9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland to carry out an assessment of the potential likely and significant effects of the Proposed Development (Wind Farm Site, Cable Route and Slievecallen WF Substation Extension) 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 natural resources) in the area of the Proposed Development;
- Identify likely significant effects of the Proposed Development on surface water and groundwater natural resources during construction, operational and decommissioning phases of the project;
- Identify mitigation measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects; and,
- Assess cumulative effects of the Proposed Development and other local developments (as described in Chapter 2 of this EIAR).

Please note that in this chapter we refer to the Wind Farm Site (turbines, access roads, borrow pits, temporary construction compounds, metrological mast, forestry felling and ancillary infrastructure), the Underground Cable Route (7.1km long running from the Wind Farm Site to Slievecallan substation), the substation extension and the Proposed Development study area.

The baseline environment, potential direct, indirect and cumulative impacts of replanting lands on the water environment has been assessed in the Section 7 of Appendix 4-3 Assessment of Forestry Replacement Lands.

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 wind farm 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 David Broderick and Michael Gill.

David Broderick (BSc, H. Dip Env Eng, MSc) is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Slievecallan Wind Farm, Cahermurphy (Phase I & II) Wind Farm, and Oweninny Wind Farm, and over 60 other wind farm related projects across the country.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Slievecallan Wind Farm, Cahermurphy (Phase I & II) Wind Farm, and Carrownagowan Wind Farm, and over 100 other wind farm related projects across the country.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process and the List of Consultees is outlined in Section 2.5 of this EIAR. Matters raised by Consultees in their responses with respect to the water environment are summarised in Table 9-1 below.

All third-party submissions from statutory and non- statutory consultees relating to the previous planning applications (refer to Chapter 1) have been addressed in this chapter where applicable to the water environment.

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

Consultee	Matters Raised - Description	Addressed in Section
Department of Culture, Heritage and the Gaeltacht	Ground and surface water quality should be protected during the construction and operation of the proposed development and if applicable the applicant should ensure that adequate sewage treatment facilities are or will be in place prior to any development. The applicant should also ensure that adequate water supplies are present prior to development.	Sections 9.5.2.5, 9.5.2.6 and 9.5.2.7
Department of Agriculture, Food & the Marine	Under Hydrology and Hydrogeology, it would be important that the EIAR study would evaluate the potential impact of the required changes to the drainage of the site and the potential to cause additional flooding downstream of the site.	Sections 9.3.4, 9.3.6, 9.4.1, 9.5.2.2 and 9.5.4.1
Geological Survey of Ireland (Groundwater Section)	A generic response was provided with respect potential impacts on groundwater resources/sources.	Sections 9.3.14 and 9.5.2.10

9.1.4 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.

The requirements of the following legislation are complied with:

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

- S.I. No 296 of 2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by the Directive 2014/52/EU into Irish Law;
- 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;
- 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 replaced 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. 294 of 1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 74/440/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: European Communities (Drinking Water) 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. 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.

9.1.5 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 of Environmental Impact Statements);
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (2006): Environmental Management in the Extractive Industry;

- European Commission (2017): Environmental Impact Assessment of Projects – Guidance on the Preparation of the Environmental Impact Assessment Report;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Watercourses;
- 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 Proposed Development study area was 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 of the following:

- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and 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 17 (Geology of Shannon Estuary Bay). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland (2003) – Groundwater Body Initial Characterization Reports;
- OPW Indicative Flood Maps (www.floodinfo.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).

9.2.2 Baseline Monitoring and Site Investigations

Geological and hydrological baseline monitoring and sampling was originally undertaken by HES in May 2020 for the previously proposed layout. An additional site visit was carried out on 26th February 2021 with regard the revised proposed layout.

A geotechnical assessment was undertaken by Fehily Timoney and Company (FT) during the same period.

Site investigations to address the Water Section of the EIAR included the following:

- A walkover survey and hydrological mapping of the Proposed Development study area was undertaken by HES whereby water flow directions and drainage patterns were recorded;
- A total of 700 no. peat probes were undertaken by HES and FT Ltd to determine the thickness and geomorphology of the blanket peat overlying the Proposed Development site;
- Trial pitting was undertaken by FT on 17th June 2021;
- A geotechnical assessment was undertaken by FT for the Proposed Development site;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin of surface water flows; and,
- A total of 4 no. surface water samples were taken by HES to determine the baseline water quality of the primary surface waters originating from the Proposed Development site.

9.2.3 Impact Assessment Methodology

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

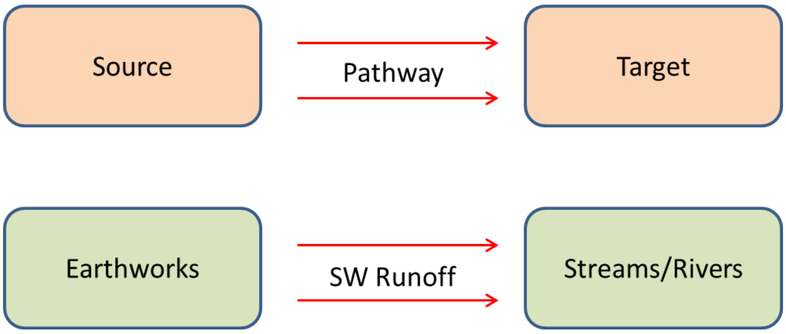
In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are used to assess the potential effect that the Proposed Development may have on them.

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

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

9.2.4 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.



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); and,
- Advice Notes For Preparing Environmental Impact Statements DRAFT (EPA, 2015).

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 9.5), 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 construction and operation and decommissioning 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 this type of development, 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 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 this type of development, 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 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 this type of development, these measures are 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.

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Hydrology and Hydrogeology Chapter of the EIAR.

9.3 Receiving Environment

9.3.1 Site Description and Topography

The Proposed Development site is located in the townland of Glendine (and neighbouring townlands as described in Chapter 4) which is situated approximately 5km northeast of Milltown Malbay, Co. Clare. The Proposed Development is characterised by a northeast / southwest orientated topographic divide. The elevation range of the Wind Farm Site is between 90 and 250m OD. The more elevated areas of the Wind Farm Site (i.e., >150m OD) are covered by blanket peat while the lower-lying areas are generally dominated by poorly draining peaty soil (grassland). Conifer plantations exist in the central more elevated area of the Wind Farm Site. Areas of cutover bog are frequent throughout the Wind Farm Site but are particularly evident on the eastern section of the site.

The planning application includes for the construction of underground electricity cabling to the existing Slievecallan 110kV substation. The cable route measures approximately 7.1 km in total and is mainly located on existing forest roads / land, existing Slievecallan access roads, agricultural land and within the public road corridor.

It is proposed to extend and expand the existing Slievecallan 110kV substation to accommodate the connection of the Proposed Development. The footprint of the proposed substation extension compound measures approximately 2,461 square metres. The proposed substation extension will be located on an existing cleared and level area.

9.3.2 Water Balance

Long term Average Annual Rainfall (AAR) and evaporation data was sourced from Met Éireann. The 30 year annual average rainfall (AAR) recorded at Inagh (Mt. Callan), 4km southeast of the Wind Farm Site, are presented in Table 9-3. This is the most appropriate station to use with respect distance and elevation.

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

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Inagh		116500		177500		122		1987		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
173	115	124	92	93	104	107	142	145	173	173	175	1616

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Shannon Airport, approximately 40km southeast of the Wind Farm Site. The long-term average PE for this station is 540mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the Wind Farm Site is estimated as 513mm/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

= 1616 mm/yr – 513mm/yr

ER = 1,103mm/yr

Based on recharge coefficient estimates from the GSI, an estimate of 5% recharge is taken for the Proposed Development site as an overall average. This value is for "Peat" with a "High" vulnerability rating. Areas of thinner peat or thin peaty soils (i.e. Extreme vulnerability) may have slightly higher recharge rates, but on this Wind Farm Site and Underground Cable Route, these areas are generally on sloping ground with very poor natural drainage. The lowest value in the available range was chosen to reflect the large coverage of blanket peat. Therefore, annual recharge and runoff rates for the Proposed Development site are estimated to be 55mm/yr and 1048mm/yr respectively.

9.3.3 Regional Hydrology

In terms of regional hydrology, the western half of the Wind Farm Site, substation extension works and approximately 4.5km of the Underground Cable Route are located in the Annagh River catchment (Annagh(Clare)_SC_010). The eastern half of the Wind Farm Site and approximately 2km of the Underground Cable Route are located in the Inagh River surface water catchment (Inagh(Ennistymon_SC_010). The Inagh River flows approximately 1km to the northeast of the Wind Farm Site.

Both regional catchments are located within Hydrometric Area 28 of the Shannon River Basin District. Six of the proposed 8 no. turbines are located in the Inagh River surface water catchment and 2 no. are located in the Annagh River catchment. A regional hydrology map is shown Figure 9-1.

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

Locally the Proposed Development site exits within four surface water sub-catchments. The north-western and southwestern sections of the Wind Farm Site drain into the headwaters of the Glendine River (Glendine(Clare)_010) and the Kildeema River (Kildeema_010) respectively with both rivers entering the Atlantic Ocean at the same point south of Spanish Point. The eastern section of the Wind Farm Site drains into the headwaters of the Inagh River (Inagh(Ennistymon_SC_040) which enters the Atlantic Ocean north of Lahinch.

The southern section of the Underground Cable Route and substation extension is located in the Annagh River catchment. A local hydrology map is shown as Figure 9-2.

A summary of the local hydrology with regard the Proposed Development site is shown in Table 9-4 below.

9.3.4 Proposed Development Site Drainage

The pattern of local hydrology is controlled, particularly in the uplands, by the regional structural lineation in the area, which is a pattern of northeast – southwest trending fold axes. River valleys are constrained in part by this lineation, which results in a quite complex river catchment and flow direction pattern in the area of the site. Based on the site topography, the three main Wind Farm Site local surface water sub-catchments are divided into four Wind Farm Site sub-catchments. A Wind Farm Site drainage map is shown as Figure 9-3.

Wind Farm Site Sub-Catchment A

Sub-catchment A, which is the headwaters of the Glendine River valley, is covered by peat on the elevated south-eastern section of the catchment while the lower-lying western section of the catchment is dominated by poorly draining grassland.

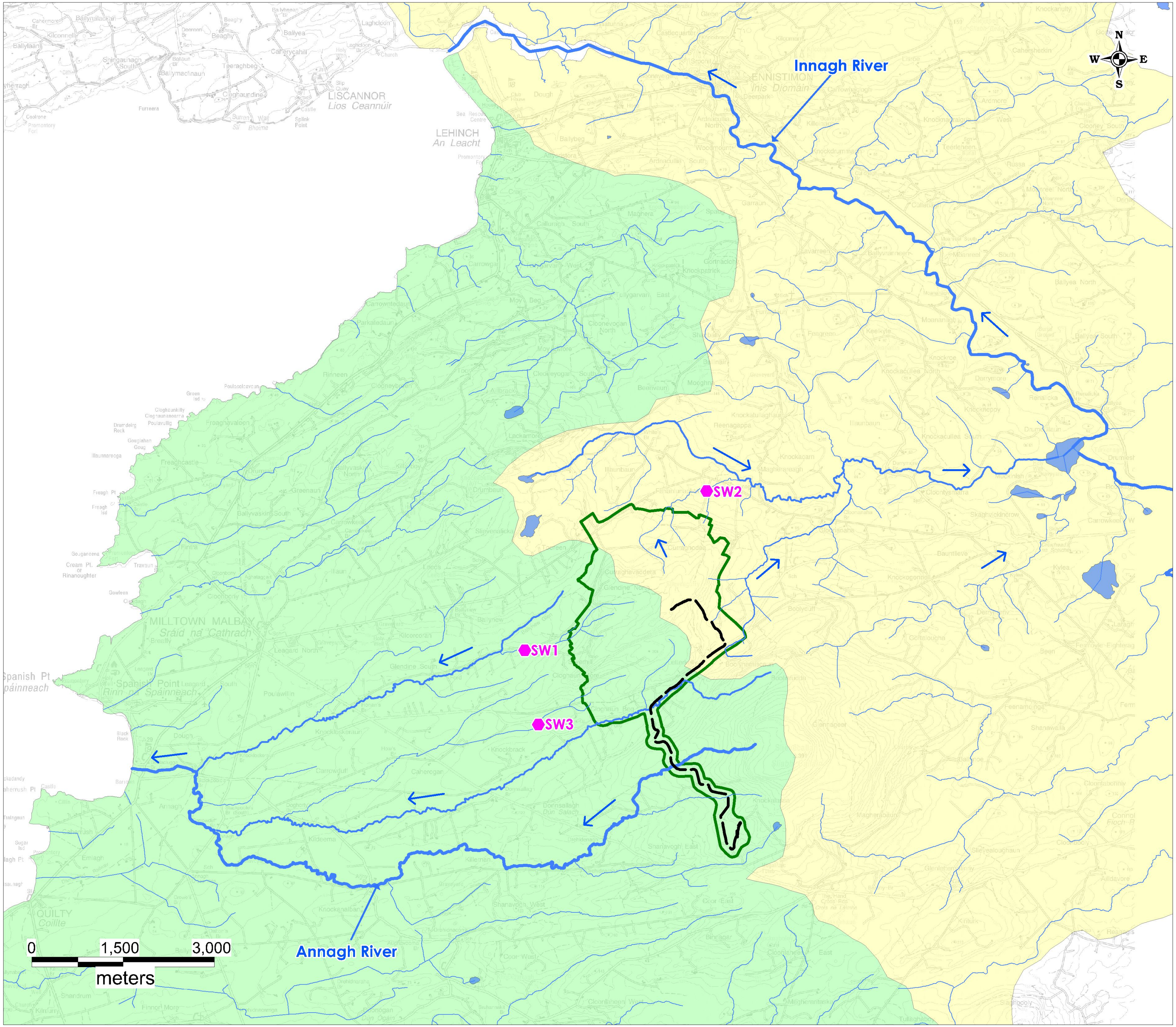
The catchment drains to three main streams (S1, S2 & S3). Streams S1 and S2 drain a broad valley that exists between turbines T3 and T7. This valley, which has significant areas of cutover peat, was noted to be very wet and quaking in places. S3 emerges from a separate small valley to the north of T7 which was also noted to significantly water logged. Turbine T7 is located in sub-catchment A.

Wind Farm Site Sub-Catchment B

Sub-catchment B, which is the headwaters of the Kildeema River valley, is dominated by poorly draining grassland with areas of thin peat with some forestry. The catchment drains to two primary streams (S4 & S5) that converge downstream of the site to form the Kildeema River. The western section of the catchment, which includes the area of borrow pit no. 1 and the construction compound drains to stream S4. The eastern section of the catchment is drained by stream S5. Turbine T8 is located in sub-catchment B.

Wind Farm Site Sub-Catchment C

The eastern verge of the Wind Farm Site is characterised by steeply sloping terrain that drains to a river which is a tributary of the Inagh River. The catchment is drained by two primary streams (S6 & S7) that emerge from an area of forestry to the south of T6. T6 is the only turbine located in sub-catchment C.



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Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Regional Hydrology Map	
Figure No: 9-1	
Drawing No: P1159-4-1121-A3-901-00A	
Sheet Size: A3	Project No: P1159-4
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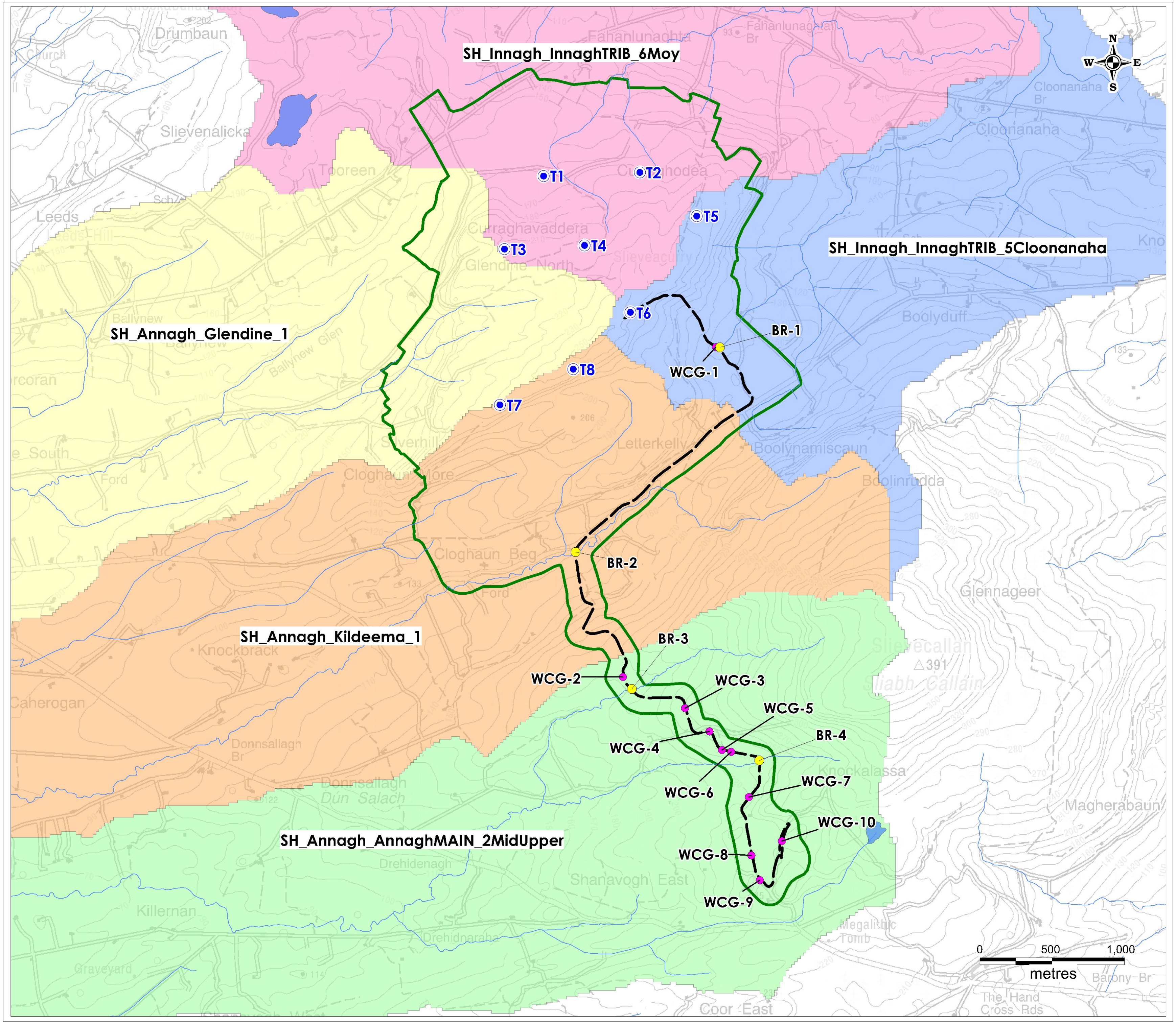

Legend

EIAR Siet Boundary

Proposed Turbine Layout

Proposed Grid Route

Rivers

Lakes

Existing Culvert Crossing along Grid Route

Existing Bridge Crossings

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Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Local Hydrology Map	
Figure No: 9-2	
Drawing No: P1159-4-1121-A3-902-00B	
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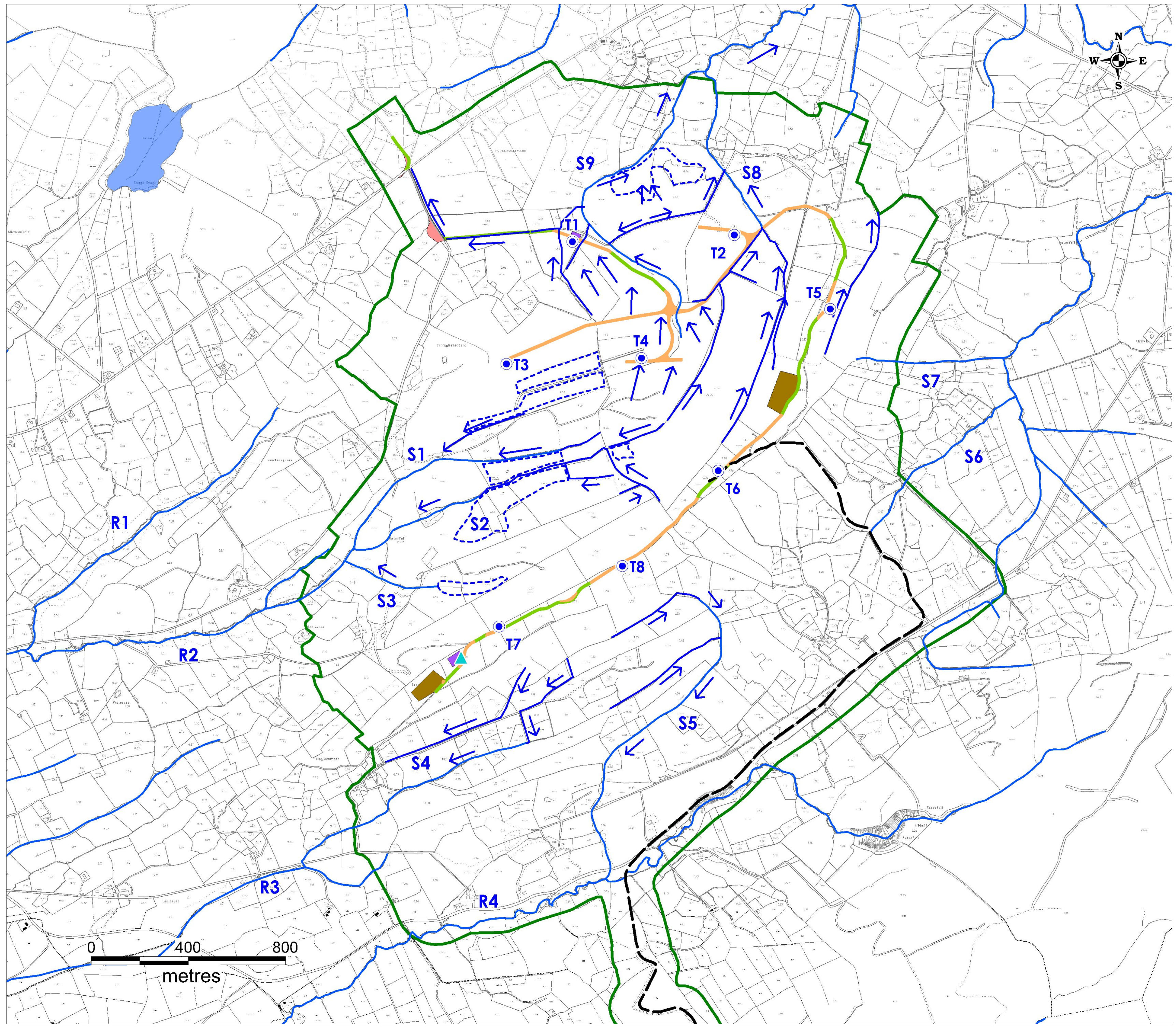

Legend

- EIAR Site Boundary
- Proposed Grid Route
- Proposed Turbine Layout
- Proposed Met Mast
- Proposed Construction Compound
- Proposed Borrow Pit
- Junction Works Area
- Proposed New Roads
- Existing Roads Proposed to be Upgraded
- Existing Public Road
- Public Road Expansion Area
- Lakes
- Flow Direction
- Rivers/Streams
- Wet Area

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Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Site Drainage Map	
Figure No: 9-3	
Drawing No: P1159-4-1121-A3-903-00B	
Sheet Size: A3	Project No: P1159-4
Scale: 1:15,000	Drawn By: GD
Date: 11/11/2021	Checked By: MG

Wind Farm Site Sub-Catchment D

Sub-catchment D, which is also the headwaters of the Inagh River valley, is dominated by blanket peat on the southern more elevated area of the catchment while the northern lower lying end of the catchment is characterised by poorly draining grassland. The catchment is drained by two primary streams (S8 & S9) that converge close to the northern boundary of the site. Stream S9 emerges on the southern end of the catchment and drains a large plantation of conifer trees that exists in the vicinity of turbine T1. S8 emerges from a steep sided valley that runs in a northerly direction between T2 and T5. Turbines T1, T2, T3, T4 & T5 are located in sub-catchment D.

In addition to the primary drainage features described above, there is also a significant drainage network associated with conifer plantations, peat cutting and existing access roads. Where possible, this forestry drainage network was mapped and the layout is shown on the site drainage map (Figure 9-3).

Underground Cable Route

As summarised in Table 9-4 below, the Underground Cable Route, passes through 3 no. local catchments (i.e., Kildeema River, Annagh River and Inagh River catchments). There are a total of 14 no. watercourse crossings along the proposed Underground Cable Route, of which 4 no. are existing stream crossings. The remaining 10 no. crossings are classified as existing culverts.

Table 9-4 Summary of Local Hydrology and Proposed Development Site Drainage

Main River (EPA Sub-catchment Name)	Main Development Infrastructure	Primary Wind Farm On-site Drainage Features
Glendine River (Glendine[Clare]_SC_010)	1 no. turbine and 1 no. construction compound	Streams S1, S2 & S3
Kildeema River (Kildeema_010)	1 no. turbine, borrow pit no. 1 and 1 no. construction compound, met mast, 2.4km of the underground cable route	Stream S4 & S5
Annagh River (Annagh_Clare_010)	2.6km of underground cable route and the Slievecallan substation upgrades works	n/a
Inagh River (Inagh(Ennistymon)_Clare_040)	6 no. turbines, borrow pit no. 2 and 1.5km of the underground cable route	Stream S6, S7, S8 & S9

9.3.5 Baseline Assessment of Development Site Runoff

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

The rainfall depths used in this water balance, are long term averages, are not used in the design of the sustainable drainage system for the Proposed Development.

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 9-5).

It represents, therefore, the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the site pre- development. The surface water runoff co-efficient for the Proposed Development site is estimated to be 95% based on the predominant peat coverage (refer to Section 9.3.2 above).

The highest long-term average monthly rainfall recorded at Inagh over 30 years occurred in the month of December, at 175mm. The average monthly evapotranspiration for the synoptic station at Shannon Airport over the same period in December was 3.1mm. The water balance presented in Table 9-6 indicates that a conservative estimate of surface water runoff for the Proposed Development site during the highest rainfall month is 1,292,590m^3/month or 41,696m^3/day for the Proposed Development site.

Table 9-5: Water Balance and Baseline Runoff Estimates for Wettest Month (December)

Water Balance Component	Depth (m)
Average December Rainfall (R)	0.175
Average December Potential Evapotranspiration (PE)	0.0031
Average December Actual Evapotranspiration (AE = PE x 0.95)	0.00295
Effective Rainfall December (ER = R - AE)	0.172
Recharge (5% of ER)	0.01
Runoff (95% of ER)	0.163

Table 9-6: Baseline Runoff for the Proposed Development Site

Wate Balance Area	Approx. Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
Proposed Development Site	793	1,292,590	41,696

9.3.6 Flood Risk Assessment

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

No recurring flood incidents within the Proposed Development site boundary were identified from OPW's Flood Hazard Mapping. The closest mapped recurring flood event is 5.5km downstream of the site on the Kildeema River.

The PFRA mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (i.e., river) and pluvial (i.e., rainfall) flood events. The 100-year fluvial flood zones mapped within the Proposed Development site occurs along the main watercourses draining the Wind Farm Site (i.e., S1 – S9).

All proposed turbine locations, construction compounds, met mast, borrow pits, access roads and substation extension (with the exception of stream crossings and road upgrades) are located at least 50m away from streams and are outside of the fluvial indicative 100-year flood zone.

There is no text on local available historical 6" or 25" mapping for the Proposed Development site that identify areas that are "prone to flooding" within the Proposed Development site.

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

9.3.7 Surface Water Quality

EPA Q-rating data (https://www.catchments.ie/data) is available for the Glendine River, Kildeema River and the Inagh River downstream of the Proposed Development site. Most recent data (2018) show that the downstream EPA monitoring points on the Glendine River and the Inagh River have a Q-4 rating (Good Status). Downstream of the Proposed Development site the Kildeema River has been given a Q-rating of 3-4 (Moderate Status).

Q values (Q1-Q5) are a classification system given to waterbodies, determined by the EPA, which relate to their biotic and chemical condition. A high value (Q4-5) indicates a high status, unpolluted waterbody.

Electrical conductivity values for the local streams ranged between 98µS/cm and 120µS/cm. pH values which were all slightly basic ranged from 7.1 to 7.3. The measurements were taken during a dry spell and the recorded measurements will be more characteristic of baseflow hydrochemistry (i.e., groundwater baseflow being the primary component of the stream discharge). During wetter periods electrical conductivity values are likely to be lower due to runoff from the bog surface. Refer to Table 9-7 below for field hydrochemistry data.

Table 9-7:Field Hydrochemistry Data (February 2021)

Location ID	Easting	Northing	Conductivity (µS/cm)	pH	Dissolved Oxygen mg/l	Temp °C
SW1	113223	181835	112	7.2	11.1	8.9
SW2	109429	179036	98	7.0	10.3	8.9
SW3	110984	177816	119	7.3	10.8	8.9
SW4	111297	175995	120	7.1	11.7	8.3

* *SW (surface water sample locations), FP (random field parameter measurement)*

Water samples were taken from surface waters draining from the site on 19th May 2020 at locations SW1, SW2, SW3 and SW4. (Refer to Figure 9-2). The sampling was repeated on 26th February 2021 for the revised layout.

These locations are on the main watercourses draining the Wind Farm Site and Underground Cable Route. All measurements were undertaken in natural streams as many drains were dry.

Results of analysis are show in Table 9-8 and Table 9-9 below alongside relevant Environmental Quality Standards (EQS) values for surface water. Laboratory reports are presented in Appendix 9-1.

Table 9-8: Analytical Results of HES Surface Water Samples (May 2020)

Parameter	EQS	Sample ID			
		SW1	SW2	SW3	SW4
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5
Ammonia (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	<0.02	0.02	<0.02	0.06
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	0.02	0.16	0.04
Nitrate - NO_3 (mg/L)	-	<5	<5	<5	<5
Phosphorus (mg/L)	-	<0.1	<0.1	0.18	0.13
Chloride (mg/L)	-	39.4	30	31.1	25.4
BOD	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	6	1	2	<1

(+) S.I. No. 293 of 1988: Quality of Salmon Water Regulations.
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009.

Table 9-9: Analytical Results of HES Surface Water Samples (February 2021)

Parameter	EQS	Sample ID			
		SW1	SW2	SW3	SW4
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5
Ammonia (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	<0.02	0.02	0.02	0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5	<5	<5	8.7
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1	<0.1
Chloride (mg/L)	-	19.9	15	14.9	14.6
BOD	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	5	<1	<1	<1

(+) S.I. No. 293 of 1988: Quality of Salmon Water Regulations.
(*) S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009.

Total suspended solids were <5mg/L for all samples taken in both sampling rounds (May 2020 and July 2021) which is well below the standard set out in S.I. 293 of 1988.

Except for SW4 in February 2021, results for nitrate and nitrite were at or below the detection limit of the laboratory. Phosphorus was only detected in SW3 and SW4 in May 2020 and was below the detection limit in all other samples.

Ammonia ranged between <0.02 and 0.06mg/L over both sampling rounds with SW1 to SW3 being below the "High Status" threshold in both rounds as SW4 only achieved "Good Status" in May 2020 with respect the Surface Water Regulations (S.I. 272 of 2009).

Orthophosphate ranged between 0.02 and 0.16mg/L with SW1 and SW2 being below the "High Status" threshold and SW3 and SW4 exceeding both the High Status and Good Status threshold in May 2020. Results for orthophosphate in February 2021 were all below the "High Status" threshold.

Biological Oxygen Demand (BOD) was reported as between <1 and 6mg/L with SW2 and SW4 being below the "High Status" threshold and SW1 and SW3 exceeding both High Status and Good Status threshold with regard the Surface Water Regulations threshold values (S.I. 272 of 2009).

9.3.8 Hydrogeology

The rocks of the Central Clare Group, which underlie the Proposed Development site are classified by the GSI (www.gsi.ie) as a Locally Important Aquifer, having bedrock which is generally unproductive except for local zones (Ll). The Namurian rocks of the Central Clare Group which comprises sequences of sandstones, siltstone and shale are generally devoid of intergranular permeability. Groundwater flow occurs only in fractures, joints and faults, except for the top few metres of the rock where the rocks are likely to be more fractured and/ or weathered.

Bedrock fissures are generally poorly connected, with fissure permeability reducing rapidly with depth (GSI, 2003). Most flow is therefore expected to occur in the top 5 to 15m of the bedrock. Due to the low subsoil permeability, and low infiltration rates, a high proportion of the rainwater will leave the Proposed Development site as surface runoff. Where groundwater flow does occur, it is normally relatively shallow and closely linked to surface waters due to short flow paths (30 – 300m).

Base flow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain summer base flows due to low storativity with the aquifer. In winter, low permeabilities will lead to a high water table and potential water logging of soils which is consistent with the mapped soil type of the site (i.e. poorly drained mineral & peaty soil).

Local groundwater flow directions will mimic topography whereby flow paths will be from topographic high points to lower elevated discharge areas at local streams.

9.3.9 Groundwater Vulnerability

The vulnerability of the aquifer underlying the Proposed Development site is classified as predominately "Extreme" by the GSI (www.gsi.ie). Blanket peat, which has a low permeability, overlies much of the Wind Farm Site with an average thickness of 0.6m. Based on the site investigation data the vulnerability rating is "Extreme". All proposed turbine sites are located in areas of "Extreme" vulnerability (i.e., <3m peat) (GSI, 1999). However, due to the low permeability nature of the bedrock aquifer underlying the Proposed Development site, groundwater flow paths are likely to be short, 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 making surface water bodies such as drains and streams more vulnerable than groundwater at this site.

9.3.10 Groundwater Hydrochemistry

Namurian bedrock aquifers (including the Central Clare Group) have predominantly $Ca\text{-}HCO^3$ hydrochemical signatures. These signatures vary from 'fresh' signatures to Mg-Na/K-Cl signatures indicative of ion exchange and long flow paths and residence times. A $Ca\text{-}Mg\text{-}HCO^3$ would be expected for groundwaters close to the recharge area of the aquifer (Working Group on Groundwater, 2004). There is a possibility that due to the proximity to the coast the $Ca\text{-}HCO^3$ signature may vary towards a K/Na-Cl due to the influence of seawater chemistry on the rainfall that is recharging the aquifer.

9.3.11 Groundwater Body Status

Local Groundwater Body (GWB) status information are available (www.catchments.ie).

The Milltown Malbay GWB (GWB: IE_SH_G_167) underlies the Proposed Development site and extends west as far as the coastline. It is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

9.3.12 Surface Water Body Status

The Proposed Development site is located within the Glendine River, Kildeema River, Annagh River and Inagh River sub-catchments (See Figure 9-2).

The Glendine_010 sub-basin is given a "Poor Status" in terms of water quality by the WFD 2013-2018 cycle. The Kildeema_010 sub-basin is assigned "Good Status", while both the Annagh(Clare)_010 and the Inagh(Ennistymon)_040 sub-basins are assigned "Moderate Status".

9.3.13 Designated Sites and Habitats

Designated sites include National Heritage Areas (NHAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The Proposed Development site is not located within any designated conservation-sites.

The closest designated site to the Proposed Development is Slievecallan Mountain Bog NHA (Site code 2397) which exists approximately 2.5km to the southeast of the Wind Farm Site and approximately 0.5km east of the Underground Cable Route. The Proposed Development site is not connected hydraulically in any way to this designated site.

The Inagh River Estuary SAC (site code 36) which is designated for a number of habitats and species is located approximately 6.8km downstream of the Proposed Development site. The Mid-Clare Coast pSPA (site code 4182) exists downstream of the Proposed Development site. It encompasses a coastal area from Spanish Point south to Doonbeg and at its nearest point is 7km from the Wind Farm Site (see Ecology, Chapter 6). The largely coincident Carrowmore Point to Spanish Point and Islands cSAC (site code 1021) is designated for a number of coastal habitats that are listed under Annex I of the Habitats Directive. Surface waters in the vicinity of the Proposed Development site enter the sea south of Spanish Point which is approximately 9km down-gradient of the Proposed Development site.

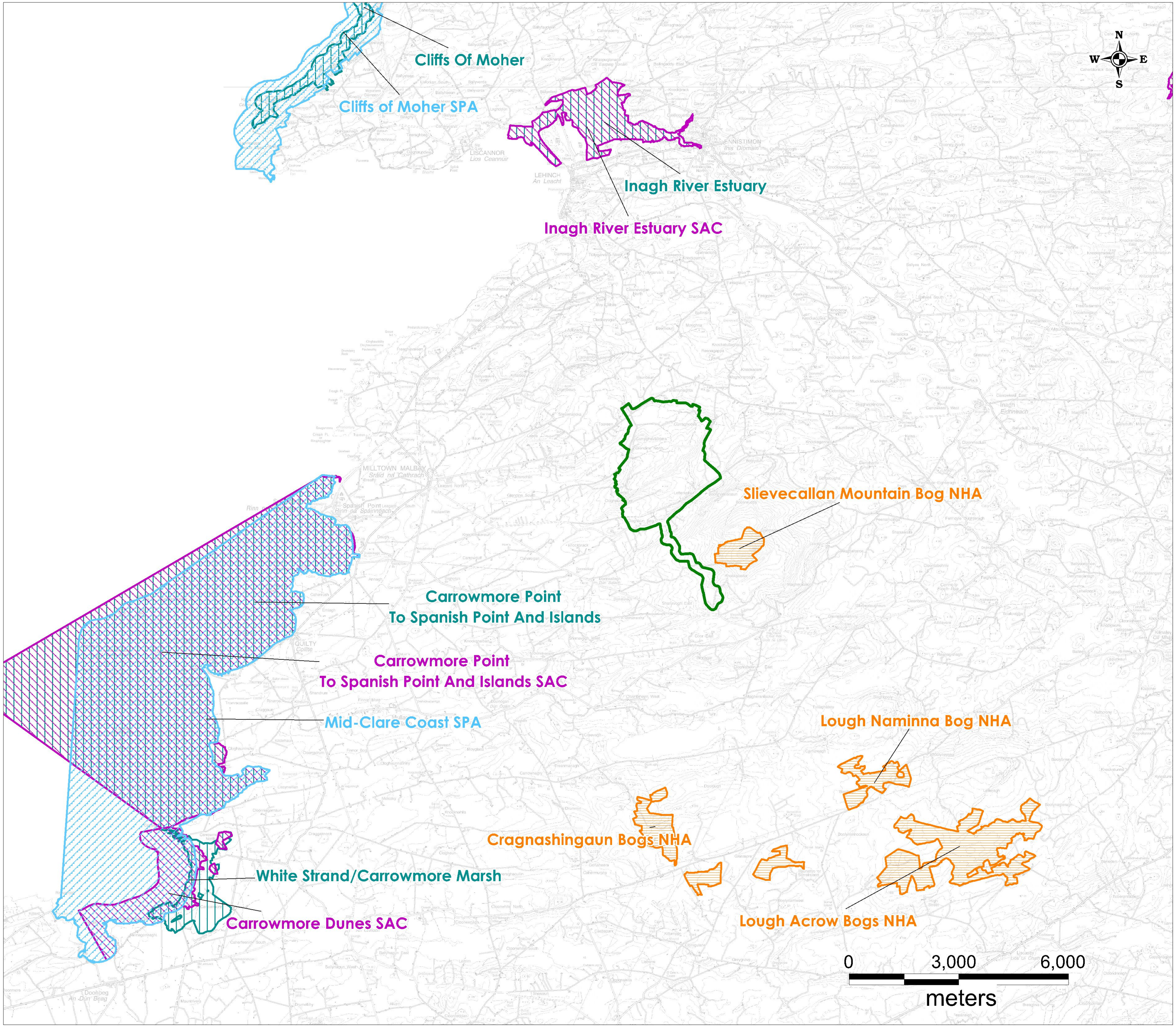
Local designated sites are shown on Figure 9-4.

9.3.14 Water Resources

A search of the Geological Survey of Ireland (GSI) well database (www.gsi.ie) indicates that there are no private wells, public water supplies or group schemes within 1km of the Proposed Development site.

Lough Naminna which his located ~10km to the southeast of the proposed wind farm site (refer to Figure 9-7), is a source for the Inagh Kilmaley Group Water Scheme. The is no proposed development in the surface water catchment to Lough Naminna.

As the GSI well database is not exhaustive in terms of the locations of all wells in the area (as the database relies on the submission of data by drillers and the public etc) 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 a very conservative worst-case assessment approach). Shown on Figure 9-5 are the locations of private dwellings within 1.5km of the development site boundary.



Legend

- EIAR Site Boundary
- SPA
- SAC
- pNHA
- NHA

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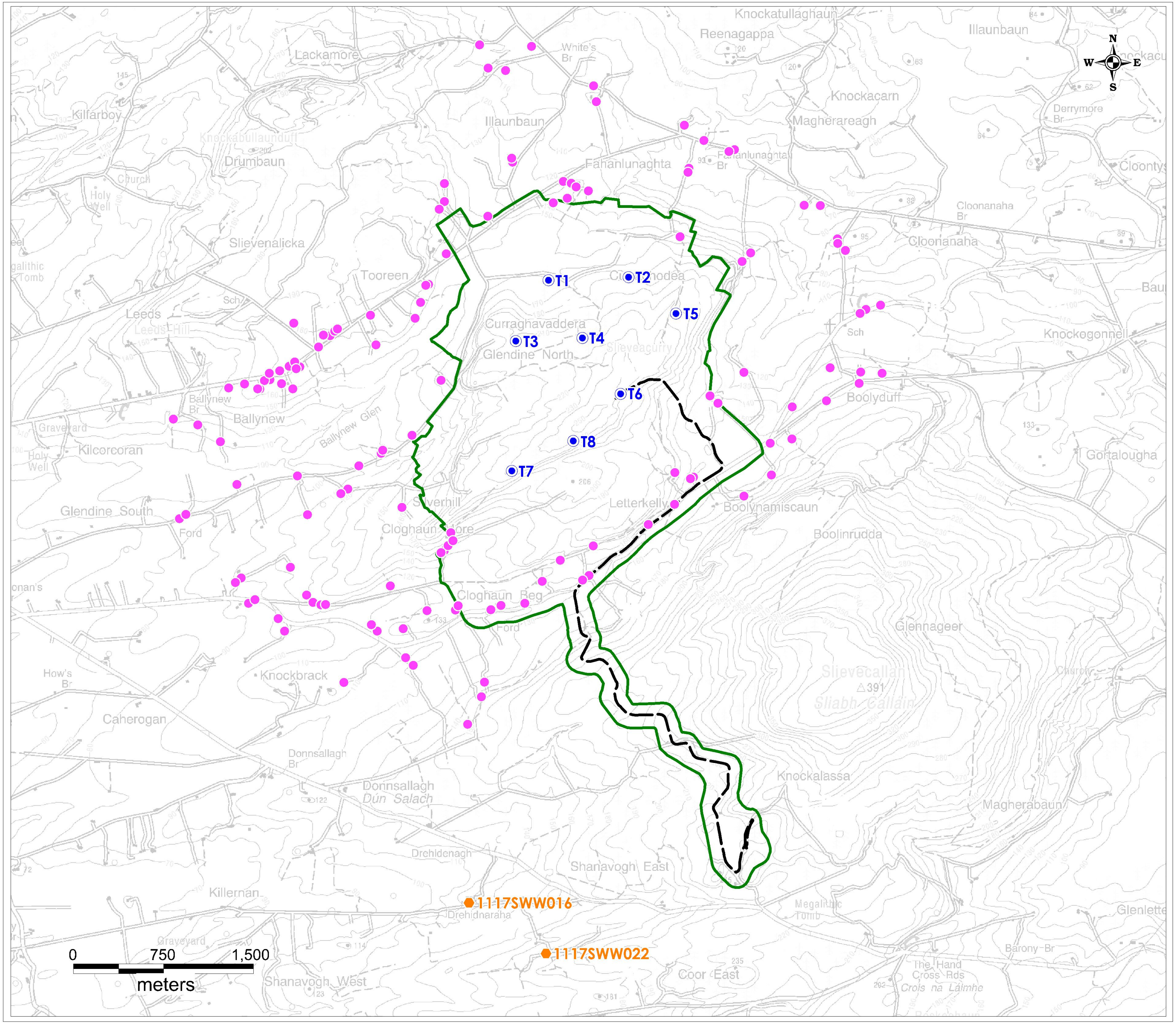
Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Designated Sites Map	
Figure No: 9-4	
Drawing No: P1159-4-1121-A3-904-00B	
Sheet Size: A3	Project No: P1159-4
Scale: 1:100,000	Drawn By: GD
Date: 11/11/2021	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Grid Route
- GSI Mapped Wells (<50m accuracy)
- Private Dwelling Houses

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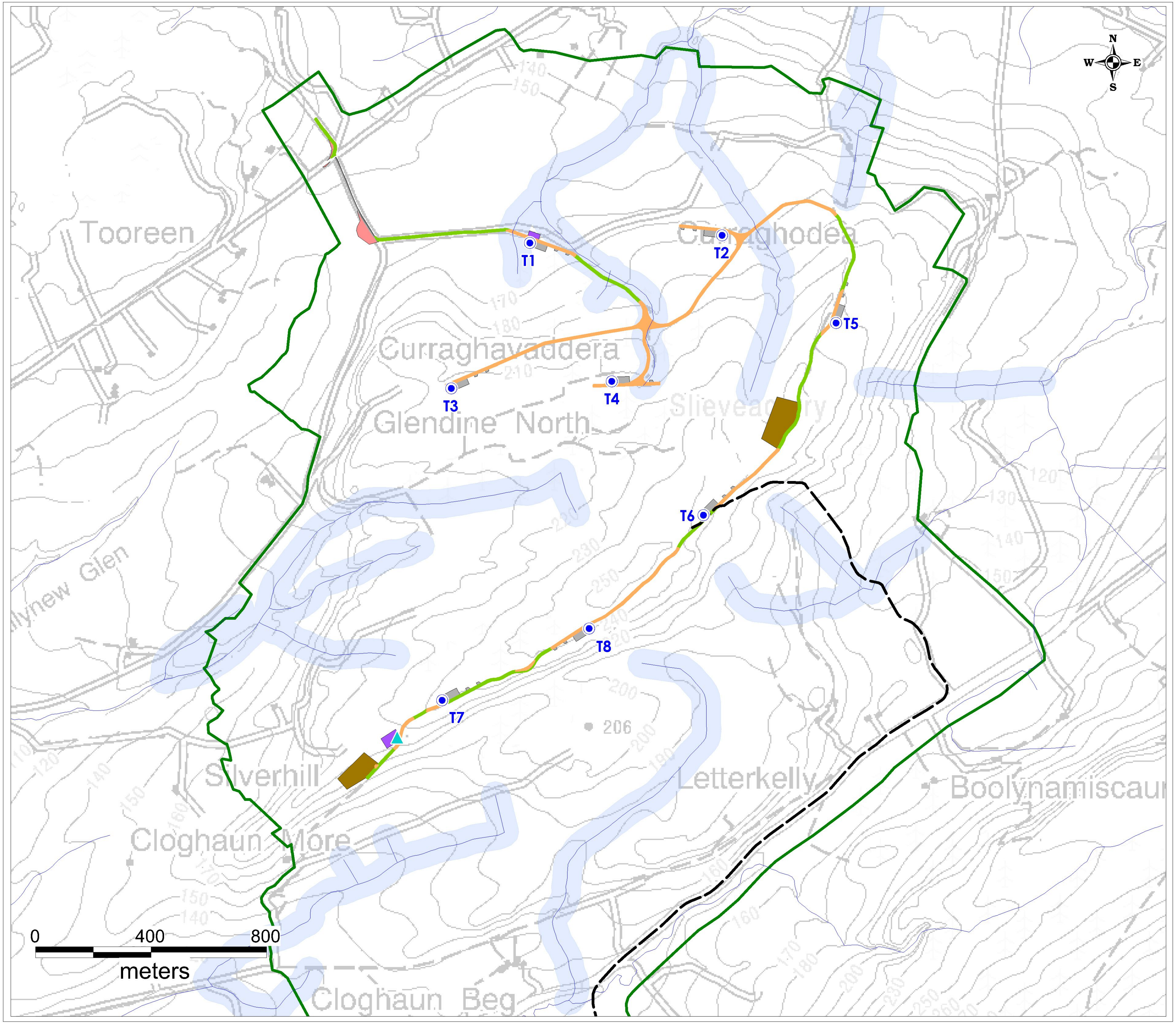
Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Water Well Supply Map	
Figure No: 9-5	
Drawing No: P1159-4-1121-A3-905-00B	
Sheet Size: A3	Project No: P1159-4
Scale: 1:30,000	Drawn By: GD
Date: 11/11/2021	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Grid Route
- Proposed Turbine Layout
- Proposed Met Mast
- Proposed Construction Compound
- Proposed Hardstand
- Proposed Borrow Pit
- Junction Works Area
- Proposed New Roads
- Existing Roads Proposed to be Upgraded
- Existing Public Road
- Public Road Expansion Area
- Rivers
- 50m River Buffer

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Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Hydro-Constraints Map	
Figure No: 9-6	
Drawing No: P1159-4-1121-A3-906-00B	
Sheet Size: A3	Project No: P1159-4
Scale: 1:12,500	Drawn By: GD
Date: 11/11/2021	Checked By: MG

The majority of these dwellings are very remote to the Proposed Development site and given the bedrock geology type within the Wind Farm Site and the unproductive nature of the underlying aquifer there will be no hydraulic connection between any potential wells and groundwater flow from the Wind Farm Site. The groundwater flow direction in the aquifer underlying the Wind Farm Site will mimic the topography whereby flow paths will be from topographic high points to lower elevated discharge areas at streams and rivers. As stated above, flow paths are thought to be between 30 – 300m in length and given the fact that all dwelling houses are more 500m away there is a low risk of impact.

Nevertheless, using the conceptual model of groundwater flow mimicking topography, the potential impact of excavations and the borrow pit on down-gradient water wells is assessed below in Section 9.5.2.10.

9.3.15 Receptor Sensitivity

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

Based on criteria set out in Table 9-1 groundwater at the Proposed Development site is classed as Sensitive to pollution because the Namurian bedrock is classified as a Locally Important Aquifer (Ll). However, the majority of the Proposed Development site is covered in peaty poorly draining topsoil 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. The low permeability of the bedrock means that any contaminant that may reach the bedrock would not disperse and would remain localised to the source or would be removed as runoff during wet periods.

Surface waters such as the downstream Glendine River, Annagh River, Kildeema River and Inagh River and are very sensitive to potential contamination. These rivers are not known to be of salmonid quality, but it is considered to be of salmonid potential (see Ecology, Chapter 6).

There are no designated freshwater dependant sites/ecosystems downstream of the Proposed Development site. The Mid-Clare Coast (pSPA), which is located downstream of the Proposed Development site, is a marine site designated for a number of coastal habitats that are listed under Annex I of the Habitats Directive. From a hydrological perspective there will be no impact on this marine designated site. This designated site is not sensitive to the Proposed Development.

Mitigation measures will ensure that surface runoff from the developed areas of the Proposed Development 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 Proposed Development site will mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the site.

A hydrological constraints map for the Proposed Development site is shown as Figure 9-6. The map shows that the majority of Proposed Development areas (with the exception of watercourse crossings and some sections of existing road upgrades) are significantly away from areas on the Wind Farm 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 etc. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features. This will allow attenuation of surface runoff to be more effective.

9.4 Characteristics of the Proposed Development

The development comprises of the following:

- Construction of 8 No. wind turbines with an overall ground-to-blade tip height in the range of 175 metres maximum to 173 metres minimum; a blade length in the range of 75 metres maximum to 66.5 metres minimum; and hub height in the range of 108.5 metres maximum to 100 metres minimum;
- A thirty-year operational life from the date of full commissioning of the development and subsequent decommissioning;
- A Meteorological Mast with a height of 30 metres;
- All associated underground electrical cabling (33kV) connecting the proposed turbines via Ring Main Unit (RMU) to the 110kV substation in the townland of Knockalassa;
- Permanent extension to the 110kV substation at Knockalassa comprising extension to the existing substation compound, provision of a new control building with welfare facilities and all associated electrical plant and equipment for an additional 110kV bay and security fencing;
- Upgrade of access junctions;
- Upgrade of existing tracks/ roads and provision of new site access roads and hardstand areas;
- 2 no. borrow pits;
- 2 no. temporary construction compounds;
- Site Drainage;
- Forestry Felling;
- Operational stage site signage; and
- All associated site development ancillary works and apparatus.

9.4.1 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 site. 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 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 9-1 below. A detailed drainage plan showing the layout of the proposed construction and operational drainage design elements as shown in Plate 9-1 and in Appendix 4-5.

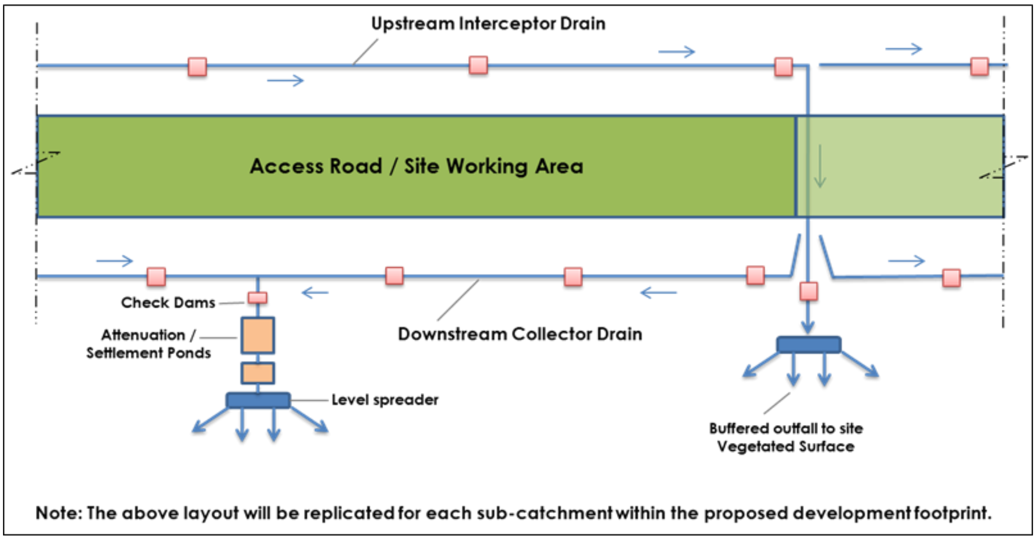


Plate 9-1 Schematic of the Proposed Drainage Management

9.5 Likely Significant Effects and Mitigation Measures

The potential impacts of the Proposed Development and mitigation measures that will be put in place to eliminate or reduce them are set out below.

9.5.1 Do Nothing Scenario

Current land use practices will continue. In particular, commercial felling and replanting 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.

9.5.2 Construction Phase – Likely Significant Effects and Mitigation Measures

9.5.2.1 Clear Felling of Coniferous Plantation

A total of 26.59 hectares of forestry will have to be permanently felled within and around the footprint of the Proposed Development. An additional 1.90 hectares of trees will be required to be temporarily felled around all turbines in order to facilitate infrastructure construction and or bat mitigation. It is estimated, for the purposes of this EIAR, that an additional 30 hectares of commercial forestry could be required to be temporarily felled in order to prevent the trees causing a turbulence effect.

Potential impacts during tree felling occur mainly from:

- Exposure of soil and subsoils due to vehicle tracking 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 (Glendine River, Kildeema River, Inagh River and Annagh River) and associated dependant ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, temporary, likely 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 9-9.

Table 9-10 : 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 turbine construction phase a self-imposed buffer zone of 50 metres will be maintained for all streams where possible. These buffer zones are shown on Figure 9-6. With the exception of existing road upgrades and proposed stream crossings all proposed tree felling areas are located outside of imposed buffer zones. Additional mitigation (detailed below) will be carried where tree felling is required inside the buffer zones.

The large distance between most of the proposed felling areas and sensitive aquatic zones means that potential poor quality (sediment laden) runoff from felling areas will be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes. Where tree felling is required within the 50m buffer, 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 (i.e., handheld or mechanical) will be chosen which are most suitable for ground conditions 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 will 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 50 metre buffer is required, it will be necessary to install double or triple sediment traps;
- All drainage channels will taper out before entering the 50m 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 will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50 metre 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;
- A permit to refuel system will be adopted;
- 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;
- Crossing of streams will not be permitted;
- Trees will be cut manually from along streams and using machinery to extract whole tree; and,
- Travel only perpendicular to and away from stream.

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 pre-felling inspections 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 inspections 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.

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 will be conducted within 4 weeks of the felling activity commencing, 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, downstream locations will 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.

Also, daily surface water monitoring forms will also be utilised at every works site near any watercourse. These will be taken daily and kept on site for record and inspection.

Residual Impact: The potential for the release of suspended solids to watercourse receptors during tree felling is a risk to water quality and the aquatic quality of the receptor. Proven forestry best practice measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effect is considered to be - Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality and aquatic habitats. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: With the application of the mitigation outlined above, no significant effects on the surface water quality will occur.

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

Construction phase activities that will require earthworks resulting in removal of vegetation cover and excavation of peat and mineral subsoil (where present) are detailed in Chapter 4 the Description of the Proposed Development. 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 underground 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 (Glendine River, Kildeema River, Inagh River and Annagh River) and dependant ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, significant, temporary, likely impact.

Mitigation by Avoidance:

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible. From Figure 9-6 it can be seen that all of the key areas of the Proposed Development are actually significantly away from the delineated buffer zones with the exception of existing road upgrades new roads, 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 operated effectively. The proposed buffer zone will:

- Avoid physical damage to watercourses, and associated release of sediment;
- Avoid excavations within close proximity to surface water courses;
- 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 appropriate 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 Proposed Development drainage system. The integration of the existing forestry drainage network and the Proposed Development 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, stilling 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 Development drainage into the existing site drainage network. 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;
- Runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through stilling 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; and,
- Drains running parallel to the existing roads requiring widening will be upgraded, widening will be targeted to the opposite side of the road. 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.

Pre-commencement Temporary Drainage Works

Prior to the commencement of road upgrades (or new road/hardstand or turbine base installs) the following key temporary drainage measures will be installed:

- All existing dry forestry drains that intercept the proposed works area will be temporarily blocked down-gradient of the works using forestry check dams/silt traps;
- Clean water diversion drains will be installed upgradient of the works areas;
- Check dams/silt fence arrangements (silt traps) will be placed in all existing forestry drains that have surface water flows and also along existing forestry roadside drains; and,
- A double silt fence perimeter will be placed down-slope of works areas that are located inside the watercourse 50m buffer zone.

Water Treatment Train:

A final line of defence will be provided by a water treatment train such as a "Siltbuster". If the discharge water from construction areas fails to be of a high quality during regular inspections, 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 water courses 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 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 placed within drains down-gradient of all construction areas inside the 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, the majority of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters or sedimats Sediment entrapment mats, consisting of coir or jute matting, will be placed at the silt bag location to provide further treatment of the water outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. The sedimat will extend to the full width of the outfall to ensure all water passes through this additional treatment measure.

Settlement Ponds:
The proposed development footprint will be divided into drainage catchments (based on topography, outfall locations, catchment size) and stormwater runoff rates based on the 10-year return period rainfall event will be calculated for each catchment. These flows will then be used to design settlement ponds for each drainage catchment. The settlement ponds will either be designed for 4.1hr or 24hr retention times used to settle out medium silt (0.01mm) and fine silt (0.004mm) respectively (EPA, 2006)[2]. Settlement pond at borrow pits will designed to allow 24hr retention and settlement ponds along access roads and at turbine hardstands will have 4.1hr retention as there is additional in-line drainage controls proposed along access tracks and at hardstands.

The supporting design calculations for all settlement ponds are included in Appendix 9-2.

Pre-emptive Site Drainage Management

The works programme for the entire construction stage of the development will also take account of weather forecasts and predicted rainfall in particular. Large excavations and movements of peat/subsoil

[2] Environmental Management Guidelines - Environmental Management in the Extractive Industry (Non-Scheduled Minerals) (EPA, 2006).

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 will be suspended if forecasting suggests either 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 will 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 Reinstatement Areas:

It is proposed that excavated peat will be used for landscaping throughout the site and any excess peat will be used to reinstate the 2 no. proposed borrow pits. All the proposed borrow pits are located outside the 50m stream buffer zone (refer to Figure 9-6).

During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable matting will be used to control surface water runoff from the reinstatement areas. 'Siltbuster' treatment trains will be employed if previous treatment is not to a high quality.

Drainage from peat reinstatement areas will ultimately be routed to an oversized swale and a number of stilling ponds pond and a 'Siltbuster' with appropriate storage and settlement designed for a 1 in 10 year return period before being discharged to the on-site drains.

Peat/subsoil reinstatement 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 reinstatement areas will no longer be a potential source of silt laden runoff.

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 construction 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. Checks will be carried out on a daily basis.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (as per the CEMP is included in Appendix 4-4 of this EIAR).

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact on down gradient rivers, water quality, and dependant ecosystems. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, no significant effects on the surface water quality will occur.

9.5.2.3 Potential Impacts on Groundwater Levels and Local Well Supplies During Excavation of Borrow Pits.

Dewatering of borrow pits (as required) and other deep excavations (i.e., turbine bases) have the potential to impact on local groundwater levels. However, groundwater level impacts will not be significant due to the local hydrogeological regime and the proposed borrow pit excavation method as outlined below. Piling, which will be undertaken at the turbine locations as required, does not require dewatering and therefore has no potential to impact on groundwater levels.

No groundwater level impacts are predicted from the construction of the underground cabling trench, access roads, substation extension, compound or met mast due to the shallow nature of the excavation (i.e., 0 -~1.2m).

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Impact: Direct, negligible, slight, short term, unlikely impact.

Impact Assessment:

The proposed borrow pits (2 no.) are located in bedrock which is generally unproductive in terms of groundwater flow. 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 will be required during the works to the borrow pits during the construction phase. 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 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 230m OD and therefore are rock outcrops;
- These elevations are 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 shales/limestone and is known to be generally unproductive. This means that groundwater flows will be relatively minor;
- The flow paths (i.e., the distance from the point of recharge to the point of discharge) in this type of geology is 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 soil 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.

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: Due to large separation distances between Proposed Development works and water wells and local stream and rivers, and the relatively shallow nature of the proposed borrow pit works, and also the prevailing geology of the Proposed Development site the potential for water level drawdown impacts at receptor locations is considered negligible. The residual effect is considered to be – Negative, imperceptible, direct, short term, unlikely impact on groundwater levels, and Negative, imperceptible, short term, unlikely impact on groundwater quality. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, no significant effects on groundwater levels and groundwater quality will occur.

9.5.2.4 Excavation Dewatering and Potential Impacts on Surface Water Quality

Some minor groundwater/surface water seepages will likely occur in turbine base excavations, the borrow pits and sections of the underground cabling trenches, 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 and therefore baseline contamination does not occur.

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies (Glendine River, Kildeema River, Inagh River and Annagh River).

Pre-Mitigation Potential Impact: Indirect, negative, significant, temporary, unlikely impact to surface water quality.

Proposed Mitigation Measures:

Management of groundwater 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, or via specialist treatment systems such as a Siltbuster unit;
- 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 will 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. They will be used as final line of defence if needed.

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be – Negative, imperceptible, indirect, short term, unlikely impact on local surface water quality. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of the Effects: For the reasons outlined above, no significant effects on the surface water quality will occur.

9.5.2.5 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 (Glendine River, Kildeema River, Inagh River and Annagh River).

Pre-Mitigation Potential Impact:

Indirect, negative, slight, short term, likely impact to local groundwater quality.

Indirect, negative, significant, short term, unlikely impact to surface water quality.

Proposed Mitigation Measures:

Mitigation measures proposed to avoid release of hydrocarbons at the site are as follows:

- 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 refuelling 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 refuelling operations;
- Onsite refuelling will be carried out by trained personnel only;
- A permit to fuel system will be put in place;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be included within the Construction and Environmental Management Plan (Appendix 4.4). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Impact: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status or ecology of downstream waters. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact to local groundwater quality. Negative, imperceptible, indirect, short term, unlikely impact to surface water quality. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, no significant effects on surface water or groundwater quality will occur.

9.5.2.6 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 (Glendine River, Kildeema River, Inagh River and Annagh River).

Pre mitigation Impact:

Indirect, negative, significant, temporary, unlikely impact to surface water quality.

Indirect, negative, slight, temporary, unlikely impact to local groundwater.

Proposed Mitigation Measures:

- It is proposed to manage wastewater from the staff welfare facilities in the control buildings by means of a sealed storage tank, with all wastewater being tankered off site by permitted waste collector to wastewater treatment plants. It is not proposed to treat wastewater on-site.

Residual Impact: No residual impact.

Significance of Effects: No significant effects on surface water or groundwater quality will occur.

9.5.2.7 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 $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of $\pm$ 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, likely impact to surface waters (Glendine River, Kildeema River, Inagh River and Annagh River).

Proposed Mitigation Measures:

- 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;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. 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 will be undertaken at lined cement washout ponds;
- Weather forecasting will be used to plan dry days for pouring concrete; and,
- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Impact: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status or ecology of downstream waters. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact to surface water quality. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of the Effect: For the reasons outlined above, no significant effects on surface water quality will occur.

9.5.2.8 Morphological Changes to Surface Water Courses & Drainage Patterns

Diversion, culverting and bridge crossing of surface watercourses can result in morphological changes, changes to drainage patterns and alteration of aquatic habitats. Construction of structures over water courses has the potential to significantly interfere with water quality and flows during the construction phase.

It is proposed that 3 no. new stream crossings will be required to facilitate the Wind Farm Site development infrastructure.

There are a total of 14 watercourse crossings along the proposed Underground Cable Route, of which 4 no. are existing stream crossings. The remaining 10 no. crossings are classified as existing culverts.

Pathway: Site drainage network.

Receptor: Surface water flows (Glendine River, Kildeema River, Inagh River and Annagh River), stream morphology and water quality.

Pre-Mitigation Potential Impact: Negative, direct, slight, long term, likely impact.

Proposed Mitigation Measures (Wind Farm Site):

- All proposed new stream crossings will be bottomless or clear span culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no direct impact on the stream at the proposed crossing location;

- Where the proposed Underground Cable Route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- All guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland[3] is 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", i.e., 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 (any deviation from this will be done in discussion with the IFI);
- 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; and,
- All new 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.

With respect to the Underground Cable Route watercourse crossings, 3 construction crossing methods are proposed that will avoid in-stream works and these include:

- Option 1 - Where adequate cover exists above a culvert, a standard trench arrangement will be used where the cable ducts pass over a culvert without any contact with the existing culvert or water course. The cable trench will pass over the culvert in a standard trench.

- Option 2 - Where the culvert consists of a socketed concrete or sealed plastic pipe and sufficient depth is not available over the crossing, a trench will be excavated beneath the culvert and cable ducts will be installed in the standard formation 300mm below the existing pipe.

- Option 3 – Where cable ducts are to be installed over an existing culvert and sufficient cover cannot be achieved, the ducts will be laid in a much shallower trench, the depth of which will be determined by the cover available at the culvert crossing location. The ducts within the shallow formation trench will be encased in 6mm thick steel galvanized plates and backfilled with 35N concrete.

  Where sufficient deck cover is not available to fully accommodate the required ducts, it may be necessary to locally raise the pavement level. Any addition of a new pavement will be tied back into the existing road pavement at grade.

Residual Impact: With the application of the best practice mitigation outlined above, we consider the residual effect to be - Negative, imperceptible, direct, long term, unlikely impact on stream flows, stream morphology and surface water quality. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

[3] *Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters*

Significance of Effects: For the reasons outlined above, no significant effects on stream morphology or stream water quality will occur at crossing locations.

9.5.2.9 Potential Hydrological Impacts on Designated Sites

The designated sites that are hydraulically connected (surface water flow paths only) to the Proposed Development include the Inagh River Estuary SAC (Site Code 000036), Mid-Clare Coast SPA (Site Code 004182) and Carrowmore Point to Spanish Point and Islands cSAC (Site Code 001021). From a hydrological perspective there will be low risk of impact on these marine designated sites as they are not freshwater dependant ecosystems and therefore less sensitive to sediment input which is the main potential pollutant from the Proposed Development, particularly during construction. However, as described in this chapter measures will be put in place to prevent surface water quality impacts.

Pathway: Surface water flowpaths.

Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Potential Impact: Indirect, negative, imperceptible, short term, likely impact.

Impact Assessment & Proposed Mitigation Measures:

Due to the nature and scale of the development, the downstream distance (~9km) and the fact the downstream designated sites are not freshwater dependant habitats, no impacts will occur.

Nevertheless, mitigation measures for surface water quality protection are summarised again below:

The proposed mitigation measures which will include buffer zones and drainage control measures (i.e., interceptor drains, swales, stilling ponds) will ensure that the quality of runoff from Proposed Development areas will be very high. As stated in Impact Section 9.5.2.2 above, there could potentially be an “imperceptible, short term, likely impact” on local streams and rivers but this would be very localised and over a very short time period (i.e., hours). Therefore, no significant direct, or indirect impacts on the downstream designated sites will occur.

Residual Impact: No impacts. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: No significant impacts on designated sites will occur.

9.5.2.10 Potential Effects on Local Groundwater Well Supplies

A baseline definition of groundwater flow at the study site is outlined in Section 9.3.8. Using this conceptual model of groundwater flow an impact assessment for local wells is undertaken below. This assessment is completed in accordance with “Wind farms and groundwater impacts - A guide to EIA and Planning considerations (DoE/NIEA, 2015).

The biggest risk to wells will be from where deep excavations are required such as the borrow pits and turbines bases. Construction of the Wind Farm Site access road, Underground Cable Route trench and substation extension will not have the potential to effect local wells due to the shallow nature of the works.

Pathway: Groundwater flowpaths.

Receptor: Groundwater Supplies.

Pre-Mitigation Potential Impact: Negative, imperceptible, indirect, long term, low probability effect.

Impact Assessment:

Due to the low permeability the Central Clare Group aquifers and low recharge characteristics, flow paths are generally short. Flow paths are estimated at a minimum of 30m to a maximum of 300m for aquifers in this groundwater body (GSI, 2003) with the majority of groundwater flows emerging as springs/baseflow along nearby rivers/streams. In the case of the Proposed Development site a worst-case flow path of 300m is assumed however the high drainage density would indicate this is likely to be less. The flow path is the distance and direction from the aquifer recharge area to where groundwater is discharged as surface water in rivers, seeps or springs. Therefore, it is unlikely that groundwater flow volumes and direction could be impacted by any activity that is at a distance of greater than 300m from a given point in the aquifer. Also, the low permeability would mean that a pollutant would take months/years to travel this distance as demonstrated below by means of the Darcy mean velocity equation presented below.

Listed in Table 9-10 are the distances from each proposed turbine and borrow pit location to the closest potentially down-gradient dwelling house (which is assumed to have a well).

Table 9-11 Development Areas and Distance to Closest Dwelling

Turbine No.	Distance to Closest Potentially Downstream Dwelling (m)
T1	690
T2	515
T3	830
T4	1,156
T5	716
T6	780
T7	800
T8	690
Borrow Pit 1	720
Borrow Pit 2	530

Given the distance that the above dwellings (listed in Table 9-10) are away from the Proposed Development (i.e. >300m) it is extremely unlikely that any impact could occur to any potential wells as a result of the Proposed Development. Also, the distance and low permeability would mean that groundwater would take months/years to travel this distance (if a flow path exceeding 300m did exist) as demonstrated below by means of the Darcy mean velocity equation:

q = k.i (Darcy's law for specific discharge)

v = q/ ne (Darcy velocity)

T = L / v (Time of Travel - ToT)

where:

q = specific discharge (m/day)

k = permeability m/day (a value of 0.52m/day for low permeability bedrock is used).

ne = porosity (a value of 0.025 is used for low permeability bedrock).

i = slope of the water table in low permeability rock is estimated from on topography (a value of 0.07 is used for this site (220mOD -120mOD)/1400m = 0.07).

v = Darcy velocity (m/day)

L = Distance (m)

T = travel time (days)

With a calculated groundwater flow velocity of 1.4m/day, the time of travel (ToT) for a potential pollutant to flow from a turbine excavation to the nearest house (i.e., 515m) would be in the order of 367 days. During this time any discharge would be assimilated and attenuated by groundwater flow and will also be diluted by rainfall recharge. Also, any entrained sediment would be filtered within the low permeability bedrock aquifer. Therefore, the risk posed to potential well sources from potential spills and leaks from excavations is negligible. In addition, there are proposed mitigation measures that will minimise and prevent potential for accidental discharges in these areas (these are dealt with below).

Therefore, to summarise the well impact assessment:

- The site is underlain by an aquifer of low permeability;
- Groundwater flowpaths are therefore typically very short (~300m maximum);
- Consequently, the majority of groundwater flows within the site emerge as springs/baseline along streams/rivers and leave the site as surface water flows and not groundwater flows;
- The potential to impact on local wells (whether they are downslope or not) is very low as groundwater flowpaths between the proposed development infrastructure and locals wells do not exist due to the large setback distance (>900m);
- Mitigation is provided in the EIAR to deal with construction phase groundwater hazard such as oils and fuels; and,
- Based on our hydrogeological assessment of the site with regard to groundwater user risk and the proposed mitigation measures, we can robustly say the potential to impact on local wells/water supply sources is negligible.

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), It has been assessed there is no potential to impact on local wells. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, no impacts on groundwater supplies will occur.

9.5.2.11 Turbine Delivery Route Works

Minor earthworks are required for turbine delivery. These include for temporary widening of existing roads and junctions. These TDR works are described in Section 14.1.8 of the EIAR.

Pathway: Surface water flowpaths.

Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Potential Impact: Indirect, negative, slight, short term, likely impact.

Proposed Mitigation Measures:

- All works are minor and localised and cover very small areas;
- These works are distributed over a wide area; and,
- All works are temporary in nature.

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact on down gradient rivers, water quality, and dependant ecosystems. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, no significant effects will occur on surface waters.

9.5.2.12 Effects of Tree Felling and Construction Works on the WFD Status of Downstream Waterbodies

The Glendine_010 sub-basin is given a "Poor Status" in terms of water quality by the WFD 2013-2018 cycle. The Kildeema_010 sub-basin is assigned "Good Status", while both the Annagh(Clare)_010 and the Inagh(Ennistymon)_040 sub-basins are assigned "Moderate Status". Without mitigation the proposed construction works have the potential to adversely impact on surface water quality which may negatively impact on the WFD status of these downstream surface waterbodies.

To ensure the objectives of the WFD are met, surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all. This is reflected in the strict mitigation measures in relation to maintaining a high quality of surface water from the development will ensure that the status of surface waterbodies in the vicinity of the Wind Farm Site will be at least maintained regardless of their existing status.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters (Glendine River, Kildeema River, Inagh River and Annagh River) and associated dependant ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, temporary, likely impact.

Proposed Mitigation Measures:

Comprehensive surface water mitigation and drainage controls are outlined in Section 9.5.2.1 (Felling of Coniferous Plantations), Section 9.5.2.2 (Earthworks), Section 9.5.2.4 (Excavation Dewatering), Section 9.5.2.5 (Hydrocarbons), Section 9.5.2.7 (Cement-based Products) and Section 9.5.2.8 (Morphological Changes to Watercourses). These will ensure the protection of surface water quality and flows in all downstream receiving watercourses.

Residual Impact: The potential for the release of suspended solids, hydrocarbons, cement-based products or altered flows to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigation measures have been proposed and will break the pathway between the potential pollutant sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely impact on down gradient rivers, water quality, and dependant ecosystems. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: For the reasons outlined above, and with the implementation of the proposed mitigation, no significant effects on the surface water quality will occur.

9.5.2.13 Potential for Increased Surface Water Runoff

There is some potential for increased surface water runoff in the construction phase of the development (although the primary potential impact is during the operational phase when all hardstanding areas have been constructed, refer to Section 9.5.3.1 below).

Increased surface water runoff may result from the replacement of vegetated and natural surfaces with impermeable surfaces such as at roads and turbine hardstands. This loss of natural surface reduces local the infiltration rates and increases the volumes of surface water runoff entering downstream watercourses.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters (Glendine River, Kildeema River, Inagh River and Annagh River) and associated dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, permanent, moderate probability effect on all downstream surface water bodies.

Proposed Mitigation Measures:

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface waterbodies. During the construction phase all runoff from works areas will be attenuated and treated to a high quality prior to diffuse release over a vegetated surface. The drainage system in place during the construction phase will comprise of interceptor drains, swales, check dams, transverse drains and settlement ponds and will delay runoff from any hardstand areas entering surface downstream surface watercourses. The proposed drainage system will ensure that runoff rates will reflect greenfield runoff rates.

Residual Impact: Direct, negative, neutral, long term, likely impact. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: No significant effects on surface water quality or quantity will occur during the construction phase of the Proposed Development.

9.5.3 Operational Phase – Likely Significant Effects and Mitigation Measures

9.5.3.1 Increased Surface Water Runoff Rates due to Road and Hardstand Emplacement

The potential for increased surface water runoff is the primary potential impact during the operational phase of the Proposed Development.

Progressive replacement of the vegetated surface with impermeable surfaces will decrease the permeability of the ground within the Wind Farm Site footprint (i.e., turbine bases, hardstandings, and to a lesser extent the new access roads) and substation extension. It should be noted that approximately 2.8km of the proposed wind farm roads already exist and are proposed for upgrade. The permeability along the internal underground cabling route through the Wind Farm Site will not be significantly altered, as the fill material will not be compacted. This will result in an increase in the proportion of surface water runoff reaching the surface water drainage network as outlined in Table 9-11.

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 approximately 738m^3/month (Table 9-12). This represents a potential increase of approximately 0.057 % in the average daily/monthly volume of runoff from the site 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 overall Proposed Development site being developed. Specifically, the proposed permanent development footprint is approximately 8.2ha, representing 1.03% of the total EIAR Study Area of 793ha.

The additional volume is low due to the fact that the runoff potential from the Wind Farm Site is naturally high (95%). Also, this calculation assumes that all hardstanding areas will be impermeable which considered to be a worst-case scenario. The increase in runoff from most of the development catchment will therefore be negligible and this is before mitigation measures will be put in place. This water balance assessment demonstrates that even in the absence of mitigation, the potential to alter the hydrology of the site is imperceptible. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

Table 9-12: Baseline Site Runoff V Development Runoff

Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Footprint Area (m^2)	Footprint Area 100% Runoff (m3) (m^3)	Footprint Area 95% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)	% Increase from Baseline Conditions (m^3)
1,292,590	41,696	82,000	14,104	13,366	738	23.8	0.057

Pathway: Site drainage network.

Receptor: Surface waters (Glendine River, Kildeema River, Inagh River and Annagh River) and dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, permanent, moderate probability effect on all downstream surface water bodies.

Proposed Mitigation by Design:

The proposed drainage philosophy outlined in Section 9.4.1 states that 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 being 'keeping clean water clean' and the second involving the collection of any drainage waters from work area and to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. The second method relates to proposed design measures that will prevent road surface and other hardstand areas acting as preferential flowpaths. All runoff from the development footprint will be collected, attenuated, treated and then released in a diffuse and regular manner that does not significantly change the natural drainage regime/hydrology of the site.

The operational phase drainage system of the Proposed Development will consist of the continued maintenance of the drainage system installed and constructed in conjunction with the road and hardstanding construction work as described below and as shown on the Drainage drawings submitted with this planning application:

- Interceptor drains will be maintained 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 will 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 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.

These measures will ensure all surface water runoff from upgraded roads and new road surfaces (including hardstands and turbine base areas) will be captured and treated prior to discharge/release. Settlement ponds, check dams and buffered outfalls will prevent roads acting as preferential flowpaths by providing attenuation and water quality treatment.

Due to the much-reduced risk of sediment entrainment in surface water runoff during the operational phase, maintenance of the drainage control measures as outlined above will be scaled back appropriately as the site revegetates and stabilises over the course of its operation..

Residual Impact: Direct, negative, neutral, long term, likely impact. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: No significant effects on surface water quantity will occur during the operational phase of the Proposed Development.

9.5.3.2 Effects on Hydrology during Operational Phase

As outlined in Section 9.4.1, any new or introduced drainage works at the Proposed Development Site are intended to mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the site. This is a core strategy of the drainage design. This will be achieved by minimal re-routing of flows from baseline conditions, and by attenuating all surface water runoff from the proposed development footprint and releasing it as the greenfield runoff rate thereby maintaining normal flows in downstream watercourses. Ultimately all water entering downstream watercourses would have reached the same watercourse anyway. There will be no transfer of water from one catchment to another.

It should be noted that the site is already extensively drained. The integration of the wind farm drainage with the existing drainage is a key component of the proposed drainage management within the Wind Farm Site. This means maintaining surface water flowpaths where they already exist, avoiding the creation of new or altered surface water flowpaths, and maintaining the drainage regime within each forestry or field compartment. Critically, there will be no alteration of the catchment size contributing to each of the main downstream watercourses. All water captured within individual site sub-catchments will be attenuated and released within the same sub-catchment, thereby maintaining the existing hydrological regime.

The water balance assessment demonstrates that even in the absence of drainage mitigation, the potential to alter the hydrology of the site is imperceptible due to the naturally high runoff of the site resulting from peat coverage and poorly draining soils/subsoils.

Pathway: Site drainage network.

Receptor: Surface waters (Glendine River, Kildeema River, Inagh River and Annagh River) and dependant ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, permanent, moderate probability effect on all downstream surface water bodies.

Proposed Mitigation by Design

Even in the absence of mitigation, the potential for altering the natural hydrology is low. Nevertheless a series of mitigation measures will be implemented on-site to attenuate surface water runoff during the operational phase of the Proposed Development. These mitigation measures are the same as those outlined above in Section 9.5.3.1 consisting of interceptor drains, swales/road side drains, transverse drains, check dams and settlement ponds.

Due to the much-reduced risk of sediment entrainment in surface water runoff during the operational phase (limited site traffic, and only infrequent access track maintenance), maintenance of the drainage control measures as outlined above will be scaled back appropriately as the natural vegetation filters mature.

Residual Impact: Direct, negative, neutral, long term, likely impact. The residual impact will be the same for any selected turbine that is within the range of dimensions for which planning permission is sought.

Significance of Effects: No significant effects on surface water quality or quantity will occur during the operational phase of the Proposed Development.

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the Proposed Development will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works. A description of the decommissioning works is contained in Chapter 4 of this EIAR.

During decommissioning, it will be possible to reverse or at least reduce some of the potential effects caused during construction, and to a lesser extent operation, by rehabilitating constructed areas such as turbine bases and hard standing areas. This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation.

The Wind Farm Site roadways will be kept and maintained following decommissioning of the turbine infrastructure, as these will be utilised by ongoing forestry works and by local farmers.

The electrical cabling connecting the site infrastructure to the on-site substation will be removed, while the ducting itself will remain in-situ rather than excavating and removing it, as this is considered to have less of a potential environmental impact, in terms of soil exposure, and thus on the possibility of the generation of suspended sediment which could enter nearby watercourses.

The turbines will be removed by disassembling them in a reverse order to their erection. This will be completed using the same model cranes as used in their construction. They will then be transported off-site along their original delivery route. The disassembly and removal of the turbines will not have an impact on the hydrological/hydrogeological environment at the Wind Farm Site.

Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude than the construction phase because of the smaller scale of the works and reduced volumes on-site.

As noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is, therefore:

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

Some of the impacts will be avoided by leaving elements of the Proposed Development in place where appropriate. The substation extension will be retained by EirGrid as a permanent part of the national grid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant effects on the hydrological and hydrogeological environment are envisaged during the decommissioning stage of the Proposed Development.

9.5.5 Risk of Major Accidents and Disasters

None, as indicated above the risk of flooding at the Proposed Development is determined to be negligible/none.

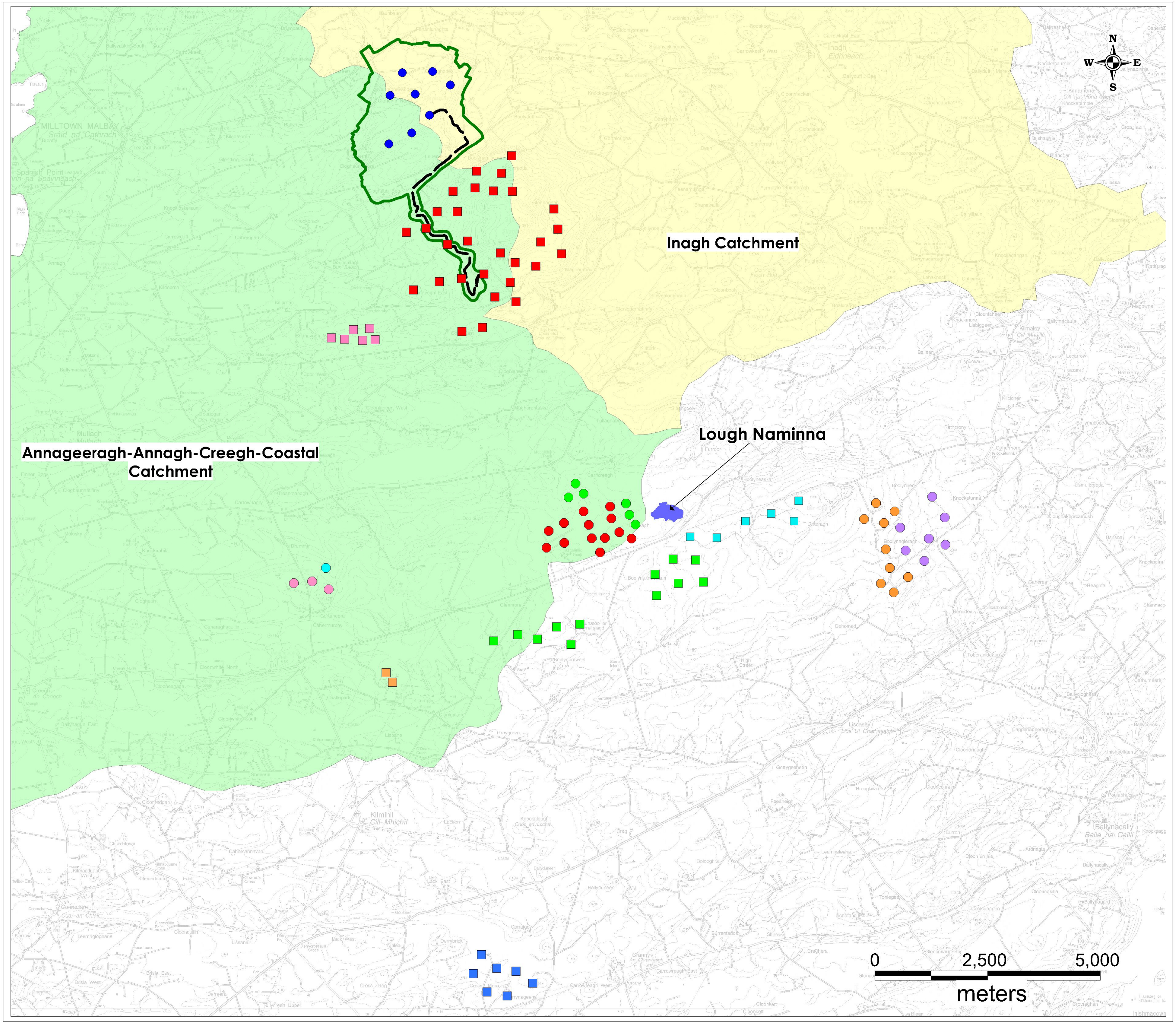
9.5.6 Cumulative Impacts

The majority of the proposed Development turbines (6 no. of 8 proposed turbines) are located in the Inagh River catchment (Inagh(Ennistymon)_SC_010) while the majority of the Underground Cable Route (5km of the total 6.45km) is located in the Annagh River catchment (Annagh(Clare)_SC_010). Therefore, the underground cable works (even in the absence of mitigation) are not expected to contribute to cumulative effects with respect to the Wind Farm Site.

A cumulative impact assessment was undertaken regarding other wind farm developments located within the Annagh River and Creegh River catchments. The developments assessed are listed in Table 9-12 below and are shown on Figure 9-7. There are no other types of developments (as listed in Chapter 2, Section 2.4) within the Annagh River or Inagh River catchments to contribute to significant cumulative hydrological impacts.

In terms of the potential impacts of developments on downstream surface water bodies, the biggest risk is during the construction phase of the Proposed Development as this is the phase when earthworks and excavations will be undertaken at the sites. However, within the Annagh River and the Inagh River catchments the vast majority of the other wind farm developments are operational therefore construction phase impacts with the Proposed Development cannot occur if the proposed development is permitted.

In terms of cumulative operational phase hydrological effects, the total number of turbines that could potentially be operating within the Inagh River catchment is 14 no. (which includes 6 no. from the Proposed Development). The total catchment area of the Inagh River catchment is ~140km^2 and therefore this equates to 1 turbine for approximately every ~10km^2 which would not be considered high density. Therefore, based on turbine density cumulative effects on catchment hydrology and water quality will not occur.



Legend

EIAR Site Boundary

Proposed Turbine Layout

Proposed Grid Route

Boolynagleragh WF (Under Construction)

Boolynagleragh Extension WF (Under Construction)

Cahermurphy WF (Operational)

Cahermurphy WF (Permitted)

Coor West WF (Appealed to ABP)

Crossmore WF (Permitted)

Glenmore WF (Operational)

Kiltumper WF (Operational)

Letteragh WF (Operational)

Slieve Callan WF (Operational)

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Client: MKO	
Job: Slieveacurry Renewable Energy Development	
Title: Cumulative Impact Assessment Map	
Figure No: 9-7	
Drawing No: P1159-4-1121-A3-907-00A	
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Scale: 1:80,000	Drawn By: GD
Date: 11/11/2021	Checked By: MG

In terms of cumulative operational phase hydrological effects, the total number of turbines that could potentially be operating within the Annagh River catchment is 25 no. (which includes 2 no. from the Proposed Development). The total catchment area of the Annagh River catchment is ~105km^2 and therefore this equates to 1 turbine for approximately every ~4.2km^2 which is considered to be low density and therefore, cumulative effects on the Annageeragh River catchment will not occur.

No hydrological cumulative effects with respect other wind farm developments is anticipated due to the fact that majority of the other wind farm turbines are constructed and also due to the low turbine density within the two regional catchments.

With regard non-wind farm related forestry activities and the potential for cumulative impacts, all scheduled tree felling or replanting will be planned around the Proposed Development construction phase in order to prevent hydrological cumulative impacts. No non wind farm related scheduled tree felling will occur in the site where wind farm construction is taking place.

The replanting lands are located in counties Longford, Mayo, Roscommon and in a different water catchment and therefore are not likely to contribute to potential cumulative impacts with the Proposed Development. The potential direct, indirect and cumulative impacts of replanting lands on water has been assessed in the Section 7 of Appendix 4-3 Assessment of Forestry Replacement Lands.

Table 9-13: List of Other Developments Assessed for Hydrological Cumulative Impacts

Regional Catchment	Wind Energy Developments	Total Turbine No.	Turbine No. in Catchment
Inagh River	Slievecallan Wind Farm (Operational)	29	8
Totals		**29**	**8**
Annagh River	Slievecallan Wind Farm (Operational)	29	21
	Coor West Wind Farm (Proposed)	4	2
Totals		**33**	**23**

9.5.7 Conclusion

During each phase of the Proposed Development (construction and operation / maintenance and decommissioning) 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 avoid impact on 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 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 will occur from the Proposed Development and other wind farm developments.