9. WATER

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential, direct, indirect and cumulative significant effects of the proposed 7 no. turbine Curraglass Renewable Energy Development (Proposed Development), which is located approximately 5.6km northeast of Kealkill and 5.5km southwest of the village of Ballingeary, Co. Cork on water aspects (hydrology and hydrogeology) of the receiving environment.

The objectives of the assessment are:

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

9.1.2 Statement of Authority

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

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

This chapter of the EIAR was prepared by Michael Gill 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 has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm-related projects.

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

9.1.3 Scoping and Consultation

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

Table 9-1 below.

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

Consultee	Description	Addressed in Section
Irish Water (IW)	A generic response was provided with respect potential impacts in terms of any local groundwater and surface water abstractions	Sections 9.3.15 and 9.5.3.9
Geological Survey of Ireland (Groundwater Section)	A generic response was provided with respect potential impacts on groundwater resources/sources	Sections 9.3.15, 9.3.16 and 9.5.3.9

9.1.4 Relevant Legislation

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

The requirements of the following legislation are complied with:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1994, S.I. No. 101 of 1996, S.I. No. 351 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001, S.I. 134 of 2013 and the Minerals Development Act 2017), the Planning and Development Act 2000 (as amended), and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 2011/92/EU and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) establishing a framework for the Community action in the field of water policy and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC) on the protection of groundwater against pollution and deterioration. Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council Directive 2013/64/EU; and Commission Directive 2014/101/EU ("WFD"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003);
- S.I. No. 684 of 2007: Waste Water Discharge (Authorisation) Regulations 2017, resulting from EU Directive 2000/60/EC on the protection of water; S.I. No. 106 of 2007: European Communities (Drinking Water) Regulations 2007and S.I. No. 122 of 2014: European Communities (Drinking Water) Regulations 2014, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the "Drinking Water Directive") and EU Directive 2000/60/EC;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended by S.I. No. 389/2011; S.I. No. 149/2012; S.I. No. 366/2016; the Radiological Protection (Miscellaneous Provisions) Act 2014; and S.I. No. 366/2016); and,

- S.I. No. 296 of 2009: The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (as amended by S.I. No. 355 of 2018).

9.1.5 Relevant Guidance

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

- Environmental Protection Agency (2017): *Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;*
- Environmental Protection Agency (September 2015): *Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);*
- Environmental Protection Agency (2006): *Environmental Management in the Extractive Industry;*
- 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;*
- Department of Environment, Heritage and Local Government (2006): *Wind Energy Development Guidelines for Planning Authorities;*
- Inland Fisheries Ireland (2016): *Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;*
- Scottish Natural Heritage (2010): *Good Practice During Wind Farm Construction*;
- 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, 2006).
- *Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment* (DoHPLG, 2018); and,
- *Guidance on the preparation of the EIA Report* (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.2 Methodology

9.2.1 Desk Study

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

- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Cork-Kerry). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland (2003) – Groundwater Body Initial Characterization Reports;
- OPW Indicative Flood Maps (www.floodinfo.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.2 Baseline Monitoring and Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES in February 2020.

Geotechnical ground investigations and a peat stability assessment were undertaken by Gavin and Doherty Geosolutions Ltd (GDG) during January/February 2020. The combined geological and hydrogeological dataset collated by MKO, HES and GDG has been used in the preparation of this EIAR Chapter.

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

- Walkover surveys and hydrological mapping of the site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- A total of 230 peat probes were undertaken by MKO, GDG & HES to determine the thickness and geomorphology of the peat overlying the site;
- A Geotechnical and Peat Stability Assessment was undertaken by GDG (April 2020);
- A total of 20 no. gouge core sample points were undertaken by HES across the site to investigate peat and mineral soil lithology;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) and surface water flow measurements were taken to determine the origin and nature of surface water flows surrounding the site; and,
- A total of 4 no. surface water samples were taken to determine the baseline water quality of the primary surface waters originating from the Proposed Development site.

9.2.3 Impact Assessment Methodology

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

- In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity, which are defined in

Table 9-2, are used to assess the potential effect that the Proposed Development may have on them.

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

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

Sensitivity of Receptor	
	groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

9.2.4 Overview of Impact Assessment Process

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

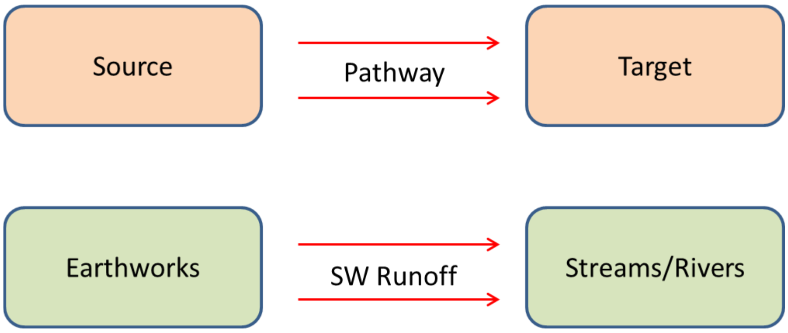


Plate 9-1 Source-Pathway-Target Model

As outlined previously, where potential impacts are identified, the classification of impacts in the assessment follows the descriptors set out in the Impact Classification Terminology (EPA, 2017) as outlined in Chapter 1 of this EIAR.

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5.2 and 9.5.3), we have presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process (Table 9-3). 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, operation and decommissioning activities.

Table 9-3: Impact Assessment Process Steps

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

9.3 Receiving Environment

9.3.1 Site Description and Topography

The proposed site is located west of the R584 adjacent to the rocky Pass of Keimaneigh which is situated approximately 6.5km to the northeast of Kealkill, Co. Cork. The Proposed Development site is a forested site with a total area of approximately 620ha. Access to the site is from the Pass of Keimaneigh itself which runs along the north-eastern boundary of the site. There is a network of existing access roads within the site from the previously existing wind farm development. The topography is mountainous in setting with various rocky peaks of the Shehy Mountains located to the east and west.

The site topography is characterised by a central north/south trending ridge line which slopes to the east and west. The highest point of the ridge is an approximately 350m OD which slopes steadily to approximately 150m OD within the confines of the proposed site. The majority of the Proposed Development infrastructure is located the western slopes of the central trending ridge line. Most of the site is forestry covered except on the eastern slopes of the central ridge with is dominated by shallow pockets of blanket bog and rocky outcrops which is typical of the local landscape.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall recorded at the Ballingeary (Tooreenaneen) rainfall station, located ~2.8km east of the site are presented in Table 9-4. This is the nearest and most appropriate station with respect topography and elevation.

Table 9-4 Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Ballingeary		200,400		216,000		37		1928		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
267	189	187	128	126	114	117	148	163	256	228	244	2,167

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Cork Airport, approximately 58km east of the site. The long-term average PE for this station is 512mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 486mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 2,167 mm/yr – 486mm/yr

ER = 1,681mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate of 100mm/year average annual recharge is given for this area (recharge coefficient of ~6%). This means that the hydrology of the site is characterised by very high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the site are estimated to be 100mm/yr and 1,581mm/yr respectively.

[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.

In addition to average rainfall data, extreme value rainfall depths are available from Met Éireann. A summary of various return periods and duration of rainfall depths for the area of the development site are presented in Table 9-5.

Table 9-5 Return Period Rainfall depths (mm)

	Return Period (Years)			
Storm Duration	1	5	30	100
5 mins	3.8	6.6	13.9	17.1
15 mins	6.2	10.9	19.5	28.0
30 mins	7.8	12.3	22.9	32.0
1 hour	10	16.2	26.8	36.5
6 hours	18.6	27.2	40.4	51.5
12 hours	23.6	33.3	47.3	58.9
24 hours	30	40.6	55.5	67.3
2 days	37.1	48.6	63.9	75.8

9.3.3 Regional Hydrology

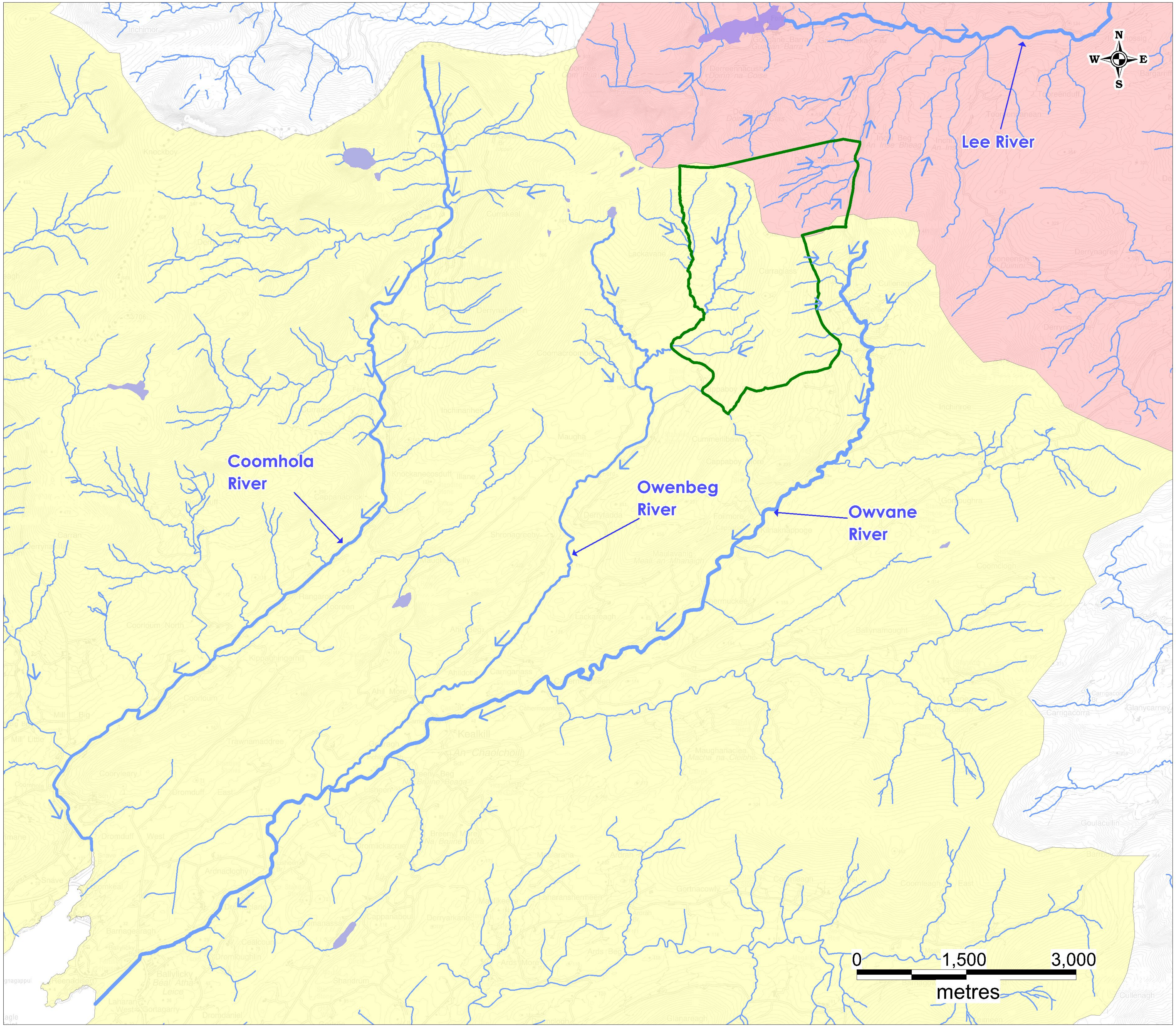
Regionally the southern section of the proposed site (including 6 no. of the proposed 7 no. turbines) is located in the Owvane River surface water catchment (IE21_02), while the northern section of the site (including 1 no. of the proposed 7 no. turbines) is located in the River Lee surface water catchment (IE19_01) within Hydrometric Area 21 of the South Western River Basin District. The Owvane River flows immediately to the southeast of the site and discharges into Bantry Bay approximately 11km to the southwest of the site. The River Lee flows easterly towards Lough Allua approximately 1.5km to the north of the site and then on towards Cork Harbour.

A regional hydrology map is shown as Figure 9-1

On a more local scale, the eastern half of the site within the Owvane River surface water catchment drains directly into the Owvane River itself which flows in a southerly direction immediately to the southeast of the site (there is no Proposed Development infrastructure in the south-eastern section of the site). The western half of the site within the Owvane River surface water catchment drains towards the Lackavane River which flows southerly along a section of the western boundary of the site.

The northern section of the site (which is located in the River Lee surface water catchment) drains directly via a small stream network into the River Lee upstream of Lough Allua.

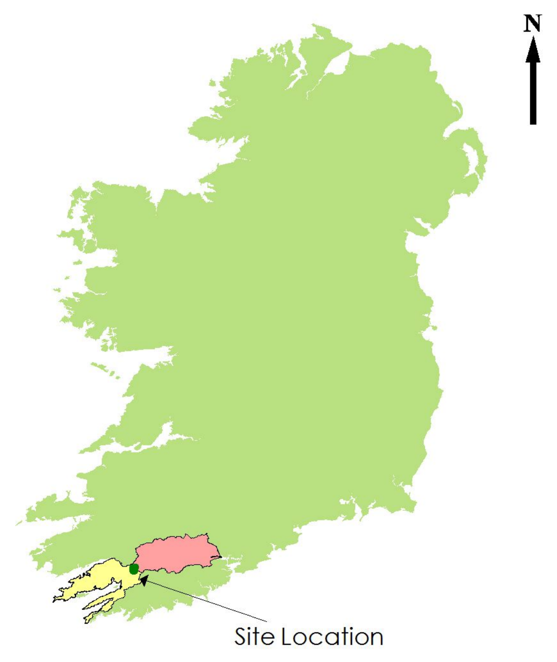
A local hydrology map is shown as Figure 9-2



Legend

- EIAR Site Boundary
- Existing Overhead Line to Ballylickey
- Rivers/Streams
- Flow Direction
- Lakes
- Owvane-Mealagh-Glengarriff-Coastal Catchment
- Lee Catchment

KEY PLAN



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Client: MKO

Job: Curraglass WF, Co. Cork

Title: Regional Hydrology Map

Figure No: 9-1

Drawing No: P1483-0-0620-A3-9-1-0A

Sheet Size: A3	Project No: P1483-0
Scale: 1:50,000	Drawn By: GD
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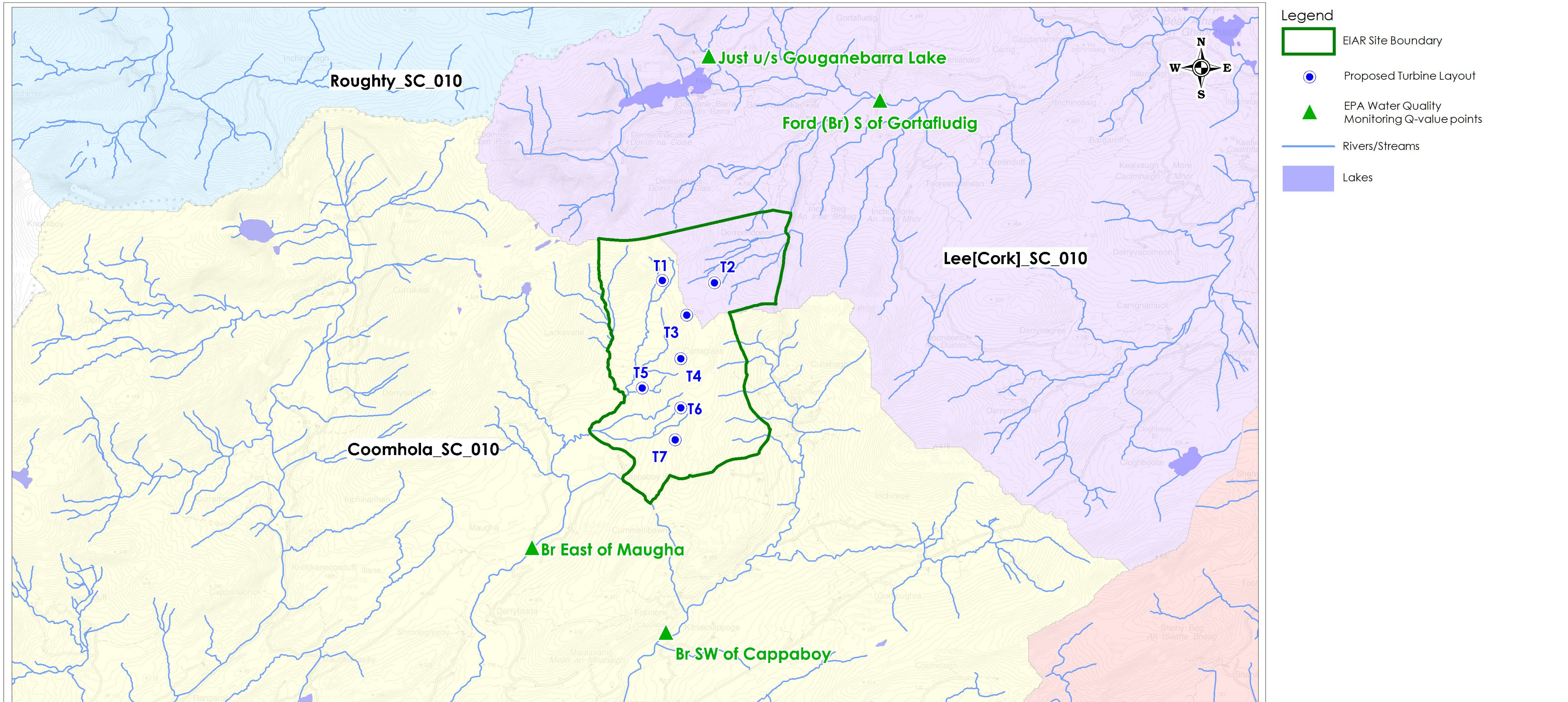

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Job: Curraglass WF, Co. Cork

Title: Local Hydrology Map

Figure No: 9-2

Drawing No: P1483-0-0460-A3-9-2-0A

Sheet Size: A3	Project No: P1483-0
Scale: 1:50,000	Drawn By: GD
Date: 24/06/2020	Checked By: MG

9.3.4 Site Drainage

The majority of the site drains to the Lackavane River (including the majority of the Proposed Development infrastructure) which flows along the western boundary of the site. Several headwater streams of the Lackavane River rise along the western facing slopes of the site and these streams flow steeply down towards the Lackavane River. These streams intercept many of the existing forestry roads and proposed access roads. Several headwater streams of the Owvane River flow off the steep rocky eastern facing slopes of the site. There is no Proposed Development in the south-eastern section of the site. A similar hydrology exists on the northern section of the site, where several small headwater streams of the River Lee flow from the northern facing slopes of the site.

An existing site drainage map is shown within Figure 9-3.

Within the Proposed Development site there are also numerous manmade drains that are in place predominately to drain the forestry plantations. The current internal forestry drainage pattern is influenced by the topography, peat subsoils, layout of the forest plantation and by the existing road network. The existing forest plantations within the EIAR site boundary (332ha), which cover ~53% of the study area (where deforestation has occurred forests drains still exist as before) are generally drained by a network of mound drains which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation.

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

The forestry drains are the primary drainage routes towards the natural streams on the development site, but the flows in these drains are generally very low. The integration of the existing main drains with the proposed wind farm drainage is a key component of the drainage design which is discussed further in Section 9.4.2 and Section 9.5.3.2 below.

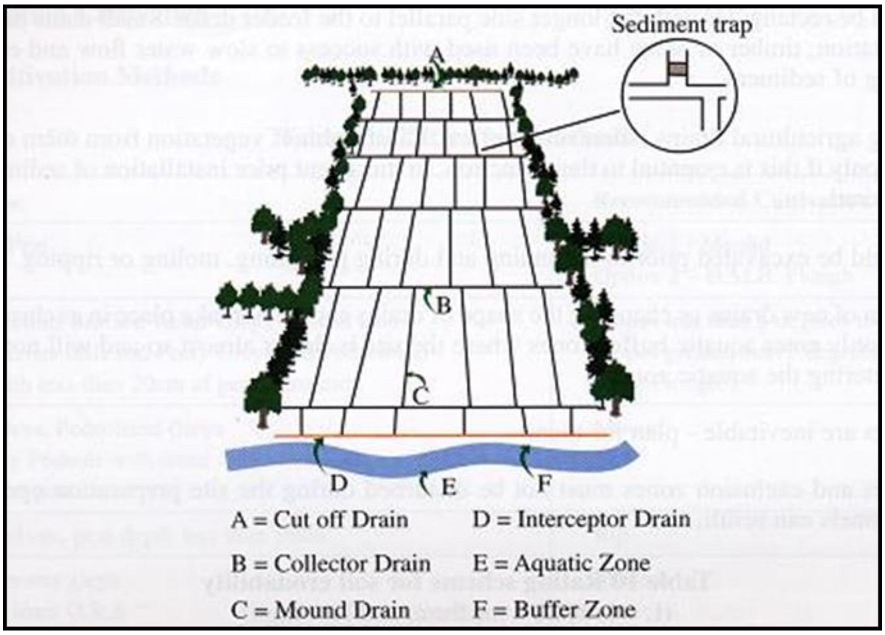
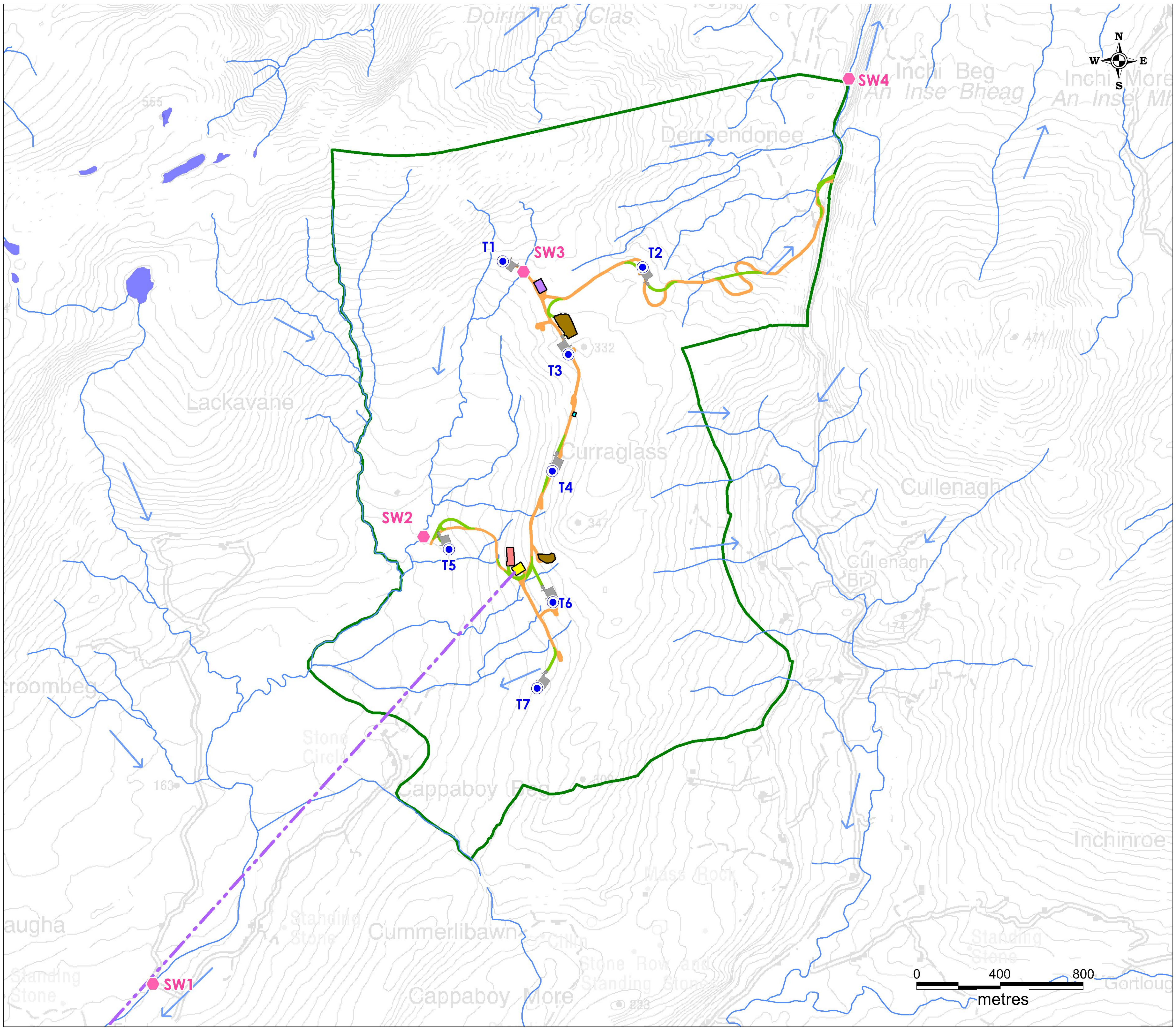


Plate 9-2 Existing Forestry Drainage Layout



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Existing Overhead Line to Ballylickey
- Current Substation Location
- Proposed Substation
- Proposed Temporary Construction Compound
- Proposed Borrow Pits
- Proposed Met Mast Location
- Proposed Hardstanding
- Proposed New Site Roads
- Existing Roads - Upgrade Proposed
- Rivers/Streams
- Flow Direction
- Lakes
- SW Monitoring Locations

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Figure No: 9-3	
Drawing No: P1483-0-0620-A3-9-3-0A	
Sheet Size: A3	Project No: P1483-0
Scale: 1:17,500	Drawn By: GD
Date: 24/06/2020	Checked By: MG

9.3.5 Baseline assessment of site runoff

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

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

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-6). It represents, therefore, the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the site pre-wind farm development. The surface water runoff co-efficient for the site is estimated to be 94% (refer to Section 9.3.2).

The highest long-term average monthly rainfall recorded at Ballingeary over 30 years occurred in the month of January, at 267mm. The average monthly evapotranspiration for the synoptic station at Cork Airport over the same period in December was 5.1mm. The water balance presented in

Table 9-7 indicates that a conservative estimate of surface water runoff for the site during the highest rainfall month is 1,525,102m^3/month or 49,294m^3/day for the Proposed Development site.

Table 9-6: Water Balance and Baseline Runoff Estimates for Wettest Month (January)

Water Balance Component	Depth (m)
Average January Rainfall (R)	0.267
Average January Potential Evapotranspiration (PE)	-0.0051
(AE = PE x 0.95)	-0.0048
Effective Rainfall December (ER = R - AE)	0.262
Recharge (6% of ER)	0.016
Runoff (94% of ER)	0.246

Table 9-7: Baseline Runoff for the Site

Study Area	Approx. Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
Development Site	620	1,525,102	49,294

9.3.6 Flood Risk Assessment

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

No recurring flood incidents within the site boundary were identified from OPW's Flood Hazard Mapping - Refer to Plate 9-3.

The closest mapped recurring flood event is 5km downstream of the site on the River Lee. There is also a recurring flood event mapped 10km downstream of the site on the Owvane River.

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

Where complete, the CFRAM OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the PFRA maps. The PFRA maps are no longer publicly available

The Proposed Development site is not identified on the CFRAM flooding fluvial extent mapping, dated February 2015 as being located in either Flood Zone A or B. Therefore, according to CFRAMs the Proposed Development is located in Flood Zone C, where the probability of flooding is low. This suggests that the site is suitable for the Proposed Development in terms of flood risk.

Due to the elevated (above local major watercourses) and sloping nature of the proposed site there is a low risk of both pluvial and fluvial flooding at the Proposed Development areas.

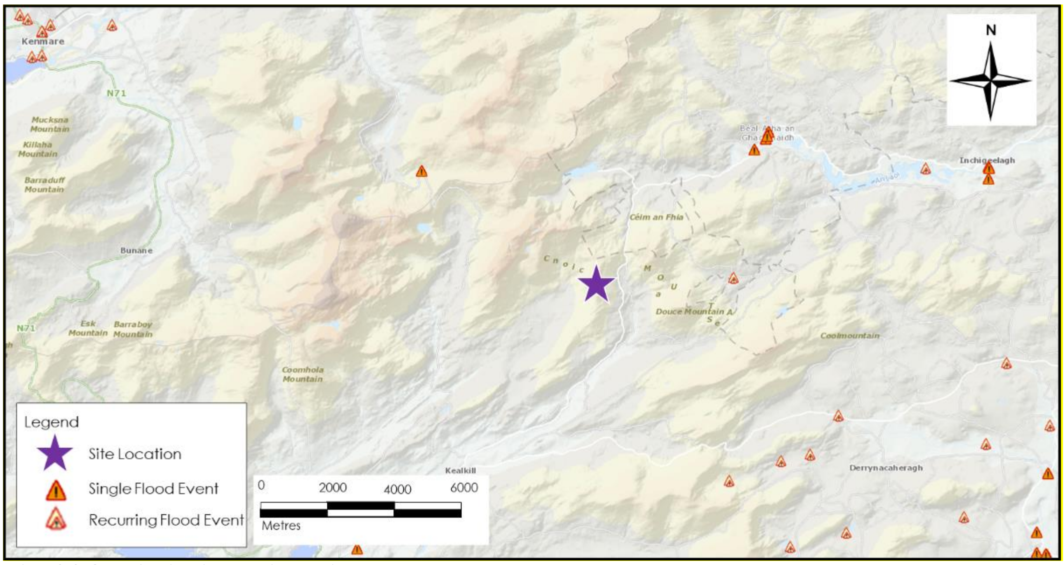


Plate 9-3 OPW's Flood Hazard Mapping

9.3.7 Surface Water Quality

Biological Q-rating data for EPA monitoring points on the Lackavane River, Owvane River and River Lee are shown in Table 9-8 below. Most recent data available (2004 to present) show that the Q-rating for the rivers is mainly 'High' downstream of the Proposed Development site.

Table 9-8:EPA Water Quality Monitoring Q-Rating Values

Waterbody	Station ID	Easting	Northing	EPA Q-Rating Status
Lackavane	Br East of Maugha	107120	60140	High
Lackavane	Br u/s of Owvane confluence	104410	56750	High
Owvane	Br NE of Kealkill	104840	56580	Good
Owvane	Br SW of Cappaboy	108840	59050	Good
Owvane	Piersons Bridge	102390	54480	High
Lee	Just u/s Gouganebarra Lake	109390	66450	High
Lee	Ford (Br) S of Gortafludig	111590	65880	High

Field hydrochemistry measurements of electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken within surface watercourses downstream of the Proposed Development (refer to Figure 9-3 for locations). The results are listed (along with estimated flows) in Table 9-9. The monitoring locations are mainly upstream and downstream of the site on the Lackavane River as this is where most of the Proposed Development drains to. The field measurements were made on 11th February 2020.

Electrical conductivity (EC) values at the monitoring location ranged between 80 and 96µS/cm which indicates the flow mainly comprises of surface water runoff from the peat / rocky surface.

The pH values were generally slightly acidic, ranging between 6.7 and 6.9. Slightly acidic pH values of surface waters would be typical of peatland environments due to the decomposition of peat.

Table 9-9: Field Parameters - Summary of Surface Water Chemistry Measurements

Location ID	Easting	Northing	Temp °C	EC (µS/cm)	pH	Flow (L/s)
SW1	107,117	60,124	3.2	80	6.9	200
SW2	108,413	6,2267	3.3	92	6.7	80
SW3	108,893	6,3537	3.2	85	6.9	25
SW4	110451	6,4461	3.1	96	6.9	35

Surface water samples were also taken at these monitoring points for laboratory analysis on 11th February 2020. Results of the laboratory analysis are shown alongside relevant water quality regulations in

Table 9-10 below.

In addition, the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272 of 2009) (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) are shown in Table 9-11. Original laboratory reports are attached as Appendix 9-1.

Table 9-10: Analytical Results of HES Surface Water Samples (11/02/2020)

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(*)	0.04	0.02	0.02	0.04
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05
Nitrate NO_{23} (mg/L)	-	<5	<5	<5	<5
Ortho-Phosphate – P (mg/L)	-≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02
Nitrogen (mg/L)	-	<1	<1	<1	<1
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1	<0.1
Chloride (mg/L)	-	21.4	21.7	25.5	22.5
BOD	≤ 1.3 to ≤ 1.5(*)	<2	<2	<2	<2

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

Total suspended solids were <5mg/L in all samples which is below the European Communities (Quality of Salmonid Waters) Regulation value (S.I. No. 293 of 1988) of 25mg/L.

Results for nitrate, nitrite, nitrogen, phosphorus and orthophosphate were at or below the detection limit of the laboratory (i.e. very low levels).

Ammonia ranged between 0.02 and 0.04mg/L which is below the "High Status" with respect the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. 272 of 2009). Ortho-Phosphate was below 0.02mg/L in all samples which is also below the "High Status" threshold.

BOD was reported as less than 2mg/L which is the laboratory detection limit.

*Table 9-11: Chemical Conditions Supporting Biological Elements**

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

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

9.3.8 Hydrogeology

The Devonian Old Red Sandstones (ORS) which underlie the Proposed Development site are predominately classified by the GSI (www.gsi.ie) as a Locally Important Aquifer (Ll), having bedrock which is moderately productive only in local zones.

The sandstones of this area have no inter-granular permeability; groundwater flow occurs in fractures and faults; in-filling of fractures is to be expected. The permeability of individual fractures and the degree of interconnection will be generally low, with fracturing confined to local zones. Permeability is highest in the upper few metres but generally decreases rapidly with depth. In general, groundwater flow is concentrated in the upper 15m of the aquifer, although deeper inflows from along fault zones or connected fractures can be encountered. Significant yields can be obtained where boreholes are drilled into known fault zones. In these rocks groundwater flow paths are expected to be relatively short, typically from 30-300m, with groundwater discharging to small springs, or to the streams that traverse the aquifer. Flow directions are expected to approximately follow the local surface water catchments (GSI, 2004).

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

Local groundwater flow directions will mimic topography closely whereby flow paths will be from topographic high points to lower elevated discharge areas at local streams, such as the watercourses immediately to the east and west of the site. The majority of the groundwater flowpaths in the areas proposed for development are expected to flow westerly towards the Lackavane River.

9.3.9 Groundwater Vulnerability

The vulnerability of the aquifer underlying the site is classified as predominately "Extreme" by the GSI (www.gsi.ie). This is consistent with site observations and the site investigation data (the higher the vulnerability rating is a reflection of how close bedrock is to the ground surface).

All proposed infrastructure appears to be located in areas of "Extreme" vulnerability (i.e. <3m peat and subsoil combined)(GSI, 1999). However, due to the low permeability nature of the bedrock aquifer underlying the site, groundwater flow paths are likely to be short, with recharge emerging close by at seeps and surface streams. This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore making surface water bodies more vulnerable than groundwater at this site.

9.3.10 Groundwater Hydrochemistry

There is no groundwater quality data for the Proposed Development site and groundwater sampling would generally not be undertaken for this type of development, as groundwater quality impacts would not be anticipated given the low potential for groundwater dispersion and movement within the aquifer as outlined in the preceding section.

Based on data from GSI on the Beara Sneem GWB, types of rocks groundwater alkalinity ranges between 10-300mg/L (as $CaCO_3$) and hardness ranges between 40-220mg/L (moderately soft to moderately hard). In general, these sandstone formations largely contain calcium bicarbonate type water. Conductivities in these units are relatively low, ranging between 125-600µS/cm, with an average of approximately 300µS/cm. In general, high iron (Fe) and manganese (Mn) concentrations can occur in groundwater derived from sandstones and mudstones, due to the dissolution of Fe and Mn from the sandstone/shale where reducing conditions occur (GSI, 2004).

9.3.11 Water Framework Directive Water Body Status & Objectives

The River Basin Management Plan was adopted in 2018 and has amalgamated all previous river basin districts into one national river basin management district. The River Basin Management Plan (2018 - 2021) objectives, which have been integrated into the design of the proposed wind farm development, include the following:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2021;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objectives and (2) addressing more complex issues that will build knowledge for the third cycle.

Our understanding of these objectives is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all.

Strict mitigation measures (refer to Section 9.5.2 and 9.5.3) in relation to maintaining a high quality of surface water runoff from the development and groundwater protection will ensure that the status of both surface water and groundwater bodies in the vicinity of the site will be maintained (see below for WFD water body status and objectives) regardless of their existing status.

9.3.12 Groundwater Body Status

Local Groundwater Body (GWB) and Surface water Body (SWB) status reports are available for review from (www.catchments.ie)

The Beara Sneem GWB (IE_SW_G_019) underlies most of the development site. This GWB is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB. The Ballinhassig _2 GWB (IE_SW_G_005) underlies the extreme west of the site and is also assigned 'Good Status'.

9.3.13 Surface Water Body Status

A summary of the EPA/WFD status and risk result of Surface Water Bodies (SWBs) in which development is proposed (or immediately upstream of) is shown below.

The southwestern section of the site (majority of the site) drains to the Owenbeg (Owvane)_010 surface water body which achieved 'High' status under the WFD 2013-2018. The upper reaches of the Owvane River (Owvane(Cork)_010) in the area of the site also achieved 'High' status.

However, further downstream the status of the Owvane River (Owvane (Cork)_020) reduces to 'Good'. The Lee (Cork)_010 surface water body to which the northern section of the site drains achieved 'High' status under the WFD 2013-2018.

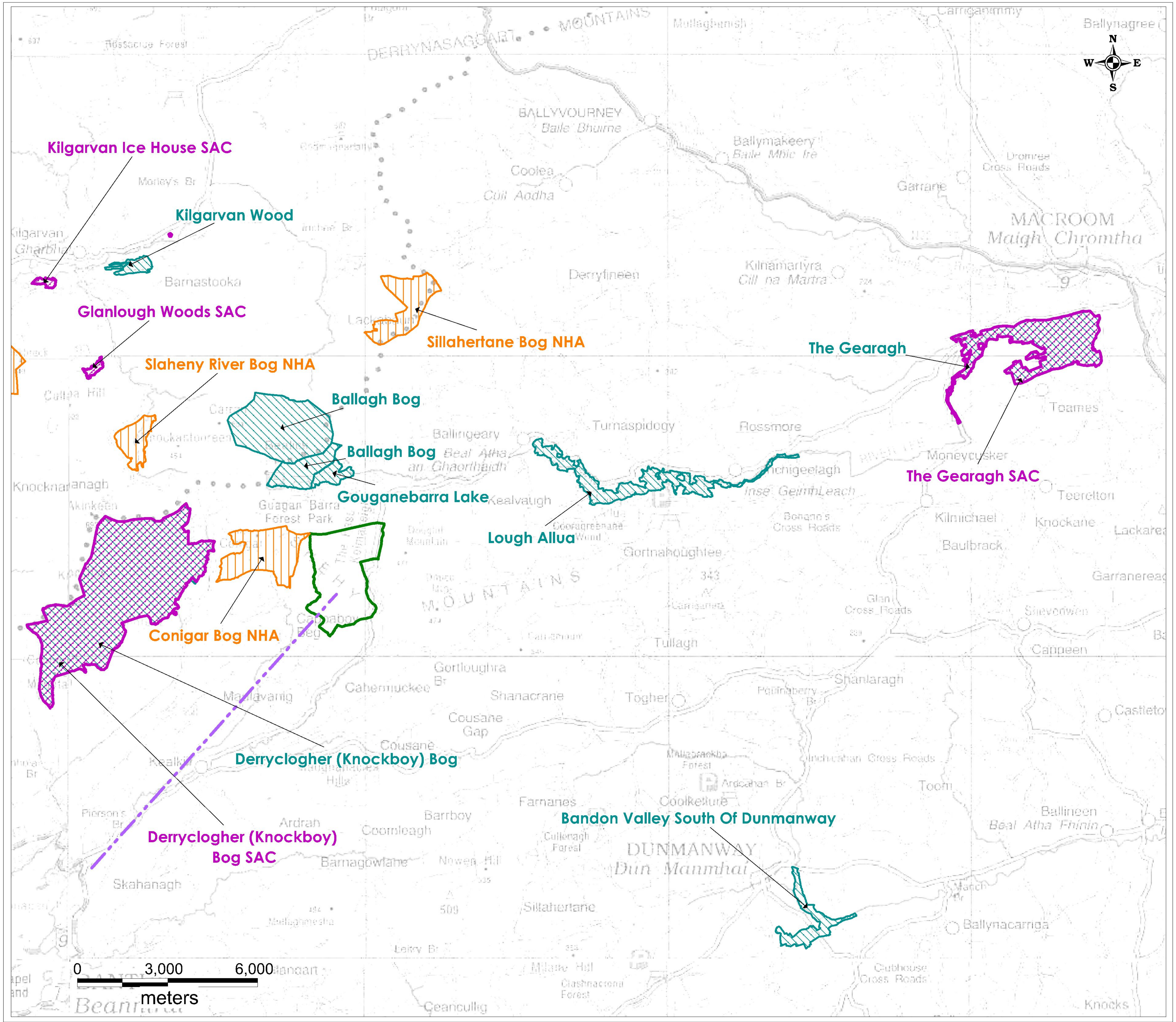
9.3.14 Designated Sites and Habitats

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), candidate Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). Designated sites within the same surface water catchments as the Proposed Development site are listed below:

- Conigar Bog NHA (Site Code: 002386), is located approximately 5m to the west of the EIAR Site Boundary;
- Lough Allua pNHA (Site Code: 001065), is located approximately 5.5km to the east of the EIAR Site Boundary;
- Gouganebarra Lake pNHA (Site Code: 001057), is located approximately 1.5km to the north of the EIAR Site Boundary;
- Derryclogher (Knockboy) Bog SAC (Site Code: 001873), is located approximately 4km to the west of the EIAR Site Boundary;
- The Gearagh SAC (Site Code: 000108), is located approximately 19.4km (over 24km hydrological distance) to the northeast of the EIAR Site Boundary.

A summary of potential hydrological pathways (surface water connections) and hydrogeological pathways (groundwater connections) is included below as Table 9-12.

Designated sites in proximity to the Proposed Development site are listed below and shown on Figure 9-4. Other sites, outside of those listed above are considered to be remote from the Proposed Development, and as such due to physical and hydrological/hydrogeological separation cannot be affected (from a water perspective) by the Proposed Development. An impact assessment of these remaining listed sites is completed below at Section 9.5.2.8.



Legend

- EIAR Site Boundary
- Existing Overhead Line to Ballylickey
- SAC
- NHA
- pNHA

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Client: MKO	
Job: Curraglass WF, Co. Cork	
Title: Designated Sites Map	
Figure No: 9-4	
Drawing No: P1483-0-0620-A3-9-4-0A	
Sheet Size: A3	Project No: P1483-0
Scale: 1:120,000	Drawn By: GD
Date: 24/06/2020	Checked By: MG

Table 9-12: Relative distances and connectivity to designated sites

Designated Site	Distance to European Site	Hydrological connectivity to European Sites	Groundwater connectivity to Designated / European Sites
Conigar Bog NHA	~5 m	No, there is no surface water drainage from the development towards Conigar Bog	No, Conigar Bog NHA is separated from the proposed site by the Lackavane River valley and therefore there is no groundwater connectivity
Gouganebarra Lake pNHA	~1.5km	No, there is no surface water drainage from the development into Gouganebarra	No, Groundwater flow is expected to mimic surface water flow and therefore no groundwater connectivity is expected between the pNHA and the proposed site
Lough Allua pNHA	~5.5km	Yes, the northern section of the Proposed Development site (1 no. turbine) drains to Lough Allua	Yes (indirect), Groundwater flow from the Proposed Development site is expected to emerge as surface water flow in the River Lee prior to reaching Lough Allua
Derryclogher (Knockboy) Bog SAC	~4km	No, there is no surface water drainage from the development towards Derryclogher (Knockboy) Bog	No, Derryclogher (Knockboy) Bog SAC is separated from the proposed site by the Lackavane River valley and the Coomhola River valley therefore there is no groundwater connectivity
The Gearagh SAC	19.4km	Yes, the northern section of the Proposed Development site (1 no. turbine) drains into the River Lee along which the The Gearagh is located	Yes (indirect), Groundwater flow from the Proposed Development site is expected to emerge as surface water flow in the River Lee prior to reaching The Gearagh.

9.3.15 Water Resources

There is 1 no. mapped PWS (Carranadouraig Public Water Supply Scheme) within 10km of the site. This PWS is located 6km northeast of the site, approximately 2 km north of Ballingeary. The mapped source protection zone for this GWS does not fall within the Proposed Development site boundary.

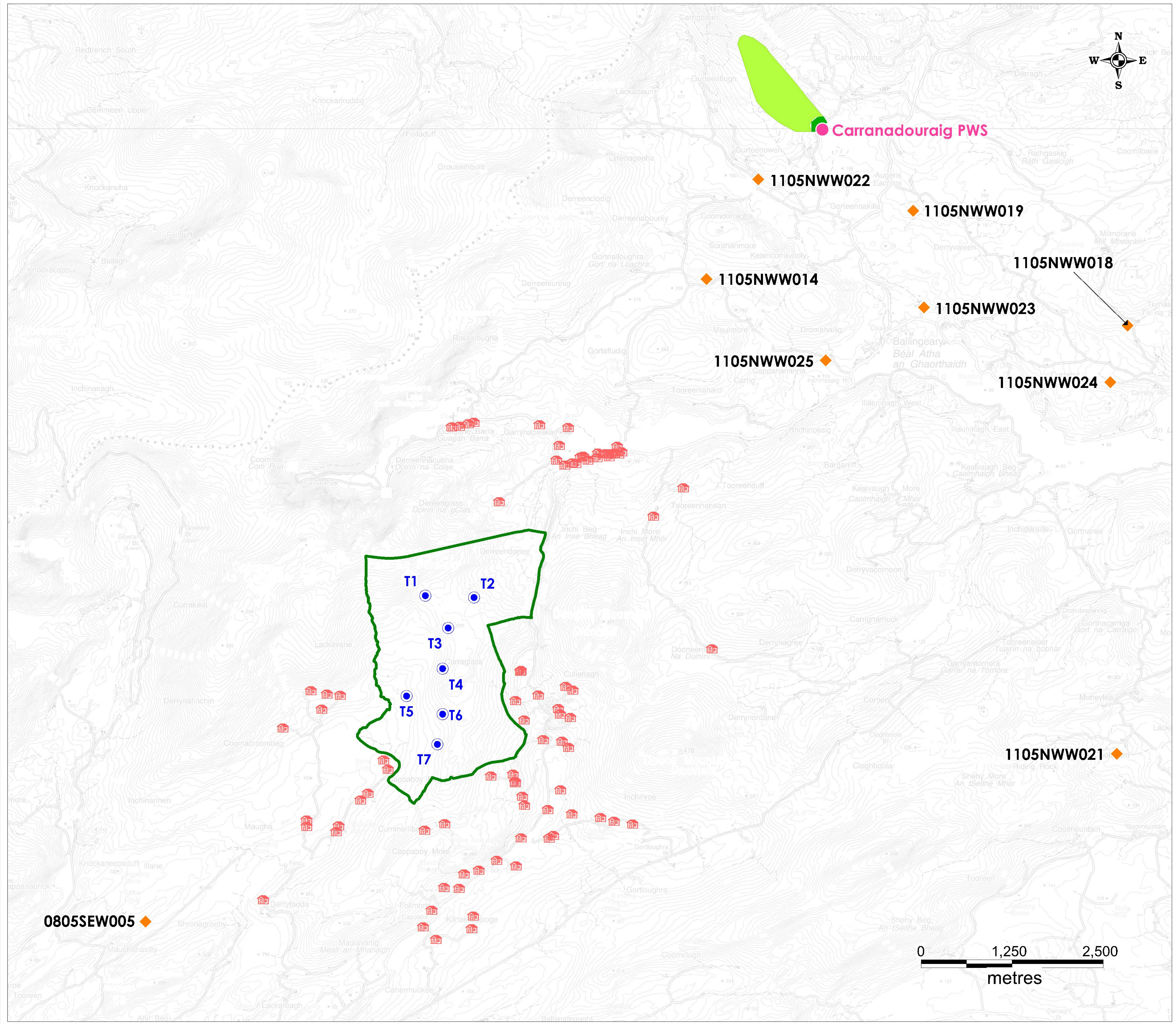
A search of private well locations was undertaken using the GSI well database (www.gsi.ie). 1 no. well with an accuracy of 1–50m was mapped within 2km of the Proposed Development site, which was mapped as belonging to private dwelling/farm. This well is not located down-gradient of the Proposed Development.

To overcome the poor accuracy problem of other GSI mapped wells (>50m accuracy) it is conservatively assumed (for the purpose of assessment only) that every private dwelling in the area (shown on Figure 9-5) has a well supply and this impact assessment approach is described further below in the impact and mitigation section. (Please note wells may or may not exist at each property, but our conservative rationale here is that it is better to assume a well may exist at each downgradient property and assess the potential impacts from the Proposed Development on such assumed wells, rather than make no assessment and find out later that groundwater wells do actually exist).

The majority of the private dwellings are located along the R584 to the east of the site, with others sporadically distributed along minor roads to the west/southwest of the site. The impact of potential wells at these houses is assessed in Section 9.5.2.9 below.

Based on the EPA water abstraction register, there are no registered surface water abstractions downstream of the site in the Owvane River or River Lee catchments.

A Public and Private Water Supply map for the wind farm site is shown as Figure 9-5.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Private Well Locations
- GSI Mapped Wells (<50m accuracy)
- Carranadouraig Public Water Supply
- ZOC SI
- ZOC SO

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Client: MKO	
Job: Curraglass WF, Co. Cork	
Title: Public and Private Water Supply Map	
Figure No: 9-5	
Drawing No: P1483-0-0620-A3-9-5-0A	
Sheet Size: A3	Project No: P1483-0
Scale: 1:50,000	Drawn By: GD
Date: 24/06/2020	Checked By: MG

9.3.16 Receptor Sensitivity

Due to the nature of wind farm developments, being near surface construction activities, impacts on groundwater are negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risks to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages, potential piling works, and construction of the proposed underpasses. These potential significant effects are assessed in Section 9.5.2 and Section 9.5.3. Some of these are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources will be carefully managed at the site during the construction and operational phases of the development and mitigation measures are proposed below (Section 9.5.2 and Section 9.5.3) to deal with these potential impacts.

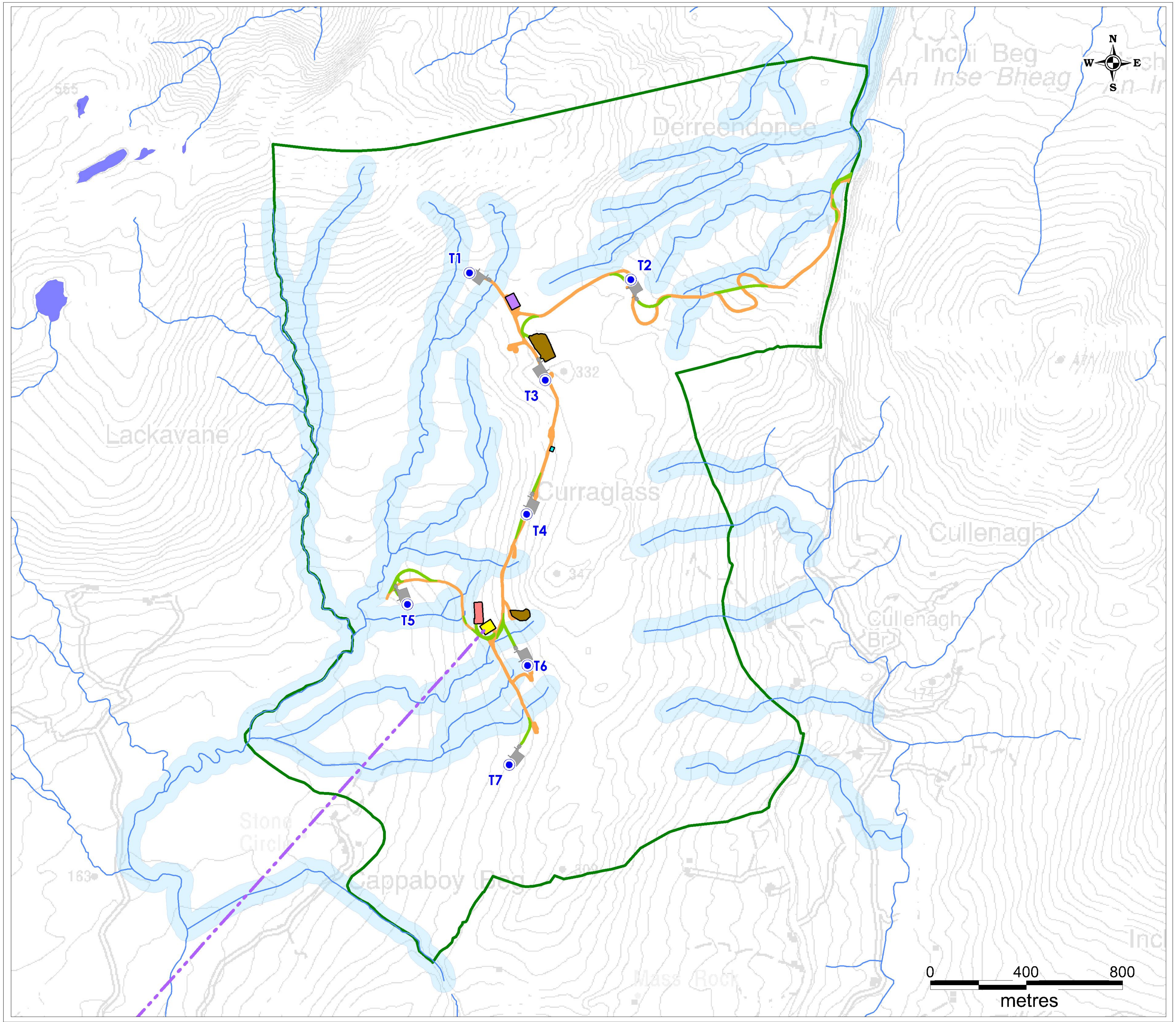
Based on criteria set out in

Table 9-2 above, the Locally Important Aquifer can be classed as Sensitive to pollution. However, due to the presence of the peat and silt/clay layers (which have low permeability and act as a barrier to infiltration), any contaminants which may be accidentally released on-site are more likely to travel to nearby streams within surface runoff. Based on the local hydrogeology and setback distance from the development, local wells are considered to be Not Sensitive to impact.

Downstream designated sites such as The Gearagh SAC and Lough Allua pNHA can be considered Very Sensitive.

A hydrological constraints map for the wind farm site is shown as Figure 9-6. A self-imposed 50m buffer from streams was applied where possible during the project design and constraints mapping and will be maintained during the construction phase. Apart from sections of the proposed access tracks, junction upgrades, upgrading of the existing watercourse crossing, new stream/drain crossing and the south-eastern edge of borrow pit no. 2, the majority of the Proposed Development areas (including all turbine locations) are located outside of areas that have been assessed to be hydrologically sensitive. The new crossing is along the access track to T6 and will consist of a culvert.

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downstream receiving waters. Mitigation measures will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the site will mimic the existing drainage regime (refer to Section 9.5.3.1).



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Existing Overhead Line to Ballylickey
- Current Substation Location
- Proposed Substation
- Proposed Temporary Construction Compound
- Proposed Borrow Pits
- Proposed Met Mast Location
- Proposed Hardstanding
- Proposed New Site Roads
- Existing Roads - Upgrade Proposed
- Rivers/Streams
- 50m River Buffer
- Lakes

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Client: MKO	
Job: Curraglass WF, Co. Cork	
Title: Hydro-Constraints Map	
Figure No: 9-6	
Drawing No: P1483-0-0620-A3-9-6-0A	
Sheet Size: A3	Project No: P1483-0
Scale: 1:15,000	Drawn By: GD
Date: 24/06/2020	Checked By: MG

9.4 Characteristics of the Proposed Development

The Proposed Development comprises 7 no. wind turbines, 1 no. anemometry masts, new and upgraded site access roads, a substation and battery storage, an associated connection to the national grid, a temporary construction compound and 2. No borrow pits.

During the delivery of turbines, there is a requirement for temporary works along the proposed turbine delivery route. The proposed turbine turning area along the R584, will be temporarily upgraded during the delivery of turbines to facilitate a reversing manoeuvre. Furthermore, the existing site entrance will be upgraded to facilitate the delivery of the construction materials and oversized loads.

A full description of the Proposed Development is included in Chapter 4 of this EIAR.

9.4.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Development. The first method involves 'keeping clean water clean' by avoiding disturbance to existing drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards new proposed silt traps and settlement ponds (or stilling ponds) prior to controlled diffuse release into the existing drainage network. There will be no direct discharges to the existing drains.

During the construction phase, all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as Plate 9-4 below. A detailed drainage plan showing the layout of the proposed drainage design elements during construction and operation is shown in Appendix 4-1 of the EIAR.

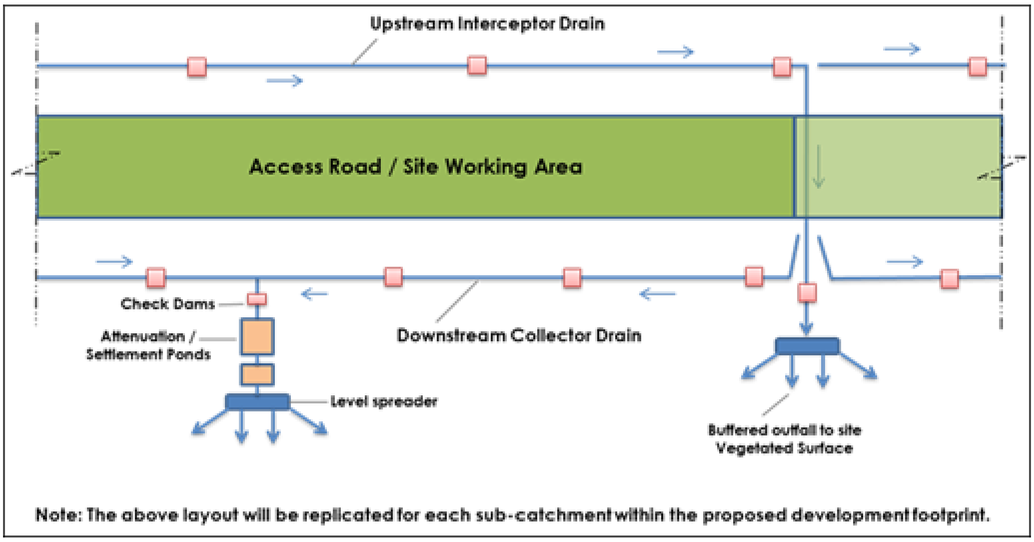

Plate 9-4 Schematic of Proposed Site Drainage Management

9.4.2 Development Interaction with the Existing Forestry Drainage Network

In relation to hydrological constraints, a self-imposed buffer zone of 50m has been put in place for on-site streams and rivers. Manmade forestry drains at the site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.

The general design approach to wind farm layouts in existing forestry is to utilizes and integrate with the existing forestry infrastructure where possible, whether it be existing access roads, or the existing forestry drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations, which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing forestry drains have no major ecological or hydrological value and can be readily integrated into the proposed wind farm drainage scheme using the methods outlined below (Section 9.5.3.1 and Section 9.5.4.1).

9.5 Likely Significant Effects and Associated Mitigation Measures

9.5.1 Do -Nothing Scenario

If the Proposed Development were not to proceed, no changes would be made to the current land-use practice of forestry and the site would continue to be managed under the existing commercial forestry arrangements.

The hydrology of the site would remain largely as it is described in the baseline characterisation.

9.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

9.5.2.1 Clear Felling of Coniferous Plantation

It is estimated that 41.32 (hectares) in total of existing plantation forestry will be felled to allow for development of the proposed infrastructure. This includes 11.73ha that will be permanently felled, 4.59ha that will be temporarily felled, as well as 25ha that will be felled for turbulence purposes.

The total amount to be felled accounts for ~12% of the forestry coverage at the site (332ha).

Potential impacts during tree felling occur mainly from:

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

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters and associated dependant ecosystems.

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

Proposed Mitigation Measures:

Best practice methods relating to water protection incorporated into the forestry management and mitigation measures (listed below) have been derived from:

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

Mitigation by Avoidance:

There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "*Forestry and Water Quality Guidelines*" are shown in Table 9-13.

Table 9-13 : Minimum Buffer Zone Widths (Forest Service, 2000)

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

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

The large distance between most proposed felling areas (which are outside the 50m buffer zone) and sensitive aquatic zones means that potential poor quality runoff from felling areas will be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes.

The following additional mitigation measures will be employed during tree felling. Additional measures are indicated for felling inside the 50m buffer zone.

Mitigation by Design:

Mitigation measures which will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses comprise best practice methods (from the guidance listed above) which are set out as follows:

- Machine combinations (i.e. hand held or mechanical) will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Trees will be cut manually inside the 50m buffer and using machinery to extract whole trees only;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;

- In areas particularly sensitive to erosion or where felling inside the 50 metre buffer is required, it will be necessary to install double or triple sediment traps;
- Double silt fencing will also be put down slope of felling areas which are located inside the 50 metre buffer zone;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50 metre watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- No crossing of streams by machinery will be permitted and only travel perpendicular to and away from stream will be allowed;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- A permit to refuel system will be adopted at the site; and,
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

Silt Traps:

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

Drain Inspection and Maintenance:

The following items shall be carried out during pre-felling inspections and after:

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

Surface Water Quality Monitoring:

Sampling will be completed before, during (if the operation is conducted over a protracted time) and after the felling activity. The 'before' sampling will be conducted within 4 weeks of the felling activity, 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). The felling surface water monitoring data will also be compared with the EIAR baseline water quality sampling data.

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

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

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

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and best practice measures with regard tree felling to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is assessed to be Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality and aquatic habitats.

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

9.5.2.2 Earthworks Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities including access road construction, junction upgrade works, turbine base/hardstanding construction, construction compound construction, met mast construction, substation and battery storage construction, cable route works and temporary works along the turbine delivery route, will require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. Potential sources of sediment-laden water include:

- Drainage and seepage water resulting from excavations;
- Stockpiled excavated material providing a point source of exposed sediment; and,
- Erosion of sediment from emplaced site drainage channels.

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and associated dependent ecosystems.

Pre-Mitigation Potential Impact: Negative, significant, indirect, temporary, medium probability effect.

Proposed Mitigation by Avoidance:

The key mitigation measure during the construction phase is the avoidance of sensitive hydrological features where possible, by application of suitable buffer zones (i.e. 50m to main watercourses). The majority of the key Proposed Development areas are located away from the delineated 50m watercourse buffer zones with the exception of the upgrading of the existing watercourse crossing, new stream/drain crossing, upgrades to existing site access tracks, junction upgrades and the south-eastern edge of borrow pit no. 2. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

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

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

Proposed Mitigation by Design:

Presented below are temporary and long-term drainage control measures that will be utilised during the construction phase of the development. As stated above there is an existing forestry drainage network at the site. The measures outlined below will be used in conjunction with the existing drainage network to ensure protection of all rivers and streams downstream of the Proposed Development site.

Source controls:

- Interceptor drains, vee-drains, diversion drains.
- Small working areas, covering temporary stockpiles, weathering off of side-cast peat/spoil and cessation of works.

In-Line controls:

- Interceptor drains, vee-drains, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriates systems.

Treatment systems:

- Temporary sumps and attenuation ponds, temporary storage lagoons, sediment traps, and settlement ponds, and proprietary settlement systems such as “Siltbuster”, and/or other similar/equivalent or appropriate systems.

There is an extensive network of drains already existing at the site, and these will be integrated and enhanced as required and used within the wind farm development drainage system. The key elements being the upgrading and improvements to water treatment elements, such as in-line controls and treatment systems, including silt traps and settlement ponds.

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system, there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the construction phase of the wind farm, runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged

locally at each turbine location through stilling ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site; and,
- Drains running parallel to the existing roads that requiring widening will be upgraded, widening will be targeted to the opposite side of the road. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

Water Treatment Train

If the discharge water from construction areas fails to be of a high quality during the daily inspections then a filtration treatment system (such as a 'siltbuster' or similar equivalent treatment train (sequence of water treatment processes)) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase. A water treatment train will be employed at borrow pit no. 2 which is partially located inside a 50m buffer zone. No runoff will be permitted from the borrow it towards the local stream.

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 the existing drainage network 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 placed downstream of works inside the 50m buffer zone such as the borrow pit no. 2 location.

Silt Bags:

Silt bags will be used where small to medium volumes of water need to be pumped from excavations (e.g. the proposed underpass locations). As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through.

Proposed Crossings:

The proposed new access track to Turbine no. 6 will traverse a forestry drain as part of providing access to the turbine area. The crossing of this drain will be completed using a culvert system. During the proposed new crossing works, the follow mitigation measures will be employed:

- Near stream/drain construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "*Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas; and,
- All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Pre-emptive Site Drainage Management:

The works programme for the construction stage of the development will also take account of weather forecasts and predicted rainfall in particular. Large excavations and movements of peat/subsoil or peat stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

The following forecasting systems are available and will be used on a daily/weekly basis, as required, to allow site staff to direct proposed and planned construction activities:

- General Forecasts: Available on a national, regional and county level from the Met Éireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3-hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Éireann 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 Éireann 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 planned works to be safely executed (from a water quality perspective) in the event of forecasting of an impending high rainfall intensity event.

Earthworks will be suspended if forecasting suggests any of the following is likely to occur:

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

Prior to earthworks being suspended the following control measures will be completed:

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

Management of Runoff from Peat and Subsoil Storage Areas:

It is proposed that excavated peat will be used for landscaping throughout the site and any excess peat will be used to reinstate the 2 no. proposed borrow pits. As stated above borrow pit no. 2 is partially located inside a 50m stream buffer, but there will be no drainage from the borrow pit towards the stream as all runoff and seepages will be contained within and treated prior to controlled realise away from the local stream.

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

Drainage from peat reinstatement areas will ultimately be routed to an oversized swale and a number of stilling ponds pond and a 'Siltbuster', with appropriate storage and settlement designed for a 1 in 100 year 6 hour return period, before being discharged to the on-site drains.

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

Timing of Site Construction Works:

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

Proposed Drainage and Water Quality Monitoring

An inspection and maintenance plan for the on-site drainage system will be prepared in advance of commencement of any works and will be included in the CEMP. 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 at dams, the settlement ponds, or any other drainage features that may decrease the effectiveness of the drainage feature, will be inspected daily and removed.

During the construction phase field testing (visual, supplemented with pH, electrical conductivity, temperature, dissolved oxygen and turbidity monitoring), sampling and laboratory analysis of a range of parameters[2] with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (i.e. weekly, monthly and event-based).

Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is assessed to be - Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality and aquatic habitats.

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

9.5.2.3 Potential Impacts on Groundwater Levels during Excavation Works

Dewatering of borrow pits (if required) and other deep excavations (i.e. turbine bases) have the potential to impact on local groundwater levels. However, temporary reductions in groundwater levels by temporary dewatering will be very localised and of small magnitude due to the nature and permeability of the local peat and subsoil geology, which comprises moderate to low permeability substrate.

Pathway: Groundwater flow paths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Impact: Slight, indirect, temporary, low probability effects on local groundwater levels.

Proposed Mitigation Measures by Design:

The proposed borrow pits (2 no.) are located in bedrock which is generally unproductive. No groundwater dewatering will be required as rock excavation will progress in a horizontal manner into the side of outcropping bedrock.

[2] example suite: pH (field measured), Electrical Conductivity (field measured), temperature (field measured), Dissolved Oxygen (field measured), Turbidity (NTU) (sonde measured), Flow (m/s), Total Suspended Solids (mg/l), Ammonia, Nitrite (NO_2) (mg/l), Ortho-Phosphate (P) (mg/l), Nitrate (NO_3) (mg/l), Phosphorus (unfiltered) (mg/l), Chloride (mg/l), and BOD (mg/l).

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

- Firstly, the borrow pit areas are located on the side of rocky local hills where the ground elevations are between 300 and 350m OD and therefore are rock outcrops;
- These elevations are above the elevations of the local valleys and streams;
- The proposed borrow pits will be between approximately 8 – 10m below ground level which is notable. However, in the context of the topographical/elevated setting of the borrow pits, this depth range is relatively shallow;
- The local bedrock comprises ORS and is known to be generally unproductive. This means that groundwater flows will be relatively minor;
- The flow paths (i.e. the distance from the point of recharge to the point of discharge) in this type of geology is short, localised, and will also be relatively shallow;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations;
- Therefore shallow groundwater inflows will largely be fed by recent rainfall, and possibly by limited groundwater seepage form localised shallow bedrock;
- The sloping nature of the ground on the hills where the borrow pits are proposed along with the coverage of soil means groundwater recharge is going to be very low;
- As such the shallow groundwater flow system will be small in comparison to the expected surface water flows from the bog surface;
- This means that there will be a preference for high surface water runoff as opposed to groundwater recharge and flow; and,
- Hence, we consider that the management of surface water will form the largest proportion of water to be managed and treated.

Residual Effects: Due to the local topography and the horizontal nature of the borrow pit extraction along with the prevailing hydrogeology of the Proposed Development site the potential for groundwater level drawdown impacts is considered negligible. The residual effect is assessed to be - Imperceptible, indirect, temporary, low probability effects on local groundwater levels.

Significance of Effects: For the reasons outlined above, no significant effects on groundwater levels are anticipated.

9.5.2.4 Excavation Dewatering and Potential Impacts on Surface Water Quality

Groundwater seepages will likely occur in turbine base, substation and battery storage, and construction compound excavations, and these will create additional volumes of water to be treated by the runoff management system.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are not anticipated in this respect. The main potential significant effects are as a result of turbidity and suspended solids on downstream surface water receptors. Poor water quality in downstream stream and rivers has the potential to affect aquatic habitats and species (e.g. fish and invertebrates).

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies.

Pre-Mitigation Potential Impact: Negative, significant, indirect, temporary, low probability effects to surface water quality.

Proposed Mitigation by Design:

Management of groundwater seepages and subsequent treatment prior to discharge into the drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build up of water in the excavation;
- The interceptor drainage will be discharged to the site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur;
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work will immediately be stopped and a geotechnical assessment undertaken; and,
- A mobile 'Siltbuster' or similar equivalent specialist treatment system will be available on-site for emergencies in order to treat sediment polluted waters from settlement ponds or excavations should they occur. Siltbusters are mobile silt traps that can remove fine particles from water using a proven technology and hydraulic design in a rugged unit. The mobile units are specifically designed for use on construction-sites. They will be used as final line of defence if needed.

Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is assessed to be - Imperceptible, indirect, temporary, low probability effects on local surface water quality and associated aquatic habitats.

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

9.5.2.5 Potential Release of Hydrocarbons during Construction and Storage

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons can cause significant pollution risk to groundwater, surface water and associated ecosystems, and to terrestrial ecology. In addition, the accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbons have 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.

Construction phase activities including access road construction, turbine base/hardstanding construction, construction compound construction, met mast construction, substation and battery storage construction and cable route works will require varying degrees of plant and machinery use.

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water.

Pre-Mitigation Potential Impact: Negative, indirect, slight, short term, medium probability effect to local groundwater quality. Indirect, negative, significant, short term, low probability effect to surface water quality.

Proposed Mitigation Measures:

- All plant will be inspected and certified to ensure they are leak free and in good working order prior to use on site;
- On-site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer or truck will be re-filled off site and will be towed/driven around the site to where machinery are located. The 4x4 jeep/fuel truck will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- 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 electrical control building will be bunded appropriately to the volume of oils likely to be stored and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used will be regularly inspected for leaks and fitness for purpose;
- A permit to refuel system will be employed;
- An emergency plan for the construction phase to deal with accidental spillages will be contained within the Construction Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

Residual Effect: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is assessed to be - Negative, imperceptible, indirect, temporary, low probability effect on groundwater and surface water.

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

9.5.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from on-site temporary wastewater treatment systems has the potential to impact on groundwater and surface water quality if site conditions are not suitable for an on-site percolation unit. Impacts on surface water quality could affect fish stocks and aquatic habitats.

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Down-gradient well supplies, groundwater quality and surface water quality.

Pre-mitigation Effect: Negative, significant, indirect, temporary, low probability effect to surface water quality. Negative, slight, indirect, temporary, low probability effect to local groundwater.

Proposed Mitigation Measures:

- During the construction phase, a self-contained port-a-loo with an integrated waste holding tank will be used at each of the site compounds, maintained by the providing contractor, and removed from site on completion of the construction works;
- Water supply for the site office and other sanitation will be brought to site and removed after use from the site to be discharged at a suitable off-site treatment location; and,
- No water or wastewater will be sourced on the site, nor discharged to the site.

Residual Effect: During the construction phase no water or wastewater will be sourced on the site, nor discharged to the site, therefore no residual effects are anticipated.

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

9.5.2.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative impacts on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of ≥ 6 ≤ 9 is set in S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) 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 species and habitats. Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to introduction of high pH alkaline waters into the system. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution.

Concrete will be used during the construction phase including during access road construction, turbine base/hardstanding construction, construction compound construction, met mast construction, substation and battery storage construction, and cable route works.

Pathway: Site drainage network.

Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Potential Impact: Negative, moderate, indirect, short term, medium probability effect to surface water.

Proposed Mitigation Measures:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- Where possible pre-cast elements for culverts and concrete works will be used;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be isolated in temporary lined wash-out pits located near proposed site compounds. These temporary lined wash-out pits will be removed from the site at the end of the construction phase;
- Will use weather forecasting to plan dry days for pouring concrete; and,
- Will ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Effect: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is assessed to be - Negative, imperceptible, indirect, short term, low probability impact.

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

9.5.2.8 Potential Impacts on Hydrologically Connected Designated Sites

The Proposed Development site is not located within any designated conservation site. Designated sites downstream of the proposed site and that are hydrologically connected to the Proposed Development include the Gearagh SAC and Lough Allua pNHA. Refer to Table 9-12 above for details of these sites.

Pathway: Surface water flowpaths, and groundwater levels.

Receptor: Down-gradient water quality and groundwater levels at designated sites.

Impact Assessment

The proposed mitigation measures which will include buffer zones and drainage control measures (i.e. interceptor drains, swales, stilling ponds) will ensure that the quality of runoff from Proposed Development areas will be very high. As stated in Impact Section 9.5.2.2 above, there could potentially be an "imperceptible, short term, likely impact" on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on the downstream designated sites.

Residual Effect: No residual effects on downstream designated sites are anticipated.

Significance of Effects: For the reasons outlined above, no significant effects on designated sites are anticipated.

9.5.2.9 Potential Effects on Local Groundwater Well Supplies

Potential groundwater level and groundwater quality effects on wells downgradient of the Proposed Development, especially where significant excavations are required such as for the borrow pits and the turbine base excavations or at the substation and battery storage site.

As discussed in Section 9.3.15 above, the majority of the private dwellings (with potential domestic wells) are located along the R584 to the east of the site, with others sporadically distributed along minor roads to the west/southwest of the site.

These dwellings are very remote to the development site and it is very unlikely that there would be any hydraulic connection between any potential wells and groundwater flow from the development site. This is assessed below.

Pathway: Groundwater flowpaths.

Receptor: Groundwater Supplies.

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

Impact Assessment

The groundwater flow direction in the aquifer underlying the site is assumed to mimic topography whereby flow paths will be from topographic high points to lower elevated discharge areas at streams and rivers. As stated above, flow paths are thought to be between 30 – 300m in length and given the fact that all dwelling houses are more than 700m away there is a low risk of impact regarding of the groundwater flow direction/gradient.

Nevertheless, using the conceptual model of groundwater flow mimicking topography, the potential impact of turbine base excavations and the borrow pits on down-gradient wells is assessed below.

The majority of the proposed infrastructure is located on the western facing slopes of the central ridgeline (this includes 6 no. of the 7 turbines and both proposed borrow pits where excavations will be deepest). The groundwater flow direction in this area of the site is westerly towards the Lackavane River which is expected to be the discharge zone for groundwater flowing off-site. There are no mapped houses within the groundwater flow path between the proposed infrastructure and the Lackavane River and therefore there is no potential to impact on groundwater well supplies.

Similarly, on the northeast of the site where proposed turbine T2 is located, groundwater drainage is expected to be north-easterly towards the stream which flows northerly within the Pass of Keimaneigh on towards the River Lee. There are no dwelling houses between the Proposed Development infrastructure and this stream therefore there is no potential for impact.

With respect to the proposed access roads, compound and substation, no impacts on groundwater wells are anticipated due to the shallow nature of the works.

The above assessment demonstrates that there is no potential to impact on local wells supplies as a result of the Proposed Development.

According to the EPA abstraction register, there are no public or private surface water abstractions located downstream of the site.

In addition, there are proposed mitigation measures (outlined above) that will minimise and prevent potential groundwater contamination from hydrocarbons and other chemicals (refer to Section 9.5.2.5, Section 9.5.2.6, and Section 9.5.2.7).

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), we consider there will be no residual effects on local wells as no impacts are anticipated.

Significance of Effects: For the reasons outlined above, no impacts on potential groundwater supplies are anticipated.

9.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

9.5.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the peat or vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. This could potentially increase runoff from the site and increase flood risk downstream of the development. In reality, the access roads will have a higher permeability than the underlying peat. However, it is conservatively assumed in this assessment that the proposed access roads and hardstands are impermeable. The assessed footprint comprises turbine bases and hardstandings, access roads, site entrances, substation and battery storage, temporary construction compounds and borrow pits. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

The emplacement of the proposed permanent development footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 1,180 m^3/month or 38m^3/day
(

Table 9-14). This represents a potential increase of approximately 0.08% in the average daily/monthly volume of runoff from the site area in comparison to the baseline pre-development site runoff conditions (

Table 9-7). This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the site being developed, the proposed total permanent development footprint being approximately 7.5 ha, representing 1.2% of the total study area of ~620 ha.

Table 9-14: Baseline Site Runoff V Development Runoff

Development Type	Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 96% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m^3)
Wind Farm	1,528,102	49,294	75,000	19,665	18,485	1,180	38	0.08

The additional volume is low due to the fact that the runoff potential from the site is naturally high (94%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate. The increase in runoff from the Proposed Development will, therefore, be negligible. This is even before mitigation measures will be put in place.

Pathway: Site drainage network.

Receptor: Surface waters and dependent ecosystems.

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

Proposed Mitigation by Design:

As the part of the proposed wind farm drainage design, it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed silt traps, settlement ponds and vegetated buffer areas prior to release into the existing drainage network. The new proposed drainage measures will then create significant additional attenuation to what is already present. The operational phase drainage system will be installed and constructed in conjunction with the existing bog drainage network and will include the following:

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed into downstream field drains;
- Collectors drains will be used to gather runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to new local settlement ponds for sediment settling;
- On sections of access road transverse drains ('grips') will be constructed in the surface layer of the road to divert any runoff off the road into swales/roadside drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;

- Settlement ponds, emplaced downstream of access road sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to existing drains;
- Settlement ponds will be designed in consideration of the greenfield runoff rate; and
- Finally, all surface water runoff from the development will have to pass through the settlement ponds at the existing bog outfall locations.

Residual Effect: With the implementation of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, we consider that residual effect are - Negative, imperceptible, indirect, long-term, moderate probability effect on all downstream surface water bodies.

Significance of Effects: For the reasons outlined above, no significant effects on downstream flood risk is anticipated.

9.5.3.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters

During the operational phase, the potential for silt-laden runoff is much reduced compared to the construction phase. In addition, all permanent drainage controls will be in place and the disturbance of ground and excavation works will be complete. Some minor maintenance works may be completed, such as maintenance of site entrances, internal roads, hardstand areas and amenity pathways. These works would be of a very minor scale and would be very infrequent. Potential sources of sediment laden water would only arise from surface water runoff from small areas where new material is added during maintenance works.

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

During such 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.

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and associated dependent ecosystems.

Pre-Mitigation Potential Impact: Negative, slight, indirect, temporary, low probability effect.

Proposed Mitigation Measures:

Mitigation measures for sediment control are the same as those outlined in Section 9.5.2.1.

Mitigation measures for control of hydrocarbons during maintenance works are similar to those outlined in Section 9.5.2.5.

Residual Effects: With the implementation of the proposed wind farm drainage measures as outlined above, and based on the post-mitigation assessment of runoff, we consider that residual effect are - Negative, imperceptible, indirect, temporary, low probability effect on downstream water quality.

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

9.5.3.3 Assessment of Potential Health Effects

Potential health effects are associated with negative impacts (i.e. contamination) on public and private water supplies and potential flooding. There are no mapped public or group water scheme groundwater protection zones in the area of the proposed site. As assessed above, all local domestic wells are remote from the Proposed Development areas and no impacts are anticipated.

Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for impacts on the groundwater environment are not significant

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues. The Flood Risk Assessment has also shown that the risk of the proposed wind farm contributing to downstream flooding is also very low. On-site drainage control measures will ensure no downstream increase in flood risk.

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the Proposed Development will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works.

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas.

This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude. However, as noted in the Scottish Natural Heritage report (SNH) *Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms* (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is, therefore:

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

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

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

9.5.5 Assessment of Cumulative Effects

The developments considered as part of the cumulative effect assessment are described in Section 2.7 of this EIAR. In this regard in order to assess overall cumulative effects on water the Proposed Development is considered in the context of other developments as detailed below.

With respect to cumulative effects arising from the wind farm construction and the grid connection, none are anticipated as the Proposed Development is proposing to connect to the national grid via the overhead line connection already established on-site to Ballylickey Substation located in the townland of Ballylickey, Co. Cork, thereby reducing the need for any off-site connection via local roads or adjacent lands. The Ballylickey Substation is located approximately 12 kilometres southwest of the site.

At present there is an existing substation at the Proposed Development site. The existing substation on site will be subject to decommissioning under the provisions of the previously granted permission. If the decommissioning of the existing substation were to occur at the same time as the construction phase of the Proposed Development, due to the localised nature of the works and the proposed construction drainage management no cumulative effects are anticipated.

A cumulative impact assessment was undertaken regarding other wind farm developments and non-wind farm developments located inside 20km within the River Lee and Owvane River surface water catchments. These developments are described in the Chapter 2 of the EIAR and shown in Figure 2-5.

The majority of the Proposed Development is located in the Owvane River surface water catchment. Development within the River Lee catchment is limited to 1 no. turbine (T2) and the proposed site entrance. Therefore, on this basis and given the size of the River Lee catchment, the potential for hydrological cumulative impacts within the River Lee catchment is negligible.

The total number of turbines that could potentially be operating inside a 20km radius within the Owvane River catchment is only 11 (6 no. from the Proposed Development and 5 no. from the Derreenacrinnig Wind Farm which is a permitted development comprising a total of 7 no. turbines. There are no existing wind farms in the Owvane River catchment.

The total catchment area of the Owvane River (inside a 20km radius) is ~500km^2 and therefore this equates to one turbine for approximately every ~45km^2 which is considered imperceptible in terms of potential cumulative hydrological impacts.

There are no non-wind farm developments (as described in Chapter 2) inside the Owvane River catchment that are expected to contribute to hydrological cumulative effects.

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

In respect to the replanting lands assessed as part of the Proposed Development, these are located in Co. Clare and Co. Roscommon. Both sites are located outside the Owvane River catchment meaning there is no potential for cumulative effects.

9.5.6 Post Consent Monitoring

None required.

9.5.7 Conclusion

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

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

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

Preventative measures also include fuel and concrete management and a waste management plan which is incorporated into the Construction and Environmental Management Plan (Refer to Appendix 4-3).

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

No significant cumulative impacts on any of the regional surface water catchment or groundwater bodies will occur from the Proposed Development, associated grid connection, haul route works or forestry replacement sites.