White Hill Wind Farm

Environmental Impact Assessment Report

Chapter 7: Water

White Hill Wind Limited

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Contents

7.1 Introduction

7.1.1 Background and Objectives

This chapter provides an assessment of the likely and significant effects of the proposed White Hill Wind Farm (along with its secondary and/or off-site elements which are described below) located c. 4km west of Oldleighlin (Co. Carlow) and c. 13km northeast of Kilkenny) on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are to:-

- Produce a baseline study of the existing water environment (surface and groundwater) in the area of the project;
- Identify likely positive and negative impacts of the project on surface and groundwater during the construction, operational and decommissioning phases of the development;
- Identify mitigation measures to avoid, remediate or reduce likely or significant negative effects; and,
- Assess likely or significant cumulative effects of the project as a result of other wind farms and other infrastructural developments.

7.1.2 Description of the Project

In summary, the project comprises the following main components as described in **Chapter 3**:-

- 7 no. wind turbines with an overall tip height of 185m, and all associated ancillary infrastructure;
- All associated and ancillary site development, excavation, construction, landscaping and reinstatement works, including the provision of site drainage infrastructure;
- Upgrades to the turbine component haul route; and,
- Construction of an electricity substation and installation of c. 15km of underground grid connection cable between the White Hill Wind Farm and the existing Kilkenny 110kV electricity substation.

The wind farm site traverses the administrative boundary between counties Carlow and Kilkenny; with 4 no. turbines located in Co. Carlow and 3 no. turbines within Co. Kilkenny. The electricity substation is located within Co. Carlow while the majority, c. 14km, of the underground electricity line is located in Co. Kilkenny. Off-site and secondary developments; including the forestry replant lands and candidate quarries which may supply construction materials; also form part of the project.

The turbine component haul route and associated upgrade works as described in **Chapter 3**. It is envisaged that the turbines will be transported from the Port of Waterford, through the counties of Kilkenny, Waterford, Carlow and Kildare to the project site. However, as the route follows motorway and national roads through counties Waterford and Kildare, it is assessed that there is no likelihood of effects on water and, therefore, these areas have been screened out from further assessment.

A full description of the project is presented in **Chapter 3**.

7.1.3 Statement of Authority

Hydro-Environmental Services (HES) are a specialist geological, 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, including wind farms and associated grid connections.

This chapter was prepared by Michael Gill and David Broderick.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael was involved in the EIS/EIAR for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 no. other wind farm related projects.

David Broderick (BSc, H.Dip Env Eng, MSc) is a hydrogeologist with over 13 years' experience in both the public and private sectors. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into Environmental Impact Assessment Reports/Environmental Impact Statements (EIAR/EIS) for a range of commercial developments. For example, David has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Meenbog WF, Arderroo WF and Yellow River WF, and over 80 other wind farm related projects across the country.

7.1.4 Relevant Legislation

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

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

- Planning and Development Act 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish Law;
- S.I. No. 94/1997: 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. 293/1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;

- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722/2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;
- S.I. No. 41/1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249/1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);
- S.I. No. 439/2000: Quality of Water intended for Human Consumption Regulations and S.I. No. 278/2007 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.106/2007: European Communities (Drinking Water) Regulations and S.I. No. 122/2014: European Union (Drinking Water) 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.

7.1.5 Relevant Guidance

This chapter has been prepared in accordance with guidance contained in the following:-

- *Guidance Document on Wind Energy Developments and EU Nature Legislation* (European Commission, 2020);
- *Guidance on the preparation of the EIA Report* (Directive 2011/92/EU as amended by 2014/52/EU);
- Environmental Protection Agency (2022) *Guidelines on the Information to be Contained in Environmental Impact Assessment Reports*;
- Institute of Geologists Ireland (2013) *Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements*;

- National Roads Authority (2005) *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*;
- DOE/NIEA (2015) *Wind Farms and Groundwater Impacts – A guide to EIA and Planning Considerations*;
- Department of the Environment, Heritage, and Local Government (2006) *Wind Energy Development Guidelines for Planning Authorities 2006*;
- Department of the Housing, Planning, and Local Government (2019) *Draft Revised Wind Energy Development Guidelines;*
- 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 Waters*;
- *Good Practice During Wind Farm Construction* (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006 *Guidance on 'Control of Water Pollution from Linear Construction Projects'* (CIRIA Report No. C648, 2006);
- CIRIA 2006 *Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors*. CIRIA C532. London, 2006.
- Department of Housing, Planning & Local Government (2018) *Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment*;
- *Carlow County Development Plan 2022-2028* (including *Strategic Flood Risk Assessment*); and,
- *Kilkenny City and County Development Plan 2021-2027* (including *Consolidated Strategic Flood Risk Assessment 2021-2027*).

7.2 Methodology

7.2.1 Desk Study

A desk study of the project site and receiving environment (described below) was completed in advance of undertaking the walkover survey, field mapping and site investigations. This involved collecting all relevant geological, hydrological, hydrogeological and meteorological information for the project and surrounding area. The desk study included consultation and review of the following data sources:-

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);

- Water Framework Directive/EPA Catchments Map Viewer (www.catchments.ie);
- Bedrock Bedrock Geology 1:100,000 Scale Map Series, Sheet 16 (Geology of Kildare - Wicklow);
- Geological Survey of Ireland (2004); Groundwater Body Initial Characterization Reports;
- OPW Past Flood Event Mapping (www.floodinfo.ie);
- CFRAM Flood Risk Assessment mapping (www.floodinfo.ie);
- Ordnance Survey Ireland (OSI) – 6 inch and 1;5000 scale basemaps; and,
- Aerial photography (www.bing.com/maps, www.geohive.ie, www.google.com/maps).

7.2.2 Site Investigations

Detailed drainage mapping, hydrological constraints mapping, and baseline monitoring was undertaken by HES on 31 August 2021, 7 October 2021 10 and 30 March 2022, and 26 May 2022.

A geotechnical assessment used to inform the assessment contained within this chapter was carried out by Fehily Timoney & Company (FT) and is enclosed at **Annex 6.1**. Separately, a Planning-Stage Spoil Management Plan has been prepared (see **Annex 3.4**) which details the treatment and management of material excavated during the construction phase of the project.

In summary, site investigations to address and inform the preparation of this water chapter include the following:-

- Walkover surveys and hydrological mapping of the project site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- A trial pit investigation to determine subsoil depth and lithology along with groundwater conditions (i.e. potential groundwater inflows). 9 no. trial pits in total were completed;
- 40 no. soil probe locations along with slope angle measurements were carried out by FT as part of the geotechnical assessment;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin and nature of surface water flows; and,
- Surface water sampling (2 no. rounds) was undertaken to determine the baseline water quality of the primary surface waters originating from the wind farm site and grid connection route.

7.2.3 Receptor Sensitivity / Importance / Impact Criteria

Using the National Roads Authority (NRA 2008) guidance, an estimation of the importance of the water environment within and downstream of the project area are quantified by applying the importance criteria set out in **Table 7.1** and **Table 7.2**; the impact magnitude is assessed using **Table 7.3** and **Table 7.4** and the impact rating using **Table 7.5**.

Importance	Criteria	Typical Example
Extremely High	• Attribute has a high quality or value on an international scale.	• River, wetland or surface water body ecosystem protected by EU legislation, e.g. 'European sites' designated under the Habitats

		Regulations or 'Salmonid Waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	• Attribute has a high quality or value on a regional or national scale.	• River, wetland or surface water body ecosystem protected by national legislation – NHA status. • Regionally important potable water source supplying >2500 homes. • Quality Class A (Biotic Index Q4). • Flood plain protecting more than 50 residential or commercial properties from flooding. • Nationally important amenity site for wide range of leisure activities.
High	• Attribute quality or value on a local scale.	• Salmon fishery Locally important potable water source supplying >1000 homes. • Quality Class B (Biotic Index Q3-4). • Flood plain protecting between 5 and 50 residential or commercial properties from flooding. • Locally important amenity site for wide range of leisure activities.
Medium	• Attribute has a medium quality or value on a local scale.	• Coarse fishery. • Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). • Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	• Attribute has a low quality or value on a local scale.	• Locally important amenity site for small range of leisure activities. • Local potable water source supplying <50 homes. • Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1residential or commercial property from flooding. • Amenity site used by small numbers of local people.

Table 7.1: Estimation of Importance of Hydrology Criteria (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	• Attribute has a high quality or value on an international scale.	• Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation, e.g. SAC or SPA status.
Very High	• Attribute has a high quality or value on a regional or	• Regionally Important Aquifer with multiple wellfields.

	national scale.	• Groundwater supports river, wetland or surface water body ecosystem protected by national legislation – NHA status. • Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source.
High	• Attribute quality or value on a local scale.	• Regionally Important Aquifer Groundwater • Provides large proportion of baseflow to local rivers. • Locally important potable water source supplying >1000 homes. • Outer source protection area for regionally. • important water source. • Inner source protection area for locally important water source.
Medium	• Attribute has a medium quality or value on a local scale.	• Locally Important Aquifer • Potable water source supplying >50 homes. • Outer source protection area for locally important water source.
Low	• Attribute has a low quality or value on a local scale.	• Poor Bedrock Aquifer Potable water source supplying <50 homes.

Table 7.2: Estimation of Importance of Hydrogeology Criteria (NRA, 2008)

Magnitude	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	• Loss or extensive change to a waterbody or water dependent. • Habitat Increase in predicted peak flood level >100mm. • Extensive loss of fishery Calculated risk of serious pollution incident >2% annually. • Extensive reduction in amenity value
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Increase in predicted peak flood level >50mm. • Partial loss of fishery. • Calculated risk of serious pollution incident >1% annually. • Partial reduction in amenity value.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Increase in predicted peak flood level >10mm. • Minor loss of fishery. • Calculated risk of serious pollution incident >0.5% annually. • Slight reduction in amenity value.

Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	• Negligible change in predicted peak flood level. • Calculated risk of serious pollution incident <0.5% annually.

Table 7.3: Magnitude of Hydrology Impact (NRA, 2008)

Magnitude	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	• Removal of large proportion of aquifer. • Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. • Potential high risk of pollution to groundwater from routine run-off. • Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Removal of moderate proportion of aquifer Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. • Potential medium risk of pollution to groundwater from routine run-off. • Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Removal of small proportion of aquifer Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems. • Potential low risk of pollution to groundwater from routine run-off. • Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	• Calculated risk of serious pollution incident <0.5% annually.

Table 7.4: Magnitude of Hydrogeology Impact (NRA, 2008)

	Magnitude of Impact			
Importance of Tribute	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant/ Moderate	Profound/ Significant	Profound

High	Imperceptible	Moderate/Slight	Significant/ Moderate	Profound/ Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

Table 7.5: Estimation of Impact Rating (NRA, 2008)

7.2.4 Consultation

The scope for this assessment has also been informed by consultation with statutory consultees and other bodies with environmental responsibility.

This consultation process is outlined in **Chapter 1** of this EIAR. Issues, concerns and recommendations highlighted by the responses in relation to the water environment are summarised in **Table 7.6** below. The full responses from each of the below consultees are provided in **Annex 1.8.**

Consultee	Summary of Consultee Response	Issue(s) Addressed in Section(s)
Geological Survey of Ireland	• Our records show that there are groundwater drinking water abstractions (Paulstown Public Water Supply (PWS) and Castlewarren Group Water Scheme (GWS)) with zones of contribution/source protection areas close to the proposed wind farm substation and grid connection route. Key to groundwater protection in general, and protection of specific drinking water supplies, is preventing ingress of runoff to the aquifer. Design of haul road drainage and substation construction will need to be cognisant of the public water schemes and the interactions between surface water and groundwater as well as run-off. Appropriate design should be undertaken by qualified and competent persons to include mitigation measures as necessary, such as SUDs or other drainage mitigation measures. • Given the nearby drinking water sources (Public Water Scheme and Group Water Scheme), the effects of any potential contamination as a result of the project would need to be assessed.	**Sections 7.3.15, 7.5.1.5, 7.5.1.10** & **7.5.2.13**.
Irish Water (IW)	• Any potential impact on the contributing catchment of water sources either in terms of water abstraction for the development (and resultant potential impact on the capacity of the source) or the potential of the development to influence/ present a risk to the quality of the water abstracted by IW for public supply.	**Sections 7.3.15, 7.5.1.5, 7.5.1.10** & **7.5.2.13**.
Carlow County Council	• A detailed survey of all existing and proposed on-site drainage should be provided, clearly identifying where all the on-site drains will discharge to and how drainage will be maintained.	**Sections 7.3.4, 7.3.5, 7.3.16, 7.3.17** & **7.5.1.2**.

	• Must clearly identify all European Sites potentially impacted by the proposed development and identify mitigation measures that will reduce any impacts.	**Sections 7.3.14** & **7.5.1.9**.
Kilkenny County Council	• Assess full network of watercourses which are affected by the proposed works – regional and local hydrology. • Detail methodology of installing infrastructure such as roads, hardstands, foundations, substation, cabling and other in proximity or crossing watercourses. • Grid connection route location, geology assessment relating to bedrock, karst, important aquifer. • Directional drilling or other crossing of watercourses proposals should be detailed.	**Sections 7.3.3**, **7.3.4**, **7.3.5** & **7.5.1.8**.
National Federation of Group Water Schemes	• NFGWS confirm that the drinking water catchment for Castlewarren Group Water Scheme, is in close proximity to the project. This Group Water Scheme supplies water to approximately 180 houses and 50 farms in the local area. • NFGWS request that the location of all Castlewarren Group Water Scheme assets into consideration whilst preparing the Environmental Impact Assessment Report.	**Sections 7.3.15** & **7.5.1.10**.

Table 7.6: Summary of Scoping Responses

7.3 Description of the Existing Environment

7.3.1 Site Location and Description

The wind farm site, which is located within an area of approximately 290ha, is located in west County Carlow and east County Kilkenny. The site is c. 4km west of Oldleighlin, c. 14km southwest of Carlow and c. 13km northeast of Kilkenny.

The wind farm site is located on an elevated plateau, known as the Castlecomer Plateau, which is located in south county Laois, northwest county Carlow and northeast county Kilkenny. The Castlecomer Plateau is characterised by undulating hills and steep escarpments at its fringes. Dissecting the lowlands on either side of the plateau are the rivers Barrow and Nore, which lie to the east and west respectively.

Current land use within the wind farm site is predominately commercial forestry and agricultural pastures, with small pockets of transitional woodland scrub within the wider landscape. Agricultural pastures are more dominant on the more elevated eastern and north-eastern section of the wind farm site.

The topography of the wind farm site is 'hilly-to-undulating' with the overall site elevation ranging between approximately 220m and 290m OD (Ordnance Datum). The higher elevations occur in the central and eastern areas of the site with the land sloping generally towards the north and west in the direction of the Coolcullen River which flows in a generally northerly direction through the wind farm site. The elevation of the electricity substation and ESS, located in the south of the wind farm site, is at approximately 280m OD.

The grid connection route runs in a southerly direction for approximately 15km between the electricity substation to the existing 110kV substation at Scart, Co. Kilkenny. The grid connection comprises underground cable to be located predominately within the carriageway of the public road network, with short sections at the respective substations being located within private lands. The ground elevation along the grid connection decreases to c. 65m OD at the substation near Kilkenny.

The haul route works are predominately located within motorway, national and regional roads. The majority of the works comprise the temporary removal of street furniture to accommodate the delivery of turbine components; along with the temporary removal of pier caps and lowering of an adjacent wall at 'Crettyard Bridge' (located approximately 10km north of the wind farm site), a temporary access track at the junction of the N78 and L1834 junction (also located approximately 10km north of the wind farm site), and carriageway strengthening works at a bridge ('Black Bridge') along the L1835 (located approximately 3km north of the wind farm site).

The forestry re-plant lands in County Monaghan are almost exclusively agricultural pasture, with fields bounded by hedgerows and treelines. Ground elevations across the re-plant lands range generally between 110m OD and 140m OD.

7.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (AAR; 1981-2010) recorded at Coon, approximately 3km northwest of the project site, are presented in **Table 7.7** below.

Coon												
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
99.2	75.2	84.4	75.8	74.1	78.3	73	89.2	82.2	113.8	107.8	103.2	1056.2

Table 7.7: Local Average Long-Term Rainfall Data (mm)

The closest synoptic[1] weather station where the average potential evapotranspiration (PE) is recorded is at Kilkenny, approximately 13km southwest of the wind farm site. The long-term average PE for this station is 448mm/yr. This value is used as a best estimate of the project site's PE. Actual Evaporation (AE) at the site is estimated as 425mm/year (calculated as 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

= 1056mm/year – 425mm/year

ER = 631mm/year

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 25% recharge is taken for the project site. This value is for "Till overlain by poorly

[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.

drained (gley) soil" (i.e. tills as described at **Chapter 6**). The relatively high drainage density in the area, found to be present during the site drainage surveys (refer to **Section 7.3.4** below), also suggest that surface drainage is the dominant flow regime at the site.

The recharge coefficient of 25% was used to calculate values for key hydrological properties. Therefore, annual recharge (25%) and runoff rates (75%) for the project site are estimated to be c. 158mm/year and c. 473mm/year respectively.

Table 7.8 presents return period rainfall depths for the project site. This data is taken from https://www.met.ie/climate/services/rainfall-return-periods and provides rainfall depths for various storm durations and sample return periods (10-year, 50-year, 100-year). These extreme rainfall depths have been incorporated into the proposed wind farm drainage design.

Duration	10-year Return Period (mm)	50-Year Return Period (mm)	100-Year Return Period (mm)
15 min	13	21	25.6
1 hour	21	32.6	39.1
6 hour	38.7	57.4	67.6
12 hour	49	71.5	83.6
24 hour	62.2	89.1	103.4

Table 7.8: Return Period Rainfall Depths for Project Site

7.3.3 Local and Regional Hydrology

On a regional scale, the wind farm site is located predominantly (c. 97%) in the River Nore surface water catchment within Hydrometric Area 15. The southernmost section of the wind farm site (c. 3%), which includes only the location of the proposed electricity substation, is situated within the regional River Barrow surface water catchment within Hydrometric Area 14.

On a more local scale, the majority (c. 97%) of the wind farm site (including all of the proposed turbine locations) is located in the Dinin River sub-catchment (Dinin [South]_SC_010). The Dinin River drains into the River Nore approximately 25km downstream of the wind farm site.

The southernmost section (c. 3%) of the wind farm site within the regional River Barrow catchment drains locally to the Monefelim River within the Barrow_SC_120 sub-catchment. The Monefelim River drains into the River Barrow approximately 15km downstream of the wind farm site.

The majority of the grid connection route (c. 13km of the total c. 15km) is located in the River Nore surface water catchment within the Dinin [South]_SC_010 and Nore_SC_100 sub-catchment. The remaining c. 2km is located in the regional River Barrow surface water catchment within the Monefelim River sub-catchment (Barrow_SC_120).

The proposed haul route works at the junction of the N78 and L1834, Crettyard Bridge and Black Bridge are located in the Dinin [North]_SC_010.

The replanting lands are located in the Fane_SC_010 sub-catchment.

A local hydrology map is shown below as **Figure 7.1.**

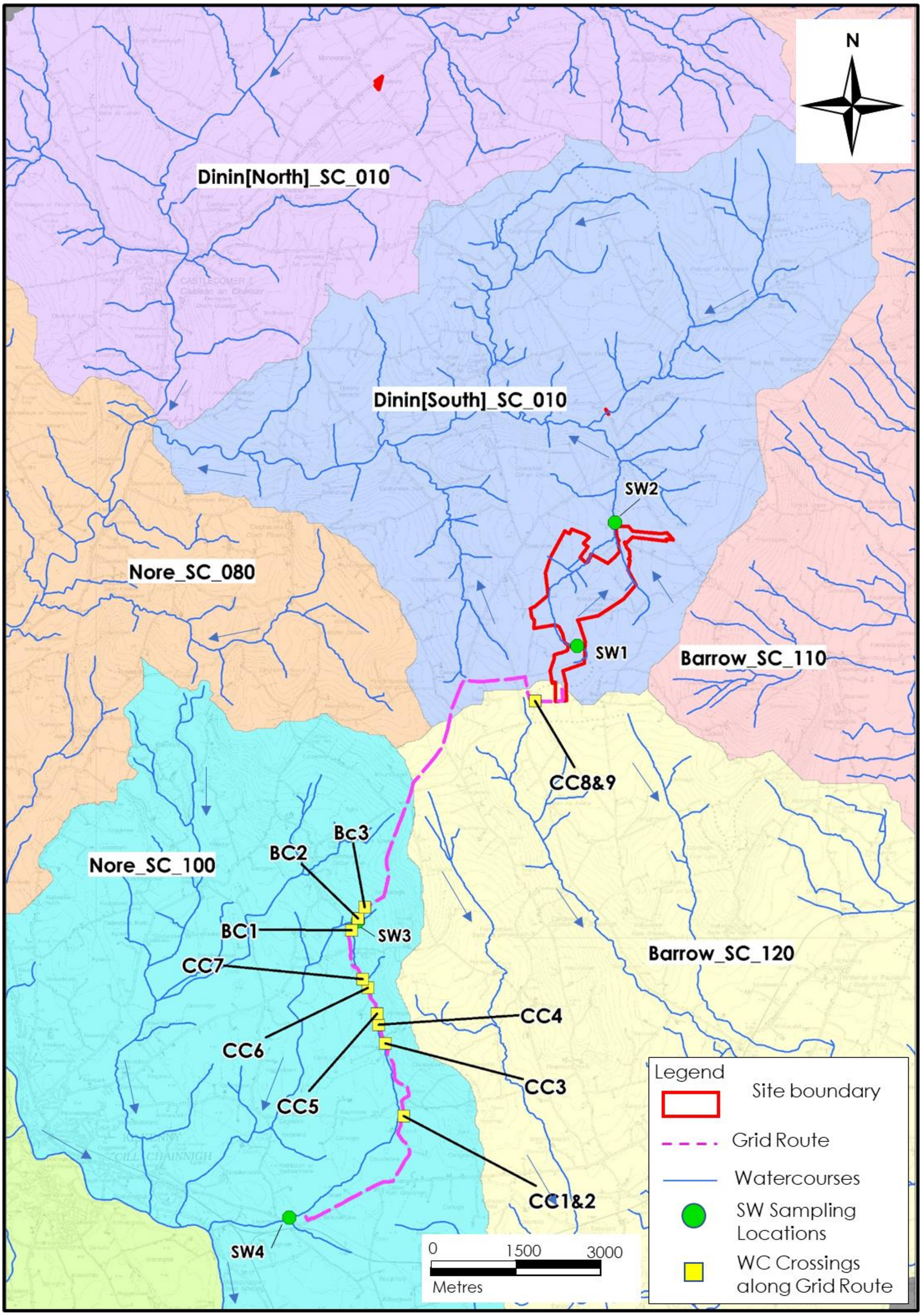


Figure 7.1: Local Hydrology Mapping

7.3.4 Existing Wind Farm Drainage Features

The primary drainage feature within the wind farm site is the Coolcullen River (also known as the Knocknabranagh & Knockbaun stream) which rises at the south of the wind farm site and flows in a general northerly direction along the western site boundary before flowing through the northern section of the site and exiting at the northern boundary. The course of the Coolcullen River in the environs of the wind farm is mainly through forestry.

The second dominant drainage feature within the wind farm site is a tributary (referred to here as the Coolcullen Stream) of the Coolcullen River which emerges to the east of the wind farm site and then flows northerly through the north-eastern portion of the wind far, which is mainly grassland, prior to joining with the Coolcullen River just outside the northern site boundary.

6 no. watercourse crossings will be required within the wind farm site. The watercourses proposed for crossing are either 1st or 2nd order streams. All proposed watercourses crossings within the wind farm site are new open channel crossings.

In addition to the primary water features described above, there is also a network of drains associated with the agricultural land and the forestry. Many of the lower lying agricultural areas have field boundary drains.

Within the forested areas, there are also numerous manmade drains that are in place to drain the forestry plantations. The current internal forestry drainage pattern is influenced by the topography, subsoils, layout of the forest plantation, and by the existing forest road network. The forest plantations (180ha), which cover ~62% of the wind farm site (where deforestation has occurred forests drains remain), are generally drained by a network of mound drains which typically run perpendicular to the topographic contours of the plantation and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation. The forestry areas within the proposed development site drain mainly to the Coolcullen River.

Mound drains and ploughed ribbon drains are generally spaced approximately every 15m and 2m respectively. As illustrated at **Figure 7.2** below, interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of forestry access roads and watercourses. Culverts are generally located at stream crossings and at low points under forestry access roads which drain runoff onto down-gradient forest plantations.

A schematic of a typical standard forestry drainage network is illustrated at **Figure 7.2.** This schematic is representative of the drainage network if the forestry plantations at the wind farm site and that which will be implemented at the proposed forestry re-plant lands.

The forestry drains are the primary drainage routes towards the Coolcullen River on the proposed development site, but the flows in the higher elevated drains are generally very low or absent most of the time. The integration of the existing main drains with the proposed wind farm drainage is a key component of the drainage design, and is discussed further at **Section 7.3.16** and **Section 7.5.1.2** below.

The existing drainage regime at the wind farm site is illustrated at **Figure 7.3**.

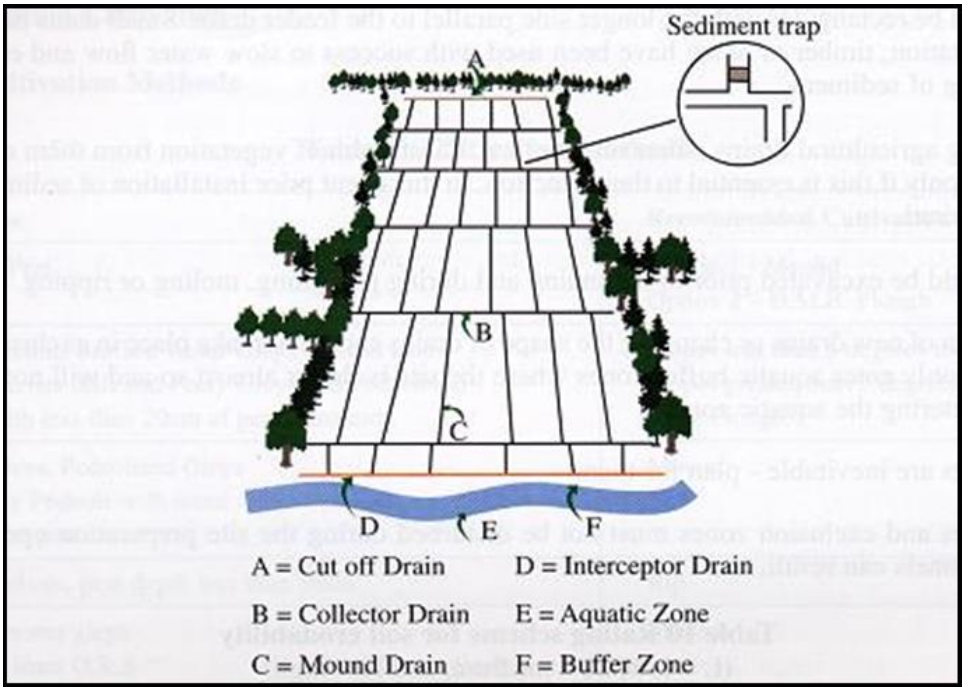


Figure 7.2: Schematic of Existing Forestry Drainage

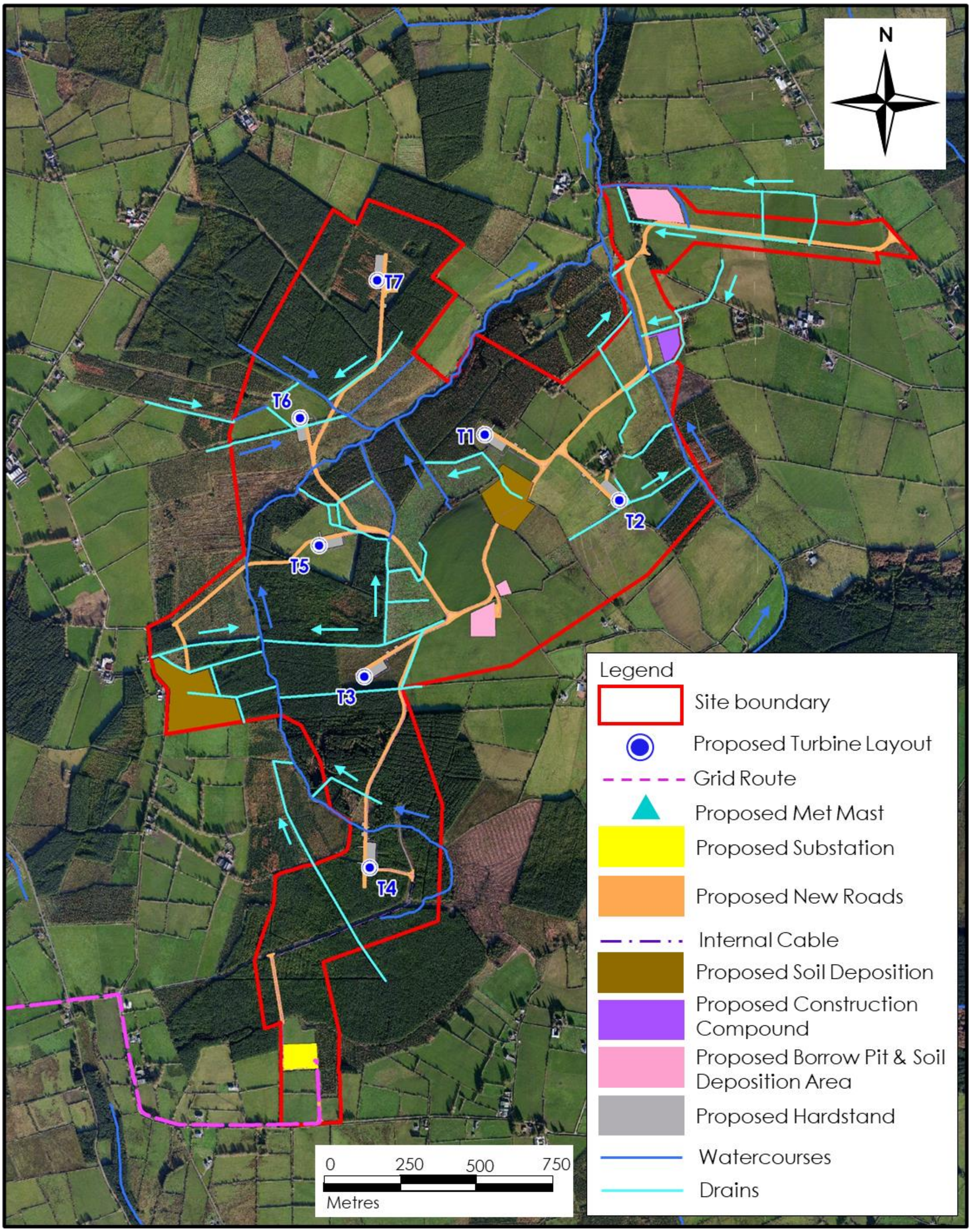


Figure 7.3: Wind Farm Site Drainage Map

7.3.5 Grid Connection Drainage

Along the grid connection route, there will be a requirement for 10 no. watercourse crossings; which comprise 3 no. bridge crossings and 7 no. culvert crossings.

All watercourses crossed are 1st or 2nd order headwater streams. The 3 no. bridge crossed watercourses and 1 no. of the culvert crossings are mapped by the EPA (www.epa.ie).

Watercourse crossings along the grid connection route are illustrated at **Figure 7.1**.

7.3.6 Changes to Surface Water Runoff

The following water balance assessment gives a preliminary indication of the highest monthly average volume of surface water runoff expected. The calculations are carried out for the month with the highest average recorded rainfall versus evapotranspiration, for the current baseline site conditions, in terms of subsoil type and thickness (**Table 7.9**). It represents, therefore, the average wettest monthly scenario in terms of volumes of surface water runoff from the study area pre-development.

The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the project. As outlined in **Section 7.5.1.2** below, a '1-in-100 year return' period has been used for design purposes.

The surface water runoff co-efficient for the wind farm site is estimated to be 75%, based on the poorly draining soil and moderate permeability subsoil coverage at the site. The highest long-term average monthly rainfall recorded at Coon over the period 1981 – 2010 occurred in October, at 113.8mm.

The average monthly evapotranspiration for the synoptic station at Kilkenny over the same period in October was 16.2mm. The calculation is carried out for the entire development landholding are (c. 516ha). The balance indicates that a conservative estimate of surface water runoff for the site during the highest rainfall month is 379,260m^3/month, which equates to an average of 12,234m^3/day, as outlined in **Table 7.10.**

Water Balance Component	Depth (m)
Average October Rainfall (R)	0.1138
Average October Potential Evapotranspiration (PE)	0.0162
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.0154
Effective Rainfall October (ER = R - AE)	0.098
Recharge (25% of ER)	0.0245
Runoff (75% of ER)	0.0735

Table 7.9: Water Balance and Baseline Runoff Estimates for Wettest Month (October)

Landholding Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
516	379,260	12,234

Table 7.10: Baseline Runoff for the Landholding

7.3.7 Flood Risk Identification

OPW's River Flood Extents Mapping, National Indicative Fluvial Mapping, Past Flood Event mapping (https://www.floodinfo.ie/map/floodmaps/) and historical mapping (i.e. 6" & 25" base maps) were consulted to identify those areas of the project which are at risk of fluvial flooding.

No recurring flood incidents within the project site boundary, along the grid connection, haul route work areas, or forestry re-plant lands were identified from OPW's Past Flood Event Mapping (refer to **Figure 7.4**).

The closest mapped recurring flooding event to the wind farm site is at Lackan townland approximately 2.5km to the southeast of the wind farm where OPW flood reports refer to the occurrence of localised road flooding. This mapped flood event is not downstream of the wind farm. There are no mapped recurring flooding events downstream of the wind farm.

Identifiable map text on local available historical 6" or 25" mapping for the project site area do not identify any lands that are "liable to flood".

There is no OPW River Flood Extents Mapping available for the project site and therefore the National Indicative Fluvial Mapping (**Figure 7.5**) was consulted which has estimated fluvial flood zones for the Coolcullen River.

Based on the National Indicative Fluvial Mapping (NIFM), the 100-year and 1000-year flood zone of the Coolcullen River does not encroach the project site. There are fluvial flood zones associated with the Coolcullen River immediately downstream of the northern wind farm site boundary.

No flood zones are mapped along the grid connection, haul route works areas, or forestry re-plant lands.

All project infrastructure is located above the mapped 1000-year flood level and therefore all infrastructure is located in Flood Zone C (Low Risk).

It is a key design feature of the project to ensure that 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, as a result of the project, is prevented and controlled is through avoidance by design.

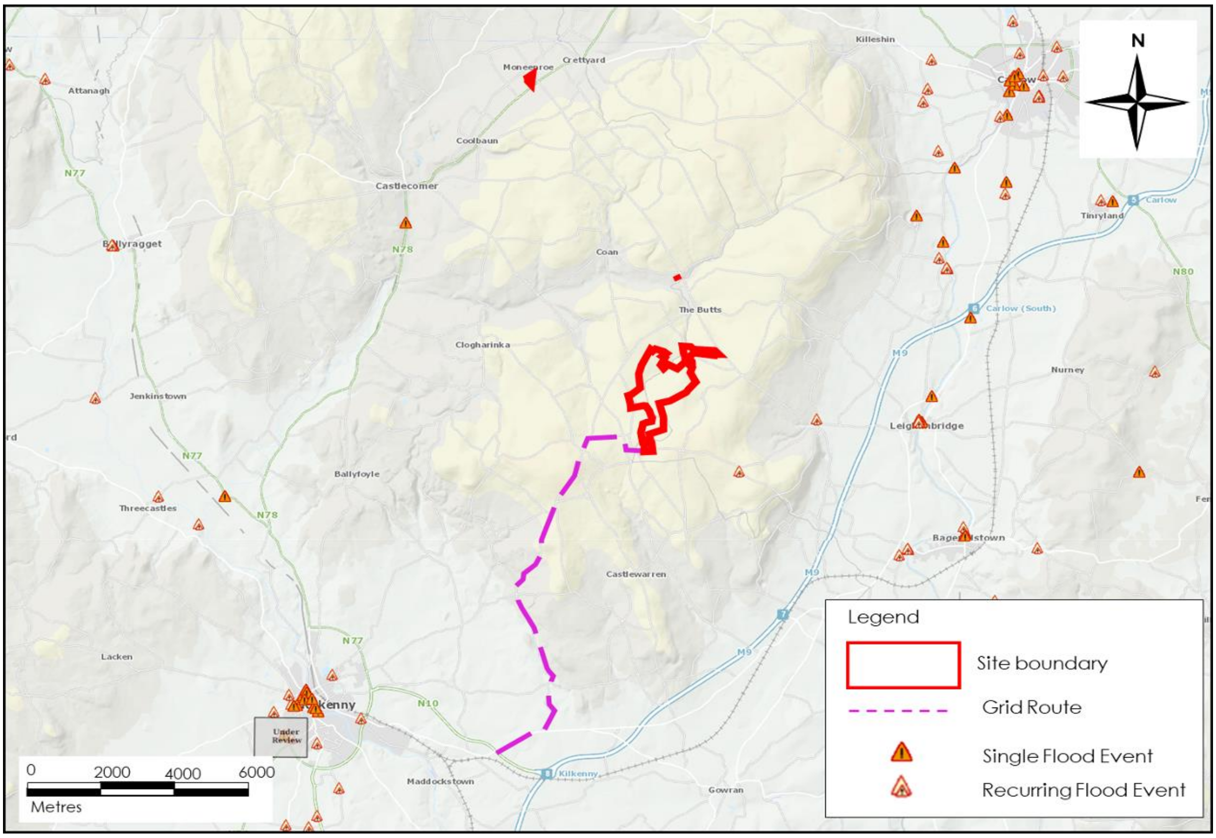


Figure 7.4: OPW Flood Hazard Mapping

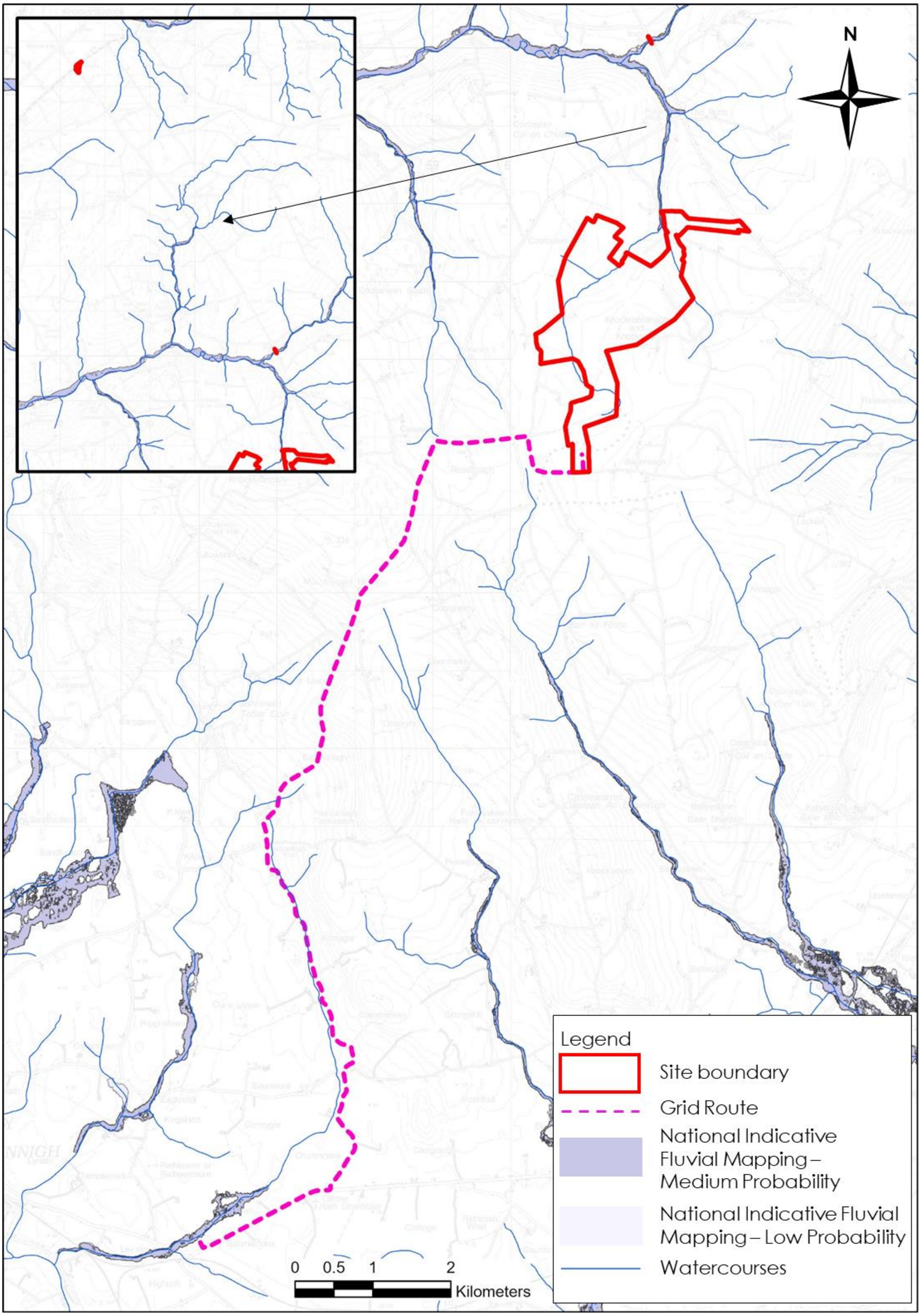


Figure 7.5: National Indicative Fluvial Mapping

7.3.8 Surface Water Quality/Hydrochemistry

Biological Q-rating[2] data for EPA monitoring points on nearby river water bodies are listed at **Table 7.11** below. Most recent data available (2017-2019) shows that the Q-rating ranges from ‘Good’ to ‘High’ in the vicinity of the wind farm site and grid connection route.

Approximately 8km downstream of the wind farm site at Dysart Bridge, the Dinin River achieves a Q-rating of 4, i.e. ‘Good Status’. Similarly, the Monefelim River achieves a Q-rating of 4, less than 4km south of the wind farm site. Other rivers downstream of the grid connection route, including the Gowran and the Nore achieved Q-rating of 4-5 and 4 respectively.

Q-rating values for the Dinin River (Dinin_north_020) downstream of the haul route works near the N78 indicate Moderate Status (Q-rating 3-4).

Station Name	River Waterbody	Year	Q-Value Score	Status
Dysart Br.	Dinin_south_020	2019	Q4	Good
Castlewarren Br.	Monefelim_010	2017	Q4	Good
Br SW of Garryduff Crossroads	Monefelim_020	2017	Q4	Good
Br E of Freneystown	Gowran_010	2017	Q4-5	High
NE of Warrington d/s Kilkenny	Nore_180	2019	Q4	Good
Massford Bridge	Dinin_north_020	2019	Q3-4	Moderate

Table 7.11: EPA Q-Rating

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units), temperature (˚C) and dissolved oxygen (DO-%) were taken at surface water sampling location (SW1–SW4) downstream of the project on 7th October 2021 and again on 26th May 2022 and the results are listed in **Table 7.12** below. Refer to **Figure 7.2** for sample locations.

Electrical conductivity (EC) values for surface waters at the proposed development area ranged between 106 and 145µS/cm which would be typical for the local mapped geology (*i.e.* siltstone/sandstone).

It is considered that measurement in higher-flow conditions (during winter) is likely to result in an overall lower electrical conductivity range due to higher volumes of surface water runoff within streams.

The pH values, which ranged between 7.7 and 7.9, were generally near neutral, would be typical of catchments with mineral soil coverage. The dissolved oxygen concentrations are within the normal range for a ‘Good’ to ‘High’ status watercourses.

Surface water samples (2 no. rounds) were also taken at the 4 no. sampling locations for laboratory analysis. Results of the laboratory analysis are shown alongside relevant water quality regulations (EQS) in **Table 7.13** (Round No. 1) and **Table 7.14** (Round No. 2) below. Original laboratory reports are attached as **Annex 7.1**.

[2] The Q-Rating scheme method is used whereby a Quality-index is assigned to a river or stream based on macroinvertebrate data.

Location	EC (µS/cm)		pH		Dissolved Oxygen (%)	
	07/10/21	26/05/22	07/10/21	26/05/22	07/10/21	26/05/22
SW1	125	115	7.9	7.9	95	98
SW2	115	106	7.9	7.7	99	94
SW3	145	130	7.7	7.8	97	98
SW4	138	135	7.8	7.7	95	93

Table 7.12: Summary of Surface Water Chemistry Measurements

Parameter	EQS	Sample ID			
		SW1	SW2	SW3	SW4
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	<0.02	0.03	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	10.8	<5	5.7	<5
Nitrogen (mg/L)	-	2.5	0.03	1.5	1.3
Phosphorus (mg/L)	-	<0.1	<0.1	0.1	<0.1
Chloride (mg/L)	-	12.9	11.3	11.5	11.9
BOD	≤ 1.3 to ≤ 1.5(*)	<2	<2	<2	<2

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

Table 7.13: Analytical Results of Surface Water Sampling (Round No. 1, 07/10/2021)

Parameter	EQS	Sample ID			
		SW1	SW2	SW3	SW4
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.05	0.03	0.02	0.02
Nitrite NO_2 (mg/L)	-	<0.01	<0.01	<0.01	<0.01

Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	0.02	0.02
Nitrate - NO_3 (mg/L)	-	<0.01	<1	<1	<1
Nitrogen (mg/L)	-	<1	<1	<1	<1
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1	<0.1
BOD	≤ 1.3 to ≤ 1.5(*)	1	<1	1	1

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

Table 7.14: Analytical Results of Surface Water Sampling (Round No. 2, 26/05/2022)

Total suspended solids were <5mg/L in all samples during both sampling rounds which is below the S.I. No. 293/1988 Maximum Acceptable Concentration (MAC) of 25mg/L.

Nitrite, ortho-phosphate and BOD values were at or below the laboratory detection limits.

Phosphorus and nitrogen levels were generally low in all samples. Levels of chloride are typical of surface waters in an inland setting.

Ammonia ranged between <0.02 to 0.05mg/L, and in comparison to the Environmental Objectives Surface Water Regulations (S.I. 272/2009), all results for ammonia were below the 'High Status' threshold except SW1 Round No. 2 sampling which was below the 'Good Status' threshold. All results for BOD were also below the 'High Status' threshold.

7.3.9 Hydrogeology

The Westphalian Shales and Westphalian Sandstones, which underlie the wind farm site and the northern section of the grid connection route, are classified by the GSI (www.gsi.ie) as a Poor Aquifer (bedrock which is generally unproductive- Pu) and a Locally Important Aquifer (bedrock which is generally moderately productive-Lm). The haul route works at the junction of the N78 and L1834, at Crettyard Bridge and Black Bridge are mapped to be underlain by Westphalian Shales. The mapped bedrock type (Silurian Metasediments and Volcanics) at the replanting lands are classified as a Poor Aquifer (Bedrock which is Generally Unproductive except for Local Zones).

The Westphalian rocks and Silurian Metasediments and Volcanics generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 15m.

Groundwater levels in this bedrock type elsewhere have been measured mainly 0-5m below ground level. Groundwater flowpaths are likely to be short (30m-300m), with groundwater discharging to nearby streams and small springs. Water strikes deeper than the estimated interconnected fissure zone suggests a component of deeper groundwater flow, however shallow groundwater flow is thought to be dominant. Groundwater flow directions are expected to follow topography and therefore groundwater directions within the site are expected to be towards the primary streams within the valleys of the site (GSI, 2004).

Baseflow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain significant summer baseflows due to low storativity within the aquifer. Local groundwater flow directions will mimic topography, whereby flowpaths will be from topographic high points to lower elevation points at streams and rivers.

Namurian Sandstones and Shales which underlie the central section of the grid connection route are classified as a Poor Aquifer – bedrock which is Generally Unproductive except for Local Zones (PI). Further south the Dinantian Upper Impure Limestones and Dinantian Pure Bedded Limestones are classified as Regionally Important Aquifer – Karstified (diffuse) (Rkd) and Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones (LI).

In terms of local Groundwater Bodies (GWBs), the wind farm site and the northern section of the grid connection route are located in the Castlecomer GWB (IE_SE_G_034). Sections of the grid connection route, further south, are mapped in the Shanragh GWB (IE_SE_G_124), the Ballingarry GWB (IE_SE_G_009) and the Kilkenny GWB (IE_SE_G_078) before terminating with in the Clifden GWB (IE_SE_G_038). The haul route works at the junction of the N78 and L1834, at Crettyard Bridge and Black Bridge are also located in the Newtown GWB (IE_SE_G_104).

The replanting lands are located in the Louth GWB (IEGBNI_NB_G_019).

During the trial pit investigation of the windfarm site, no significant groundwater inflows or seepages were noted at the depths achieved by the trial pits (0.5–3.3m below ground level).

Based on criteria shown in the **Table 7.1** above, the Poor bedrock aquifers and Locally Important aquifers have a Low to Medium Importance. The Regionally Important aquifer at the southern end of the grid connection route has a High Importance.

A local bedrock aquifer map is shown as **Figure 7.6** below.

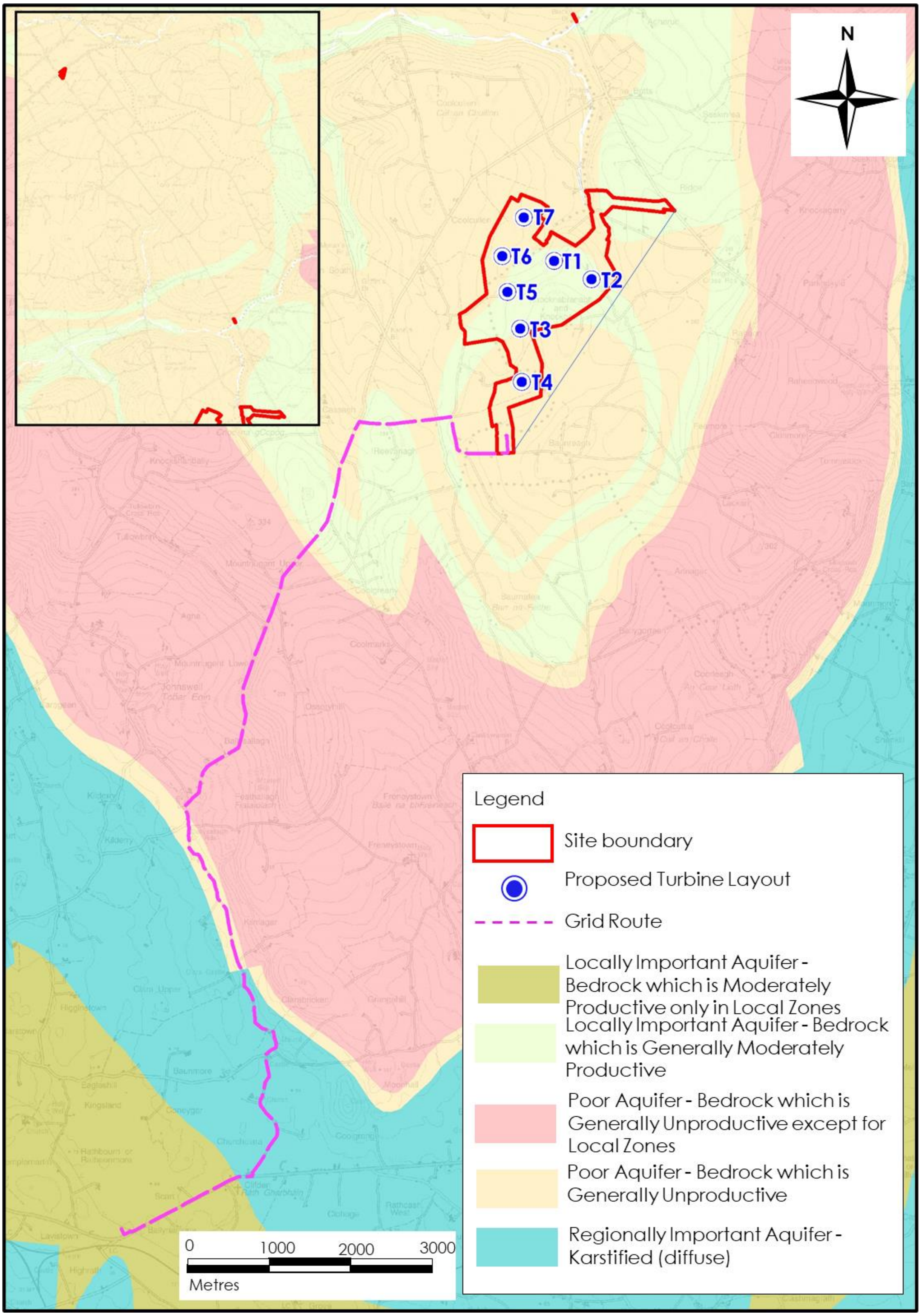


Figure 7.6: Bedrock Aquifer Mapping

7.3.10 Groundwater Vulnerability

The mapped groundwater vulnerability rating of the aquifer beneath the project ranges from Low to Extreme (X).

At the wind farm site, the eastern, more elevated portion of the site, is mapped as Extreme (X) which suggests bedrock at or close to the surface (<3m of overburden). This is consistent with the depth to bedrock encountered during the trial pitting.

The western portion of the site, which is slightly lower lying, is mapped as having Moderate to High groundwater vulnerability rating which is also consistent with the findings of the trial pits (>3m of overburden). The haul route works at the junction of the N78 and L1834, at Crettyard Bridge and Black Bridge are mapped as Moderate vulnerability.

The vulnerability rating along the proposed grid connection route is mainly Extreme at the northern and central sections of the route, and Low to Moderate at the lowering lying southern end of the route.

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

7.3.11 Groundwater Hydrochemistry

Based on data from the GSI publication on the Castlecomer GWB, alkalinity is expected to be in the range of 10 to 470 mg/l $CaCO_3$. The groundwaters are typically calcium-magnesium-bicarbonate type waters with conductivities ranging from 80 to 470µS/cm.

Waters close to recharge-outcrop area have a calcium-bicarbonate signature. Waters in the deeper, confined parts of the aquifer have a sodium bicarbonate signature, a result of ion exchange, reflecting long residence times. Waters are 'moderately soft' to 'moderately hard'; while concentrations of iron and manganese are also naturally high.

The groundwater type in the Newtown GWB and Louth GWB have a non-calcareous signature where the water are 'soft' to 'moderately soft'.

7.3.12 Groundwater Body Status

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

The wind farm site and the northern section of the grid connection route are located in the Castlecomer GWB (IE_SE_G_034). Sections of the grid connection further south are mapped in the Shanragh GWB (IE_SE_G_124), the Ballingarry GWB (IE_SE_G_009) and the Kilkenny GWB (IE_SE_G_078) before terminating with in the Clifden GWB (IE_SE_G_038).

The haul route works and replanting lands are located in the Newtown GWB and Louth GWB respectively.

All GWBs in the area of the project as assigned 'Good Status', which is defined based on the quantitative status and chemistry.

7.3.13 Surface Water Body Status

This section is a summary of the WFD Assessment undertaken for the Proposed Project site. The full WFD Assessment report is attached **Annex 7.3.**

River Water Body status information is also available from www.catchments.ie. River Water Body status information is available for the Dinin River and Monefelim River in the area of the wind farm site and haul route works. Both Water Bodies have been assigned an overall 'Good Status'.

The grid connection route passes through the Gowran_010 and Nore_190 river waterbodies which have been assigned a Moderate Status. The Fane_020 river water body, to which the replanting lands drains, has a Moderate Status.

Refer to **Table 7.15** below for additional information such Risk Result and Pressure Category.

Taking the view that all watercourses are required to have at least 'Good Status' in terms of the Water Framework Directive and by applying the criteria in **Table 7.1** above, local and downstream watercourses have a High to Very High Importance.

European Code	River Waterbodies	Ecological Status	Overall Status	Risk Result	Pressure Category
IE_SE_15D080600	Dinin (South)_010	Good	Good	Not at Risk	n/a
IE_SE_15D070200	Dinin (North)_010	Good	Good	Not at Risk	n/a
IE_SE_14M030100	Monefelim_010	Good	Good	Not at Risk	n/a
IE_SE_14G030100	Gowran_010	Moderate	Moderate	At Risk	Agriculture
IE_SE_15N012090	Nore_190	Moderate	Moderate	Review	Urban Runoff
UKGBNI1NB060608253	Fane_020	Moderate	Moderate	At Risk	n/a

Table 7.15: WFD Status and Risk Result

7.3.14 Designated Sites & Habitats

Within Ireland, designated sites include Natural Heritage Areas (NHAs), proposed Natural Heritage Areas (pNHAs), candidate Special Areas of Conservation (cSAC), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs).

Local designated sites in the area and downstream of the proposed development site, grid connection and haul route works are shown on **Figure 7.7** below. The project is not located within any designated conservation site.

The project is hydrologically connected to the River Barrow and River Nore SAC (Site Code: 002162). At its closest point, this designated site is located approximately 1.5km to the north (as crow flies) of the wind farm site and is downstream (hydrologically connected) via the Coolcullen River.

The project site is located in the catchment of the specified Freshwater Pearl Mussel (FPM) populations which is the qualifying interest of the River Barrow and River Nore Special Area of Conservation (SAC).

In addition, all of the surface waterbodies draining the grid connection route drain into the River Barrow and River Nore SAC and the River Nore SPA (Site Code: 004233). Given the features of interest of the River Barrow and River Nore SAC, it is considered to be Very Sensitive to the effects of water quality deterioration; while a deterioration in water quality could also affect the Kingfisher which is present in the River Nore SPA.

There are a number of NHA and pNHA designated sites locally (i.e. Coan Bogs NHA, Whitehall Quarries pNHA, Dunmore Complex pNHA, Newpark Marsh pNHA, etc.) but there is no hydrological connectivity to these designated sites due to the setback distance and presence of intermediate rivers acting as hydraulic boundaries.

Local designated sites in the area, and downstream, of the proposed development are shown at **Figure 7.7** below.

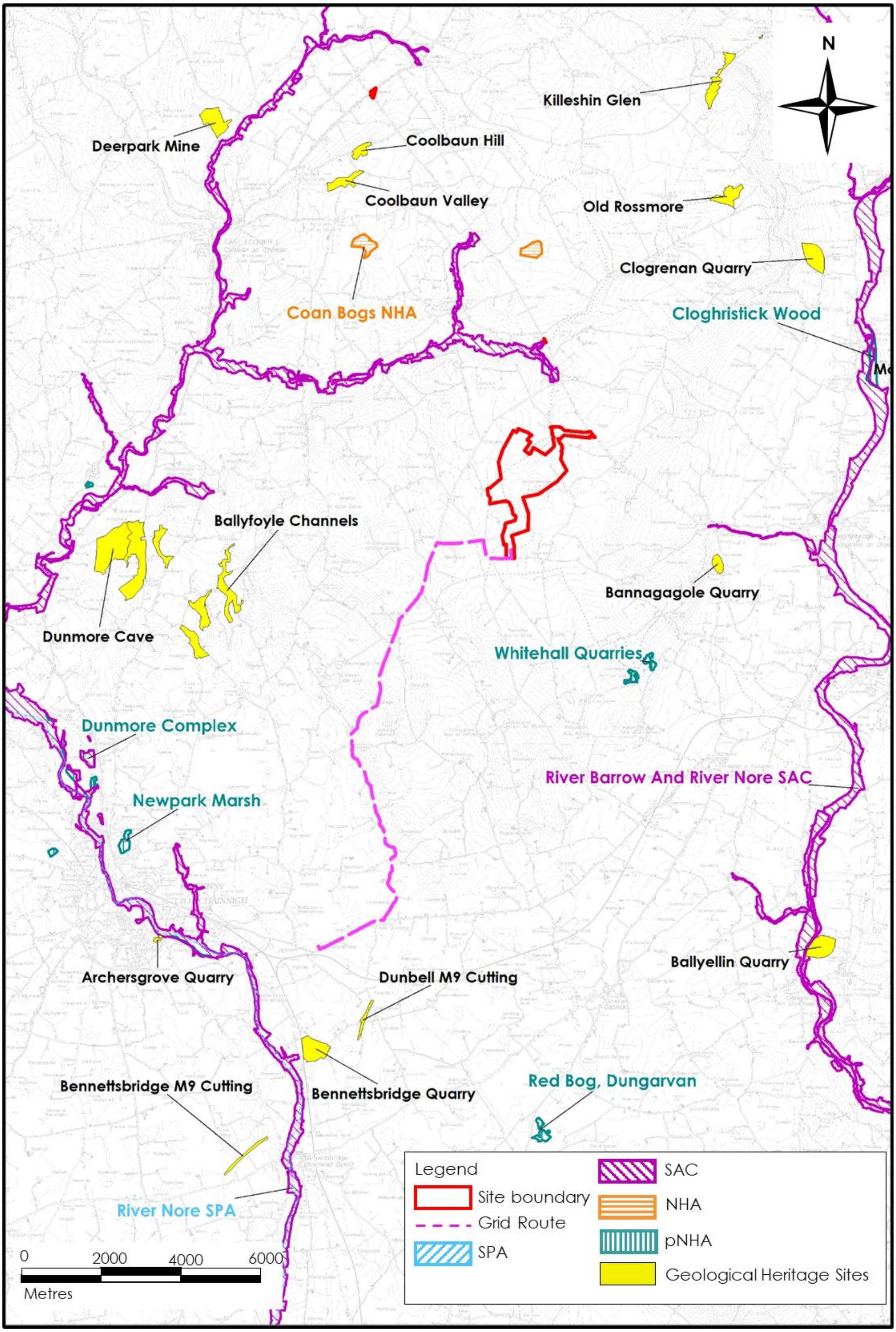


Figure 7.7: Designated Sites

7.3.15 Water Resources

According to the GSI online groundwater protection area mapping, the Castlewarren Group Water Scheme (GWS) source protection area is located immediately to the southwest of the wind farm site; however, no component of the wind farm site is located within the Castlewarren GWS source protection area (part of the grid route is as outlined below).

According to the National Federation of Group Water Schemes (NFGWS), the Castlewarren GWS supplies water to approximately 180 no. houses and 50 no. farms in the local area. The GWS is supplied by five boreholes (BH1–BH5) and one spring source, located across four separate sites north of the village of Castlewarren.

The locations of the source protection area, boreholes and spring are shown on **Figure 7.8**. Four of the boreholes (BH1–BH3 & BH5) are located approximately 400m to the southwest of the wind farm site and 1 no. borehole (BH4) is located c. 600m to the west. The spring is located 1.8km to the south of the wind farm.

Approximately 850m of the proposed development grid connection route is located inside the Castlewarren GWS source protection area. The closest borehole to the grid connection route (BH3) is located c. 270m to the south of the route. The grid connection infrastructure, located within the source protection area, will be located within the carriageways of local public roads.

The Paulstown Public Water Supply (PWS) outer source protection area is located approximately 800m to the southeast of the wind farm site. None of the wind farm or grid connection route is located inside the mapped outer source protection area. Paulstown PWS is supplied by springs which are located c. 9.5km to the southeast of the wind farm site.

However, the Monefelim River channel is included in the inner protection zone for the Paulstown Public Water Supply. The southern extremity of the wind farm site is located in the Monefelim River catchment; while the electricity substation, energy storage system (ESS) and c. 1.9km of the grid connection route are also located inside the surface water catchment to the Monefelim River. The Monefelim River rises approximately 600m to the southwest of the wind farm site and almost 800m to the southwest of the proposed substation / ESS location.

Based on the GSI *Paulstown PWS Source Protection Report* (May 2002), the streams/rivers flowing off the Castlecomer Plateau indirectly recharge the limestone aquifer from which the spring source emerges. However, the proportion coming from the Monefelim River catchment is reported to be less important:-

> "*As the streams flow off the Castlecomer Plateau and onto the karstic aquifer, a proportion of streamflow will sink back down into groundwater before flowing to the springs. Most of this river recharge will occur from the Acore catchment to the north of the springs, rather than from the Monefelim catchment to the north west*".

Private well locations (accuracy of <50m only) were reviewed using GSI well database (www.gsi.ie). There is one well within the site which is belong to a landowner. There are third party GSI located down-gradient of the wind farm site.

Wells along the grid connection route, haul route works areas, and forestry re-plant lands were not identified as no effects on groundwater are expected due to the shallow nature of the proposed works (refer to **Figure 7.9**).

GSI mapped wells with accuracy greater than 50m were not assessed due to the poor information/accuracy regarding their location. To overcome the poor accuracy, it is conservatively assumed that every private dwelling in the area of the wind farm (shown on **Figure 7.9**) has a well supply and this impact assessment approach is described further below. Private dwellings (i.e. potential wells) along the grid connection route, at the haul route works areas, and at the forestry re-plant lands were not identified due to the very low risk posed to any potential well.

The private well assessment undertaken below also assumes the groundwater flow direction underlying the site mimics topography, whereby flow paths (30 – 300m) will be from topographic high points to lower elevated discharge areas such as the Coolcullen River which flow through the wind farm.

Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the wind farm are identified (if any) and an impact assessment for these actual and potential well locations is undertaken if required.

This assessment focused on the wind turbine and borrow pit locations as these are the locations where the deepest excavations will be undertaken. All excavations required for site entrances, access tracks, crane hardstandings, compounds, and the electricity substation will be shallow and therefore there is no likelihood of significant effects on groundwater supplies.

Based on the above approach, no private dwelling houses were identified to be located immediately down-gradient (i.e. downslope; nearest dwelling located in excess of 700m from the location of the wind farm (and in particular wind turbine locations and borrow pits) and, therefore, there is no likelihood to significant effects on groundwater supplies given that groundwater flowpaths in the aquifer type are 30–300m in length.

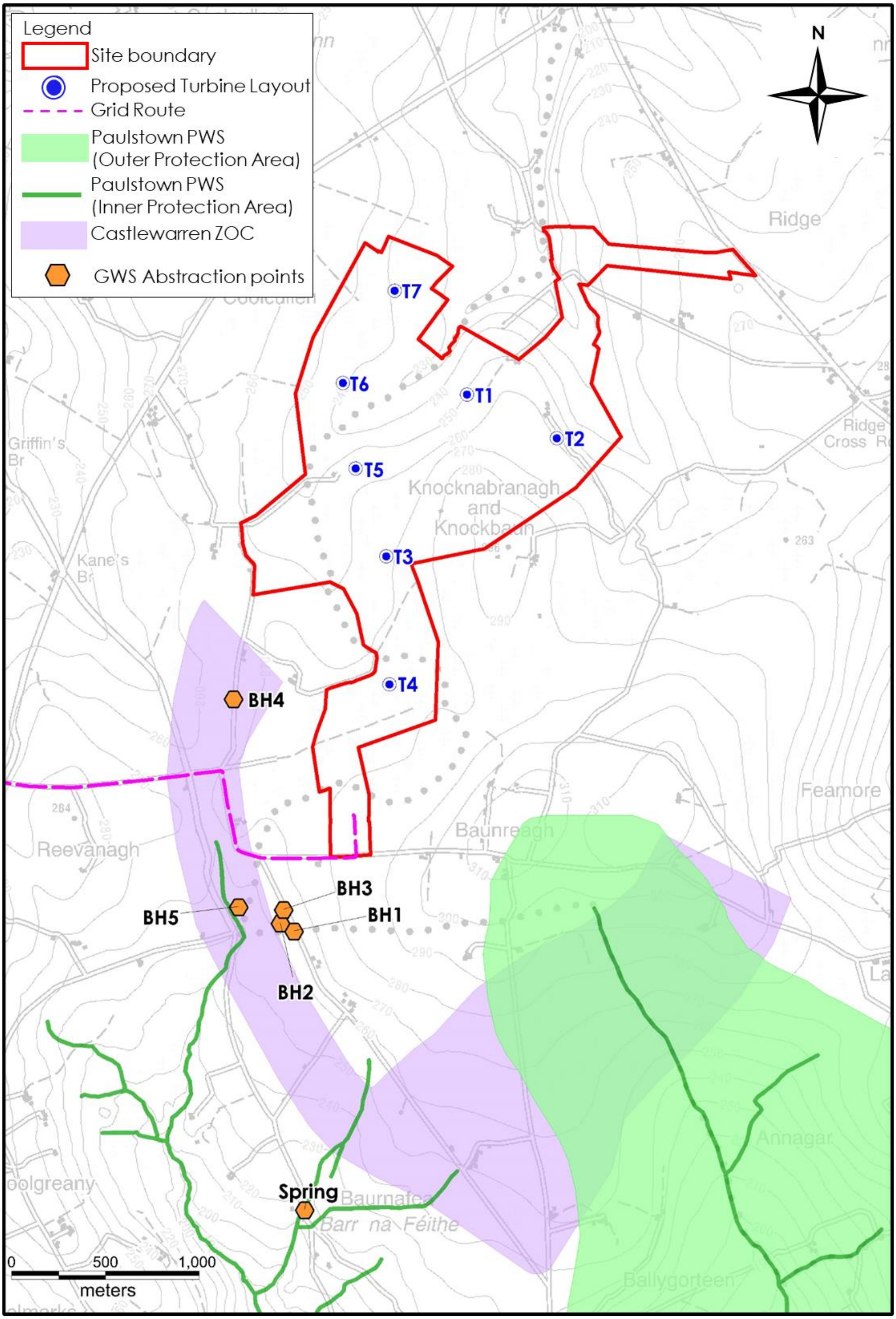


Figure 7.8: Groundwater Source Protection Areas

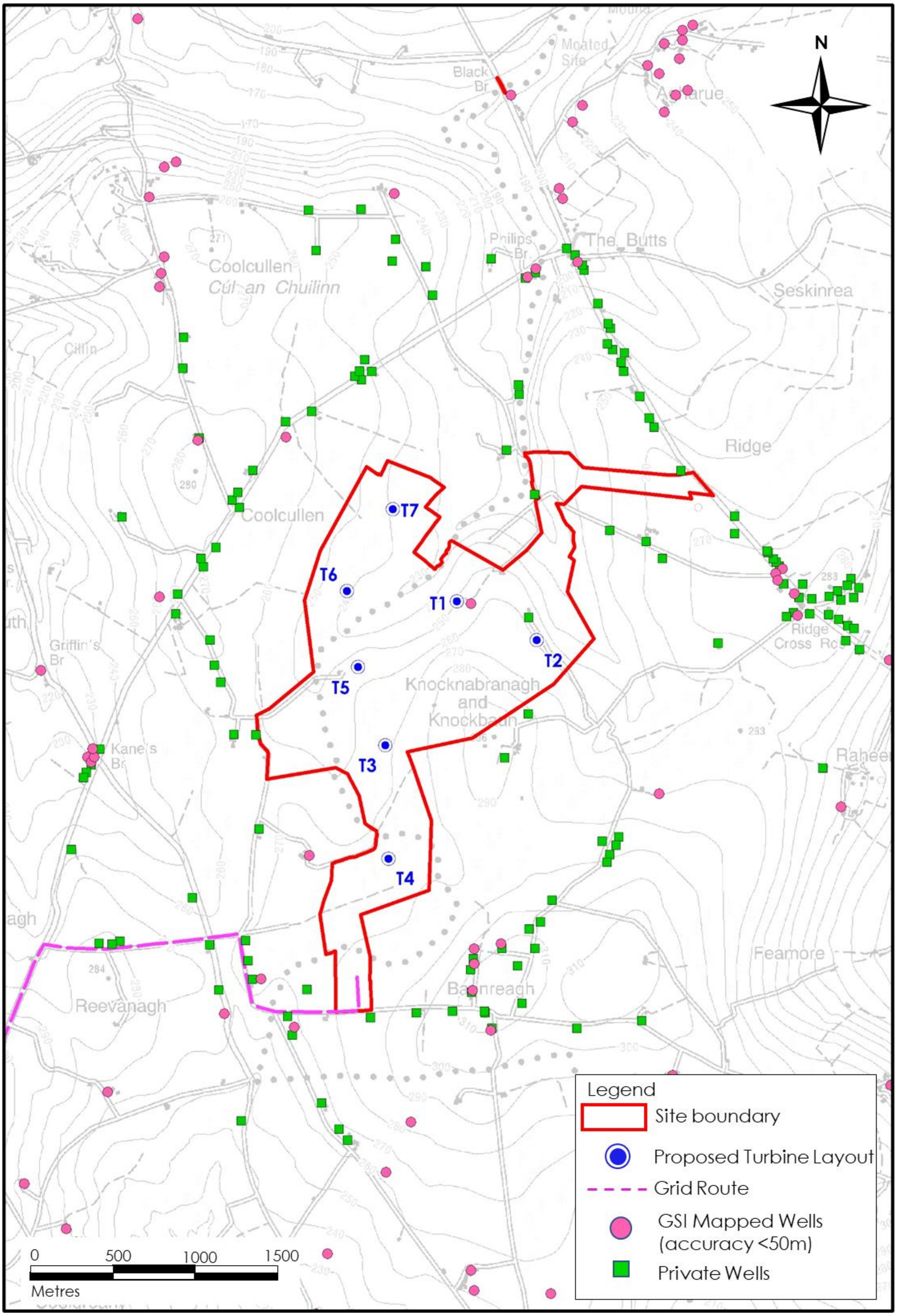


Figure 7.9: GSI Wells & Private Dwelling Locations

7.3.16 Development Interaction with the Existing Manmade Drainage Network

In relation to hydrological constraints, a self-imposed buffer zone of 50m has been put in place for on-site streams where feasible. Manmade drainage ditches at the site are not considered a hydrological constraint.

The general design approach for wind farm developments is to utilise and integrate the project with the existing land infrastructure where possible whether it be existing access tracks or the existing land drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing land/forestry drains have no notable hydrological value and can be readily integrated into the proposed drainage scheme using the methods outlined below (see **Section 7.5.1.2**).

7.3.17 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 project. 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 project site which may 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, through various attenuation methods, to a high quality prior to being released. Examples of attenuation methods include interceptor drains, collector drains, check dams, stilling/silt/sediment ponds, settlement lagoons, and buffered outfalls.

A schematic of the site drainage management is shown as **Figure 7.10** below. A Planning-Stage Surface Water Management Plan (SWMP) has been prepared and is enclosed at **Annex 3.4**. The SWMP, prepared by GES on the basis of a drainage design by Jennings O'Donovan & Partners, incorporates drainage design features to ensure the appropriate management of surface waters at the project site.

A detailed SWMP, incorporating a further-developed drainage design, will be prepared, post consent, as part of the detailed design process prior to construction (as is the normal course) demonstrating the implementation of the drainage design and attenuation infrastructure.

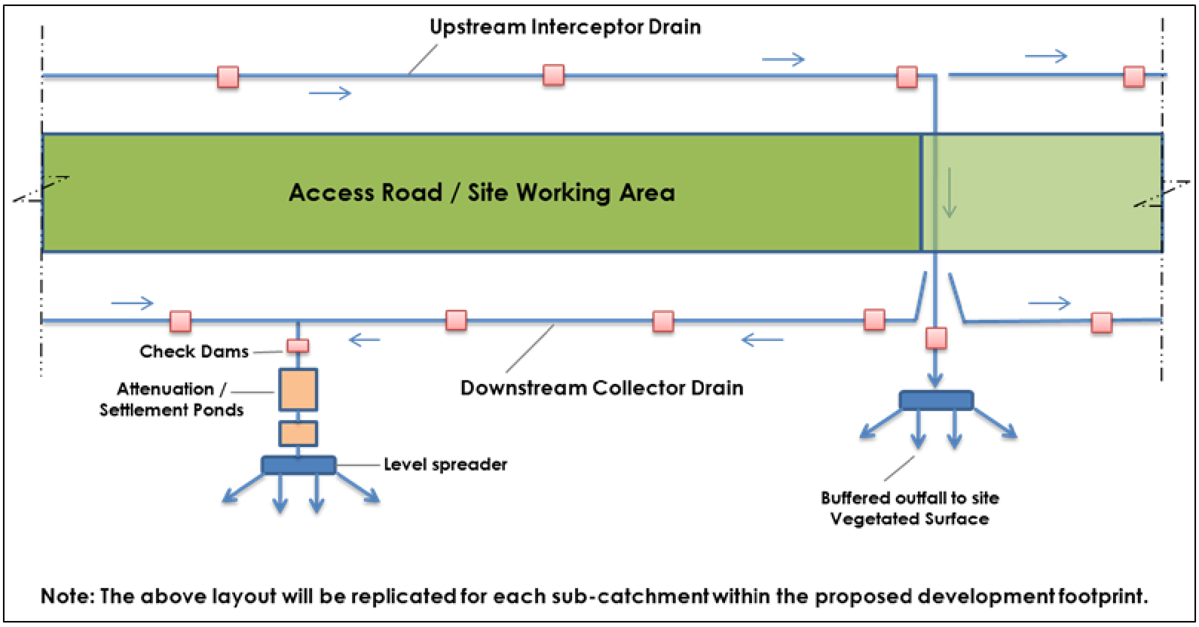


Figure 7.10: Schematic of Proposed Primary Site Drainage Management

In addition to the silt/settlement ponds, a tertiary lagoon treatment system will also be provided to absorb any fine particles that may not settle in the primary and secondary settlement ponds.

7.3.18 Receptor Sensitivity

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

Based on criteria set out in **Table 7.2**, groundwater at the project site can be classed as Low to Medium Importance in terms sensitivity to pollution because the bedrock is generally unproductive. Any contaminants which may be accidentally released are most likely to travel to nearby streams within surface water runoff.

Surface waters such as the Coolcullen River, Coolcullen Stream, Dinin River and Monefelim River are classed as High to Very High Importance and are very sensitive to potential contamination.

The designated sites that are hydraulically connected (surface water flow paths only) to the project include the River Barrow and River Nore SAC and the River Nore SPA and therefore have Extremely High Importance. These designated sites can be considered very sensitive in terms of potential impacts

The project is also located in the catchment of the specified Freshwater Pearl Mussel (FPM) populations as set out in First Schedule of the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009. Sedimentation poses a significant threat to the FPM which is the qualifying interest of the River

Barrow and River Nore SAC.

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

The key design approach has been the avoidance of sensitive aquatic areas, where possible, by implementing a 50m buffer. From the constraints map (**Annex 7.2**), it is evident that; other than some sections of access tracks, watercourse crossings (5 no.) and part of the crane hardstanding of turbine T4; the majority of the wind farm (including all turbine locations, borrow pit and spoil deposition areas) is located outside of areas that have been assessed to be hydrologically sensitive.

The hydrological buffer will ensure that the drainage mitigation/management measures (discussed below) can be installed up-gradient of primary drainage features within sub-catchments to facilitate appropriate, efficient and effective attenuation and treatment of surface water runoff.

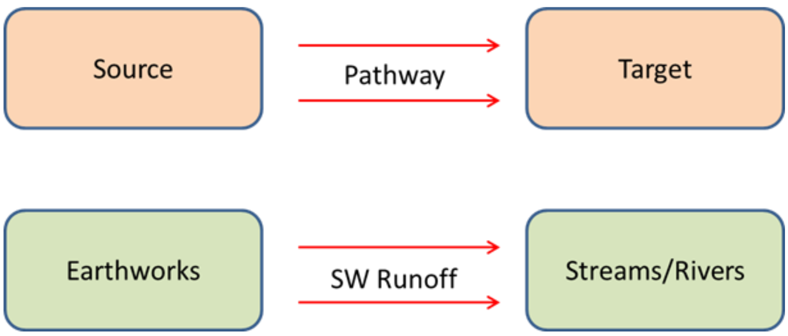
Due to the remoteness of the forestry replanting lands from sensitive receptors and the absence of any potential for significant effects, replanting works/activities have been scoped out of further assessment.

7.4 Description of Likely Effects

The likely effects of the proposed development are set out below, with mitigation measures that will be put in place to eliminate or reduce them are providing in following sections.

7.4.1 Overview of Impact Assessment Process

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



Where likely 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):-

- *Guidelines on the Information to be Contained in Environmental Impact Assessment Reports* (EPA, 2022);

The description process clearly and consistently identifies the key aspects of any likely 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 (**Sections 7.4.3, 7.4.4 & 7.4.5**), 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 wind farm construction and operation activities which have the potential to generate a source of significant negative impact on the hydrological and 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 likely 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 likely impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to this type of development, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

7.4.2 Do Nothing Scenario

In the do nothing scenario, there would be no alteration to the hydrological and hydrogeological environment. The hydrological regime, including runoff rates, would remain unchanged and current land use practices would continue. Existing land drainage arrangements would continue to function in their current manner.

7.4.3 Construction Phase

7.4.3.1 Clear Felling and Surface Water Quality Effects

A total of 15 hectares of forestry, accounting for 8.3% of the existing forestry coverage at the wind farm site, will be permanently felled to accommodate the construction and operation of the wind farm.

The tree felling activities will be the subject of a Felling Licence application to the Forest Service, in accordance with the Forestry Act 2014 and the Forestry Regulations 2017 (SI. 191/2017) and as per the Forest Service's policy on granting felling licenses for wind farm developments.

Likely effects during tree felling activities occur mainly from:-

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

Attribute	Description
Receptor	Down-gradient streams, rivers and dependant ecosystems
Pathway/Mechanism	Drainage and surface water discharge routes
Pre-Mitigation Effect	Indirect, negative, slight, temporary, likely effect

Table 7.16: Clear Felling and Surface Water Quality Effects

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

Construction phase activities that will require earthworks resulting in removal of vegetation cover and excavation of soil and mineral subsoil (where present) are detailed in **Chapter 3**. Potential sources of sediment laden water include:-

- Drainage and seepage water resulting from infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the grid connection including cable trench and haul route works 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, pearl mussels and fish stocks of downstream water bodies. The likely effects are assessed to be significant if in the absence of mitigation.

Attribute	Description
Receptor	Down-gradient streams, rivers, pearl mussels and dependant

	ecosystems
Pathway/Mechanism	Drainage and surface water discharge routes
Pre-Mitigation Effect	Indirect, negative, moderate, short term, likely effect

Table 7.17: Earthworks

7.4.3.3 Groundwater Levels and Local Private Well Supplies During Excavation Works

Dewatering of deep excavations (such turbine foundations and borrow pits) may affect local groundwater levels and nearby wells. However, groundwater level effects are assessed to be minimal (if any) due to the existing local hydrogeological regime as outlined above and further discussed below.

No groundwater level effects are anticipated from the construction of the haul route and grid connection works (including underground cabling) due to the shallow nature of the excavations (i.e. ~1-2m).

Attribute	Description
Receptor	Groundwater levels / flow paths
Pathway/Mechanism	Groundwater flowpaths
Pre-Mitigation Effect	Indirect, slight, short term, unlikely impact

Table 7.18: Groundwater Levels & Local Wells

The deepest excavation works will be centred around the turbine foundations and borrow pits. Turbine foundation depths are expected to have a maximum depth of c. 3m and borrow pits to have a maximum depth of c. 6-8m below ground level.

Based on the trial pit investigation, the groundwater table at the wind farm site is more than 2.5–3m below ground level as no groundwater was intercepted during the trial pit excavations. The bedrock is also shallow (<2m) at the majority of turbine locations and therefore deep excavations are unlikely to be required as the shallow rock will provide a suitable supportive substratum for the turbine gravity bases. Also due to the short groundwater flowpath distance (30-300m) there will be no interruption of off-site groundwater flowpaths.

Furthermore, the hydrogeological setting (i.e. elevated ground and underlying shallow, low permeability, competent bedrock) at the turbine and borrow pit locations means groundwater dewatering is unlikely to be required (assessed further below).

In terms of local well supplies, the assessment undertaken at **Section 7.3.15** above identified no potential wells down-gradient of turbine or borrow pit locations. Based on the well impact assessment and the nature of the local hydrogeological regime (groundwater flow-path distance 30–300m), effects on local well supplies are not assessed as likely and, therefore, no specific mitigation or monitoring measures, other than best practice construction methodologies, are required or proposed.

The likelihood of effects on local wells (whether they are downslope or not) is very low as groundwater flowpaths between wind farm infrastructure and locals wells typically do not exist due to the large setback distance (>300m).

7.4.3.4 Excavation Dewatering and Likely Effects on Surface Water Quality

Some minor surface water/shallow groundwater seepages and direct rainfall input will likely occur in excavations which will create additional volumes of water to be treated by the runoff/surface water management system. Inflows will require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are not assessed as likely to occur.

Attribute	Description
Receptor	Down-gradient surface water bodies
Pathway/Mechanism	Overland flow and site drainage network
Pre-Mitigation Effect	Indirect, negative, moderate, temporary, unlikely effect on surface water quality

Table 7.19: Excavation Dewatering

7.4.3.5 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.

Attribute	Description
Receptor	Groundwater, surface water, ecosystems and pearl mussels
Pathway/Mechanism	Groundwater flowpaths and site drainage network
Pre-Mitigation Effect	Indirect, negative, slight, short term, unlikely effect on local groundwater quality. Given the nature of the groundwater environment, discussed at **Sections 7.3.9**, **7.3.10** and **7.3.12** above, negative effects on groundwater quality are assessed to be unlikely. Indirect, negative, significant, short term, likely effect to surface water quality

Table 7.20: Release of Hydrocarbons

7.4.3.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from site welfare wastewater treatment systems has the potential to impact on groundwater and surface water quality.

Attribute	Description
Receptor	Groundwater quality, surface water quality, pearl mussels and ecosystems
Pathway/Mechanism	Groundwater flowpaths and site drainage network
Pre-Mitigation Effect	Indirect, negative, significant, temporary, unlikely effect on surface water quality. Indirect, negative, slight, temporary,

	unlikely effect on local groundwater.

Table 7.21: Contamination from Wastewater

7.4.3.7 Release of Cement-Based Products

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

Attribute	Description
Receptor	Surface water hydrochemistry, ecosystems and pearl mussels
Pathway/Mechanism	Site drainage network
Pre-Mitigation Effect	Indirect, negative, moderate, brief, likely effect on surface water

Table 7.22: Release of Cement-Based Products

7.4.3.8 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. The construction of structures over water courses also has the potential to significantly interfere with water quality and flows during the construction phase.

5 no. watercourse crossings will be required within the wind farm site and 10 no. along the grid connection route. The watercourses to be crossed are either 1st or 2nd order streams. All watercourses crossings within the wind farm site are new crossings[3] and all crossings along the grid connection are existing bridge/culvert crossings.

The grid connection watercourse crossings comprise 3 no. bridge crossings and 7 no. culvert crossings. No instream works are required and directional drilling will be employed at the 3 no. bridge crossings.

The works at Crettyard Bridge and Black Bridge will not result in any morphological changes to watercourses.

Attribute	Description
Receptor	Surface water flows, stream morphology and water quality.
Pathway/Mechanism	Site drainage network.
Pre-Mitigation Effect	Negative, direct, slight, long term, likely impact.

[3] The installation of crossing infrastructure over the Coolcullen River to the west of turbine T5 will avoid the requirement for plant & machinery to pass through the watercourse, as is currently the case.

Table 7.23: Morphological Effects

7.4.3.9 Hydrological Effects on Designated Sites

The project is hydrologically connected to the River Barrow and River Nore SAC (Site Code: 002162). At its closest point, this designated site is located approximately 1.5km to the north (as crow flies) of the wind farm site and is downstream (hydrologically connected) via the Coolcullen River and Monefelim River.

Surface water effects are unlikely to be significant due to dilution/assimilation capacity effects over such distances. Notwithstanding this, surface water management and mitigation is proposed to protect local surface water and avoid significant negative downstream surface water quality effects.

Attribute	Description
Receptor	Down-gradient water quality and designated sites
Pathway/Mechanism	Surface water flow-paths
Pre-Mitigation Effect	Indirect, negative, slight, short term, unlikely effect

Table 7.24: Effects on Designated Site

7.4.3.10 Effects on the Castlewarren GWS and Paulstown PWS Water Supplies

The Monefelim River channel is included in the inner protection zone for the Paulstown Public Water Supply as the Monefelim River provides, an albeit limited, recharge to the limestone aquifer which sustains the spring source.

Based on the GSI *Paulstown PWS Source Protection Report* (May 2002), the streams/rivers flowing off the Castlecomer Plateau indirectly recharge the limestone aquifer from which the spring source emerges. However, the proportion coming from the Monefelim River catchment is reported by the GSI to be less important.

The southern extremity of the wind farm site is located in the Monefelim River catchment including the electricity substation and c. 1.9km of the grid connection route are also located inside the surface water catchment of the Monefelim River. There are no wind turbines, borrow pits or spoil deposition areas within the Monefelim River catchment.

Approximately 850m of the grid connection route is also located inside the Castlewarren GWS source groundwater protection area. The grid connection infrastructure, located within the source protection area, will be located within the carriageways of local public roads; and associated excavations are not assessed to be of a sufficient depth to result in significant negative effects on water supplies.

During the construction phase, hydrocarbons (oils, fuels, etc.) will be stored within the temporary construction compound and no storage of hydrocarbons will be permitted within the protection zones of either the Castlewarren GWS or Paulstown PWS.

Attribute	Description
Receptor	Down-gradient groundwater quality and PWS/GWS drinking water sources
Pathway/Mechanism	Groundwater and surface water flowpaths

Pre-Mitigation Effect	Indirect, negative, imperceptible, short term, unlikely effect

Table 7.25: Public & Group Water Scheme Drinking Water Supplies

7.4.3.11 Effects on the WFD Status

The wind farm site and the northern section of the grid connection route are located in the Castlecomer GWB. Sections of the grid connection further south are mapped in the Shanragh GWB, the Ballingarry GWB and the Kilkenny GWB before terminating with in the Clifden GWB. The haul route works (Crettyard Bridge, junction of N78 and L1834 and Black Bridge) are located in the Newtown GWB.

All GWBs are currently assigned 'Good Status' which is defined on the basis of the quantitative status and chemical status of the GWB.

River Water Body status and risk information for the Nore River, Dinin River, Monefelim River and Gowran River in the area of the wind farm site, grid connection and haul route works are detailed at **Table 7.15** above.

Effects on surface water and groundwater quality as a result of the project may negatively affect the WFD status in the absence of appropriate mitigation.

Attribute	Description
Receptor	Down-gradient groundwater and surface water bodies status
Pathway/Mechanism	Groundwater and Surface water flowpaths
Pre-Mitigation Effect	Indirect, negative, slight, short term, unlikely effect

Table 7.26: WFD Status Effects

A full WFD assessment has been undertaken and is provided at **Annex 7.3**.

7.4.4 Operational Phase

Activities during the operational phase of the proposed development will be significantly reduced compared to the construction phase, with extremely limited sources for likely significant negative hydrological and hydrogeological effects.

7.4.4.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

The progressive replacement of the vegetated surface with impermeable surfaces could result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The permanent development footprint comprises turbine hardstands, access tracks and electrical substation amongst others. During rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading to local drains and streams, resulting in erosion of watercourses and impact on downstream aquatic ecosystems.

Attribute	Description
Receptor	Surface waters and dependant ecosystems.
Pathway/Mechanism	Site drainage network.
Pre-Mitigation Effect	Direct, negative, moderate, permanent, likely impact.

Table 7.27: Operational Phase Effects

The emplacement of the proposed development footprint, as described in **Chapter 3**, (assuming emplacement of impermeable materials) could result in an average total site increase in surface water runoff of 2,205m³/month, for the month of highest average recorded rainfall. This equates to an average increase of 71.1m³/day (**Table 7.28**). This represents a 0.58% increase in the average daily/monthly volume of runoff from the site 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 study area being developed. Specifically, the proposed permanent development footprint is approximately 9ha, representing 1.7% of the total landholding area of 516ha.

The additional runoff volume is low due to the fact that the runoff potential from the site is already relatively high (75% runoff coefficient) due to the prevailing baseline hydrogeological conditions at the site. Also, this calculation assumes that all hardstanding areas will be impermeable which is a conservative approach given that access tracks and crane hardstands will be constructed of aggregates which will facilitate the permeation/recharge of rainfall. A water balance assessment is provided below.

Baseline Runoff/month (m³)	Baseline Runoff/day (m³)	Permanent Footprint Area (m²)	Footprint Area 100% Runoff (m3) (m³)	Footprint Area 75% Runoff (m³)	Net Increase/month (m³)	Net Increase/day (m³)	% Increase from Baseline Conditions (m³)
379,260	12,234	90,000	8,820	6,615	2,205	71.1	0.58

Table 7.28: Baseline Runoff for the Wind Farm Site

7.4.4.2 Hydrocarbons Spillages/Leakages

During operational maintenance works, there is a small risk associated with release of hydrocarbons from site vehicles, although it is not envisaged that any significant refuelling works will be undertaken on site during the operational phase.

Oil used in transformers (at the substation and within each turbine) and storage of oils at the substation could leak during the operational phase and result in effects on water quality.

Attribute	Description
Receptor	Surface waters, groundwater and dependant ecosystems.
Pathway/Mechanism	Site drainage network.
Pre-Mitigation Effect	Direct, negative, slight, long-term, unlikely impact.

Table 7.29: Hydrocarbons Spillages Leakages during the Operational Phase

7.4.5 Decommissioning Phase

Decommissioning phase effects are likely to be very similar to construction phase impacts but the overall likelihood for significant negative effects will be much lower due to reduced groundworks and excavations taking place. Some of the effects will be reduced or avoided by retaining some elements of the project where appropriate; for example, access tracks within the site are likely to be retained for agricultural uses.

7.4.6 'Worst-Case' Scenario

The 'worst-case' for hydrological and hydrogeological effects are assessed to comprise the contamination of surface water features during the construction, operational and decommissioning phases, which in turn could affect the ecology and quality of the downstream surface water bodies. Also, it is assessed that localised groundwater contamination from spillages or hydrocarbons and other pollutants could occur. However, best practice construction methodologies and dedicated mitigation measures will be put in place to prevent this 'worst-case' scenario from arising.

7.4.7 Cumulative Effects

The main likelihood of cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater). Due to the hydrogeological setting of the site (i.e. low permeability soils, silts and clays overlying an unproductive bedrock aquifer) and the near surface nature of construction activities, cumulative impacts with regard groundwater quality or quantity arising from the proposed development are assessed as being unlikely to occur.

In terms of cumulative hydrological effects arising only from elements of the project (wind farm infrastructure, grid connection, haul route works and forestry replanting), no likely significant effects are expected for the reasons described below.

Due to the construction methodologies, construction programme (i.e. the grid connection trench will be excavated in stages) and the transient nature of the works over several kilometres, significant surface water quality effects are not anticipated as a result of the construction methodologies to be implemented, the surface water control measures to be put in place and the general adherence to the 50m hydrological buffer. Additional drainage control measures are outlined below, where works or infrastructure is located inside a 50m buffer zone.

A hydrological cumulative impact assessment of the project has been undertaken with regards cumulative effects with other projects and plans, including wind energy developments, located in the regional River Barrow and River Nore surface water catchments within a 20km radius of the wind farm site.

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

A number of developments, identified at **Chapter 1**, also have the potential to result in cumulative hydrological effects; however, the mitigation measures outlined below will ensure that the project will not result in any likely significant effects and it is assessed that there is no potential for interaction with other developments or for cumulative effects to occur.

Within the River Barrow catchment, there are 2 no. existing and 1 no. proposed wind turbines within 20km of the subject wind farm; while we are also aware of the proposed Freneystown Wind Farm, 8 no. turbines of which will be located within the River Barrow catchment. Due to the limited extent of the subject project located within the River Barrow catchment (electrical substation and c. 2km of the grid connection route), no significant hydrological cumulative effects are expected within the River Barrow catchment.

All turbine locations (7 no.) at the subject wind farm site are located within the River Nore catchment along with the haul route works and the remainder of the grid connection.

The total number of wind turbines that could potentially be operating within a 20km radius of the wind farm site within the River Nore catchment is 62 no. (7 no. from the subject project and 55 no. other turbines from the other wind farms (Pinewoods Wind Farm, Gortahile Wind Farm, Seskin Wind Farm, Bilboa Wind Farm, Ballynalacken Wind Farm, Freneystown Wind Farm (remaining 2 no. turbines) and Coolglass Wind Farm).

The total area of the River Nore catchment (inside a 20km radius) is c. 680km^2 which equates to 1 no. turbine per 11km^2 which is considered not significant in terms of likely cumulative hydrological effects on the River Nore. This turbine density calculation is also conservative as it does not include the area of the remainder of the Nore catchment outside the 20km radius.

The likelihood of cumulative effects on the Dinin River sub-catchment is more pronounced given the relatively small catchment area upstream of the proposed development, the permitted Bilboa Wind Farm and the proposed Seskin Wind Farm; however, the likelihood of cumulative effects remains low and will be further mitigated through the measures described at **Section 7.5** below.

The water balance assessment, undertaken at **Section 7.4.4.1**, demonstrates that even in the absence of mitigation, the likelihood of increased runoff from the proposed development is negligible. Therefore, the implementation of the proposed drainage control, which will release stormwater from the project site at Greenfied rates, will ensure cumulative effects with regard flood risk will be neutral.

With regard likely cumulative surface water quality effects, it is assessed in **Section 7.4.3.1** and **Section 7.4.3.2** that any residual effects will be imperceptible and short term following the implementation of measures described in the Planning-Stage SWMP (outlined below). This will ensure there will be no likely significant cumulative adverse effects on the water quality environment from the proposed development and therefore the likelihood for hydrological cumulative impacts is unlikely.

7.5 Mitigation & Monitoring Measures

The overarching objective of the proposed mitigation measures is to ensure that all surface water runoff is comprehensively treated and attenuated such that no silt or sediment laden waters or deleterious material is discharged into the local drainage system. A Planning-Stage SWMP, incorporating the surface water drainage design has been prepared, see **Annex 3.4**, and incorporates the principles of Sustainable Drainage Systems (SuDS) through an arrangement of surface water drainage infrastructure. The SWMP has regard to Greenfield runoff rates and is designed to mimic same and is sufficient to accommodate a 1-in-100 year rainfall event.

While the SuDS is an amalgamation of a suite of drainage infrastructure; the overall philosophy is straightforward. In summary:-

- All surface water runoff will be directed to specially constructed swales surrounding all areas of ground proposed to be disturbed (including the area for the temporary storage of material);
- The swales will direct runoff into settlement ponds/silt traps where silt/sediment

will be allowed to settle;

- In addition to the silt/settlement ponds, a tertiary treatment system will also be provided to absorb any fine particles that may not settle in the primary and secondary settlement ponds. From the silt/settlement ponds, water will flow through lagoons which will be designed with a retention time of 10-days; and,
- Following the tertiary treatment, clean water will be discharged indirectly to the local drainage network via buffered outfalls thus ensuring that no scouring occurs.

The suite of surface water drainage infrastructure will include interception drains, collector drains swales, sedimats, flow attenuation and filtration check dams, settlement ponds/silt traps, and buffered outfalls.

The design criteria implemented as part of the SuDS are as follows:-

- To minimise alterations to the ambient site hydrology and hydrogeology;
- To provide settlement and treatment controls as close to the site footprint as possible and to replicate, where possible, the existing hydrological environment of the site;
- To minimise sediment loads resulting from the development run-off during the construction phase;
- To preserve greenfield runoff rates and volumes;
- To strictly control all surface water runoff such that no silt or other pollutants shall enter watercourses and that no artificially elevated levels of downstream siltation or no plumes of silt arise when substratum is disturbed;
- To provide settlement ponds to encourage sedimentation and storm water runoff settlement;
- To reduce stormwater runoff velocities throughout the site to prevent scouring and encourage settlement of sediment locally;
- To manage erosion and allow for the effective revegetation of bare surfaces;
- To manage and control water within the site and allow for the discharge of runoff from the site below the MAC of the relevant surface water regulation value; and,
- The high sensitivity of downstream receptors such as freshwater pearl mussels.

7.5.1 Construction Phase

7.5.1.1 Clear Felling and Surface Water Quality Effects

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

- Department of Agricultural, Food and the Marine (2019) *Standards for Felling and Reforestation*;
- Forestry Commission (2004) *Forests and Water Guidelines, Fourth Edition*. Publ. Forestry Commission, Edinburgh;
- Coillte (2009) *Forest Operations and Water Protection Guidelines*;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Coillte (2009) *Methodology for Clear Felling Harvesting Operations*; 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 detailed at **Table 7.30**.

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

Table 7.30: Minimum Buffer Zone Widths (Forest Service, 2000)

During the construction phase, a self-imposed conservative buffer zone of 50m will be maintained for all streams. These buffer zones are illustrated at **Annex 7.2**. With the exception of the northern portion of the crane hardstanding for turbine T4 and watercourse crossings, the proposed tree felling areas are located outside of imposed buffer zones.

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

Mitigation by Design (Prevention)

Mitigation measures which will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses comprise best practice methods, 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 tracks and culverts will be ongoing through any felling operation. No tracking of vehicles through watercourses will occur. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the areas 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 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 spoil disposal areas. All new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion or where felling inside the 50m buffer is required, it will be necessary to install double or triple sediment traps;

- 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 topsoil and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place before 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 the 50m watercourse buffer. Straw bales and check dams will 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/tracks and culverts will be ongoing 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;
- Trees will be cut manually from along streams and using machinery to extract whole trees; and,
- Travel will only be permitted perpendicular to and away from surface water features.

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 will be carried out during pre-felling inspections and regularly thereafter:-

- Communication with tree felling operatives in advance to determine whether any areas have been reported where there is unusual waterlogging 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 will be identified. Where possible, the pre-felling inspection will be carried out during rainfall;

- Following tree felling, all main drains will be inspected to ensure that they are functioning;
- Extraction tracks within 10m of drains will 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, if impeded by silt or debris, 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).

Details of the proposed surface water quality monitoring programme are outlined in the Water Quality Monitoring Plan (refer to **Annex 3.4**).

The surface water sampling locations used in this EIAR for the wind farm site (i.e. SW1 – SW2) will also be used as sampling locations during felling activities.

Also, daily surface water monitoring forms (for visual inspections and field chemistry measurements) will also be utilised at every works site near any watercourse. These will be taken daily and kept on site for record and inspection.

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

Mitigation by Avoidance

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas by using a 50m buffer. From the constraints map (**Annex 7.2**), it is evident that apart from some sections of access track, a small section of the T4 hardstand along with the watercourse crossing locations, the majority of the project infrastructure (including all turbine locations, borrow pits and spoil storage areas) are located outside of areas that have been assessed to be hydrologically sensitive.

As described above and at **Chapter 3**, specific mitigation measures, incorporated into the design of the project and through implementation of best practice methodologies (discussed below) will be employed where work inside buffer zones is proposed.

The generally large setback distance from sensitive hydrological features ensures that sufficient space is provided for the installation of drainage mitigation measures (discussed below) and to ensure their effective operation. The proposed buffer zone will ensure:-

- Avoidance of physical damage to watercourses, and associated release of sediment;
- Avoidance of excavations within close proximity to surface water courses;

- Avoidance of the entry of suspended sediment from earthworks into watercourses; and,
- Avoidance of 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 (Prevention)

The following section details the measures which will be put in place during the construction phase to ensure that surface water features are protected from the release of silt or sediment and to ensure that all surface water runoff is fully treated and attenuated to avoid the discharge of dirty water.

Source controls to limit the likelihood for 'dirty water' to occur:-

- Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with clean washed gravel, filter fabrics, and other similar/equivalent or appropriate systems; and,
- Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.

In-Line controls to ensure appropriate management of silt laden water:-

- 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 to fully attenuate silt laden waters prior to discharge:-

- 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; and,
- Final tertiary treatment lagoons which follow a design outlined by Altmuller and Dettmer (2006)[4].

It should be noted for this site that an extensive network of land and forestry drains already exists and these will be integrated and enhanced as required and used within the wind farm drainage system. The integration of the existing land drainage network and the proposed wind farm network is common practice in wind energy developments and will also result in benefits to surrounding agricultural lands.

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 wind farm drainage into the existing site drainage network. This will reduce the likelihood of any increased risk of downstream flooding or sediment transport/erosion;

[4] Altmüller R. & Dettmer, R. (2006) *Successful species protection measures for the Freshwater Pearl Mussel (Margaritifera margaritifera) through the reduction of unnaturally high loading of silt and sand in running waters – Experiences within the scope of the Lutterproject.*

- Silt traps will be placed in the existing drains upstream of any streams where construction works is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area; and,
- 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.

Water Treatment Train

While the primary, secondary and tertiary silt/sediment ponds and lagoons are assessed as providing a sufficient level of protection to avoid any deterioration in downstream water quality; a final line of defence can be provided by a water treatment train such as a 'Siltbuster', if required. If the discharge water from construction areas fails to be of a high quality, then a filtration treatment system (such as a 'Siltbuster' or similar equivalent treatment train [sequence of water treatment processes]) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This water treatment train will apply for the entirety of the construction phase.

Silt Fences

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

Silt Bags

Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters or sedimats (sediment entrapment mats, consisting of coir or jute matting) 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.

Tertiary Treatment System/Lagoons

In addition to the silt/settlement ponds, a tertiary treatment system will also be provided to remove any fine particles that may not settle in the primary and secondary settlement ponds. From the silt/settlement ponds, water will flow through lagoon which will be designed with a retention time of 10-days. These ponds; the design of which will be adapted to the characteristics of the project site but based on the principles of Altmuller & Dettmer (2006); will be vegetated so as to perform the role of a 'plant filtration bed'.

Management of Runoff from Soil Deposition Areas

It is proposed that excavated overburden/spoil will be utilised for reinstatement of excavated areas etc. and for landscaping purposes. Excess material, or material which is unsuitable for this purpose, will be stored, permanently, at 2 no. dedicated spoil deposition areas and in the 3 no. spent borrow pits (if developed).

Both proposed spoil deposition areas and all borrow pits are located outside the 50m stream buffer zone (refer to **Annex 7.2**).

During the initial placement of spoil in the deposition areas, silt fences, straw bales and biodegradable matting will be used to control surface water runoff. Drainage from overburden deposition areas will ultimately be routed to an oversized swale and a number of silt/settlement ponds (and lagoons) with appropriate storage and settlement capacity, designed for a '1-in-100 year 6-hour return' period, before being discharged.

Spoil deposition areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff. Once re-vegetated and stabilised, spoil deposition areas will no longer be a likely source of silt laden runoff. Surface water protection infrastructure will be left in place until the areas have stabilised.

Grid Connection Installation Works

Temporary silt fencing/silt trap arrangements will be placed within existing roadside/field drainage features along the grid connection route to remove any suspended sediments from the works area. The trapped sediment will be removed and disposed of at an appropriate licenced facility. Any bare-ground will be re-seeded/reinstated immediately and silt fencing temporally left in place if necessary.

Directional Drilling

The following mitigation will be carried out during directional drilling works:-

- The works area will be clearly marked out with fencing or flagging tape to avoid unnecessary disturbance of vegetation;
- A minimum 10m buffer zone will be maintained between disturbed areas and the watercourse bank. There will be no storage of material/equipment, excavated material (see below) or overnight parking of machinery inside the 10m buffer zone;
- Double silt fencing will be placed upslope of the buffer zone on each side of the watercourse.
- Temporary storage of excavated material will be undertaken outside of the 10m buffer on flat ground or within a local hollow area. A containment berm will be placed downslope of the excavated material which in turn will be surrounded by secondary silt fence protection to prevent saturated soil from flowing back into the watercourse;
- Operation of machinery and use of equipment within the 10m buffer will be kept to a minimum to avoid any unnecessary disturbance;
- There will be no refuelling allowed within 100m of the watercourse crossing;
- All plant will be checked for purpose of use prior to mobilisation at the watercourse crossing; and,
- Works shall not take place during periods of heavy rainfall and will be scaled back or suspended if heavy rain is forecasted.

Measures relating to the use of a mixture of a natural, inert and fully biodegradable drilling fluid such as Clear Bore™ and water for directional drilling include:-

- The area around the Clear Bore™ batching, pumping and recycling plants will be bunded using terram and sandbags in order to contain any spillages;

- One or more lines of silt fences will be placed between the works area and adjacent rivers and streams on both banks;
- Accidental spillage of fluids will be cleaned up immediately and transported off site for disposal at a licensed facility; and,
- Adequately sized skips will be used for temporary storage of drilling arisings during directional drilling works. This will ensure containment of drilling arisings and drilling flush.

Pre-emptive Site Drainage Management

The works programme for the initial construction stage of the development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of soil/subsoil or vegetation stripping will be suspended or scaled back if prolonged or intense 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;
- Meteo Alarm: 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 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.

Timing of Site Construction Works

The construction of the site drainage system will be carried out, at the respective locations, prior to other activities being commenced. The construction of the drainage system will only be carried out during periods of, where possible, no rainfall, therefore avoiding runoff. This will avoid 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 functional for all subsequent construction works.

Monitoring

Prior to the commencement of development, a detailed Site Drainage Plan and SWMP will be prepared to detail the siting and composition of the surface water management measures. The respective plans, which will form part of a detailed Construction Environmental Management Plan (CEMP), will be prepared prior to the commencement of development.

The CEMP will also include a detailed Water Quality Monitoring Plan for the monitoring of surface waters in the vicinity of the construction site by a designated Environmental Manager. The monitoring programme will comprise field testing and laboratory analysis of a range of agreed parameters. The civil works contractor, who will be responsible for the construction of the site drainage system, and Environmental Manager will undertake regular inspections of the drainage system to ensure that all measures are functioning effectively. The surface water sampling locations used in this EIAR (i.e. SW1 – SW4) will be used during construction activities. 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.

Any excess build-up of silt levels that may decrease the effectiveness of the drainage feature, will be removed and disposed of in an appropriate manner.

7.5.1.3 Excavation Dewatering and Effects on Surface Water Quality

The management of excavation dewatering (pumping), particularly in relation to any accumulation of water in foundations or electricity line trenches, 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;
- The interceptor drainage will be discharged to the site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters to ensure that Greenfield runoff rates are mimicked;
- If required, pumping of excavation inflows will prevent build-up of water in the excavation;
- The pumped water volumes will be discharged via volume and silt/sediment ponds and settlement lagoons 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 wind farm excavations by the Environmental Manager will occur during the construction phase. If high levels of seepage inflow occur, excavation work at this location will cease immediately and a geotechnical assessment undertaken; and,

- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies. 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.

7.5.1.4 Groundwater Levels and Local Well Supplies During Excavation Works

Mitigation measures with regard effects on groundwater levels and local well supplies will not be required for the reasons explained below.

The borrow pits at the wind farm site are located in bedrock (shales/sandstones) 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 subcrop/shallow bedrock on the hill side.

The topographical and hydrogeological setting of the borrow pit locations means no significant groundwater dewatering will be required. 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, dewatering is generally defined as a requirement to temporarily drawdown the local groundwater table by means of over pumping (for example, as would be required for the operation of a bedrock quarry in a valley floor). This example is very different in scale and operation from the development of a temporary shallow borrow pit such as that proposed, as follows:-

- The borrow pits are located at locally elevated areas where ground elevations are between 220m and 285m OD and the rock is shallow;
- These elevations are above the elevations of the local valleys and streams;
- The borrow pits will be between approximately 6m and 8m below ground level. In the context of the topographical/elevated/subcrop setting of the borrow pits, this depth range is relatively shallow;
- The local bedrock comprises shales/sandstones 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;
- Groundwater inflows will largely be fed by rainfall and by limited groundwater seepage form localised shallow bedrock; and,
- The sloping nature of the wind farm site where the borrow pits are proposed along with the coverage of peaty topsoil means groundwater recharge will be low.

Consequently, the groundwater flow system will be small in comparison to the expected surface water flows from the ground surface. As a result, there will be a preference for surface water runoff as opposed to groundwater recharge and flow; and, accordingly, it is assessed that the management of surface water will form the largest proportion of water to be managed and treated.

In conclusion, therefore, it is assessed that the project will not impact in any way on any local groundwater wells/springs for the following reasons:-

- The site is underlain by low permeability bedrock;
- Groundwater flowpaths are therefore typically very short (30-300m);

- 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; and,
- The likelihood of effects on local wells (whether they are downslope or not) is very low as groundwater flowpaths between wind farm infrastructure and locals wells typically do not exist due to the large setback distance (>450m).

Therefore, the risk of significant effects on local wells/water supply sources is very low.

Mitigation by Best Practice

Environmental management guidelines from the EPA guidance document *Environmental Management in the Extractive Industry* in relation to groundwater protection will be implemented during the construction phase, particularly the best practice measures relating to oil and fuels.

7.5.1.5 Release of Hydrocarbons during Construction and Storage

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

- The volume of fuels or oils stored on site will be minimised. All fuel and oil will be stored in an appropriately bunded area within the temporary construction compound. Only an appropriate volume of fuel will be stored at any given time. The bunded area will be roofed to avoid the ingress of rainfall and will be fitted with a storm drainage system and an appropriate oil interceptor;
- All bunded areas will have 110% capacity of the volume to be stored;
- On site refuelling 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 at the temporary compound and will be towed around the site by a 4x4 jeep to where plant and machinery is located. No refuelling will be permitted at works locations within the 50m hydrological buffer. The 4x4 jeep will also be fully stocked with 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 to avoid any accidental leakages;
- All plant and machinery used during construction will be regularly inspected for leaks and fitness for purpose;
- Spill kits will be readily available to deal with and accidental spillages;
- All waste tar material arising from road cuttings (from trenching or other works in public roads) will be removed off-site and taken to a licensed waste facility. Due to the potential for contamination of soils and subsoils, it is not proposed to utilise this material for any reinstatement works; and,
- An outline emergency plan for the construction phase to deal with accidental spillages is contained within the Planning-Stage CEMP (**Annex 3.4**). This emergency plan will be further developed prior to the commencement of development, and will be agreed with the Planning Authority as part of the detailed CEMP.

7.5.1.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Measures to avoid contamination of ground and surface waters by wastewaters will comprise:-

- Self-contained port-a-loos (chemical toilets) with an integrated waste holding tank will be installed at the site compound, maintained by the providing contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the site, nor will any wastewater be discharged to the site.

7.5.1.7 Release of Cement-Based Products

The following mitigation measures are proposed to ensure that the release of cement-based products is avoided:-

- No batching of wet-cement products will occur on site. Ready-mixed concrete will be brought to site as required and, where possible, emplacement of pre-cast products will be utilised;
- All watercourse crossings will utilise pre-cast products and the use of wet-cement products within the hydrological buffer will be avoided
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. Chute cleaning will be undertaken at lined cement washout ponds with waters being stored in the temporary construction compound, removed off site and disposed of at an approved licensed facility. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed;
- Weather forecasting will be used to ensure that prolonged or intense rainfall is not predicted during concrete pouring activities; and,
- The concrete pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

7.5.1.8 Morphological Changes to Surface Watercourses & Drainage Patterns

The following mitigation measures are proposed:-

- All proposed new stream crossings will be clear span bridges (bottomless culverts) and the stream beds will remain undisturbed. No in-stream excavation works at the crossing locations are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Where internal wind farm electrical cabling or grid connection cabling will pass above or below the existing culvert and will not directly interfere with the culvert;
- At the time of construction, all guidance/best practice requirements of the Office of Public Works (OPW) or Inland Fisheries Ireland will be incorporated into the design/construction of the proposed watercourse/culvert crossings;
- As a further precaution, in-stream construction work (if/where required) will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to *Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters* (2016) (i.e., July 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 works (i.e. within the 50m buffer zone), double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase;
- The 5 no. new watercourse crossings at the wind farm site will require a Section 50 license application to the OPW in accordance with the Arterial Drainage Act 1945. The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent; and,
- No instream works are proposed at the grid connection watercourse crossings.

7.5.1.9 Hydrological Impacts on Designated Sites

The proposed mitigation measures for protection of surface water quality, which will include buffer zones and robust drainage control measures (i.e. interceptor drains, swales, silt/settlement ponds, settlement lagoons), will ensure that the quality of runoff from development areas will be very high. In particular, we refer to the inclusion of the tertiary sediment lagoons (as per Altmuller & Dettmer (2006)) which are recognised as providing a high level of protection against downstream water quality deterioration thus ensuring the protection of Freshwater Pearl Mussel and Nore Pearl Mussel within the River Barrow & River Nore SAC.

As stated in **Section 7.6.1.2** below, an *"imperceptible, temporary effect"* on local streams and rivers would, if it occurs, be extremely localised and of a very short duration (i.e. hours). Therefore, significant indirect hydrological or water quality effects on the downstream River Barrow & River Nore SAC and River Nore SPA will not occur.

7.5.1.10 Effects on the Castlewarren GWS and Paulstown PWS Water Supplies

Due to the significant setback distance from the Monefelim River inner protection zone to the wind farm site (c. 600m), the limited construction works to be undertaken within the catchment (i.e. no turbines, borrow pits, spoil deposition areas etc), the lack of direct surface water pathways (i.e. drains/streams) between the wind farm site and the Monefelim River in addition to the comprehensive array of drainage control measures and pollution prevention measures (discussed above), it is assessed that the project will have no effects on the Paulstown Public Water Supply.

It should also be highlighted that the proportion of water coming from the Monefelim River catchment which supplies the Paulstown PWS spring is reported by the GSI to be less important than the portion coming from *the* Acore catchment (in which there are no elements of the project).

The fact that the grid connection route within the Monefelim River catchment is limited to only 1.9km, will be installed within the carriageway of a public road at a shallow depth and that no instream works are required at the 1 no. watercourse crossing, means that no effects on the Paulstown Public Water Supply will occur.

As an additional pollution prevention measure, no refuelling of plant or machinery will be permitted along the proposed grid connection works within the Monefelim River catchment.

In addition, approximately 850m of the grid connection route is located inside the Castlewarren GWS source groundwater protection area. As sated above, the grid connection infrastructure, located within the source protection area, will be located within the carriageways of local public roads. Due to the shallow nature of the works within the carriageway of roads along with the proposed drainage control measures, no effects on the Castlewarren GWS will occur. As above, no refuelling of plant or machinery will be permitted along the proposed grid connection works within the Castlewarren GWS source protection area.

7.5.1.11 Effects on the WFD Status

No additional targeted measures are required or proposed in respect of the WFD assessment. The strict implementation of the measures set out in the preceding sections will ensure that the status of both surface water and groundwater bodies in the vicinity of the site will be maintained.

With regard to treatment standards, the drainage system has been designed to achieve compliance with surface water Environmental Quality Standards (EQS) in the downstream receiving waters. Details of monitoring proposals, to ensure this compliance, is described in the Planning-Stage SWMP (**Annex 3.4**).

The application of the drainage management as outlined will ensure compliance with EU Surface Water Regulations and WFD requirements while also maintaining the baseline hydrology of the site.

As such, the project is compliant with the requirements of the Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC).

7.5.2 Operational Phase

7.5.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

The operational phase drainage system of the project is described below:-

- Interceptor drains will be installed up-gradient of all infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access tracks, turbine hardstanding areas and substation compound areas which may contain entrained suspended sediment, and channel it to settlement ponds for sediment settling;
- Transverse drains ('grips') will be constructed, where appropriate, in the surface layer of access tracks to divert any runoff into swales/track side drains;
- Check dams will be used along sections of access tracks drains to intercept silts at source. Check dams will be constructed from a 40mm non-friable crushed rock or similar;
- Swales and check dams 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 accordance the greenfield runoff rate requirements; and,
- Imported rock for construction purposes and road surfacing will be strong, well-graded limestone which will be resistant to erosion and have a low likelihood to generate fines in hardstand runoff.

The operation of the underground grid connection will not result in any likely hydrological or water quality effects and therefore do not require mitigation measures.

7.5.2.2 Hydrocarbons Spillages/Leakages

Mitigation measures relating to oils and fuels are as follows:-

- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the time period of the construction;
- The substation transformer and oil storage tanks will be located in a concrete bund, impervious to rainwater ingress, capable of holding 110% of the stored oil volume.
- Turbine transformers will be located within the turbines, and any leaks will be fully contained within the turbine thus eliminating any pathway for leakages to affect land and soil.
- Maintenance vehicles will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the operational phase to deal with accidental spillages will be contained within an Operational-Phase Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

7.5.3 Decommissioning Phase

As in the construction phase, temporary surface runoff control measures will again be put in place during decommissioning works. The drainage system will remain operational during the decommissioning phase and will serve to treat any sediment laden surface water run-off due to a renewed disturbance of soils. Following decommissioning, re-vegetation will be implemented as soon as practicable and monitored to ensure vegetation is established.

Likely effects would be similar to the construction phase but to a lesser degree. There would be increased trafficking and an increased risk of disturbance to underlying soils at the project site. Any such effects would be less than during the construction phase as the drainage system would be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site would be bunded.

Following decommissioning, turbine foundations, hardstanding areas and access tracks will be rehabilitated in accordance with the methods outlined at **Chapter 3**. The access tracks may be left in place, subject to agreement with the Planning Authority and the landowner. It is considered that this approach will result in lesser effects that would their removal.

7.6 Residual Effects

7.6.1 Construction Phase

7.6.1.1 Clear Felling and Surface Water Quality Effects

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 residual effect will be negative, imperceptible, indirect, temporary, and likely effect on downstream water quality and aquatic habitats.

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

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be a negative, indirect, imperceptible, short term, likely impact and no significant effects on water quality are assessed as likely.

7.6.1.3 Groundwater Levels and Local Well Supplies During Excavation works

Significant effects on groundwater levels/flows or groundwater supplies are not anticipated as a result of the project. It is concluded, therefore, that likely significant effects will not arise.

7.6.1.4 Excavation Dewatering and Likely Impacts on Surface Water Quality

Residual effects, following the implementation of mitigation measures, are assessed to be indirect, imperceptible, short term and no likely significant effects on surface water quality are anticipated.

7.6.1.5 Release of Hydrocarbons during Construction and Storage

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be indirect, negative, imperceptible, short term and unlikely.

No significant effects on surface water or groundwater quality are assessed as likely.

7.6.1.6 Groundwater and Surface Water Contamination from Wastewater Disposal

No significant residual effects are assessed as likely to occur.

7.6.1.7 Release of Cement-Based Products

Residual effects, following the implementation of mitigation measures, are assessed to be negative, indirect, imperceptible, short term and unlikely.

No significant effects on surface water quality are assessed as likely to occur.

7.6.1.8 Morphological Changes to Surface Water Courses & Drainage Patterns

Significant effects due to morphological changes, occurring as a result of watercourse crossings or drain diversions, are assessed to not result in significant residual effects. Residual effects are anticipated to be negative, direct, imperceptible, short term and likely.

7.6.1.9 Hydrological Effects on Designated Sites

No significant residual effects are assessed as likely to occur.

Due to the knowledge of the ground conditions (subsoil and bedrock competency) groundwater levels, gradients and flow directions as well as the mitigation measures provided to ensure the protection of water quality and water quantity (recharge), the residual effects on surface water ecosystems is considered to be – No residual effect on designated sites will occur.

7.6.1.10 Effects on the Castlewarren GWS and Paulstown PWS Water Supplies

Due to the relatively small scale and shallow depth of the works within the Castlewarren GWS and Paulstown PWS source protection areas, in addition to, the proven and effective measures to mitigate the risk of releases of sediment and contaminants, no effects on the either Castlewarren GWS and Paulstown PWS will occur.

7.6.1.11 Effects on WFD Status

No effects on WFD status of surface water or groundwater bodies will occur.

7.6.2 Operational Phase

7.6.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Following the implementation of appropriate mitigation measures, as outlined above, the residual effect is assessed to be direct, neutral, long term and likely; however, significant effects are not likely.

7.6.2.2 Hydrocarbons Spillages Leakages during the Operational Phase

Residual effects, following the implementation of mitigation measures, are assessed to be negative, indirect, imperceptible, short term and unlikely.

7.6.3 Decommissioning Phase

No likely significant residual effects on the hydrological environment or on water quality are envisaged during the decommissioning stage of the project.

7.7 Summary

During each phase of the project (construction, operation and decommissioning) a number of activities will take place which will have the potential to significantly affect the hydrological regime or water quality at the site or its vicinity. These significant potential effects 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 any likely adverse impacts on water quality and downstream designated sites. A self-imposed 50m stream buffer was used to inform the layout of the wind farm, thereby avoiding sensitive hydrological features.

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

Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the detailed CEMP to be prepared prior to the commencement of development.

Overall, the project presents no likelihood for significant effects on surface or groundwater quality following the implementation of the proposed mitigation measures; while the project can be constructed, operated and decommissioned without affecting the WFD status of any waterbody or adversely affecting the achievement of WFD status. Additionally, this assessment has determined that there is no likelihood for significant cumulative effects to arise due to the construction, operation or decommissioning of the proposed development.