.12.

Table 9.12 Minimum Buffer Zone Widths (Forest Service, 2000)

Average slope leading to the aquatic zone		Buffer zone width on either side of the aquatic zone	Buffer zone width for highly erodible soils
Moderate	(0 – 15%)	10 m	15 m
Steep	(15 – 30%)	15 m	20 m
Very steep	(>30%)	20 m	25 m

During the wind farm construction phase a self-imposed buffer zone of 50m will be maintained for all streams where possible. These buffer zones are shown on Figure 9.8. With the exception of existing road upgrades and proposed stream crossings all proposed tree felling areas are generally located outside of imposed buffer zones. Approximately 4ha of permanent tree felling and 5.3ha of temporary tree felling will be required inside the 50m buffer zone. Additional mitigation (detailed below) will be carried where tree felling is required inside the buffer zones.

The large distance between proposed felling areas and sensitive aquatic zones means that potential poor-quality runoff from felling areas can be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes. Where tree felling is required in the vicinity of streams, the following additional mitigation measures will be employed.

Mitigation by Design:
Mitigation measures which will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses comprise best practice methods which are set out as follows:

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion or where felling inside the 50m buffer is required, it will be necessary to install double or triple sediment traps. This measure will be reviewed on site during construction;
- Double silt fencing will also be put down slope of felling areas which are located inside the 50m buffer zone;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- 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 should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;

- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

Silt Traps:
Silt traps will be strategically placed down-gradient within forestry drains near streams. The main purpose of the silt traps and drain blocking is to slow water flow, increase residence time, and allow settling of silt in a controlled manner.

Drain Inspection and Maintenance:
The following items shall be carried out during inspection pre-felling and after:

- Communication with tree felling operatives in advance to determine whether any areas have been reported where there is unusual water logging or bogging of machines;
- Inspection of all areas reported as having unusual ground conditions;
- Inspection of main drainage ditches and outfalls. During pre-felling inspection the main drainage ditches shall be identified. Ideally the pre-felling inspection shall be carried out during rainfall;
- Following tree felling all main drains shall be inspected to ensure that they are functioning;
- Extraction tracks nears drains need to be broken up and diversion channels created to ensure that water in the tracks spreads out over the adjoining ground;
- Culverts on drains exiting the site will be unblocked; and,
- All accumulated silt will be removed from drains and culverts, and silt traps, and this removed material will be deposited away from watercourses to ensure that it will not be carried back into the trap or stream during subsequent rainfall.

Tree felling Cross-Border Mitigation Measures
The "Wildlife Action in Derry~Londonderry & Strabane 2008-2013" Local Biodiversity Action Plan highlights a number of priority habitats and species that may be impacted by the proposed project. Environmental impacts on water based environments and appropriate mitigation measures for these impacts are considered in this chapter of the EIAR. In addition, regarding the impacts of tree felling undertaken as part of this project, communication will be undertaken with Forest Service NI to determine the schedules of their felling plans. By coordinating the level of felling activities under Forest Service NI felling plans and under the Proposed Development, total felling activities in catchments can be adjusted to an appropriate level, ensuring no cumulative impact on the environment.

Surface Water Quality Monitoring:
Sampling will be completed before, during (if the operation is conducted over a protracted time) and after the felling activity. The 'before' sampling should be conducted within 4 weeks of the felling activity, preferably in medium to high water flow conditions. The "during" sampling will be undertaken once a week or after rainfall events. The 'after' sampling will comprise as many samplings as necessary to demonstrate that water quality has returned to pre-activity status (*i.e.* where an impact has been shown).

Criteria for the selection of water sampling points include the following:

- Avoid man-made ditches and drains, or watercourses that do not have year-round flows, *i.e.* avoid ephemeral ditches, drains or watercourses;
- Select sampling points upstream and downstream of the forestry activities;
- It is advantageous if the upstream location is outside/above the forest in order to evaluate the impact of land-uses other than forestry;
- Where possible, three downstream locations should be selected: one immediately below the forestry activity, the second at exit from the forest, and the third some distance from the second (this allows demonstration of no impact through dilution effect or contamination by other land-uses where impact increases at third downstream location relative to second downstream location); and,
- The above sampling strategy will be undertaken for all on-site sub-catchments streams where tree felling is proposed.

Residual Impact
Indirect, negative, slight, temporary, low probability impact.

Significance of Effects
No significant effects on the surface water quality are anticipated.

9.4.2.2 Earthworks (Removal of Vegetation Cover, Excavations and Stock Piling) Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities of the Proposed Development that will require earthworks resulting in removal of vegetation cover and excavation of peat and mineral subsoil (where present) are detailed in the Development Description Chapter (Chapter 4). Potential sources of sediment laden water include:

- Drainage and seepage water resulting from infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the grid connection cable trench resulting in entrainment of sediment from the excavations during construction; and,
- Erosion of sediment from emplaced site drainage channels.

These activities can result in the release of suspended solids to surface watercourses and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream water bodies. Potential impacts are significant if not mitigated against.

Pathways: Drainage and surface water discharge routes.
Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Impact
Indirect, negative, significant, temporary, medium probability impact.

Proposed Mitigation Measures

Mitigation by Avoidance:

The key mitigation measure during the construction phase of the Proposed Development is the avoidance of sensitive aquatic areas where possible. From Figure 9.8 it can be seen that all of the key areas of the Proposed Development areas are actually significantly away from the delineated buffer zones with the exception of proposed stream crossings and existing stream crossings requiring upgrading. Additional control measures, which are outlined further on in this section, will be undertaken at these locations).

The large setback distance from sensitive hydrological features means that adequate room is maintained for the proposed drainage mitigation measures (discussed below) to be properly installed and operate effectively. The proposed buffer zone will:

- Avoid physical damage to watercourses, and associated release of sediment;
- Avoid excavations within close proximity to surface watercourses;
- Avoid the entry of suspended sediment from earthworks into watercourses; and,
- Avoid the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone;

Mitigation by Design:

- Source controls:
    - Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.
    - Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.
- In-Line controls:
    - Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriates systems.
- Treatment systems:
    - Temporary sumps and attenuation ponds, temporary storage lagoons, sediment traps, and settlement ponds, and proprietary settlement systems such as Siltbuster, and/or other similar/equivalent or appropriate systems.

It should be noted for this site that an extensive network of forestry and roadside drains already exists, and these will be integrated and enhanced as required and used within the drainage system of the Proposed Development. The integration of the existing forestry drainage network and the proposed wind farm network is relatively simple. The key elements being the upgrading and improvements to water treatment elements, such as in line controls and treatment systems, including silt traps, settlement ponds and buffered outfalls.

The main elements of interaction with existing drains will be as follows:

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network where possible. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the operational phase of the wind farm runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site;
- Drains running parallel to the existing roads requiring widening will be upgraded. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters; and,
- Existing culverts will be lengthened where necessary to facilitate road widening. Larger culverts will be installed as required (refer to Figure 9.9 for crossing locations and Appendix 9.2 for the culvert survey/assessment).

Water Treatment Train:
If the discharge water from construction areas fails to be of a high quality then a filtration treatment system (such as a 'siltbuster' or similar equivalent treatment train (sequence of water treatment processes) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase.

Silt Fences:
Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to watercourses of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these structures during construction phase is critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase. Double silt fences will be emplaced within drains down-gradient of all construction areas inside the hydrological buffer zones, this will also include off-road sections of grid connection cable route within hydrological buffer zones.

Silt Bags:
Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters.

Pre-emptive Site Drainage Management:
The works programme for the initial construction stage of the Proposed Development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of peat/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

The following forecasting systems are available and will be used on a daily basis at the site to direct proposed construction activities:

- **General Forecasts:** Available on a national, regional and county level from the Met Eireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3 hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3 hour record is given and is updated every 15 minutes. Radar images are not predictive; and,
- Consultancy Service: Met Eireann provide a 24 hour telephone consultancy service. The forecaster will provide interpretation of weather data and give the best available forecast for the area of interest.

Using the safe threshold rainfall values will allow work to be safely controlled (from a water quality perspective) in the event of forecasting of an impending high rainfall intensity event.

Works should be suspended if forecasting suggests any of the following is likely to occur:

- >10 mm/hr (*i.e.* high intensity local rainfall events);
- >25 mm in a 24 hour period (heavy frontal rainfall lasting most of the day); or,
- >half monthly average rainfall in any 7 days.

Prior to works being suspended the following control measures should be completed:

- Secure all open excavations;
- Provide temporary or emergency drainage to prevent back-up of surface runoff; and,
- Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Peat and Subsoil Storage Areas:
It is proposed that excavated peat will be used for landscaping throughout the site of the Proposed Development and any excess peat will be utilized to re-instate the 3 no. proposed borrow pits. All the proposed borrow pits are located outside the 50m watercourse buffer zones (refer to Figure 9.8).

During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from the storage

areas. 'Siltbuster' treatment trains will only be employed if previous treatment is not to a high quality.
Drainage from peat storage areas will ultimately be routed to an oversized swale and a number of settlement ponds with appropriate storage and settlement designed for a 1 in 100 year 6 hour return period before being discharged to the on-site drains.

Peat/subsoil storage areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff. Once re-vegetated and stabilised peat/subsoil storage areas will no longer be a potential source of silt laden runoff.

Management of Runoff from the Grid Connection Cable Route:

Where construction of the grid cable connection route is undertaken along sections of proposed access road or existing roads requiring upgrade, the proposed wind farm drainage infrastructure (as outlined above) will be in place to manage and control runoff from the trench excavation area. Where the cable trench is to be constructed off-road (within the development site) or along public roads (*i.e. N15*), surface water control measures such as silt fences will be employed when work is required within hydrological buffer zones.

Timing of Site Construction Works:
Construction of the site drainage system will only be carried out during periods of low rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses. Construction of the drainage system during this period will also ensure that attenuation features associated with the drainage system will be in place and operational for all subsequent construction works.

Monitoring:
An inspection and maintenance plan for the on-site drainage system will be prepared in advance of commencement of any works. Regular inspections of all installed drainage systems will be undertaken, especially after heavy rainfall, to check for blockages, and ensure there is no build-up of standing water in parts of the systems where it is not intended. Inspections will also be undertaken after tree felling.

Any excess build up of silt levels at dams, the settlement pond, or any other drainage features that may decrease the effectiveness of the drainage feature, will be removed.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs should be undertaken for each primary watercourse, and specifically following heavy rainfall events (*i.e.* weekly, monthly and event based).

Residual Impact

Negative, indirect, imperceptible, temporary, low probability impact.

Significance of Effects

No significant effects on the surface water quality are anticipated.

9.4.2.3 Potential Impacts on Groundwater Levels During Excavation Works & from Proposed Borrow Pits

Dewatering of borrow pits (if required) and other deep excavations (*i.e.* turbine bases) have the potential to impact on local groundwater levels. However, groundwater level impacts are not anticipated to be significant due the local hydrogeological regime and the proposed borrow pit excavation method as outlined below. No groundwater level impacts are anticipated from the construction of the grid connection cable trench due to the shallow nature of the excavation (*i.e.* ~1.2m), the excavation of the trench within the road carriageway and the unsaturated nature of the subsoil/bedrock to be excavated.

Pathway: Groundwater flowpaths.
Receptor: Groundwater levels.

Pre-Mitigation Impact
Direct, negligible, slight, short term, low probability impact.

Impact Assessment

The proposed borrow pits (3 no.) are located in bedrock that has been classified as a Poor aquifer. No groundwater dewatering will be required as rock excavation will progress in a horizontal manner into the side of outcropping bedrock.

The topographical and hydrogeological setting of the proposed borrow pits locations means no significant groundwater dewatering is anticipated to be required during the operation of the borrow pits. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management. For the avoidance of doubt we would generally define dewatering as a requirement to permanently drawdown the local groundwater table by means of over pumping, e.g. as would be required for the operation of a bedrock quarry in a valley floor. We consider that this example is very different in scale and operation from the proposed operation of a temporary shallow borrow pit on the side of a hill. In order to explain this thoroughly we will outline our reasoning in a series of bullet points as follows:

- Firstly, the borrow pit areas are located on the side of local hills where the ground elevations are between 200 and 300m OD;
- These elevations are significantly above the elevations of the local valleys and streams;
- The proposed borrow pits will be between approximately 8 – 10m below ground level which is notable. However, in the context of the topographical/elevated setting of the borrow pits, this depth range is relatively shallow;
- The local bedrock comprises quartzites, gneisses and schists is known to be generally unproductive. This means that groundwater flows will be relatively minor;
- Observations from the existing borrow pit exposures show that the bedrock is massive with very little, if any fractures. Any jointing / fractures that were seen were noted to be very tight;
- The flow paths (i.e. the distance from the point of recharge to the point of discharge) in this type of geology will be short, localised, and will also be relatively shallow;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations;
- Therefore shallow groundwater inflows will largely be fed by recent rainfall, and possibly by limited groundwater seepage form localised shallow bedrock;
- The sloping nature of the ground on the hills where the borrow pits are proposed along with the coverage of peat means groundwater recharge is going to be very low;
- As such the shallow groundwater flow system will be small in comparison to the expected surface water flows from the bog surface;

- This means that there will be a preference for high surface water runoff as opposed to groundwater recharge and flow; and,
- Hence we consider that the management of surface water will form the largest proportion of water to be managed and treated.

Relevant environmental management guidelines from the EPA quarry 2006 guidance document – "*Environmental Management in the Extractive Industry*" in relation to groundwater issues will be implemented during the construction phase.

Residual Impact

Direct, negligible, imperceptible, temporary, low probability impact.

Significance of Effects

No significant effects on groundwater levels are anticipated.

9.4.2.4 Excavation Dewatering and Potential Impacts on Surface Water Quality

Some minor groundwater/surface water seepages will likely occur in turbine base excavations and borrow pits and this will create additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site of the Proposed Development and therefore pollution issues are not anticipated.

Pathway: Overland flow and site drainage network.
Receptor: Down-gradient surface water bodies.

Pre-*Mitigation *Impact

Indirect, negative, significant, temporary, low probability impact to surface water quality.

Proposed Mitigation Measures

Mitigation by Design:
Management of excavation seepages and subsequent treatment prior to discharge into the drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build up of water in the excavation;
- The interceptor drainage will be discharged to the site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, along with use of more specialist treatment systems such as a Siltbags;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped and a geotechnical assessment undertaken; and,
- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are

mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites.

Residual Impact

Indirect, negligible, temporary, low probability impact on local surface waters.

Significance of Effects

No significant effects on the surface water quality are anticipated.

9.4.2.5 Potential Release of Hydrocarbons during Construction and Storage

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to groundwater, surface water and associated ecosystems, and to terrestrial ecology. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in death of aquatic organisms.

Pathway: Groundwater flowpaths and site drainage network.
Receptor: Groundwater and surface water.

Pre*-Mitigation *Impact

Indirect, negative, slight, short term, medium probability impact to local groundwater quality.
Indirect, negative, significant, short term, low probability impact to surface water quality.

Proposed Mitigation Measures:

Mitigation by Design:

- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refueling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refueling operations;
- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the time period of the construction;
-
- The plant used should be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Construction (?)Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

Residual Impact

Indirect, negative, imperceptible, temporary, low probability impact on groundwater and surface water.

Significance of Effects

No significant effects on surface water or groundwater quality are anticipated.

9.4.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from domestic wastewater treatment systems has the potential to impact on groundwater and surface waters if site conditions are not suitable for an on-site percolation unit.

Pathway: Groundwater flowpaths and site drainage network.
Receptor: Down-gradient well supplies, groundwater quality and surface water quality.

Pre-mitigation Impact

Indirect, negative, significant, temporary, low probability impact to surface water quality.
Indirect, negative, slight, temporary, low probability impact to local groundwater.

Proposed Mitigation Measures

Mitigation by Avoidance:

- A self-contained port-a-loo with an integrated waste holding tank will be used at each of the site compounds, maintained by the providing contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use from the site to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the site, or discharged to the site.

Residual Impact

No impact

Significance of Effects

No significant effects on surface water or groundwater quality are anticipated.

9.4.2.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥ 6 ≤ 9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ± 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment. Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to introduction of high pH alkaline waters into the system. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution.

Pathway: Site drainage network.
Receptor: Surface water and peat water hydrochemistry.

Pre*-Mitigation *Impact

Indirect, negative, moderate, short term, medium probability impact to surface water.

Proposed Mitigation Measures

Mitigation by Avoidance:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- Where possible pre-cast elements for culverts and concrete works will be used;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute need be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be tanked and removed from the site to a suitable, non-polluting, discharge location;
- Use weather forecasting to plan dry days for pouring concrete; and,
- Ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Impact

Negative, Indirect, imperceptible, short term, low probability impact.

Significance of Effects

No significant effects on surface water quality are anticipated.

9.4.2.8 Morphological Changes to Surface Watercourses & Drainage Patterns

Diversion, culverting, road and grid cable crossing of surface watercourses can result in morphological changes, changes to drainage patterns and alteration of aquatic habitats. Construction of structures over watercourses has the potential to significantly interfere with water quality and flows during the construction phase of the Proposed Development. There is no diversion of watercourses proposed.

It is proposed that 5 no. new stream crossings and potentially 19 no. existing stream/main drain crossing upgrades will be required to facilitate the Proposed Development . One of new proposed crossing (PC1) is on the Bunadaowen River itself.

Refer to Figure 9.9 for existing and proposed crossing locations and Appendix 9.2 for the preliminary culvert assessment. Along sections of proposed and existing access roads, the grid connection cable will be constructed within the road crossing.

Pathway: Site drainage network.
Receptor: Surface water flows and stream morphology.

Pre-Mitigation Impact

Negative, direct, slight, long term, high probability impact.

Proposed Mitigation Measures

Mitigation by Design

- Where possible all proposed new stream crossings will be bottomless culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Where the proposed grid connection cable route runs adjacent to a proposed access road or road proposed for upgrade, the cable will pass over the culvert within the access road;
- Where a grid connection cable stream crossing is required off-road, the cable will pass over the watercourse via suspended ducting thereby avoiding any morphological impacts;
- It is proposed that the grid connection cable will pass beneath the Mourne Beg River at the bridge in the townland of Meenbog. Directional drilling will be required to install the duct under the river without impacting on the watercourse channel;
- Any guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings;
- As a further precaution near stream construction work will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "*Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*", that is, May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses;
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas;
- Directional drilling will be undertaken to avoid in-stream works where there is a requirement to cross a watercourse upstream of the Lowreymore River (See Section 9.4.2.12 below for impacts and mitigation relating to these works); and,
- All access road river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Residual Impact

Neutral, direct, negligible, short term, high probability impact.

Significance of Effects

No significant effects on stream morphology or stream water quality are anticipated at crossing locations.

9.4.2.9 Potential Impacts on Hydrologically Connected Designated Sites

The site of the proposed wind farm site and a section of the grid connection drains to the Mourne Beg River and the Derg River (within Northern Ireland) which also forms part of the River Foyle and Tributaries ASSI and SAC designated site. The section of the proposed grid connection route adjacent to the N15 drains to Lough Eske which is a designated SAC.

Possible effects include water quality impacts which could be significant if mitigation is not put in place.

Pathway: Surface water flowpaths.
Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Impact

Indirect, negative, negligible, temporary, low probability.

Proposed Mitigation Measures

The proposed mitigation measures for protection of surface water quality which will include buffer zones and drainage control measures (*i.e.* interceptor drains, swales, settlement ponds) will ensure that the quality of runoff from proposed development areas will be very high.

As stated in Impact Section 9.4.2.2 above, there could potentially be an "*imperceptible, temporary, low probability impact*" on local streams and rivers but this would be very localised and over a very short time period (*i.e.* hours). Therefore, significant indirect impacts on Lough Eske SAC or the River Foyle and Tributaries ASSI / SAC designated sites are not anticipated.

Residual Impact

No impacts on designated sites are anticipated.

Significance of Effects

No significant impacts on designated sites are anticipated.

9.4.2.10 Potential Impacts on the Proposed Lough Mourne Surface Water abstraction

Donegal County Council is proposing to abstract surface water from the Bunadaowen River within the site of the Proposed Development site and pump it to Lough Mourne Reservoir.

As stated above, due to the carefully designed layout of the infrastructure of the Proposed Development within the surface water catchment to the source is limited to a ~2km stretch of existing foresty track (to be upgraded as part of the windfarm).

Pathway: Surface water flowpaths
Receptor: Lough Mourne Reservoir

Pre-Mitigation Impact

Indirect, negative, slight, long term, low probability impact.

Impact Assessment

There is minimal development proposed within the surface water catchment to the proposed intake (refer to Figure 9.7). Works will be limited to upgrading the 2km stretch of existing forestry track (works for maintaining this road are ongoing in any case). Internal windfarm cabling installation will also be carried out as part of the access road upgrade works.

Any surface water quality effects within the catchment to the proposed abstraction will be temporary and reversible.

Proposed Mitigation Measures

Significant infrastructure works have been omitted from the proposed abstraction intake catchment. The proposed mitigation measures for protection of surface water quality as described above will include drainage control measures (*i.e.* interceptor drains, swales, settlement ponds) which will ensure that the quality of runoff from the proposed development areas will be very high.

The proposed works are close to ground surface, are not particularly intrusive and therefore will have no potential impact on the local hydrologiocal regime.

Residual Impacts

No residual impacts on the Lough Mourne Abstraction or Reservoir are anticipated.

Significance of Effects

No significant impacts on the Lough Mourne Reservoir Abstraction are anticipated.

9.4.2.11 Potential Hydrological Impacts on Intact Upland Blanket Bog

Two (2 no.) of the proposed 19 no. turbines (T16 and T19) are located in an area of intact blanket bog on the northeast of the proposed site. Peat removal and excavation of bedrock for road and turbine excavation has the potential for hydrological impacts on blanket bog.

Pathway: Surface water and groundwater flowpaths
Receptor: Intact blanket bog hydrology

Pre-Mitigation Impact

Direct/indirect, negative, slight, temporary, low probability impact.

Impact Assessment / Mitigation

Proposed turbine locations T16 and T19 are located in areas of thin (<1m) intact blanket bog which was found to directly overly solid bedrock (refer to the Land, Soils and Geology Chapter, Chapter 8). Both proposed turbine locations are situated only a short distance within the intact peat from the nearby forestry plantation (where the rest of the proposed windfarm is located) and therefore only short spurs (<30m) of new access roads are required within the blanket bog. Due to the shallow depth of peat overlying competent, low permeability bedrock, hydrological impacts on blanket bog are only expected to be localised to the works area and temporary in nature (*i.e.* construction phase).

Residual Impacts

Direct/indirect, negative, slight, temporary, low probability impact.

Significance of Effects

No significant impacts on upland blanket bog hydrology are expected.

9.4.2.1 Potential Surface Water Quality Impacts during Directional Drilling

Surface water quality impacts on the Lowerymore River during groundworks associated with directional drilling under the stream channel bed. It is proposed that directional drilling under the stream bed will be undertaken to prevent direct impacts on the watercourse. However, there is a risk of indirect impacts from sediment laden runoff during the launch pit and reception pit excavation works. There is also the unlikely risk of fracture blow out and contamination of the watercourse with drilling fluid.

Pathway: Surface water and groundwater flowpaths
Receptor: Local stream / Lowerymore River / Lough Eske.

Pre-Mitigation Impact
Indirect, negative, moderate, temporary, low probability impact.

Mitigation Measures

- In order to prevent significant water quality impacts and morphological impacts, trenchless technology will be carried out to install the cable below the watercourse;
- Although no in-stream works are proposed, the drilling works will only be done over a dry period between July and September (as required by IFI for in-stream works) to avoid the salmon spawning season and to have more favourable (dryer) ground conditions;
- The crossing works area will be clearly marked out with fencing or flagging tape to avoid unnecessary disturbance of vegetation;
- A minimum 15 metre vegetative buffer zone will be maintained between the works area and the watercourse;
- There will be no storage of material / equipment or overnight parking of machinery inside the 15m buffer zone;
- Before any ground works are undertaken, double silt fencing will be placed upslope of the watercourse channel along the 15m buffer zone boundary;
- Additional silt fencing or straw bales (pinned down firmly with stakes) will be placed across any natural surface depressions / channels that slope towards the watercourse;
- Silt fencing will be embedded into the local soils to ensure all site water is captured and filtered;
- The area around the bentonite batching, pumping and recycling plant will be bunded using terram (as it will clog) and sandbags in order to contain any spillages;
- Drilling fluid returns will be contained within a sealed tank / sump to prevent migration from the works area;
- Spills of drilling fluid will be clean up immediately and stored in an adequately sized skip before been taken off-site;
- If rainfall events occur during the works, there will be a requirement to collect and treat small volumes of surface water from areas of disturbed ground (i.e. soil and subsoil exposures created during site preparation works);
- This will be completed using a shallow swale and sump down slope of the disturbed ground; and water will be pumped to a proposed percolation area at least 50m from the watercourse
- The discharge of water onto vegetated ground at the percolation area will be via a silt bag which will filter any remaining sediment from the pumped water. The entire percolation area will be enclosed by a perimeter of double silt fencing;
- Any sediment laden water from the works area will not be discharged directly to a watercourse or drain;
- Works shall not take place during periods of heavy rainfall and will be scaled back or suspended if heavy rain is forecasted;

- Daily monitoring of the compound works area, the water treatment and pumping system and the percolation area will be completed by a suitably qualified person during the construction phase. All necessary preventative measures will be implemented to ensure no entrained sediment, or deleterious matter is discharged to the watercourse
- If high levels of silt or other contamination is noted in the pumped water or the treatment systems, all construction works will be stopped. No works will recommence until the issue is resolved and the cause of the elevated source is remedied;
- On completion of the works, the ground surface disturbed during the site preparation works and at the entry and exit pits will be carefully reinstated and re-seeded at the soonest opportunity to prevent soil erosion;
- The silt fencing upslope of the river will be left in place and maintained until the disturbed ground has re-vegetated;
- There will be no batching or storage of cement allowed at the watercourse crossing;
- There will be no refuelling allowed within 100m of the watercourse crossing; and,
- All plant will be checked for purpose of use prior to mobilisation at the watercourse crossing.

Fracture Blow-out (Frac-out) Prevention and Contingency Plan

- The drilling fluid/bentonite will be non-toxic and naturally biodegradable (i.e. Clear Bore Drilling Fluid or similar will be used);
- The area around the drilling fluid batching, pumping and recycling plants will be bunded using terram and/or sandbags to contain any potential spillage;
- One or more lines of silt fencing will be placed between the works area and the adjacent river;
- Spills of drilling fluid will be cleaned up immediately and transported off-site for disposal at a licensed facility;
- Adequately sized skips will be used where temporary storage of arisings are required;
- The drilling process / pressure will be constantly monitored to detect any possible leaks or breakouts into the surrounding geology or local watercourse;
- This will be gauged by observation and by monitoring the pumping rates and pressures. If any signs of breakout occur then drilling will be immediately stopped;
- Any frac-out material will be contained and removed off-site;
- The drilling location will be reviewed, before re-commencing with a higher viscosity drilling fluid mix; and,
- If the risk of further frac-out is high, a new drilling alignment will be sought at the crossing location.

Residual Impacts

Indirect, negative, imperceptible, temporary, low probability impact.

Significance of Effects

No significant impacts on surface water quality are anticipated.

9.4.3 Operational Phase Impacts

9.4.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises turbine hardstandings, upgraded access roads, substation and compound. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.
Receptor: Surface waters and dependent ecosystems.

Pre-Mitigation Impact

Direct, negative, moderate, permanent, moderate probability impact.

Impact Assessment

As determined in Section 9.3.17 above there could be a potential increase of <1% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the study area being developed, the proposed total permanent development footprint being approximately 28.45ha, representing 2.8% of the total study area of 990ha.

The increase in runoff from the most development will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

Proposed Mitigation Measures

Mitigation by Design:

The operational phase drainage system of the Proposed Development will be installed and constructed in conjunction with the road and hardstanding construction work as described below:

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to settlement ponds for sediment settling;
- On steep sections of access road transverse drains ('grips') will be constructed where appropriate in the surface layer of the road to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,

- Settlement ponds will be designed in consideration of the greenfield runoff rate.

Residual Impact

Negative, direct, negligible, long term, moderate probability impact.

Significance of Effects

No significant effects on surface water quality or quantity are anticipated.

9.4.3.2 Assessment of Potential Human Health and Population Effects

Potential health effects are associated with negative impacts on public and private water supplies and potential flooding. There are no mapped public or group water scheme groundwater protection zones in the area of the site of the Proposed Development. The proposed Lough Mourne surface water abstraction is located within the site and the minimal potential for impacts on this are assessed in Section 9.4.2.10 above. Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for impacts on the water environment are not significant

The Flood Risk Assessment has also shown that the risk of the Proposed Development contributing to downstream flooding is also very low, as the long-term plan for the site is to retain and slow down drainage water within the existing site. Drainage measures on the site will include swales, silt traps, settlement ponds, field drains and headland drains as described earlier in the chapter.

9.4.4 Do Nothing Scenario

Current land use practices such as forestry, agriculture and peat cutting will continue. In particular commercial forestry operations will continue at the site. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas.

9.4.5 Worst Case Scenario

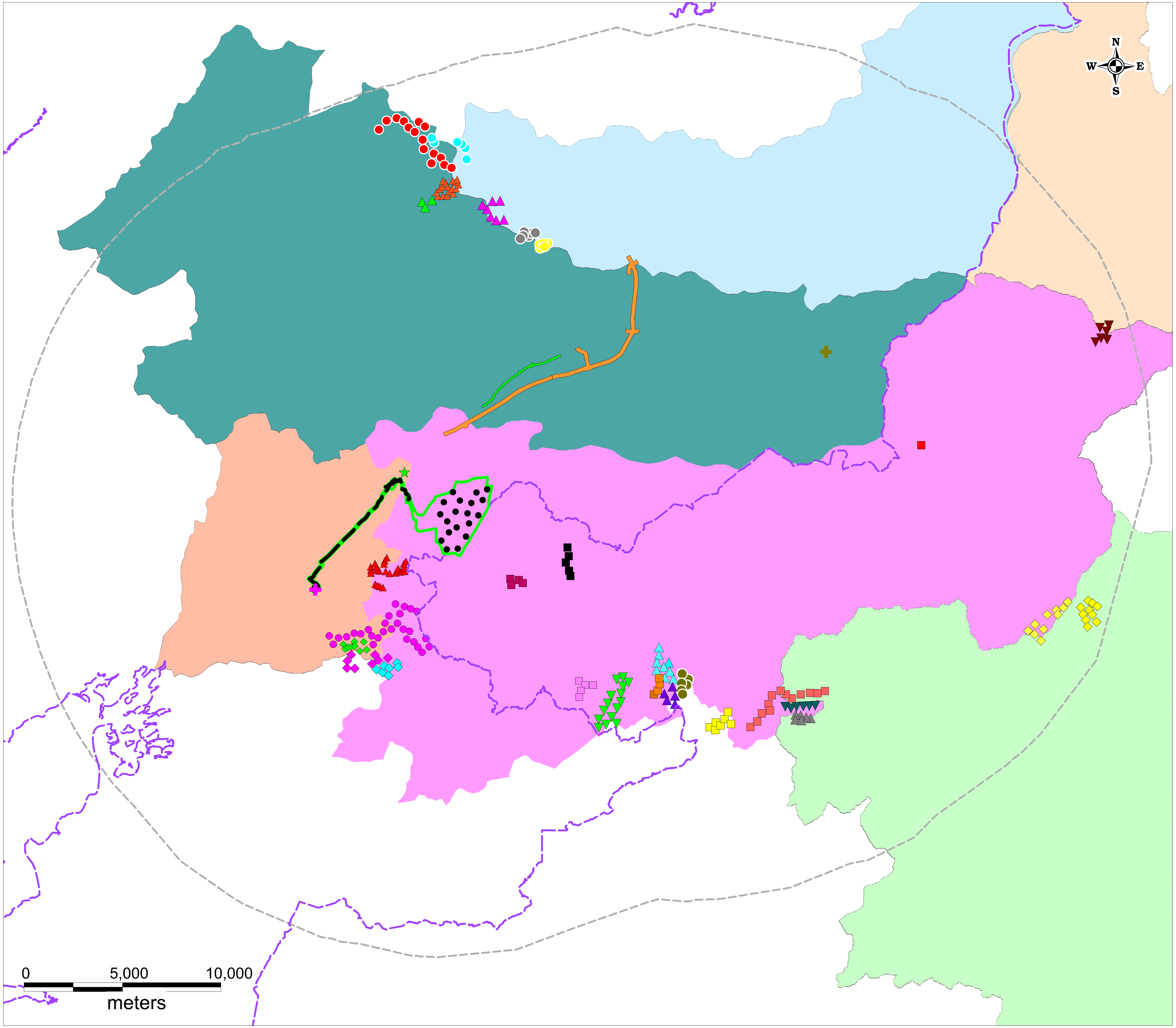
Contamination of surface water streams during the construction and operational phases of the Proposed Development, which in turn could affect the ecology and quality of the downstream water bodies such as the Lowerymore River and Mourne Beg River and Derg River. Also, potentially localised groundwater contamination may occur. However, measures will be put in place to prevent this from happening.

9.4.6 Cumulative Impacts of the Proposed Development

A hydrological cumulative impact assessment of the Proposed Development was undertaken using other wind farm developments and non wind farm projects and plans located within the Mourne River and Lough Eske catchments within a 20km radius of the site of the Proposed Development. The wind farm developments assessed are listed in Table 9.13 below and are shown on Figure 9.10.

Other local non-wind energy developments were also considered and the cumulative assessment is undertaken for the Lough Eske and Mourne River catchments below. The non-wind energy developments within a 20km radius are also shown on Figure 9.10.

In terms of the potential impacts of wind farm developments on downstream surface water bodies, the biggest risk is during the construction phase of the development as this is the phase when earthworks and excavations will be undertaken at the sites.



LEGEND:

- Carrickaduff WF EIAR Site Boundary & Turbine Location
- Burn, Dennet, Foyle Catchment
- Deele Catchment
- Finn Catchment
- Lough Eske Catchment
- Mourne Catchment
- Strule Catchment
- 20km Radius
- Northern Ireland Border
- Stranolar Bypass
- N15 Realignment Scheme
- Castlefinn Bridge Upgrade
- Grid Connection Cable Route
- Existing Clogher 110kV Substation
- Croaghonagh Quarry (Existing)

Wind Farms (Republic of Ireland)

- Dromnahough WF (Per)
- Cark Extension (Op)
- Culiagh Ext WF (Op)
- Culiagh WF (Op)
- Meenalita WF (Op)
- Meenagrauv WF (Per)
- Lough Golagh WF (Op)
- Straness WF (Per)
- Lough Cuil WF (Per)
- Meenadreen WF (OP)
- Meenahorna WF (Op)

Notes:
Op - Operational
Per - Permitted
Pro - Proposed

Wind Farms (Northern Ireland)

- Gronan WF (Pro)
- Churchill WF (8 Op, 1 Pro)
- Meenamullen WF
- Croaghanmeal WF (Per)
- Meenakeeran WF
- Meenablagh WF (Pro)
- Crighshane WF (Per)
- Tievenameeta WF (Per)
- Seegronan Wf (Per)
- Altogan WF (Pro)
- Binawooda WF (Pro)
- Bin Mountain WF (Per)
- Lough Hill WF (Op)
- Bassybell WF (16 Op, 4 Pro)
- Koram Hill WF (Pro)
- Tullywisker WF (Pro)

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Client: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Cumulative Impact Assessment	
Figure No: 9.10	
Drawing No: P1249-2-1217-A3-910-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:260,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG

Table 9.13: Other Wind Farm Developments in the Mourne River and Lough Eske catchments

Catchment Area	Wind Farm Name	Status	Potential No. of Turbines in Catchment
Lough Eske	Meenadreen	4 operational, 5 permitted	9
	Lough Golagh	25 turbines operational	6
	Straness	28 turbines permitted	13
	Lough Cuil	8 turbines permitted	1
Potential Total			29
Mourne River/River Derg	Lough Golagh	25 turbines operational	19
	Straness	28 turbines permitted	15
	Lough Cuil	8 turbines permitted	2
	Croaghanmeal	7 turbines permitted	6
	Meenakeeran	4 turbines proposed	4
	Meenablagh	5 turbines proposed	5
	Crigshane	14 turbines Permitted	14
	Tievenameenta	15 turbines permitted	14
	Gronan	4 turbines proposed	4
	Church Hill	8 turbines operational, 1 proposed	9
	Seegronan	6 turbines permitted	5
	Meenamullan	5 turbines proposed	4
	Altgolan	7 turbines proposed	2
	Binawooda	13 turbines proposed	6
	Bin Mountain	6 turbines permitted	6
	Lough Hill	6 turbines operational	1
	Bessy Bell	16 turbines operational, 4 proposed	9
	Koram Hill	6 turbines proposed	4
	Tullywisker	1 turbine proposed	1
Potential Total			130

The site of the Proposed Development is located within the Mourne River catchment. The total number of turbines that could potentially be operating inside a 20km radius within the Mourne River catchment is 149 (19 from the Proposed Development and 130 from other wind farms as shown in Table 9.13 above).

The total catchment area of the Mourne River (inside a 20km radius) is ~545km^2 and therefore this equates to one turbine for approximately every ~3.6km^2 which is considered imperceptible in terms of potential cumulative hydrological impacts. This turbine density calculation is also conservative as it does not include the area of the remainder of the catchment outside the 20km radius. In addition, it should be noted that 55 of the 149 possible turbines (*i.e.* ~37%) are already operational and therefore these developments are not anticipated to contribute to cumulative hydrological impacts as construction is complete. It is very unlikely that the remainder of the other permitted or proposed developments will be constructed at the same time as the Proposed Development and therefore no cumulative hydrological impacts are anticipated from other remote wind farm developments in the region. In terms of non-wind energy developments, there are no significant proposed projects within the Mourne River catchment. As discussed in Section 9.3.15 above there are proposals to abstract surface water from the Bunadaowen River and pump to Lough Mourne which exits to the north of the site of the Proposed Development. No cumulative impacts arising from this infrastructural project are anticipated.

Implementation of the proposed drainage mitigation will ensure there will be no cumulative significant adverse impacts on the water environment from the Proposed Development, and other wind farm developments and non-wind farm developments within a 20km radius in the Mourne River catchment. A summary of the hydrological/hydrogeological cumulative impact assessment showing the potential hydrological impacts and the post mitigation worst-case scenario are shown in Table 9.14 below.

The current application seeks planning permission for underground cabling to link with the underground grid connection cabling from the Drumnahough substation currently proposed under Pl. Ref 17/505/43 & ABP Ref. PL05E.248796 ("the Drumnahough Cable").

The proposal is a combined connection with the Drumnahough Cable, with the cable from Meenbog WF substation linking to the Drumnajhough Cable , and from there a trench with two cables will progress towards the Clogher substation (with 2 no. further minor route options closer to Clogher substation). The Drumnahough Cable and Meenbog Wind Farm grid connection cable to Clogher would be placed in a single trench and the works would be completed at the same time.

A separate connection from Meenbog WF substation to Clogher substation (with 2 no. further minor route options closer to Clogher substation) has also been assessed.

Potential hydrological cumulative impacts arising from the proposed Windfarm and proposed grid connection and the Drumnahough substation cable are also not expected to be significant because the two cables will be placed within the one trench thereby reducing overall excavation requirements. Also, no in-stream works are required along the grid connection route.

The proposed forestry replanting sites area remote from the site of the Proposed Development (in counties Clare and Cork) and in totally different groundwater and surface water catchments. There is no hydrological or hydrogeological connectivity between the replanting sites and the site of the Proposed Development, and therefore there can be no cumulative effects or interactions at any phase of the development.

The proposed amenity walkways will have negligible cumulative impact as they are relatively minor near surface works.

Table 9.14: Summary of Hydrological Cumulative Impact Assessment

Impact Assessment Scale	Hydrological Impacts Assessed	Post Mitigation Worst Case Scenario
Mourne Rivr Catchments	Low & average flows	No Impact
	Water balance	No Impact
	Flood Risk (high flows)	Long term imperceptible
	Surface Water Quality	Temporary imperceptible
Lough Eske Catchment	Low & average flows	No Impact
	Water balance	No Impact
	Flood Risk (high flows)	No Impact
	Surface Water Quality	No Impact
Ballybofey, Donegal South, Killygordan, Castlederg Groundwater Body	Groundwater Body Recharge & Flows Impacts	No Impact
	Groundwater Quality	No Impact

9.4.7 Summary

During each phase of the Proposed Development (construction and operation / maintenance) a number of activities will take place on the site of the Proposed Development, some of which will have the potential to significantly affect the hydrological regime or water quality at the site or its vicinity. These significant potential impacts generally arise from sediment input from runoff and other pollutants such as hydrocarbons and cement based compounds, with the former having the most potential for impact.

Surface water drainage measures, pollution control and other preventative measures have been incorporated into the project design to minimise significant adverse impacts on water quality and downstream designated sites. A self imposed 50m stream and lake buffer was used during the layout of the proposed development, thereby avoiding sensitive hydrological features.

The surface water drainage plan will be the principal means of significantly reducing sediment runoff arising from construction activities and to control runoff rates. The key surface water control measure is that there will be no direct discharge of wind farm runoff into local watercourses. This will be achieved by avoidance methods (*i.e.* stream buffers) and design methods (*i.e.* surface water drainage plan).

Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the Construction and Environmental Management Plan (Refer to Appendix 4.4).

Overall the Proposed Development presents no significant impacts to surface water and groundwater quality provided the proposed mitigation measures are implemented.

No significant cumulative impacts on any of the regional surface water catchment or groundwater bodies are anticipated from the Proposed Development, associated grid connection or forestry replacement sites.