APPENDIX 2

EIAR CHAPTER 9 - WATER

9. WATER

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland (MKO) to carry out an assessment of the potential effects of the Proposed Laurclavagh Renewable Energy Development. This chapter relates to potential effects on Water due to the construction, operation and decommissioning of the Proposed Project. Section 1.1.1 of Chapter 1 of this EIAR has set out the terminology used to describe each of the elements of the Proposed Project. The terminology of project elements used within this chapter is outlined below:

- The 'Proposed Wind Farm' refers to the 8 no. turbines and supporting infrastructure which is the subject of this Section 37E application.
- The 'Proposed Grid Connection' refers to the 110kV substation and supporting infrastructure which will be the subject of a separate Section 182A application.
- The 'Proposed Project' comprises the Proposed Wind Farm and the Proposed Grid Connection, all of which are located within the EIAR Study Boundary (the 'Site') and assessed together within this EIAR.

The objectives of the assessment are to:

- Produce a baseline study of the existing water environment (surface and groundwater) in the area of the Proposed Wind Farm site and Proposed Grid Connection underground cabling route;
- Identify likely positive and negative effects of the Proposed Project on surface and groundwater during construction, operational, and decommissioning phases of the Proposed Project. Identify mitigation measures to avoid, remediate or reduce significant negative effects; and,
- Assess significant residual effects and cumulative effects of the Proposed Project along with other permitted and proposed projects and plans.

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist geological, hydrological, hydrogeological and environmental practice that 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 hydrology, hydrogeology and karst hydrogeology and wind farm drainage design and management. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types including wind farm and grid connection developments.

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

Adam Keegan (BSc, MSc) is a hydrogeologist with two years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has experience in intrusive site investigation works within mapped karst environments and experience in trial and production well drilling within areas mapped as Regionally Karstified. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Seven Hills WF. Adam has also worked on water supply projects and karst related projects in Galway, Clare, Tipperary and Waterford.

Michael Gill P.Geo (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 karst hydrogeology and also in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 100 other wind farm-related projects, as well as Seven Hills WF which is situated within a mapped karst area. Michael has also worked on karst related projects in South and Mid Galway, Roscommon, Tipperary, Laois, Kilkenny, Limerick, Clare, Cork and Waterford.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.6 of this EIAR. Issues and concerns highlighted with respect to the water environment are summarised in Table 9-1 below.

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

Degree/Nature	Description	Addressed in Section
Geological Survey of Ireland (GSI)	The Groundwater Karst Viewer (online mapping) indicates numerous karst landforms in the vicinity including a karst spring, enclosed depression and caves The Groundwater Data Viewer indicates an aquifer classed as a 'Regionally Important Aquifer - Karstified (conduit)' underlies the Proposed Project. The Groundwater Vulnerability map indicates the range of groundwater vulnerabilities within the area covered is variable. We would therefore recommend use of the Groundwater Viewer to identify areas of High to Extreme Vulnerability and 'Rock at or near surface' in your assessments, as any groundwater-surface water interactions that might occur will be greatest in these areas. Our records show that there are groundwater drinking water abstractions (Group Water Schemes) with source protection areas within and adjacent to the EIAR study area: ○ Cluide – Cahermorris GWS ○ Cahermorris Glenreevagh GWS ○ Caherlea GWS ○ Rusheens GWS ○ Anbally GWS Key to groundwater protection in general, and protection of specific drinking water supplies,	The Groundwater Karst Viewer data source was consulted during the desk study phase of the assessment. Areas identified were assessed during site walkover surveys and throughout the EIAR process; The Groundwater viewer was used within the initial desk study assessment of the Site and areas of varying groundwater vulnerability were noted. Site investigation data has been used to provide further site-specific data on the nature of the subsoils (addressed in Chapter 8 and below in Section 0 and 9.3.7) The nearby Group Water Schemes were identified during the desk study assessment of the Proposed Project. At least 5 no. site visits have been performed at

Degree/Nature	Description	Addressed in Section
	is preventing ingress of runoff to the aquifer. Design of drainage will need to be cognisant of the public water scheme and the interactions between surface water and groundwater as well as run-off.	each GWS site, along with groundwater level monitoring in the GWS wells over a 24-month period to provide data on groundwater levels, groundwater flow directions and the overall hydrogeological regimen in the area.
HSE	The Proposed Project has the potential to have a significant impact on the quality of both surface and ground water. All drinking water sources, both surface and ground water, must be identified. Public and Group Water Scheme sources and supplies should be identified in addition to any private wells supplying potable water to houses in the vicinity of the Proposed Project. Measures to ensure that all sources and supplies are protected should be described. Any potential significant effects to drinking water sources should be assessed. Details of bedrock, overburden, vulnerability, groundwater flows, aquifers and catchment areas should be considered when assessing potential effects and any proposed mitigation measures. Any effects on surface water as a result of the construction of the underground cables should be identified and addressed in the EIAR.	A survey of groundwater wells has been completed in the area surrounding the Site. Due to the abundance of Group Water schemes, there is a limited number of private domestic wells. Water levels have been recorded over a 24-month period at 13 no. locations, including 7 no. GWS wells. These data are included in Section 9.3.6.5. Potential effects relating mitigation measures and the residual effects associated with Proposed Project in relation of groundwater wells are included in Sections 9.4.2.2, 9.4.2.3 and 9.4.3.1.

9.1.4 Relevant Legislation

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

The requirements of the following legislation are complied with:

- Planning and Development Acts, 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by the Directive 2014/52/EU into Irish Law;
- S.I. No. 94/1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);

- S.I. No. 293/1988: Quality of Salmon Water Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722/2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for the implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;
- S.I. No. 684/2007: Wastewater Discharge (Authorisation) Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249/1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (as amended by 2000/60/EC in 2007);
- S.I. No. 122/2014: European Union (Drinking Water) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010, as amended; and,
- S.I. No. 296/2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009, as amended.

9.1.5 Relevant Guidance

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

- Environmental Protection Agency (2022): Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Department of Environment, Heritage and Local Government (DoEHLG); Wind Energy Development Guidelines for Planning Authorities (2006);
- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016);
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- Wind Farms and Groundwater Impacts: A guide to EIA and Planning considerations (DOE/NIEA, April 2015);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006;

- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,
- 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 & Preliminary Hydrological Assessment

A desk study and preliminary hydrological assessment of the Site and the surrounding area was completed in advance of the Site walkovers, site investigation works, and in advance of seasonal monitoring being implemented. This involved collection of all relevant geological, hydrological, hydrogeological and meteorological data for the study area. This included consultation with the following sources:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 11 (Geology of South Mayo) and Sheet 14 (Geology of Galway Bay). Geological Survey of Ireland (GSI, 2005 & 2004);
- Geological Survey of Ireland (2004) – Clare-Corrib Groundwater Body Initial Characterization Reports;
- Groundwater Karst Viewer (GSI online mapping portal - www.gsi.ie);
- OPW Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- GSI Groundwater Flood mapping (www.gsi.ie);
- CFRAM flood maps (www.cfram.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie); and,
- Group Water Scheme ZOC Reports; Anbally & District GWS, Balrobuckbeg GWS, Caherlea GWS, Cahermorris-Glenreevagh GWS, Cluide (Cahermorris) GWS and Rusheens GWS.

9.2.2 Site Investigations & Seasonal Hydrological & Hydrogeological Monitoring

A comprehensive geological, hydrological and hydrogeological dataset has been collected as part of this EIAR study.

Initial walkover surveys, geological/hydrogeological mapping and baseline monitoring of water levels in nearby public and private wells were conducted on 14th-15th December 2021, 01st December 2022, 25th April 2023, 9th August 2023 and 04th-05th December 2023. During this time observations were made on near surface geological features including exposed or visible quaternary features such as eskers/drumlins which might impact the hydrological regime, during 5 no. site walkover surveys. Water level monitoring equipment was also installed within a selection of accessible nearby public (GWS) wells and domestic groundwater wells.

Water levels in the boreholes surrounding the Proposed Wind Farm site were monitored between December 2021 – December 2023. The duration and extent of the water level monitoring are outlined in the relevant section (Section 9.3.6.3.2). In total 13 no. GWS/farm/domestic wells were monitored with in-situ Diver water level dataloggers. The data were normalised with a permanent barometer located within the area and compared with rainfall data collected at the Headford (OPW) rainfall station. These data provide a 24-month record of water levels in boreholes which can be compared and correlated.

Intrusive and extrusive site investigations have been conducted between 14th December 2021 – 24th April 2023, to provide detail and clarity on the nature and extent of subsoils and bedrock and evidence for potential karstification of the Limestone bedrock. These include:

- 3 no. groundwater monitoring boreholes drilled at locations MW21-01, MW21-02 and MW21-03 in December 2021;
- 1 no. geophysical survey conducted in June 2022;
- A further 1 no. follow up geophysical survey was carried out in December 2022;
- 10 no. rotary core boreholes drilled between 20th March – 27th April 2023;
- 7 no. trial pits excavated by machine between 22nd March – 17th April 2023;
- 13 no. further infiltration trial pits excavated between 20th March – 25th April with 26 no. accompanying infiltration (k) tests completed;
- 46 no. indirect CBR tests across the Proposed Wind Farm site; and,
- 35 no. Peat Probes carried out along the Proposed Grid Connection underground cabling route,

In total 230m of drilling has been completed to determine the nature of the soil, subsoil and bedrock across the Site, with targeted locations chosen, informed by the 2 no. geophysical surveys.

In addition to the above site investigation, the following is a summary of the seasonal hydrological and hydrogeological monitoring that has been undertaken:

- Anbally GWS - 12 months of monitoring groundwater levels at 15-minute intervals;
- Ballroebuckbeg GWS - 24 months of monitoring groundwater levels at 15-minute intervals;
- Cluide Cahermorris GWS - 24 months of monitoring groundwater levels at 15-minute intervals;
- Cahermorris Glenrevagh GWS - 24 months of monitoring groundwater levels at 15-minute intervals;
- Caherlea GWS - 24 months of monitoring groundwater levels at 15-minute intervals;
- Rusheens GWS - 11 months of monitoring groundwater levels at 15-minute intervals;
- Biggeramore GWS – 21 months of monitoring groundwater levels at 15-minute intervals;
- MW21-01 - 24 months of monitoring groundwater levels at 2-hour intervals;
- MW21-02 - 24 months of monitoring groundwater levels at 2-hour intervals;
- MW21-03 - 24 months of monitoring groundwater levels at 2-hour intervals;
- Domestic Well 1 (DW1) - 24 months of monitoring groundwater levels at 2-hour intervals;
- Domestic Well 2 (DW2) - 12 months of monitoring groundwater levels at 2-hour intervals;
- Domestic Well 3 (DW3) - 12 months of monitoring groundwater levels at 2-hour intervals;
- Groundwater sampling completed at 4 no. locations in August 2023;
- Groundwater sampling completed at 4 no. locations in December 2023;
- Surface water sampling completed at 2 no. locations in August 2023;
- Surface water sampling completed at 2 no. locations in December 2023; and,
- Downloads and collation of surface water level and flow data in River Clare (2021-2023).

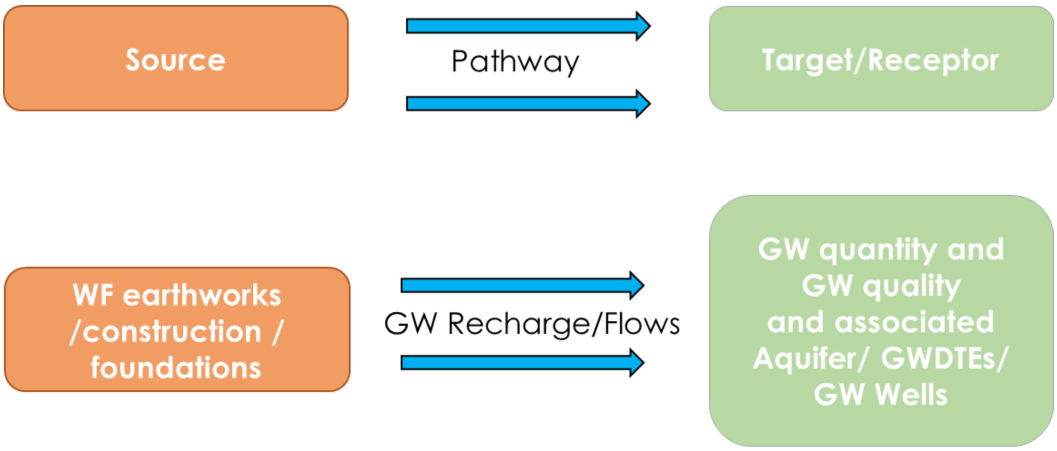
9.2.3 Impact Assessment Methodology

Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology (EPA 2022). In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are then used to assess the potential effect that the Proposed Project 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 that are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability "Low" – "Medium" classification and "Poor" aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. Surface water quality classified by EPA as A2. Salmonid species may be present and may be locally important for fisheries. Abstractions for private water supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability "High" classification and "Locally" important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value i.e. NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

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



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

- Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (EPA, 2022); and,
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003).

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.4.2 and 9.4.3), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process (refer to 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 effect descriptors are combined.

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

Table 9-3: Summary guide for stepwise assessment of impact assessment process

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 pre mitigation significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 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 effects. 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 effects after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

9.2.4 Limitations and Difficulties Encountered

Access to groundwater wells was limited to those where permission could be gained from the owners to inspect the well construction, measure and record water levels and take water samples where necessary.

However, access was gained to a suitable geographical spread of groundwater wells surrounding the Proposed Wind Farm site, which provide a large database of groundwater data in order to gain a robust, scientific understanding of groundwater levels and groundwater flows across the Proposed Wind Farm site.

9.3 Receiving Environment

9.3.1 General Site Description

The Proposed Project is located approximately 8 kilometres (km) southwest of Tuam, and approximately 10km north of Claregalway, Co. Galway. The Site covers an area of approximately 944 hectares, in total, and is divided into two distinct areas; the Proposed Wind Farm site, and the Proposed Grid Connection. The Site is shown in Figure 1-1 of Chapter 1.

9.3.1.1 Proposed Wind Farm

The Proposed Wind Farm is primarily within the townland of Laurclavagh, between the townlands of Cahermorris and Ballynacreg North. The approximate centre of the Proposed Wind Farm site is located at E137055, N243681. The Proposed Wind Farm is situated within a slightly elevated area of ground (~45-60mOD) within a broader area which is generally flat to locally undulating and with elevations generally ~30mOD. The land is mainly agricultural improved grassland, primarily used for grazing.

It is intended to access the Proposed Wind Farm off the L61461 Local Road, via a temporary access road which will connect the N83 Tuam-Galway National Road and the L61461. This proposed access route is located to the southeast of the Proposed Wind Farm, in the townlands of Pollcossaun Eighter and Pollcossaun Oughter. A site location map of the Proposed Wind Farm site is given in Figure 4-2 of Chapter 4.

9.3.1.2 Proposed Grid Connection

The Proposed Wind Farm will connect into the proposed onsite 110kV substation, which is located in the centre-east of the Proposed Wind Farm. This onsite 110kV substation will be connected to the existing 110kV Cloon Substation via a 14.3km long underground cabling route. The existing Cloon 110kV Substation is located approximately 6km northeast of the Proposed Wind Farm site. The proposed onsite 110kV Substation, adjacent temporary construction compound and the first c. 2km of the underground cabling route to Cloon Substation are elements of the Proposed Grid Connection which overlap with the Proposed Wind Farm site.

A site location map of the Proposed Grid Connection is given in Figure 4-3 of Chapter 4.

9.3.2 Water Balance

9.3.2.1 Proposed Wind Farm site

Long term rainfall and evaporation data was sourced from Met Éireann. Met Éireann has compiled a set of climate averages for the period 1991-2020 for a range of parameters including air temperature, precipitation, sunshine and wind. Annual, seasonal, and monthly average values for the period 1991-2020 were compiled using high quality data obtained from Met Éireann's observation network. Long-term averages for stations are then used to generate maps and gridded data at a 1km resolution for air temperature and rainfall.

The 30-year annual average rainfall (1991 - 2020) for the Site are presented in Table 9-4.

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

Location: E137000, N245000												
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
125	101	93	74	75	81	92	102	95	119	132	137	1226

The closest synoptic weather station where the average potential evapotranspiration (PE) is recorded is at Claremorris, approximately 35 kilometres north of the Site. The long-term average PE for this station is 407.5mm/yr. This value is used as the best estimate of the Site PE. Actual Evaporation (AE) at the Site is estimated as 387mm/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

=1226mm/yr – 387mm/yr

ER = 837mm/yr

The recharge coefficient estimates from the GSI (www.gsi.ie), range between 60-85%, based on the expected or observed outcrop/subcrop near the surface, however the distinct lack of surface water features (streams/rivers) near the Proposed Wind Farm site demonstrate that essentially all water is infiltrating to ground (i.e., 100% recharge). A recharge value of 100% is assigned for the Proposed Wind Farm site, based on the lack of surface water features, however, this will vary locally. Annual recharge and runoff rates for the Site are estimated to be 837 mm/yr and 0mm/yr respectively.

Table 9-5 presents return period rainfall depths for the centre of the Proposed Wind Farm site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year). These extreme rainfall data will be used for wind farm drainage design and not the long-term averages.

Table 9-5: Return Period Rainfall Depths for the Proposed Wind Farm site

Duration	1-year Return Period	5-year Return Period	10-year Return Period	50-Year Return Period	100-Year Return Period
15 min	6.1	9.7	11.8	17.8	21.1
1 hour	10.4	15.8	18.9	27.4	32.0
6 hours	20.7	29.8	34.7	47.7	54.5
12 hours	27.0	38.0	43.8	59.2	67.0
24 hours	35.2	48.5	55.4	78.3	82.4
48 hours	44.5	59.3	66.9	86.1	95.6

Climate change projections for Ireland are provided by Regional Climate Models (RCM's) downscaled from larger Global Climate Models (GCM's). Projections for the period 2041-2060 (mid-century) are available from Met Eireann. The data indicates a projected decrease in summer rainfall from 0 to 13% under the medium-low emission range scenario and an increase in the frequency of heavy precipitation events of 20%. In total, the projected annual reduction in rainfall near the Wind Farm Site 8% under the medium-low emission scenario and 4% under the high emissions scenario. As stated above the local average long term rainfall data for the Wind Farm Site is estimated to be 1,226mm/yr. Under the medium-low emissions scenario this may reduce to~1,128mm/yr, while under the high emissions scenario this figure may change to ~1,177mm/yr.

9.3.2.2 Proposed Grid Connection

The Proposed Grid Connection overlaps with the Proposed Wind Farm, further east, along the Proposed Grid Connection underground cabling route, the recharge coefficient estimates from the GSI range between 60 - 85% along the majority of the route, until the most eastern section of the route near the townland of Cloonmore, where the recharge coefficient is reduced to 22.5%.

The effective rainfall along the Proposed Grid Connection underground cabling route is mapped as 761mm, meaning that along the majority of the route, where recharge is estimated at ~60% the split between recharge and runoff will be 457mm/year and 304mm/year respectively, and where recharge measures ~22.5%, the split between recharge and runoff will be 171 mm/year and 590mm/year respectively.

9.3.3 Regional and Local Hydrology

9.3.3.1 Regional Hydrology

9.3.3.1.1 *Proposed Wind Farm site*

The WFD hierarchy watercourses and catchment units is essentially; river waterbodies are short sections of rivers (typically 1-10km) located in river sub-basins (which are typically 10-50km^2). These sub-basins are located within larger sub-catchments (typically 100-200km^2) denoted with _SC within the nomenclature. The sub-catchments such as the Clare(Galway)_SC_060 discussed below, contain various sub-basins (such as the Clare(Galway)_060) and accompanying sections of river waterbodies. The subcatchments are located within larger catchments (such as the Corrib catchment), and these catchments are in turn located within Hydrometric areas.

With respect to regional hydrology, the Proposed Wind Farm site is located primarily within the Corrib catchment, within Hydrometric Area 30 (Corrib) of the Irish River Basin District. On a more local scale, the Proposed Wind Farm site is contained within the Clare(Galway)_SC_060 subcatchment. The River Clare is situated ~4.0km east of the Proposed Wind Farm site and flows south, while Lough Corrib is located ~4.3km to the west/southwest.

The closest watercourse to the Proposed Wind Farm site is the Ballinduff stream (also referred to as Bunnatubber spring by the EPA) situated 2.6km west of the Proposed Wind Farm site. The upper reaches of the stream are situated near 2 no. mapped turloughs and a spring mapped in the townland of Kilcoona, as well as a further spring in the townland of Bunatober (refer to Section 0). The stream is monitored with spot flow measurements by the EPA at a bridge located at E131521, N241001. An average flow of 0.98 m^3/s is recorded, with a range between 0.078 – 4.1 m^3/s.

The Glennafosha stream is mapped ~3.7km northwest of the Proposed Wind Farm site, which flows west before discharging to the River Clare. The Cregg stream is mapped ~4.7km south of the Wind Farm site and flows west to Lough Corrib. The source of the Cregg stream is also located near a mapped spring, which has been traced back to Ballyglunin cave, located 10.7km northeast of the spring.

Water levels in the River Clare are measured at station 30004 with a 50%ile water level of ~26 mOD. Water levels in Lough Corrib are measured at Angligham station 30089. The 50%ile water level is measured at 8.72 mOD.

The regional area spanning east-west between Cahermorris and Ballycreg North and north-south between the townlands of Castlehacket and Lackanroe is distinctively void of mapped river/stream channels. The surface hydrological network does increase towards the margins of this regional area, with channels emerging 1-2km west of the River Clare and east of Lough Corrib.

A regional hydrology map is shown in Figure 9-1.

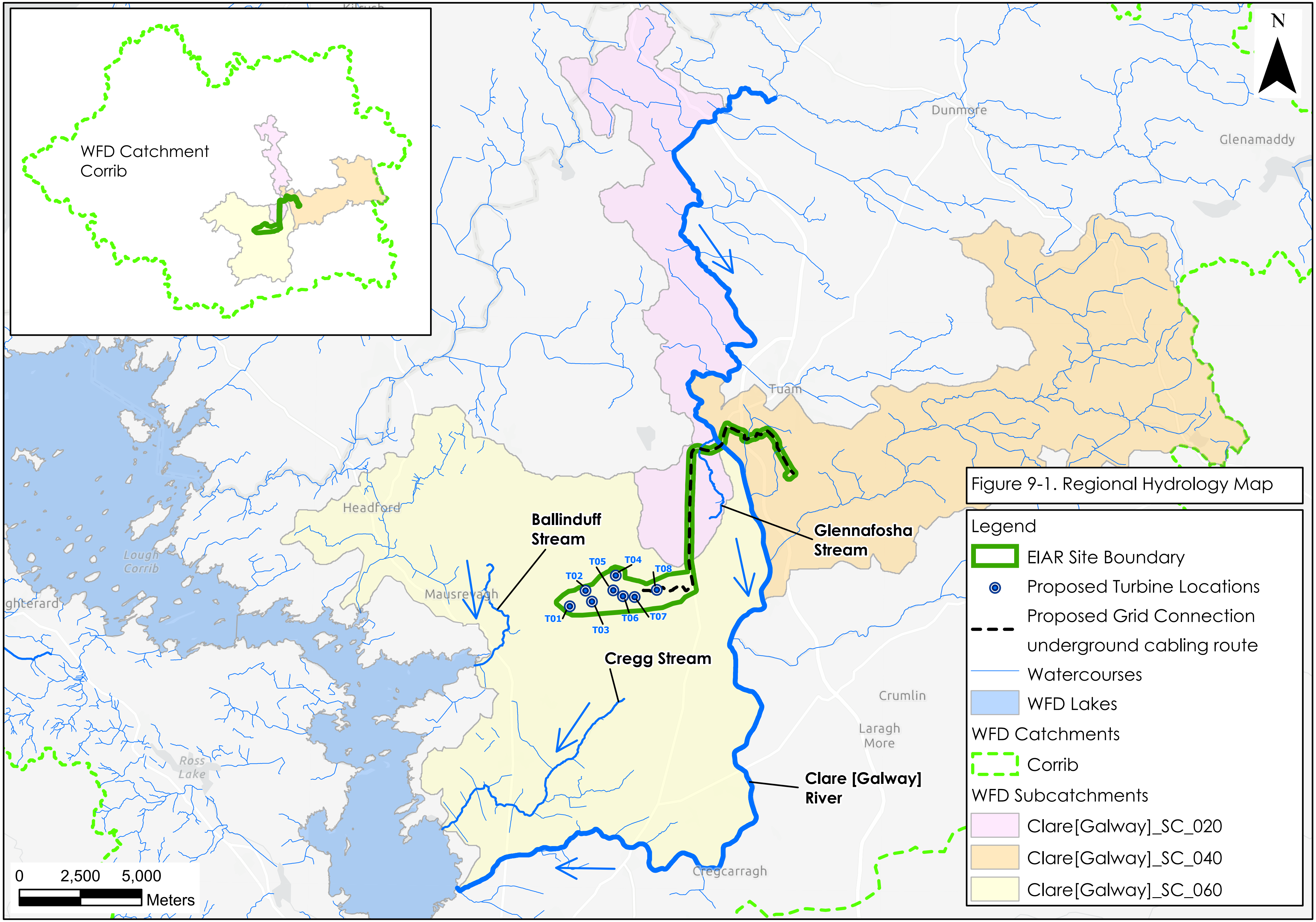


Figure 9-1. Regional Hydrology Map

9.3.3.1.2 *Proposed Grid Connection*

The Proposed Grid Connection underground cabling route is located within the Clare(Galway)_050 and Clare(Galway)_060 river waterbodies, within the Clare[Galway]_SC_060, Clare[Galway]_SC_040 and Clare[Galway]_SC_020 subcatchments. These surface water catchment areas and waterbodies are illustrated in Figure 9-1. The Proposed Grid Connection underground cabling route runs north along the N83 and crosses a tributary of the River Clare (Glennafosha stream) at Claretuam bridge, and crosses the River Clare approximately 0.9km east of this point at Cloonmore bridge. There are 4 no. watercourse crossings along the Proposed Grid Connection underground cabling route. The Proposed Grid Connection underground cabling route crossings are given below in Table 9-6 and can be seen towards the north of the black dashed line in Figure 9-1.

Table 9-6: Watercourse crossings

Townland	River	Easting	Northing
Common	Clare (Galway)_050 – tributary of River Clare	E140107	N249566
Common	Clare (Galway)_060 – River Clare	E140963	N 249731
Cloondarone	Killeelaun (Suileen river)	E141987	N249947
Cloondarone	IE_WE_30C010800	E143324	N249486

9.3.3.2 Local Hydrology

9.3.3.2.1 *Proposed Wind Farm site*

There is a distinct lack of local drainage (field drains, ditches, first-order streams etc) within the Proposed Wind Farm site and surrounding area. The topography broadly slopes southwest across the Site, although local variations do exist. Any surface water runoff from the Proposed Wind Farm site is expected to flow in this direction, however it will infiltrate to ground within a short distance, as evidenced by the lack of drainage channels. No field drains or surface watercourses were observed following numerous site walkover surveys. The agricultural fields are primarily improved grassland, which are well drained.

A local hydrology map including mapped surface water bodies is shown in Figure 9-2.

9.3.3.2.2 *Proposed Grid Connection*

Drainage along the Proposed Grid Connection underground cabling route is broadly localised to drainage ditches along the road carriageway of the N83 road. The River Clare (Galway)_050 channel (tributary of main River Clare) meets the N83 National Road approximately 3.1km southwest of Tuam, and subsequently runs approximately parallel to the N83 road, varying between 0.25 – 1.25km east of the road carriageway. Drainage from the road carriageway will primarily drain in the direction of the tributary of the River Clare, however under typical moderate rainfall conditions, the surface water will likely infiltrate through the soil/subsoil before reaching the river as shallow baseflow.

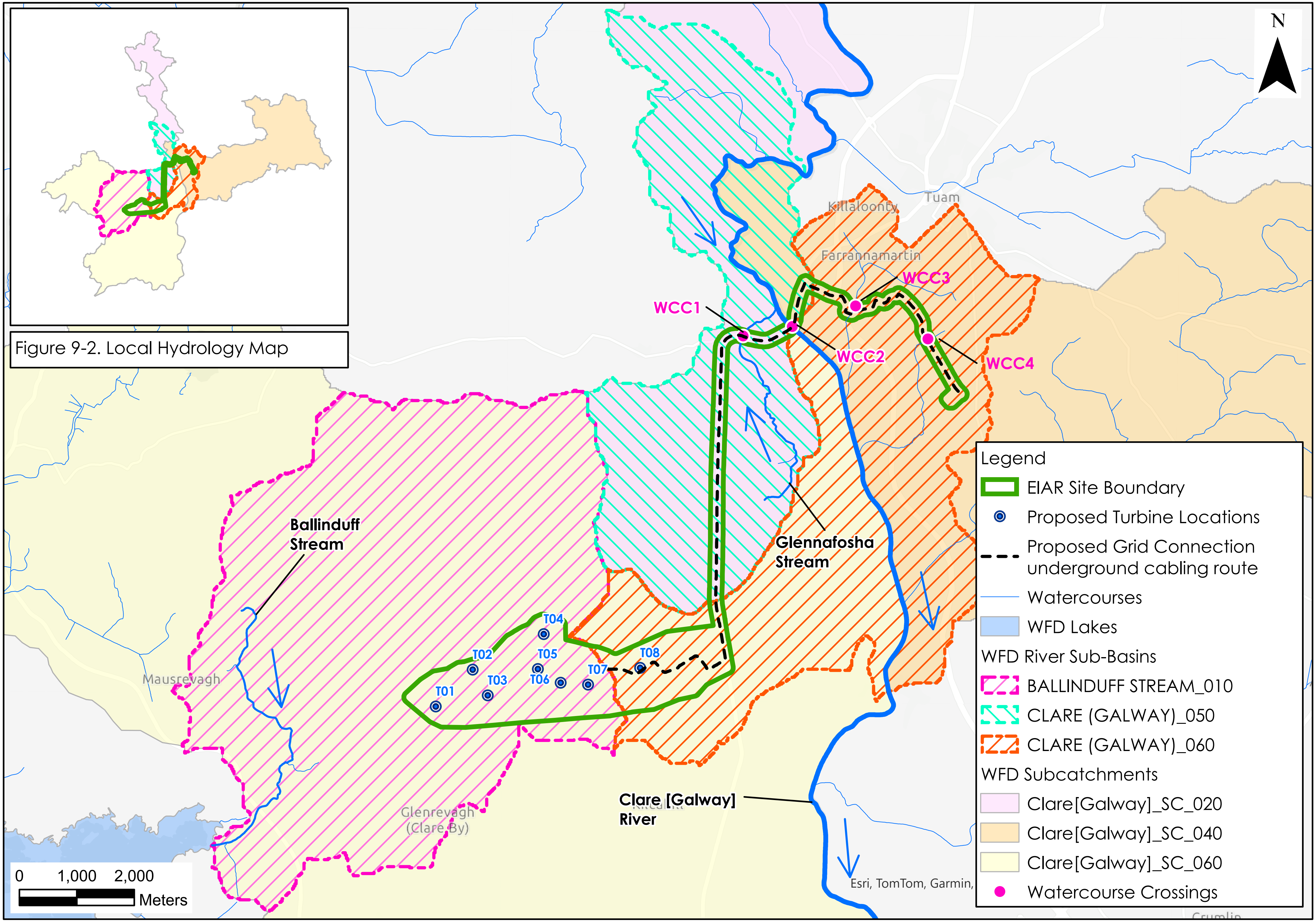


Figure 9-2. Local Hydrology Map

9.3.4 Flood Risk Identification

9.3.4.1 Proposed Wind Farm site

OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), Department of Environment, Community and Local Government on-line planning mapping (www.myplan.ie) and historical mapping (i.e., 6" & 25" base maps) were consulted to identify those areas as being at risk of flooding. A Flood Risk Assessment for the Proposed Project is included as Appendix 9-1.

No recurring flood incidents within the Proposed Wind Farm site were identified from OPW's indicative river and coastal flood map. There are several recurring flooding incidents surrounding the Proposed Wind Farm site, the closest of these being flooding mapped along the Ballinduff stream.

Groundwater flooding is mapped by the GSI (GSI GWFlood Project)[1]. The groundwater flood modelling highlights areas~3-7km from the Proposed Wind Farm site which correspond to mapped turloughs. There are no areas within the Site which are mapped within a groundwater flood zone.

The GSI Groundwater Flooding Data Viewer was also accessed to provide details on the extent of historical groundwater flooding in the area. The data viewer provides maximum historic groundwater flooding extents which are shown in Figure 9-3. These extents generally coincide with the known mapped turloughs, particularly the larger Belclare and Killower Turloughs. The proposed turbines and other Proposed Wind Farm site infrastructure are topographically upgradient of these groundwater flood zones, with the closest point of infrastructure being T2, situated ~ 250m from a historic maximum groundwater flooding area mapped as a ~ 1 hectare (ha) area east of T2.

The available PFRA mapping shows the extent of the indicative 100-year flood zone which relates to fluvial (i.e., river) and pluvial (i.e. rainfall) flood events. There are no 100-year fluvial flood zones mapped within the Proposed Wind Farm site. All proposed turbine locations, substation, construction compounds, met mast and access roads are located at least 50m away from streams and are outside of the fluvial indicative 100-year flood zone.

[1] https://www.gsi.ie/en-ie/programmes-and-projects/groundwater-and-geothermal-unit/activities/groundwater-flooding/gwflood-project-2016-2019/Pages/default.aspx

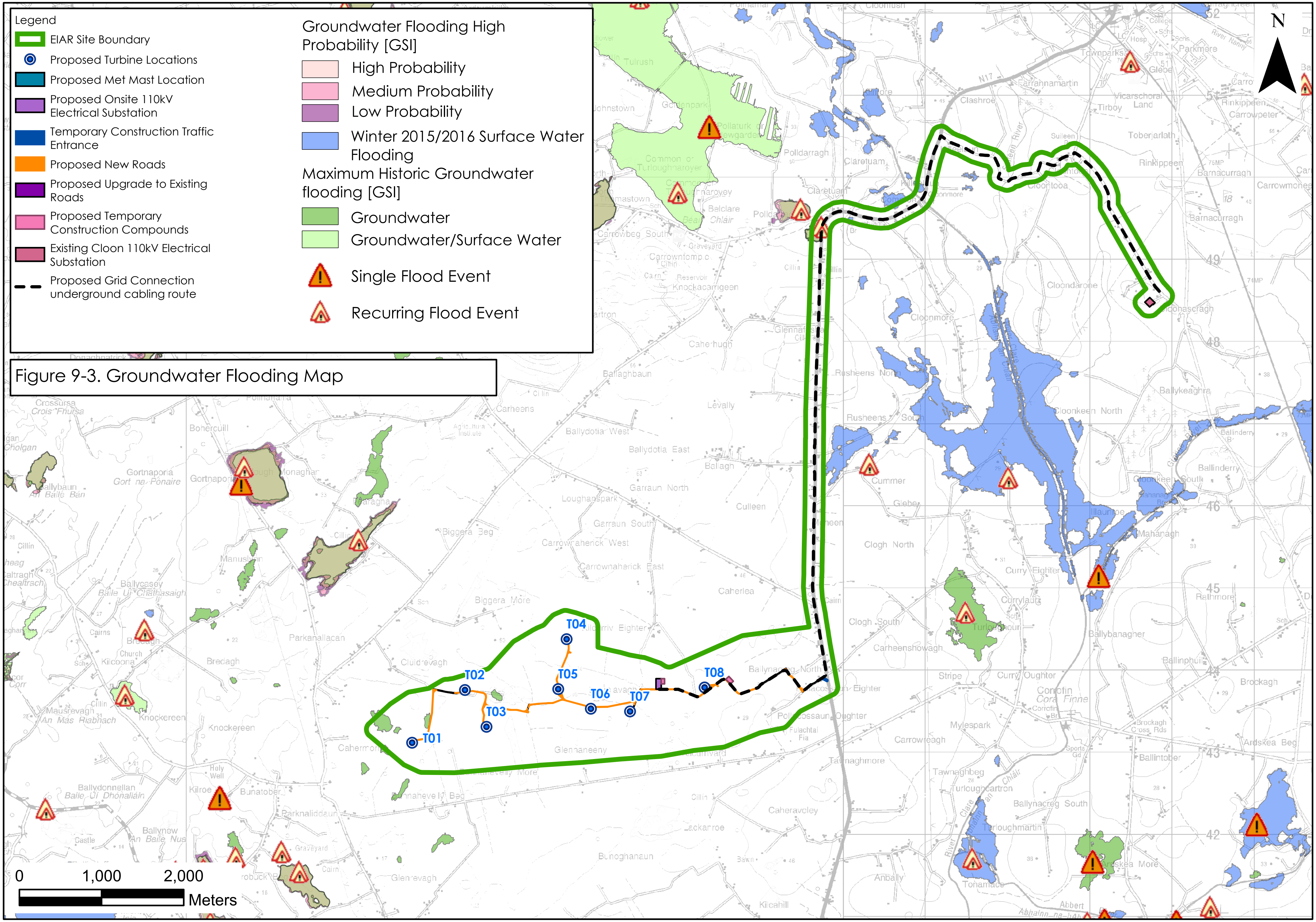


Figure 9-3. Groundwater Flooding Map

There is no text on local available historical 6" or 25" mapping for the area that identify areas that are "*prone to flooding*" within the Site. Benefitting lands are lands which have been subjected to artificial draining through the arterial drainage scheme.

9.3.4.2 Proposed Grid Connection

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

A past flooding event was recorded along the N83 at the Headford Tuam Road junction. This is noted as recurring after heavy rainfall in the area. There are no other recorded flood events along the proposed underground cabling route.

Surface water and groundwater flooding was investigated along the Proposed Grid Connection underground cabling route during walkover surveys. No evidence of groundwater or surface water flooding were observed during these surveys.

The GSI Groundwater Flooding Probability Map shows 1 no. location where groundwater flooding may occur. This location coincides with the 1. no past flooding event location along the N83 at the Headford Tuam Road junction, although the extent of both the Low probability and High probability groundwater flood does not extend on to the road carriageway.

The CFRAM river extents have been modelled along the River Clare and its tributaries, shown in Figure 9-4. The 10% AEP flood shows areas along northern section of the Proposed Grid Connection underground cabling route are prone to flooding, along the road carriageway, although as noted above there is only 1 no. location where historic flooding has been recorded. The impact of this flooding along the Proposed Grid Connection is discussed further in Section 9.4.2.4 below and within the Flood Risk Assessment included as Appendix 9-1, however it should be noted that the proposed underground cabling will be installed within an excavated and backfilled trench, and as such there is no potential for effects on or residual effects from the underground cabling. The only potential for effects exists where the installation of the cabling coincides with a flood event along this route. In this instance the installation will be suspended until the flood water recedes.

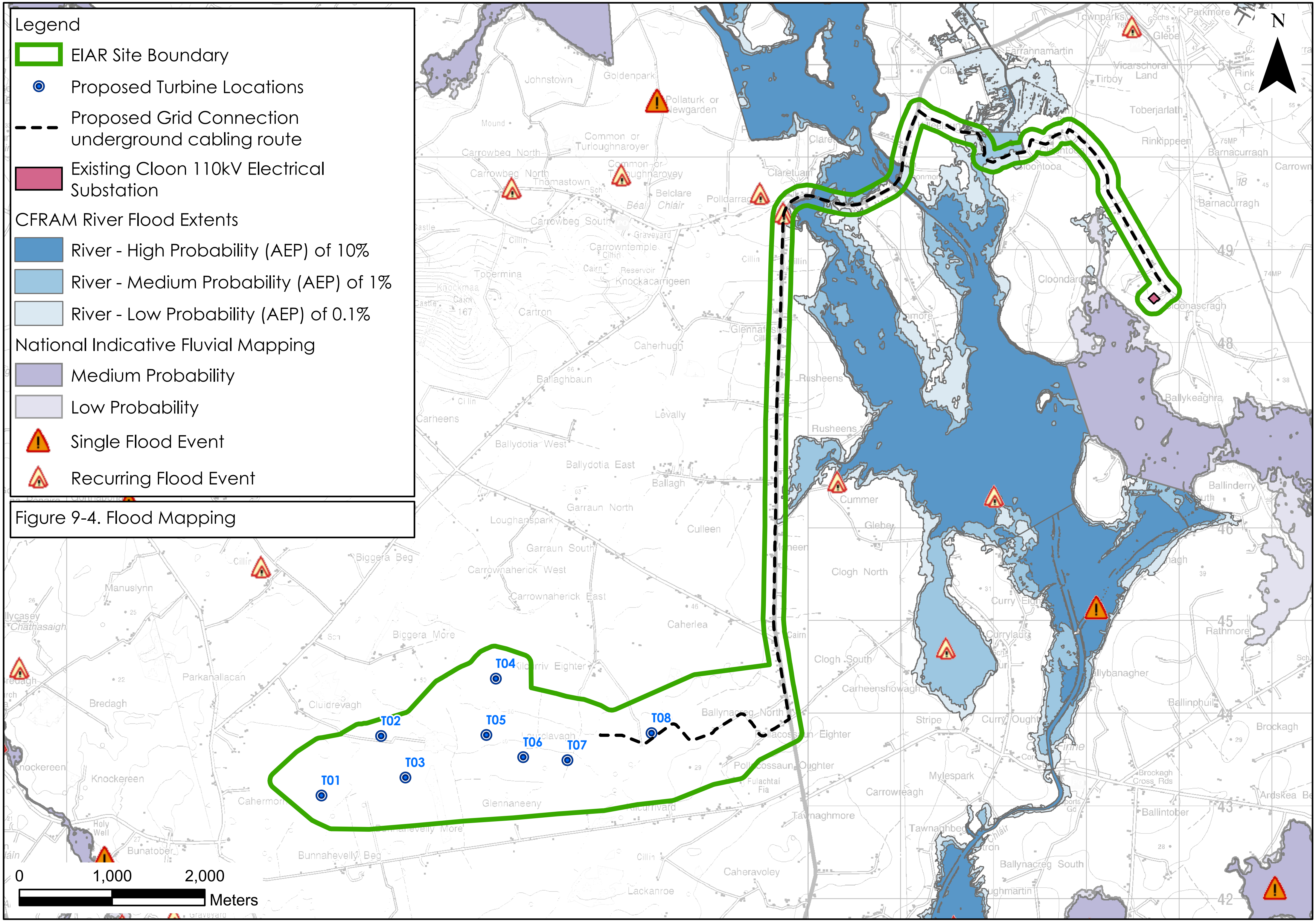


Figure 9-4. Flood Mapping

9.3.5 Surface Water Quality

Biological Q-rating data[2] for EPA monitoring points are available from locations along the River Clare, as well as the Ballinduff stream and Cregg stream.

The River Clare achieved a Q4 (Good) rating ~ 6km northeast of the Wind Farm site and a Q3-4 (Moderate) rating ~4km east of the Proposed Wind Farm site. These ratings were achieved in 2018.

The Ballinduff stream achieved a Q4 status based on sampling from 1993. The Cregg stream achieved a Q4-5 (High) rating from sampling completed in 1993 and a Q4 rating from more recent sampling in 2018.

A summary of the Q ratings is given below in Table 9-7. EPA monitoring locations are shown in Figure 9-5.

Table 9-7: River Q ratings

River	Station Code	Q rating	Status	Sampling Round
R. Clare	RS30C010700	4	Good	2018
R. Clare	RS30C010800	3-4	Moderate	2018
Ballinduff stream	RS30B050100	4	Good	1993
Cregg Stream	RS30C030050	4-5	High	1993
Cregg Stream	RS30C030100	4	Good	2018

HES completed 2 no. rounds of surface water samples on 16th August 2023 and 4th December 2023 . The recorded field chemistry data, taken with a calibrated YSI ProDSS, are given below in Table 9-8. The laboratory data are shown in Table 9-9, the full laboratory reports are included in Appendix 9-2. Sampling locations are shown in Figure 9-5.

Table 9-8: Field Hydrochemistry of water samples taken on 16/08/2023 and 04/12/2023

Location	Temp (°C)	DO (mg/L)	EC (µS/cm)	pH
SW1 (16/08/2023)	15.8	8.38	547	7.62
SW2 (16/08/2023)	17.3	6.67	667	7.13
SW1 (04/12/2023)	5.7	10.59	444	7.55
SW2 (04/12/2023)	7.2	8.67	539	7.36

[2] *The Q-Rating is a water quality rating system based on both the habitat and the invertebrate community assessment and is divided into status categories ranging from 0-1 (Poor) to 4-5 (Good/High).*

The surface water samples indicate a basic type surface water, with pH ranging between 7.13-7.62. Dissolved oxygen ranges between 6.67 -8.38 mg/L, with electrical conductivity relatively high for surface waters ranging between 547-667 µS/cm indicating there may be considerable groundwater input to the water within the River Clare and the tributary of the River Clare along the Proposed Grid Connection underground cabling route.

Table 9-9: Summary of Laboratory Analysis results (Round 1 & 2)

Parameter	EQS	Sample ID			
		SW1 (16/08/23)	SW2 (16/08/23)	SW1 (04/12/23	SW2 (04/12/23)
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	<0.02	0.12	0.04	0.09
Nitrite – N (mg/L)	≤0.01 – ≤0.03 +	<0.05	0.08	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	-≤ 0.035 to ≤0.025(*)	<0.02	0.06	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5	6.6	6.7	16.2
Chloride (mg/L)		15.3	18.1	16.5	21.5
TSS (mg/L)	25+	<5	35	<10	18
BOD	≤1.5 (mean) or ≤2.6 (95%ile)*	2	2	<1	3
Nitrogen (total)		1.2	1.8	1.9	3.6

(*) 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).

+ *Directive 2006/44/EC on the quality of fresh waters needing protection or improvement to support fish life.*

The laboratory analysis of surface water samples indicates broadly moderate - good quality surface waters, although as noted in Section 9.3.10, the River Clare at SW1 is assigned "Poor" status, while the tributary of the River Clare to the west is assigned "Moderate" status.

During Round 1 (16/08/2023), Ammonia was below the laboratory detection limit at >0.02 mg/L at SW1, while a value of 0.12 mg/L was reported at SW2. The latter is above the High status and Good status mean threshold of 0.04 mg/L and 0.065 mg/L respectively, while it is just within the 95%ile threshold value for "Good" status (0.014mg/L). The results of Round 2 (04/12/2023) are similar with values of 0.04mg/L and 0.09mg/L returned for SW1 and SW2 respectively.

During Round 1, Nitrite was below the detection limit of <0.05mg/L in SW1, while the sample from SW2 returned a reported value of 0.08 mg/L. The threshold values for Salmonid and Cyprinid waters are 0.01 and 0.03mg/L respectively. Nitrite was below the detection level (0.05mg/L) in both SW1 and SW2 during Round 2 of sampling.

During Round 1, Orthophosphate was measured at <0.02 and 0.06 mg/L in SW1 and SW2 respectively. The result from SW2 exceeds the threshold limit for both "High" and "Good" status under SI 272 of 2009. The result from SW1 is below both these threshold values. During Round 2, Orthophosphate values were lower, with the results below the dectection level (0.02mg/L) in both SW1 and SW2 samples.

Total Suspended Solids was measured at <5mg/L and 35 mg/L in SW1 and SW2 respectively. The latter value from SW2 exceeds the Freshwater Fish directive limit of 25 mg/L for both Cyprinid and Salmonid waters. The sample from SW1 is below the threshold value. The samples taken during Round 2 returned results of <10 and 18 mg/L TSS in SW1 and SW2 respectively. Both of these results are below the Salmonid and Cyprinid limits.

During Round 1, BOD was measured at 2 mg/L in both samples (SW1 and SW2). This value exceeds the mean threshold value of 1.5mg/L for “High” status, however these values are both below the 95%ile limit of 2.6 mg/L. The results of Round 2 of sampling returned values of <1 and 3 mg/L in SW1 and SW2 respectively.

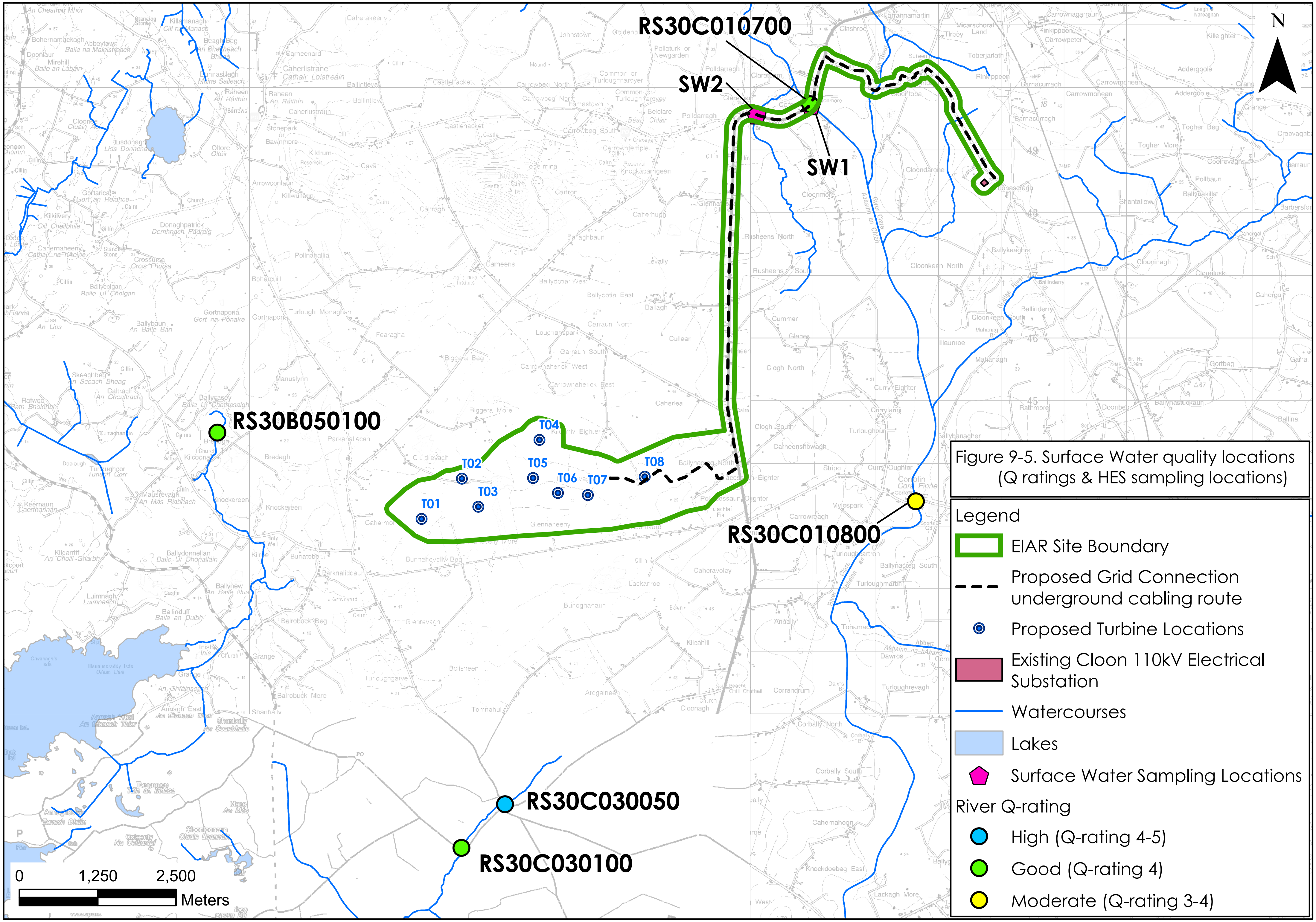


Figure 9-5. Surface Water quality locations (Q ratings & HES sampling locations)

9.3.6 Hydrogeology

9.3.6.1 Desk Study Hydrogeological Data

The Proposed Project is situated within the Clare-Corrib GWB (Groundwater Body), which extends over an area of ~1,422 km^2, stretching from Moylough and Menlough in the east, to the southern shore of Lough Corrib in the west and extending as far north as Ballyhaunis. The Clare-Corrib Groundwater Body is classified as a Regionally Important Aquifer (karstified conduit). A map of the aquifer type underlying the Site is shown in Figure 9-6. The hydrogeological description of this Groundwater Body provides a preliminary model for the hydrogeological environment at the Proposed Wind Farm site and Proposed Grid Connection underground cabling route.

A description of the Clare-Corrib GWB is provided in the Initial Characterisation Summary sheet for the Groundwater Body. The details within this text have been summarised below, with the addition of context with respect to the Proposed Project.

The topography of the Clare-Corrib Groundwater Body is characterised by small hills and low ridges, with elevation ranging from 10-160mOD. The topography slopes gently westward towards Lough Corrib (at ~8-10mOD).

The bedrock geology comprises Dinantian Pure Bedded Limestone, with areas of Pure Unbedded Limestones near Headford. Karstification is widespread in the GWB with recorded Karst features such as enclosed depressions and swallow holes mapped by the GSI. The frequency of mapped karst features is greater in the eastern section of the GWB, east of the River Clare.

Well yields are variable across the GWB ranging from excellent (>400 m^3/day) to moderate (40-100 m^3/day). The groundwater table has a high annual variation, indicating that the storage is low, with storativity ranging between 0.01-0.02 (Daly, 1985). Overall, groundwater flow directions are to the southwest, with all groundwater discharging to Lough Corrib.

The Dinantian Pure Bedded Limestones are generally over 100m thick. Most groundwater flows in a weathered epikarst layer a couple of metres thick, and in a zone of solutionally enlarged fissures and conduits that extend below this. Limestone till is the dominant subsoil type, with an average thickness of 4m in the west of the GWB, increasing to ~9m in the west.

Both point and diffuse recharge occurs over this GWS with rainfall percolating through the permeable subsoil. Point recharge to the underlying aquifer occurs by means of swallow holes and collapse features/dolines. These features are absent across the Proposed Wind Farm site, and diffuse recharge dominates.

The GWB report[3] states the following:

> *"The groundwater has a calcium bicarbonate signature. Two groundwater provinces are suggested by Drew and Daly (1993). Firstly, there is a shallow groundwater component that is characterised by high suspended solids and relatively low electrical conductivities (300-400 µS/cm). Springs that are fed by this component typically have a "flashy" throughput and often cease to flow during prolonged drought. Secondly, there is a deeper groundwater component that is characterised by relatively non-turbid groundwater with higher electrical conductivities (>450 µS/cm).*
>
> *The area is drained by the River Clare and its tributaries, however the present day drainage network has been changed significantly by arterial drainage that took place early in the nineteenth*

[3] *Clare-Corrib Groundwater Body Initial Characterisation Report, GSI., 2004*

century. According to Coxon and Drew (1983), much of the current stream network is a storm runoff system that is inactive during summer months. Thus, prior to drainage, streams sank underground via the turloughs present in the GWB.

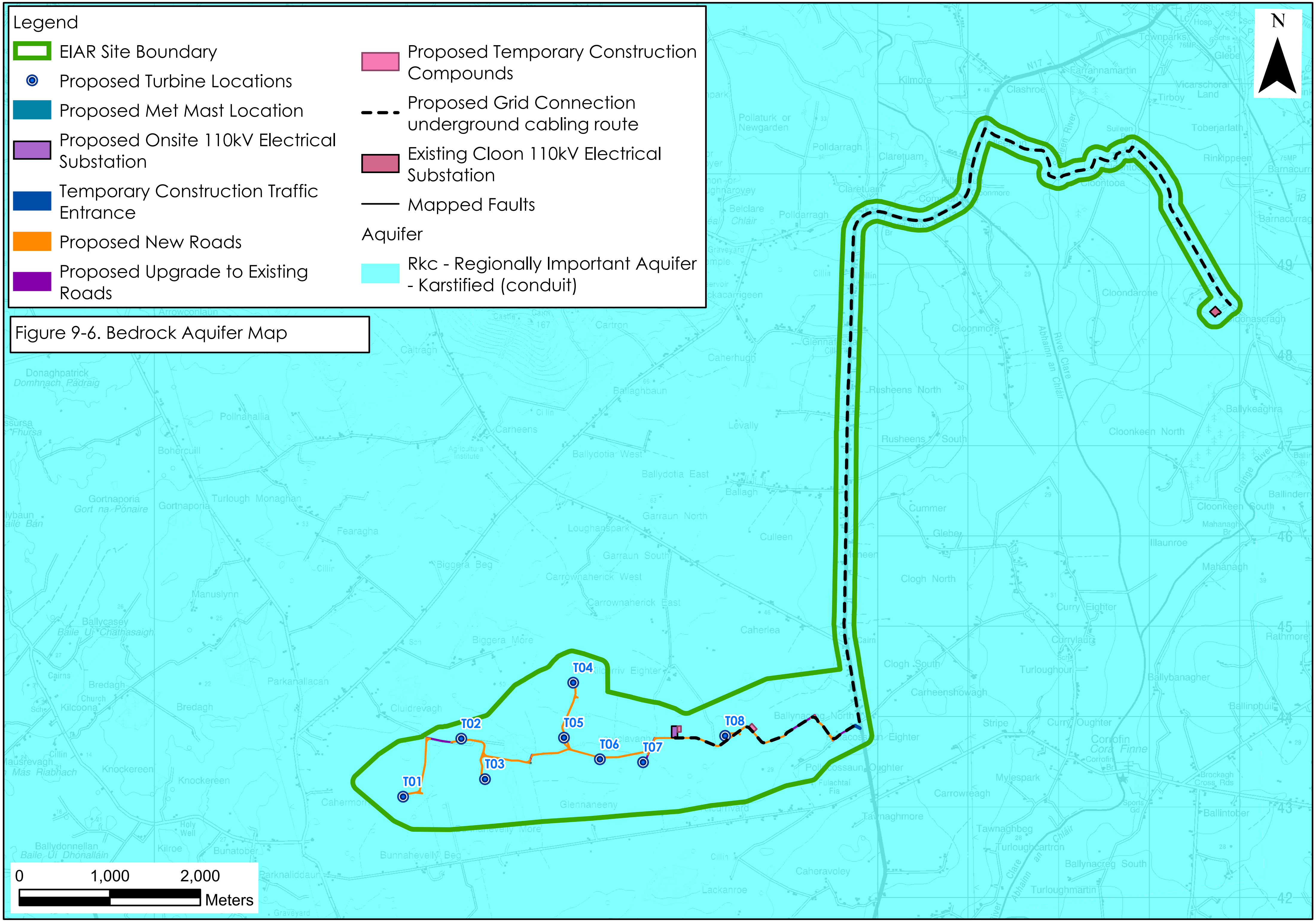


Figure 9-6. Bedrock Aquifer Map

9.3.6.2 Summary of Geological Data

9.3.6.2.1 *Proposed Wind Farm*

A detailed description of the Site geology is presented in Chapter 8. A summary is presented here to aid the discussion on hydrogeology that follows.

Baseline geological data is available from the GSI through their online Mapviewer[4]. This bedrock mapping is completed at a broad regional scale and is considered to be indicative of the bedrock type but is superseded by the collection of site investigation data which is site-specific and completed at a much finer scale. Bedrock geology across the Proposed Wind Farm site is mapped as Burren Formation Limestone, which consist of pale grey, clean skeletal Limestone. The formation is typified by pale-grey packstones and wackestones, but also contains intervals of dark cherty limestones, often associated with oolitic grainstones. There is a considerable amount of bedrock outcrop mapped across the Proposed Wind Farm site and in the surrounding area which can be seen on some of the available aerial photography. The bedrock is mapped as dipping at 3° to the southeast. A bedrock aquifer map is included in Figure 9-6.

The GSI has classified the Burren Formation bedrock as a Regionally Important Aquifer – Karstified (conduit). The Proposed Wind Farm site is located within the Clare-Corrib GWB.

The Site-specific data on the geology of the Proposed Wind Farm site is included within Sections 8.3.3 and 8.3.4 in Chapter 8 of this EIAR and is summarised into a geological conceptual model in Section 8.3.9. The conceptual model of the geology of the Proposed Wind Farm site, including the soils, subsoils and bedrock types, thicknesses and areal extent are briefly summarised below:

- There is no peat present at the Proposed Wind Farm site;
- There are shallow soils/subsoils across the Proposed Wind Farm site, which are derived from Limestone parent material and are typically 0.5-2.0m thick, but extend to ~3-4m depth in parts;
- The soil/subsoil is underlain by a layer of typically moderately weathered Limestone which generally exists within the top 1-3m of the Limestone bedrock;
- Below this zone of moderate weathering, the Limestone bedrock becomes hard and competent. No evidence of wide scale karstification was observed.

The site-specific investigations comprise an exhaustive list of intrusive and non-intrusive works carried out at the Proposed Wind Farm site which include:

- 3 no. groundwater monitoring boreholes drilled at locations MW21-01, MW21-02 and MW21-03 in December 2021;
- A geophysical survey conducted in June 2022;
- A further follow up geophysical survey was carried out in December 2022;
- 10 no. rotary core boreholes drilled between 20th March – 27th April 2023;
- 7 no. trial pits excavated by machine between 22nd March – 17th April 2023;
- 13 no. further infiltration trial pits excavated between 20th March – 25th April with 26 no. accompanying infiltration (k) tests; and,
- 46 no. indirect CBR tests.

In total 230m of drilling has been completed to determine the nature of the soil, subsoil and bedrock across the Proposed Wind Farm site, with targeted locations chosen, informed by geophysical surveys.

[4] https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

A geological conceptual model has been developed for each of the 8 no. turbine locations and the proposed onsite 110kVsubstation within the Proposed Wind Farm site. This is crucially important when considering the hydrogeological impact or potential effects of the Proposed Project on the hydrogeological environment The primary control on these potential effects is the type of basal material underlying the major infrastructure. Competent, hard limestone underlying a turbine base or substation, with groundwater levels at depth below the base provides less risk to the hydrogeological environment than a weak karstified Limestone with groundwater interactions near the land surface.

The iterative process of site investigations and multiple geophysical investigations has built up the following model:

- Turbine T1 – Geophysics interpreted overburden up to 3.3m thick over competent Limestone bedrock below. Drilling at RC03 (T1) encountered brown clay to 1.2m, gravel from 1.2-2.7m and hard grey Limestone at 2.7m. Core photos show competent dark grey Limestone from 2.7m to the base of the hole at 10m. All data indicate competent hard Limestone underlying the turbine base;
- Turbine T2 – Geophysics interpreted up to 3.2m of overburden over Limestone bedrock, as well as an area of highly weathered Limestone ~50m north of the turbine base. Drilling at RC04 (T2) recorded clay to 3.5m, Gravel from 3.5-4m and medium-hard Limestone from 4m. The core photos from RC04 indicate competent grey Limestone underlying the turbine base;
- Turbine T3 – The results of the geophysics from the first geophysical survey (June 2022) indicate up to 1.6m of medium dense soil over Limestone bedrock from between 0.7-3.0m During the drilling at MW21-03 (100m southwest of T3), very hard Limestone was met at 2.5m and throughout the subsequent drilling to a completed depth of 49.6m (refer to Table 8-5 of Chapter 8). All site data near Turbine T3 indicate competent Limestone underlying the turbine base;
- Turbine T4 – Geophysics was carried out at turbine T4 which indicated up to 2.6m of dense subsoil, underlain by Limestone bedrock at 2.2m at the turbine base centre. The drilling at borehole RC02 described firm clay to 1.2m, followed by cobbles and angular gravel to 1.75m which may be interpreted as slightly weathered Limestone bedrock, which was in turn underlain by competent, strong grey Limestone from 2.5m to the end of the borehole at 10m. The Site data at T4 indicated competent Limestone underlying the turbine base.
- Turbine T5 – Soils/subsoils interpreted to 0.3-1.0mbgl. The underlying bedrock geology is interpreted as moderately to highly weathered Limestone from 1.0-3.2mbgl, with less weathered, competent Limestone below. A zone of more weathered rock is interpreted ~10-15m west of the turbine base. The drilling of RC11, at the turbine base centre, encountered clay and gravel to 3.5m, followed by hard Limestone with very little weathering. RC05 was drilled ~15m west of the turbine centre and encountered clay and gravel to 2.3m over strong thickly laminated Limestone which was very slightly weathered. RC08 was drilled ~20m north of the turbine centre and encountered clay and gravel to 2.5m over strong grey Limestone from 2.5-10m. All site data at T5 show the turbine base is underlain by competent, strong Limestone bedrock;
- Turbine T6 - Geophysics interpreted as 0.3-1.0m of overburden, overlying Limestone bedrock with undulating depth across the survey line from 0.8-7.8m. Borehole RC09 was drilled at the T6 turbine base location and encountered sandy/sandy gravelly clay to 3m, overlying strong, dark grey Limestone with white calcite mineralisation, which was slightly weathered. The core samples show the majority of weathering in the top 1-1.3m of the Limestone bedrock (to ~4.3mbgl), with competent Limestone bedrock below from 4.3-10m. The Site data from turbine T6 indicate the turbine base is underlain by competent Limestone;
- Turbine T7 – Geophysics interpreted as loose soils up to 1.55mbgl, underlain by firmer soils up to 3.9mbgl. The bedrock geology is interpreted as Limestone from 0.9-3.9mbgl, with a weathered layer within the first 1-3m of bedrock, followed by fresh,

hard Limestone below. Borehole RC07 was drilled at the centre of the turbine base. The drilling encountered clay to 3m, followed by clayey gravel, sandy clay and clayey sand to 5.85m. This was followed by strong, dark grey Limestone with frequent calcite mineralisation which was slightly weathered in parts. The data indicates that T7 is underlain by competent Limestone;
- Turbine T8 – Geophysics interpreted as 1.2-5.5m of silty sand/gravel and gravelly clay, overlying Limestone bedrock which is moderately weathered; and,
- Substation – Geophysics interpreted as 0.3-8.0m of clayey silty sand/gravel underlain by Limestone bedrock with the top of bedrock slightly weathered.

Competent, hard to very hard Limestone bedrock underlies the Proposed Wind Farm site. Subsoils are relatively shallow, extending to 0.5-2mbgl across the majority of the Site, with areas of deeper subsoils to 3-4mbgl. A layer of moderately weathered Limestone exists at the top of the bedrock which is typically 1-3m deep and likely the result of past glacial action. Below this zone of moderate weathered bedrock, the Limestone is competent and hard in the rotary core boreholes to 10-10.5m depth.

9.3.6.2.2 *Proposed Grid Connection*

Site investigation works along the Proposed Grid Connection underground cabling route include;

- 35 no. peat probes along northern section of the Proposed Grid Connection underground cabling route where peat is mapped by the GSI;
- Site walkover survey of ground conditions and topography along the Proposed Grid Connection underground cabling route; and,
- Surface water sampling (2 no. rounds) at 2 no. locations (SW1 and SW2) along the Proposed Grid Connection underground cabling route.

The results from the peat probing indicate that peat depths are shallow, with the deepest peat measuring 0.7m; ranging between 0.1m to 0.7m, with an average depth of 0.23m. The peat and underlying subsoil will be excavated from the Proposed Grid Connection underground cabling trench to a depth of c.1.3m, before being reinstated after the cable ducting has been laid. Due to the nature of the Proposed Grid Connection underground cabling works, essentially a temporary excavation and reinstatement, the limited and sparse depth of peat subsoil will not have a major bearing on the potential effects in terms of the water environment. Nonetheless, the presence of limited peat soils is included within the assessment of significant effects (Section 9.4).

9.3.6.3 Proposed Wind Farm Field Hydrogeological Data

9.3.6.3.1 *Site Investigation Data*

Rotary core drilling was undertaken at 10 no. locations (RC01-RC9 & RC11) across the Proposed Wind Farm site, primarily centred around the turbine base (T1-T8), as well as areas offset (15-50m) from the turbine base centres. These boreholes were drilled to provide details on the depth of overburden, the bedrock lithology/type for engineering design and to provide information on any groundwater met during the drilling. Further rotary down-hole hammer boreholes were drilled at 3 no. locations (MW21-01 – MW21-03) to determine the Site-specific subsoil depth, geology, groundwater strikes and to facilitate groundwater level monitoring. A summary of these boreholes and the hydrogeological information gained is included below as Table 9-10.

Table 9-10: Proposed Wind Farm Hydrogeological Data from Site Investigations

Location	Depth (m)	Overburden	Bedrock Geology	Karst Feature	Groundwater Strike
RC01	10.5	Soft brown slightly sandy CLAY to 3.5m, GRAVEL from 3.5-4m, Medium strong light grey	Medium strong light grey LIMESTONE. Moderately weathered in parts, from 4-10.5m	None	None, water added during drilling to keep dust down
RC02	10	Firm brown CLAY to 1.2m, Loose grey cobbles and boulders from 1.2-1.75m, Grey angular limestone GRAVEL to 2.5m, Strong dark grey	Strong, dark grey LIMESTONE with white calcite veins - slightly weathered in parts, from 2.5-10m	None	None, water added during drilling to keep dust down
RC03	10	Brown CLAY, low cobble and boulder content to 1.2m, Dense grey GRAVEL to 2.7m (possibly weathered bedrock), Strong thickly laminated dark grey	Strong, thickly laminated dark grey LIMESTONE, slightly weathered in parts, from 2.7-10m	None	None, water added during drilling to keep dust down
RC04	10	Firm brown CLAY to 3.5m, Dense greyish brown fine to medium GRAVEL (possibly weathered bedrock) from 3.5-4.5m, Medium strong to strong dark grey	Medium strong to strong dark grey LIMESTONE with white calcite mineralisation in parts, from 4.5-10m	None	None, water added during drilling to keep dust down
RC05	10	Stiff brown CLAY to 1.2m, Dense brownish grey GRAVEL from 1.2-2.3m, Strong thickly laminated greyish brown	Strong, thickly laminated LIMESTONE, slightly weathered in parts, from 2.3-10m	None	None, water added during drilling to keep dust down
RC06	10	Soft brown CLAY to 2.25m, GRAVEL (weathered bedrock) from	Strong, dark grey LIMESTONE with white calcite veins - slightly	None	None, water added during drilling to keep dust down

Location	Depth (m)	Overburden	Bedrock Geology	Karst Feature	Groundwater Strike
		2.25-3m, Strong dark grey	weathered in parts, from 3-10m		
RC07	10	Soft brown CLAY with GRAVEL and SAND to 5.85m, Strong dark grey	Strong, dark grey LIMESTONE with white calcite veins - slightly weathered in parts, from 5.85-10m	None	None, water added during drilling to keep dust down
RC08	10	Brown CLAY, low cobble and boulder content to 1.2m, dense grey cobbles and boulders to 2.5m, Strong very thinly laminated light grey dolomitised	Strong, thinly laminated LIMESTONE, moderately weathered in parts, from 2.5-10m	None	None, water added during drilling to keep dust down
RC09	10	Soft brown CLAY to 3.0m,	Strong dark grey LIMESTONE with white calcite mineralisation throughout from 3-10m	None	None, water added during drilling to keep dust down
RC11	10	Brown CLAY to 1.2m, Grey GRAVEL and boulders (possibly weathered bedrock) from 1.2-3.5m,	Strong thickly laminated brownish grey LIMESTONE, slightly weathered in parts, from 3.5-10m	None	None, water added during drilling to keep dust down
MW21-01	55	Firm brown TOPSOIL over SAND and GRAVEL to 1.1m,	Medium strong weathered grey LIMESTONE to 12m, very hard Limestone from 12-55m.	None	Very minor groundwater strike at 9m (enough to keep down dust) Groundwater strike at 41m
MW21-02	24	Firm brown TOPSOIL to 0.3m, Firm to stiff brown silty gravelly CLAY to 13.2m,	Weathered Limestone from 13.2 – 18.8m, hard Limestone from 18.8-24m	None	Very minor groundwater strike at 7m (enough to keep down dust)

Location	Depth (m)	Overburden	Bedrock Geology	Karst Feature	Groundwater Strike
					Groundwater strike at 19.5m
MW21-03	49.6	Hardcore fill brownish grey sandy gravelly made ground to 0.2m, TOPSOIL from 0.2-0.4m, dense SAND and GRAVEL to 2.5m,	Very hard Limestone from 2.5-49.6m	None	Groundwater strike at 34m

There were no karst features identified during the drilling of the 10 no. rotary core boreholes or the 3 no. deeper groundwater monitoring wells. The drilling was carried out through thin subsoils, which were typically 2-3.5m in depth, but extended to 13.2m at MW21-02.

MW21-02 is 100m west of turbine T2, while the cored borehole RC04 was drilled at the centre of the proposed turbine base and encountered 3.5m of overburden (clay and gravel) over 1m of moderately weathered bedrock, underlain by hard, competent Limestone from 4.5 – 10m.

The boreholes were drilled through typically hard to very hard Limestone with no groundwater strikes or karst features noted in RC01-RC09 & RC11. Minor groundwater strikes, which only contained enough water to supress the drilling dust were encountered at 9m and 7m in MW21-01 and MW21-02 respectively, while the main groundwater strikes were met at depths of 41m, 19.5m and 34m in MW21-01, MW21-02 and MW21-03 respectively.

This demonstrates a lack of groundwater flow at these locations within the top ~20m of the bedrock aquifer, with groundwater met in narrow fissures/fractures at or below this depth.

The general geology of the Proposed Wind Farm site includes a limited depth, typically 2-3.5m of overburden (refer to histogram of overburden depths in Plate 8-1 of Chapter 8) which generally comprises brownish grey sandy gravel and gravelly sand, with brown clays also encountered. The bedrock below this overburden comprises generally Moderately Strong to Strong grey Limestone, which is occasionally soft and fractured/weathered in discrete intervals, but overall is considered to be competent bedrock with no observed below ground karst type features. This is further illustrated by the core sample photographs of boreholes RC01-RC09 & RC11 (Appendix 8-2 of Chapter 8) and by the lack of water strikes or water bearing strata as outlined in Table 9-10. Water level loggers were installed in boreholes MW21-01, MW21-02 and MW21-03 to monitor groundwater levels.

9.3.6.3.2 Groundwater Level Monitoring Data

Groundwater level data has been collected from the 13 no. monitoring locations. These data have been plotted on individual graphs, along with the corresponding water levels in the River Clare situated east of the Proposed Wind Farm site and Lough Corrib situated west of the Proposed Wind Farm site. These graphs are included as Figure A – Figure M of Appendix 9-3. A summary of this data is included in Table 9-11.

The groundwater levels in MW21-01, located ~150m from turbine T8, near the eastern boundary of the Proposed Wind Farm site range between 8.2-29.7mOD. The groundwater levels recorded show rapid response to rainfall events, with equally rapid recessions, typical of the low storativity, high transmissivity groundwater regimen as outlined in the Clare Corrib groundwater characterisation report (detailed in Section 9.3.6.1).

Similarly, in MW21-02, groundwater levels range between 11.4 - 28.2mOD and show the same variation in response to rainfall events. The hydrographs of both MW21-01 and MW21-02 resemble "flashy" systems.

Water levels in MW21-03, which is the furthest west of the 3 no. monitoring wells range between 13.6-30.9mOD. The water levels in MW21-03 again rise sharply and decline steeply following the onset and cessation of rainfall events.

As shown in Figure J – Figure M of Appendix 9-2, the water levels within the 3 no. monitoring wells range within the boundaries of the River Clare to the east of the Proposed Wind Farm site at ~32 mOD, and the water level in Lough Corrib to the west of the Proposed Wind Farm site at ~7mOD. This demonstrates that groundwater flow is in a broadly east to west direction, which is in line with the Corrib-Clare GWB description (Section 9.3.6.1) and consistent with the groundwater levels seen in the GWS and domestic wells detailed below.

Groundwater levels in Anbally GWS, which is situated ~2.5km southeast of turbine T8 and ~2km southeast of the Proposed Wind Farm site boundary, range between 9.2 – 27.4 mOD. The groundwater levels show the same flashy response as noted in well MW21-01 to MW21-03. During Summer, the groundwater levels are generally at ~9.5-10.5mOD. The groundwater system then responds to the onset of winter rainfall in October-November and begins to sharply increase during the winter months, although groundwater levels do drop down to ~10mOD in January 2023, before rising again in February and March to ~27mOD.

Groundwater levels at Balrobuckbeg GWS range between 8.1 – 11.7mOD. The groundwater levels at Balrobuckbeg show a much less pronounced response to rainfall than most other wells in the area. The Balrobuckbeg GWS is the furthest west of the wells monitored during the monitoring period and is only ~2.2km from the eastern shore of Lough Corrib.

Water levels in Biggeramore GWS range between 10.9 – 31.2mOD. Groundwater levels typically decline from March/April reaching the lowest groundwater levels in August/September due to relatively low rainfall during the summer months. Groundwater levels then rise sharply following the onset of winter rainfall and reach their peak in December/January. The cycle is then repeated, with groundwater levels declining in March/April towards the typical summer water levels.

Water levels in Caherlea GWS range between 12.3 – 30.8mOD. Groundwater levels are highest between December to March/April, then decline during the summer months. As seen in Figure D, there is also a large spread in water levels during the summer months between ~12.5mOD, which is the rest groundwater level and ~9mOD which is the level at which drawdown is induced during pumping. Water levels begin to rise again in early winter and show similar sharp rises and steep recessions as mentioned in other wells, typical of a low storativity system.

Groundwater levels in Cahermorris Glenreevagh GWS range between 12.6 – 19.8mOD (rest water level). There is a considerable amount of drawdown induced during pumping cycles in this well, which leads to ~7m of drawdown when the pump is running. There is less of a wide range in groundwater levels throughout the year in comparison to the monitoring wells and other GWS wells such as Caherlea and Biggeramore. The groundwater level peaks are attained over longer periods, with slower recessions in water levels, indicating more storativity within this area. The overall shape of the groundwater hydrograph is somewhere between the flashy response noted in the majority of the wells discussed above (Caherlea, Biggeramore etc.) and the more gradual response of the water levels in Balrobuckbeg. It should be noted that the Cahermorris Glenreevagh GWS is situated ~1km east of Balrobuckbeg and ~2km west of MW21-03, which may indicate increasing storativity further west of the Proposed Wind Farm site.

Groundwater levels in Cluide Cahermorris GWS range between 9.7 – 18.8mOD. The variability is the groundwater levels is less pronounced than the more easterly monitoring locations (MW21-01 – MW21-03, Anbally GWS, Caherlea GWS *etc*.). The groundwater levels typically recede from March/April at

15-19mOD, to the summer water level which is typically ~10mOD. There is a ~3-4m of drawdown induced during pumping in the GWS well.

Groundwater levels in Rusheens GWS range between 12.1 – 31.1mOD. The variations in water level are sharp, with steep increases in groundwater levels following the onset of rainfall during the winter months, with equally sharp recessions during periods of reduced/no rainfall. Again, the large range in groundwater levels reflects the low storativity of the system.

Groundwater levels in Domestic Well 1 behave similar to the Rusheens GWS well above. The water levels vary between 12.2 – 27.8mOD, with sharp accessions and recessions following rainfall. As this is a domestic well, with a relatively low pumping rate, the effect of pumping is not particularly evident. Groundwater levels in summer are essentially flat at ~ 12.2-12.5 mOD, following the winter rainfall/recharge being discharged out of the system towards Lough Corrib. The onset of rainfall in September/October leads to a sharp increase in water levels to ~25-27.8mOD.

Groundwater levels in Domestic Well 2 range between 14.8 – 30.6mOD. The water levels in this well responds similarly to the flashy, low storativity groundwater wells discussed above. Water levels reach their peak between December to April, before the cessation of winter rainfall leads to the groundwater system essentially emptying and discharging towards Lough Corrib. During the summer, groundwater levels are relatively stable at ~ 14.8-15.0mOD, with some external influence during pumping cycles, creating drawdown to ~8mOD. Domestic Well 2 is also used for agricultural purposes, therefore there is a greater demand on this well than other domestic wells.

Groundwater levels in Domestic Well 3 range between 13.9 – 27.7mOD. The water levels display a rapid ascension and recession in response to rainfall events, typical of the low storativity regimen previously described.

All groundwater levels recorded in the 13 no. wells range between the upgradient and downgradient controlling boundaries, namely the River Clare situated 3km east of the Proposed Wind Farm site and Lough Corrib, situated 4.1km west of the Proposed Wind Farm site. As such, groundwater levels flow west/southwest across the Proposed Wind Farm site and eventually discharge to Lough Corrib.

The reality of these groundwater levels with large ranges between ~8-30mOD, is that this groundwater can be considered as essentially only flowing through the fractures and fissures encountered at depth, noted as groundwater strikes on the logs (41m, 19.5m and 34m in MW21-01 to MW21-03 respectively). The water levels recorded in the groundwater wells are an expression of the pressure potential within the fractures/fissures which are encountered.

That is to say, that although the water levels in these wells may rise sharply to ~30mOD following heavy rainfall events, this same response would not occur in the overlying ~20m (~10-30mOD) of competent Limestone which would likely remain relatively free of a groundwater response due to its low permeability. This sharp rise would only be observed in a block or zone of karstified Limestone. The surface expression of this sharp rise in karstified Limestone would be a turlough, if the karstification extends to the surface. Note, there were no zones of karst Limestone encountered during the drilling and there are no turloughs mapped within the Site, the nearest turlough is located 2km from the Proposed Wind Farm site and 2.2km from the nearest proposed turbine (T2).

The low storativity, characteristic of this aquifer type, is due to the fact that the bulk of the Limestone bedrock is essentially impervious to groundwater movement (hence the lack of groundwater strikes in the solid Limestone encountered in RC01-RC09 & RC11), while the fractures and fissures and which groundwater moves through make up only a small percentage of the bedrock matrix. These fractures and fissures make up a small overall proportion of the bedrock matrix, such that the actual storage of groundwater within the groundwater system (storativity) is low.

Table 9-11: Boreholes and available water level data

BH Number	Elevation (m OD)	Minimum Water Level (m OD)	Maximum Water Level (m OD)	Nearest Turbine
MW21-01	43.41	8.2	29.7	Turbine 8 – 150m
MW21-02	36.21	11.4	28.2	Turbine 4 – 100m
MW21-03	32.75	13.6	30.9	Turbine 3 – 100m
Anbally GWS	43.03	9.2	27.4	Turbine 8 - 2.5km northwest
Balrobuckbeg GWS	12.52	8.1	11.7	Turbine T1 – 2.2km northeast
Biggeramore GWS	47.25	10.9	31.2	Turbine T2 – 0.9km south
Caherlea GWS	47.34	12.3	30.8	Turbine T8 – 1.6km southwest
Cahermorris Glenreevagh GWS	25.92	12.6	19.8	Turbine T1 – 1.2km northeast
Cluide Cahermorris GWS	26.31	9.7	18.8	Turbine T1 – 1.2km southeast
Rusheens GWS	33.46	12.1	31.1	Turbine T8 – 2.9km southwest
Domestic Well 1	35.41	12.2	27.8	Turbine T8 – 1.5km west
Domestic Well 2	41.8	14.8	30.6	Turbine T8 – 1.5km southwest
Domestic Well 3	28.89	13.9	27.7	Turbine T3 – 0.9km northwest

As noted above, although the water levels in these wells (outlined above in Table 9-11) may rise sharply to ~30mOD following heavy rainfall events, as seen in borehole MW21-03 in Table 9-11, this same response would not occur in the overlying ~20m (~10-30mOD) of competent Limestone which would remain relatively free of a groundwater response due to its low permeability.

This water level is only observed in the boreholes as they have intercepted water strikes at depth. Rainfall/recharge reaching these lower aquifers raises the [potentiometric] pressure of the groundwater within these aquifers. As the deep boreholes have penetrated these aquifers, the groundwater is free to rise and fall in these boreholes.

These sharp rises to ~30mOD would not be observed in a shallow borehole to ~10m depth (and similarly a shallow excavation), as the bedrock is competent, relatively impermeable Limestone. No groundwater bearing aquifer units have not been observed at these shallow depths (as evidenced by the results of the drilling of boreholes RC-01 – RC-09 and RC-11.

9.3.6.3.3 Subsoil Permeability

Site investigation works across the Proposed Wind Farm site included 13 no. trial pits excavated in order to log the soil/subsoil as well as to conduct infiltration tests on the overburden material.

26 no. infiltration tests were performed at the Proposed Wind Farm site (13 no. locations with 2 no. tests at each location), the results of which are summarised below in Table 9-12. The results of the infiltration test show that permeability varies across the Site, with permeability ranging from very low (<0.1m/h) to very high (>20 m/h). The mean infiltration rate from the tests which provided results is estimated at ~ 2m/h. The permeability across the Proposed Wind Farm site varies considerably, determined by the composition of the subsoil, however the overall net effect of permeability is a relatively well draining site, evident by the lack of surface water channels (*i.e.* all rainfall percolates to ground).

Table 9-12: Summary of infiltration test results

Location	Depth	Elevation (mOD)	Geological Description	Infiltration rate test 1 (m/h)	Infiltration rate test 2 (m/h)
ITP01	2.8	48.4	Topsoil over sandy CLAY over sandy gravelly CLAY	Very Low	-
ITP02	1	54.29	Topsoil over sandy gravelly CLAY	1.04	0.98
ITP03	1	39.8	Topsoil over Limestone COBBLES and BOULDERS	9.58	7.33
ITP04	2.8	40.01	Topsoil over sandy gravelly CLAY	0.128	-
ITP05	1.3	25.11	Topsoil over clayey fine to coarse SAND	0.072	-
ITP06	1.8	30.08	Topsoil over sandy CLAY	0.37	0.38
ITP07	1.8	31.3	Topsoil over sandy CLAY over gravelly CLAY	>20	-
ITP08	1.8	30.15	Topsoil over Limestone COBBLES over coarse GRAVEL	>20	-

Location	Depth	Elevation (mOD)	Geological Description	Infiltration rate test 1 (m/h)	Infiltration rate test 2 (m/h)
ITP09	3.2	-	Topsoil over firm CLAY	Very Low	-
ITP10	2.7	36.35	Topsoil over gravelly SILT over gravelly CLAY	Very Low	-
ITP11	2.3	33.28	Topsoil over gravelly CLAY	Very Low	-
ITP12	0.7	42.48	Topsoil over sandy CLAY	1.172	0.99
ITP13	3.5	34.46	Topsoil over gravelly CLAY	Very Low	-

9.3.6.4 Karst Features

9.3.6.4.1 *Springs*

Karst features are mapped by the GSI and available through the GSI online viewer. There are several karst features mapped near the Proposed Wind Farm site as shown in Figure 9-7. The closest mapped karst feature is a spring, situated between T7 and T8. There are also 3 no. depressions and a cave mapped ~0.8km south of the southwestern corner of the Proposed Wind Farm site (refer to Figure 9-7).

The spring between T7 and T8 has been investigated during the walkover surveys of the Proposed Wind Farm site. The spring is situated at an elevation of ~40mOD, with water levels at or near surface within the open well. The water level measured in MW21-02, a monitoring well screened within the bedrock aquifer, situated 200m south of the mapped spring, ranges between 11-26mOD.

Historic gravel excavations exist near the spring. This has created a number of pits whereby the soil/subsoil can be examined. A photograph of this pit is included as Photo 9 of Appendix 4-4, which show the gravel deposits surrounding the spring. As the water level in the pit sits ~20m above the typical water level in MW21-02, and the spring itself is surrounded by these gravel deposits, the conceptual model for groundwater flow at this location is as follows:

- The mapped karst spring is situated in an area of relatively thick gravels (>3m from on-site observations);
- Elevation at the spring is ~40mOD, with higher grounds (50-55mOD) situated east of the spring;
- Water levels at the spring are 14-29m higher than the measured bedrock groundwater level in this local area;
- Rainfall percolates through the subsoils within the area of elevated ground to the east. A percentage will infiltrate into the underlying aquifer, however some will remain perched within the overburden and likely flows along the top of the bedrock towards areas of low elevation (i.e. the mapped spring);
- This creates a small perched aquifer within the gravel deposits surrounding the spring. The spring is located within a small local hollow and the groundwater level in this perched aquifer emerges within this depression;
- Given the difference in groundwater levels between this perched aquifer (at ~40mOD) and the bedrock aquifer (14-29mOD), the available data suggests that there is no hydraulic connection between the spring and the underlying bedrock aquifer; and,
- The mapped spring is not a karst spring with water from the underlying limestone aquifer emerging at this point, but rather a shallow well intercepting water in the perched gravel aquifer.

North/northwest of the Proposed Wind Farm site, 3 no. turloughs are mapped, one of which coincides with Turlough Monaghan, while the other two are unnamed. Kilcoona spring is also mapped ~4.5km northwest of the Proposed Wind Farm site, situated between 2 no. mapped turloughs. The Kilcoona spring has been traced back to Lough Hackett, which is ~4.6km north of the spring.

Further west from the Site, 6 no. turloughs are mapped east of Lough Corrib and the N84, near the location of the Ballinduff stream. 2 no. springs are also mapped in this area, one of which is the Bunatober spring which has been traced as far back as a borehole ~4.25km northeast of the spring. The other spring is mapped 0.6km south of Bunatober and has also been traced back to the same borehole.

Tracer studies have been completed at several springs in the area in order to better understand groundwater flow directions in the underlying bedrock. The tracer studies were undertaken by introducing a dye to the water in the turlough and observing any dye discharge from known local springs. Tracer studies have identified/established groundwater connections between the following:

- Kilcoona Spring and Lough Hackett (~4.6km north to south flow);
- Bunatober spring and borehole to northeast (~4.25km northeast to southwest flow);
- Mills pond spring and borehole to northeast (~4.4km northeast to southwest flow);
- Mills pond spring and River Clare (~10.7km northeast to southwest flow); and,
- Aucloggeen Spring and Ballyglunnin Cave (~10.7km northeast to southwest flow).

The karst features and tracer study lines are included below in Figure 9-7.

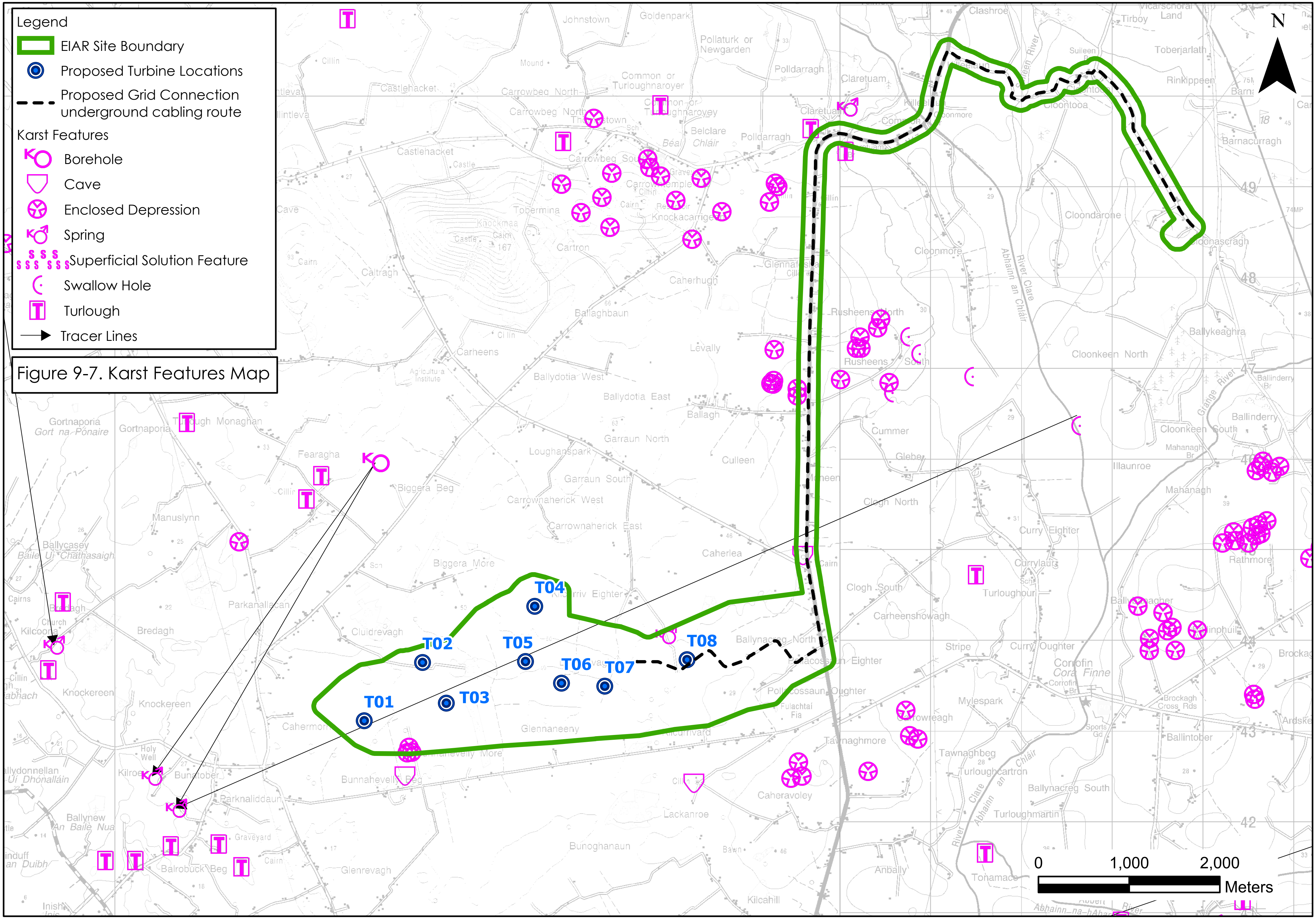


Figure 9-7. Karst Features Map

9.3.6.4.2 *Turloughs*

There are a number of turloughs mapped outside the EIAR Site Boundary. The closest mapped turlough is located 2 km north of the Proposed Wind Farm site and 2.2km from the nearest proposed turbine. A list of turloughs mapped by the GSI within 5km of the Proposed Wind Farm site is given below.

- Turlough in townland of Fearagha – 2km north of Proposed Wind Farm site;
- Turlough Monaghan – 3.5km north of Proposed Wind Farm site; and,
- 6 no. small turloughs situated in the townland of Balrobuckbeg, near the Balrobuckbeg GWS – 2km west of Proposed Wind Farm site.

The turloughs are generally small scale and distal to the Proposed Project. None of the turloughs are designated as SAC's or SPA's, while Turlough Monaghan is designated as a proposed NHA. The water level data, outlined in Section 9.3.6.3.2 from the Proposed Wind Farm site, indicates groundwater flows from east to west. As Turlough Monaghan is situated 3.5km north of the Site, groundwater from the Site will not travel in the direction of this turlough. This conceptual model of groundwater flow is supplemented by tracer studies conducted on a spring located between Turlough Monaghan and the Proposed Wind Farm site, which proves a groundwater flow direction in a southwest direction.

The location of the turloughs mapped by the GSI are included in Figure 9-7, denoted with the "T" symbol.

9.3.6.5 Group Water Schemes

9.3.6.5.1 *Group Water Schemes Summary Information*

There are 9 no. mapped group water schemes (GWS) within 5km of the Proposed Wind Farm site. The GWS are listed below, beginning with the most proximal to the Proposed Wind Farm site.

- Biggeramore GWS – 0.5km
- Caherlea GWS – 1.0km
- Cahermorris Glenreevagh GWS – 1.35km
- Cluide Cahermorris GWS – 1.4km
- Rusheens GWS – 2.1km
- Anbally & District GWS – 2.4km
- Balrobuckbeg GWS – 2.7km
- Claretuam-Belclare GWS – 4.8km
- Kilcoona Caherlistrane GWS – 4.9km

The Caherlea Group Water Scheme (GWS) is supplied from a borehole in the townland of Caherlea, County Galway, 4 km south of Belclare. The current scheme demand is 27 m^3/day, which provides water to 20 no. domestic connections and 4 no. farms. The borehole sits adjacent to the northern side of a local road that runs southeast-northwest between the N83 at Clogh, and the R333 near Caherlistrane. The GWS pumphouse is a small 2.9 m by 2.6 m roofed structure situated in the southeastern corner of an agricultural field, set back 10 m from the road. A 100 mm borehole pump supplies directly to the mains. There is no estimate of potential maximum borehole yield. The scheme uses chlorination for treatment. The borehole is an old agricultural supply, with no obvious improvement works since c. 1970.

As outlined in Section 9.3.6.3.2, groundwater levels at Caherlea GWS range between 12.3 – 30.8 mOD, with groundwater flow in a westerly direction towards Lough Corrib.

The Cahermorris-Glenreevagh GWS is supplied by 1 no. borehole that lies on the boundary between the townlands of Cahermorris and Glenreevagh, Co. Galway and is ~8.5km southeast of Headford town. The current scheme demand is 75m3/day, which provides water to 48 no. domestic connections and 12 no. farms. The borehole is situated adjacent to the junction of a local road that runs southeast-northwest between the N83 near Claregalway, and the R333 near Caherlistrane. The GWS borehole was originally a county council source operated by a hand pump. In 1971 the borehole was reportedly deepened to 122m and blasted to improve the yield.

The water levels at Cahermorris Glenreevagh GWS range between 12.6-19.8mOD.

The Cluide Cahermorris GWS is supplied from a borehole located between Cahermorris and Parkanallacan, approximately 7.9 km southeast of Headford. The borehole is located within the pump house.

The borehole was drilled in 1975 by Mulcairs Well Drilling, but the scheme did not become operational until 1977. The borehole is approximately 61 meters deep, with bedrock was encountered at 1.8 m below ground level. The pump is located approximately 41 meters below ground level and pumps a reported average yield of approximately 68 m^3/day. Yield from the borehole does not appear seasonally influenced and the scheme has not experienced water supply difficulties during extended periods of dry weather.

The surrounding area is used for agricultural and grazing. Approximately 25 years ago[5] grass was present in the pumped water following slurry spreading which was carried out approximately 170 m upgradient of the borehole. After this incident, slurry spreading stopped and no grass has been present since. There is a cluster of single dwellings in close proximity to the borehole which are likely to have a septic tank each. The nearest farmyard is approximately 200m away from the GWS borehole. Disinfection is provided by UV treatment only.

The groundwater levels at Cluide Cahermorris GWS range between 9.7-18.8mOD.

The Rusheens GWS is supplied from a borehole in the townland of Culleen, 7 km southwest of Tuam, Co. Galway. The borehole sits adjacent to the south side of a local road, approximately 200 m west of the junction with the N183 road. The current scheme demand is 216 m^3/day, supplied by a variable speed pump direct to the mains. Disinfection is provided by ultraviolet germicidal irradiation (UV) and chlorination treatment. The borehole is 64m deep, drilled by Patrick Briody in 2012. The borehole is grout sealed to 30.5m, with the main inflow coming from 49-54.3mbgl. Access to inside the borehole is difficult, as there is a steel plate borehole cap in place.

The water levels in Rusheens GWS well range between 12.1 – 31.1mOD.

The Anbally & District GWS is supplied from a borehole in the townland of Tawnaghmore, Anbally, Corofin, Co. Galway. The current scheme demand is approximately 69 m^3/day, which is estimated based on 115 no. connections. There are no borehole yield data available.

The GWS site is located 2.1 km southwest of Corofin village centre, on the south side of a cul-de-sac local road heading east off the N83 Regional Road 800 m south of the N83 junction for Corrofin. The Site comprises a short access road leading to a roughly 15 m by 15 m compound containing the pumphouse and borehole. The borehole is 99m deep, drilled in 1987 (possibly by Mulcairs). There is 150mm and 125mm casing visible within the borehole and no grout seal is mentioned within the borehole log.

Water levels in the Anbally & District GWS well range between 9.2 – 27.4mOD.

[5] *Anecdotal information contained within Cluide (Cahermorris) GWS Source Protection Zone report (Arup/GSI 2018)*

The Balrobuckbeg GWS is supplied from a borehole that lies in the townland of Balrobuckbeg, County Galway. The current scheme demand is 214 m3/d, which provides water to 190 no. domestic houses and has 340 no. metered connections in total. The borehole sits on the western side of a local road located c.1.5 km east of the N84.

The GWS site was originally a spring sump that was historically used as a bucket collection drinking water supply by locals. Galway County Council subsequently installed a handpump. The base of the spring is 1.5 m below pumphouse floor and is dry which suggests current borehole pumping has reduced water level below spring base level. The caretaker of the Balrobuckbeg GWS reports that during prolonged rainfall, groundwater levels rise to ground surface on the opposite side of the road and flow southwest, often overflowing a culvert beneath the local road.

The current borehole was installed in 1974 and is 6 m deep. A 100 mm variable speed borehole pump supplies directly to the mains. Abstracted water passes through a cumulative flowmeter and is treated by chlorination and ultra-violet treatment.

Groundwater levels in the Balrobuckbeg GWS well range between 8.1 – 11.7mOD.

The Claretuam-Belclare GWS is situated 4.8km north of the Proposed Wind Farm site. There is no available Source Protection Report for the Site, however the Source Protection Zone, which has been delineated for the GWS is visible through the GSI online mapviewer. The SPZ forms an approximate tear drop shape which covers an area of 0.2 km^2. The group water scheme serves a population of ~240 and the estimated daily usage is ~48 m^3/day.

The Kilcoona Caherlistrane GWS is situated 4.9km west of the Proposed Wind Farm site. Again, a Source Protection Report is not available, however the Source Protection Zone to the GWS well has been delineated and extends to ~1.5km^2 in a roughly oval shape (refer to Figure 9-8). This GWS serves a population of ~2500 people, with a daily abstraction of ~500 m^3/day.

A map illustrating the source protection areas of these GWSs relative to the Proposed Wind Farm site is included in Figure 9-8.

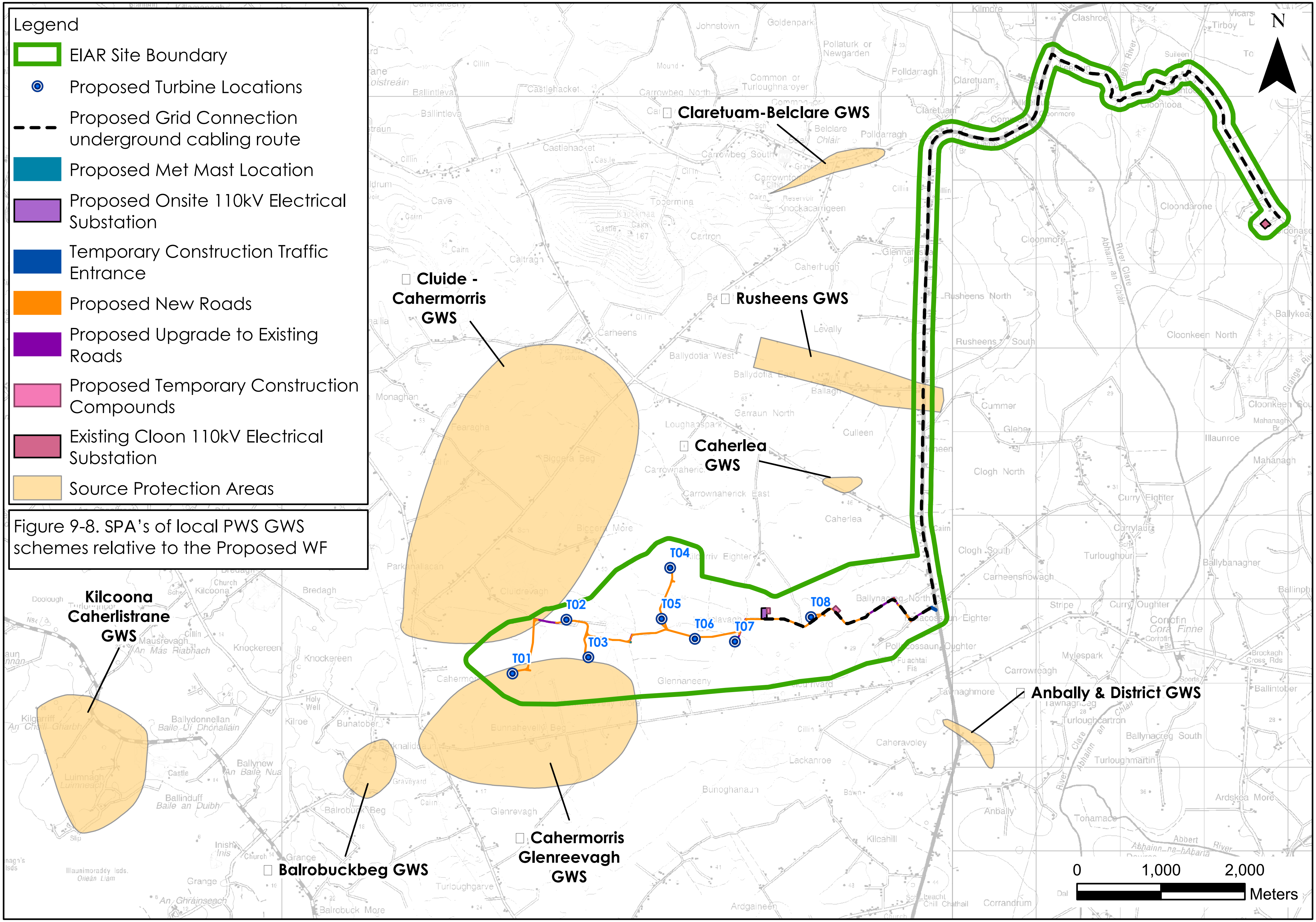


Figure 9-8. SPA's of local PWS GWS schemes relative to the Proposed WF

9.3.6.6 Conceptual Hydrogeological Site Model (CSM)

Groundwater level measurements at the Proposed Wind Farm site were collected at 13 no. locations over 24 months between December 2021 – December 2023. These data record the variation in groundwater levels within these monitoring points which are located both within the Proposed Wind Farm site and surrounding the Proposed Wind Farm in all directions. This provides a continuous database for groundwater levels at the Proposed Wind Farm site and also near the Proposed Grid Connection underground cabling route (using groundwater wells to the east of the Site) and allows an interpretation of groundwater flow across the area of the Proposed Project.

Groundwater level data has been collected from the 3 no. monitoring wells installed at the Proposed Wind Farm site, at 10 no. domestic/public water supply wells and 1 no. EPA monitoring well. In total HES have continuously monitored water levels using Diver water level loggers or attained continuous water level data from external sources, at the following locations:

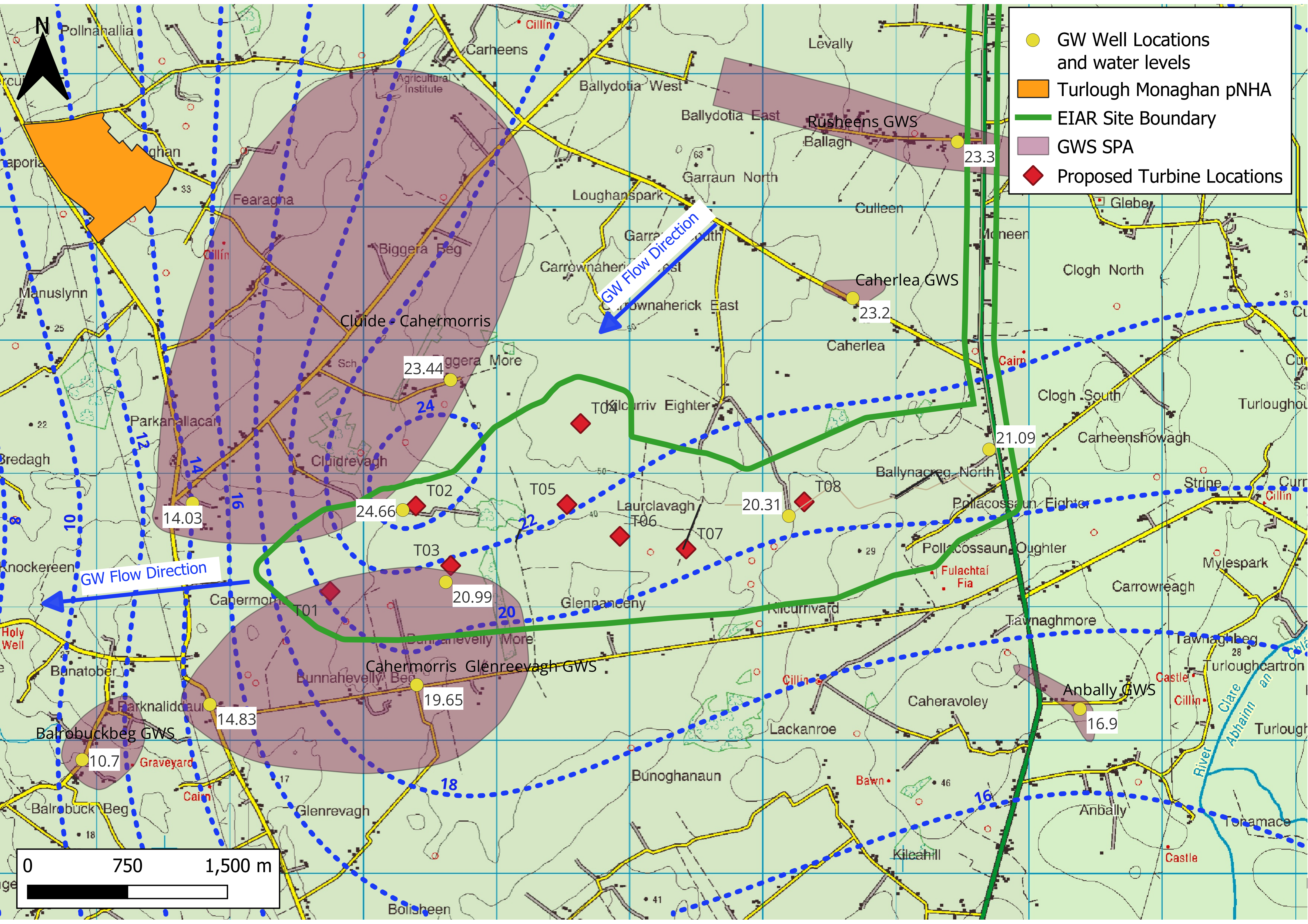
- 3 no. Site Investigation boreholes (MW21-01, MW21-02 and MW21-03) – 1,820 no. total days of data;
- 3 no. Domestic wells – 1,495 no. total days of data;
- 7 no. GWS wells – 4,950 no. total days of data; and,
- 1 no EPA monitoring well (Shrule) - 730 no. total days of data.

These data have been compiled and analysed to form a conceptual model of groundwater gradients and groundwater flow directions across the Site, primarily focusing on the Proposed Wind Farm site, as the Proposed Grid Connection underground cabling route requires near surface construction works and effects on the water environment will primarily relate to surface water.

Rainfall within the Proposed Wind Farm site, infiltrates to ground through the sandy, gravelly clay subsoils. The permeability of these subsoils is variable across the Site (refer to Section 0), however the permeability is sufficiently high that all rainfall infiltrates to ground and there is no surface water runoff at the Site.

This rainfall then infiltrates through the subsoil, and where present, through a layer of weathered Limestone bedrock at the top of rock and further down into the lower Limestone aquifer units. The spatial distribution of recharge within the upper Limestone bedrock (0-20mbgl) is expected to mimic the subsoil variability, with recharge occurring preferentially within zones of more weathered and fractured Limestone. Water which has infiltrated through the subsoil to firm, competent Limestone bedrock, may move laterally along this Limestone bedrock until a more permeable zone is reached and the water can infiltrate further.

Groundwater levels within the Proposed Wind Farm site range between 8.2 - 30.8 mOD, with groundwater flow in a westerly direction towards Lough Corrib. A groundwater contour map for the Site has been developed for both the Summer and Winter periods. These contour maps are included as Figure 9-9 and Figure 9-10.



N
GW Well Locations and water levels
Turlough Monaghan pNHA
EIAR Site Boundary
GWS SPA
Proposed Turbine Locations
GW Flow Direction
GW Flow Direction
Cluide - Cahermorris
Rusheens GWS
Caherlea GWS
Cahermorris Glenreevagh GWS
Balrobuckbeg GWS
Anbally GWS
T01
T02
T03
T04
T05
T06
T07
T08
23.3
23.2
23.44
24.66
14.03
20.99
20.31
21.09
19.65
14.83
10.7
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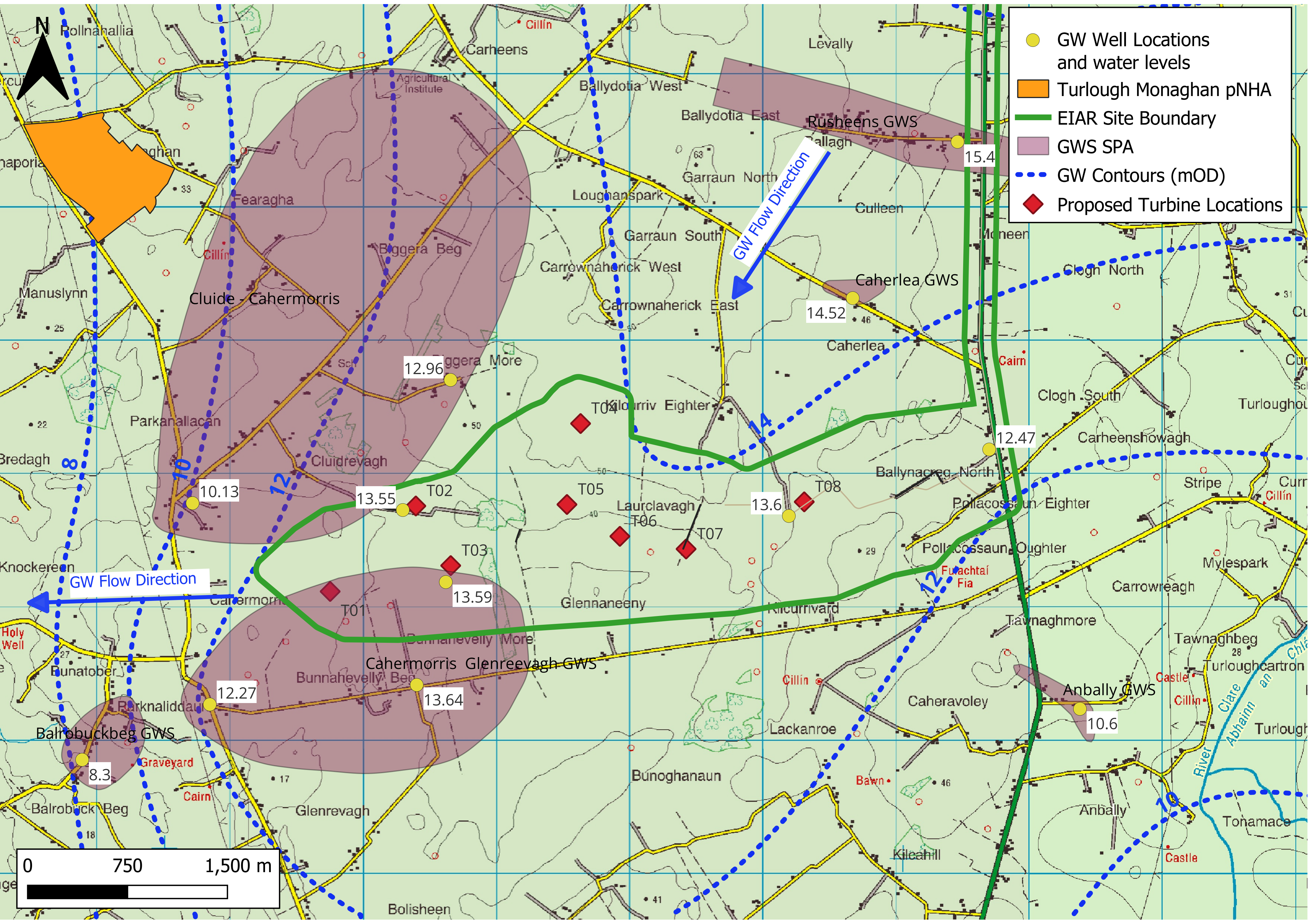
0
750
1,500 m



N
GW Well Locations and water levels
Turlough Monaghan pNHA
EIAR Site Boundary
GWS SPA
GW Contours (mOD)
Proposed Turbine Locations
GW Flow Direction
GW Flow Direction
Rusheens GWS
Caherlea GWS
Cluide - Cahermorris
Cahermorris Glenreevagh GWS
Balrobuckbeg GWS
Anbally GWS
T01
T02
T03
T04
T05
T06
T07
T08
15.4
14.52
12.96
10.13
13.55
13.59
12.47
13.6
12.27
13.64
8.3
10.6
8
10
12
14
12
10
0
750
1,500 m

9.3.7 Groundwater Vulnerability

The mapped vulnerability rating of the aquifer within the Site ranges between High to Extreme based on regionally assumed depths of subsoil. In areas where subsoil is shallow or absent and where bedrock is outcropping an Extreme vulnerability rating is mapped. The more elevated areas towards the east/northeast of the Proposed Wind Farm site are rated “High to Extreme” while areas of High vulnerability are mapped towards the west and southwest. The mapped groundwater vulnerability of the Site (Proposed Wind Farm and Proposed Grid Connection) and surrounding area is shown on Figure 9-11.

The Groundwater vulnerability ratings are based on typical overburden thicknesses which protect the underlying groundwater aquifer and are outlined in detail in DELG/EPA/GSI (1999)[6]. Plate 9-1 below outlines the decision matrix underlying the vulnerability rating.

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	>3.0m	3.0 - 10.0m	3.0 - 5.0m	>3.0m	N/A
Moderate (M)	N/A	> 10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	> 10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

Plate 9-1: Groundwater Vulnerability Matrix – Groundwater Protection Schemes Report 1999

[6] *Groundwater Protection Schemes, DELG, EPA, GSI,. 1999*

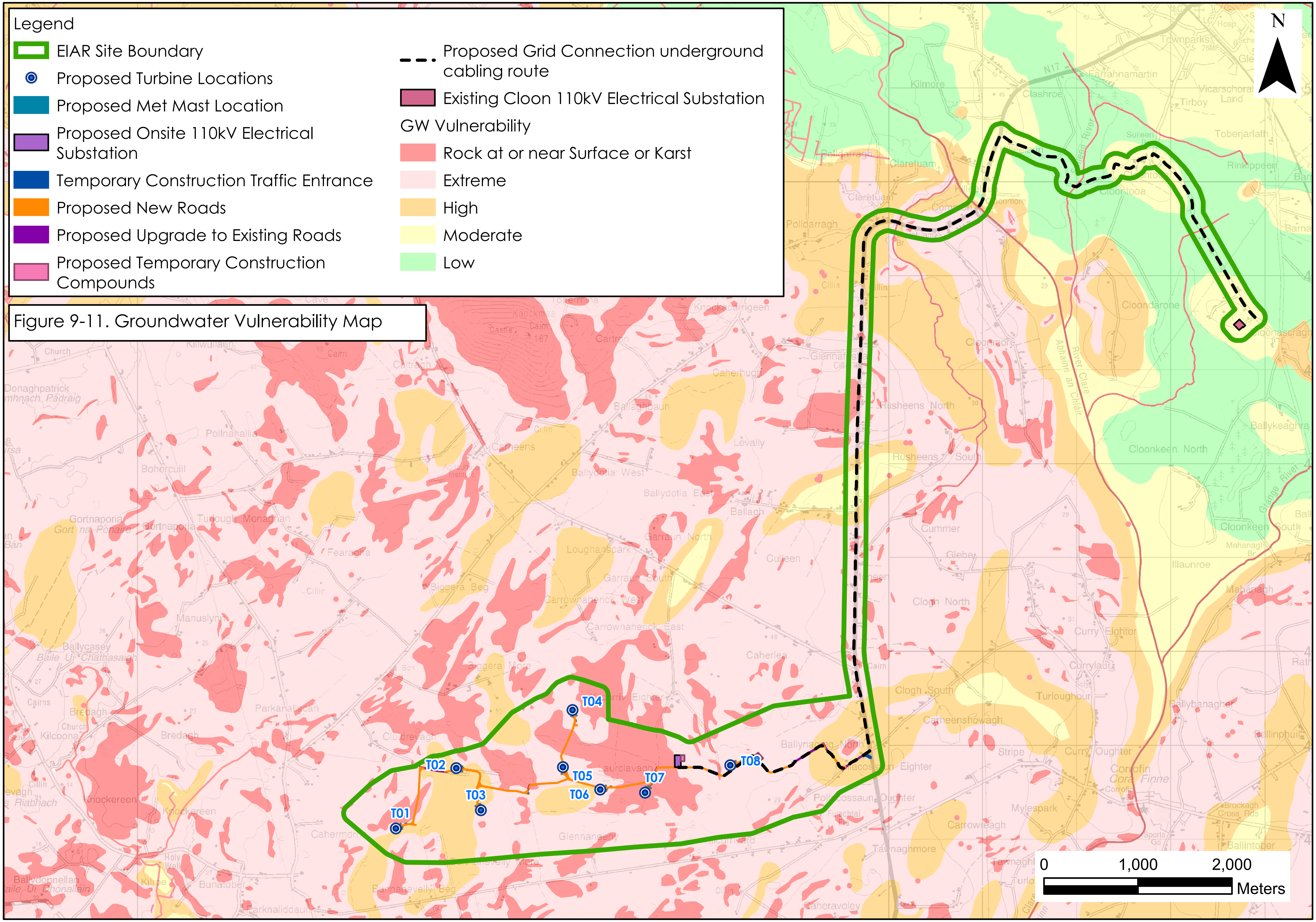


Figure 9-11. Groundwater Vulnerability Map

9.3.8 Groundwater Hydrochemistry

A regional characterisation of groundwater hydrochemistry is given within the draft Clare-Corrib GWB characterisation report. The groundwater hydrochemistry is described as:

> *"The groundwater has a calcium bicarbonate signature. Two groundwater provinces are suggested by Drew and Daly (1993). Firstly, there is a shallow groundwater component that is characterised by high suspended solids and relatively low electrical conductivities (300-400 μS/cm). Springs that are fed by this component typically have a "flashy" throughput and often cease to flow during prolonged drought. Secondly, there is a deeper groundwater component that is characterised by relatively non-turbid groundwater with higher electrical conductivities (>450 μS/cm). Springs fed by this deeper component often have smoother hydrographs where there is a gradual change in discharge. Several large springs comprise both flow components, examples are Lettera, Tobernanny and Bunatober springs."*

Data on groundwater hydrochemistry is also available within the ZoC reports for the various GWS' in the area. At Caherlea GWS, the pH was recorded at 7.2, with an electrical conductivity of 614 µS/cm. Turbidity measured 0.4 NTU, nitrate was reported at 12.1 mg/L (as NO_3) and hardness at 355mg/L. Iron and manganese were both below the relevant drinking water guideline values at 12 µg/L and <5 µg/L respectively. The sample was an untreated, raw water sample. A raw water sample was also taken at Balrobuckbeg. Here, pH measured 7.2, while electrical conductivity measured 551 µS/cm. Turbidity was reported at 0.2 NTU, nitrate at 9.03 mg/L (as NO_3) and hardness at 367 mg/L (as $CaCO_3$).

Groundwater sampling of 4 no. Group Water Scheme wells was completed on 16th August and 05th December 2023. The field chemistry data, taken with a calibrated YSI ProDSS, are given below in Table 9-13. The field hydrochemistry indicates a largely similar chemical signature of the 4 no. samples from the wells.

The pH ranges between 6.94 – 7.66, while dissolved oxygen ranges between 7.0 – 9.89 mg/L. The conductivity range 609 – 644 µS/cm is typical of groundwaters within a Limestone aquifer and is in line with available data from the Corrib-Clare groundwater body characterisation report.

Table 9-13: Summary of field chemistry from GWS sample locations and from River Clare

Location	Date	Temp (°C)	DO (mg/L)	EC (µS/cm)	pH [H^+]
Anbally GWS	16/08/2023	13.9	7.0	623	7.16
Balrobuckbeg GWS	16/08/2023	13.6	7.21	611	6.94
Biggeramore GWS	16/08/2023	14.2	9.89	609	7.66
Cluide Cahermorris GWS	16/08/2023	13.9	8.21	644	7.27
R. Clare (SW)	16/08/2023	15.8	8.38	547	7.62
Anbally GWS	05/12/2023	8.9	7.36	533	7.14
Balrobuckbeg GWS	05/12/2023	10.6	7.52	557	7.13
Biggeramore GWS	05/12/2023	10.2	10.5	527	7.81
Cluide Cahermorris GWS	05/12/2023	6.5	8.57	494.8	7.13
R. Clare (SW)	04/12/2023	5.7	10.59	444	7.55

Water quality sampling was carried out during 2 no. sampling events at 4 no. GWS wells, as well as a further 2 no. samples from the River Clare for the same analysis suite. The samples were delivered to an accredited laboratory for analysis. The water quality sampling was undertaken in order to gain a baseline understanding of groundwater hydrochemistry at the Proposed Wind Farm site, as well as comparing this to the closest major surface watercourse (River Clare) where a groundwater-surface water connection was known (refer to Section 9.3.6.4). The first sampling event was carried out on 16th August 2023, with a follow up round completed on 04TH – 05TH December 2023. The results of the laboratory analysis for the first and second round of sampling are included below as Table 9-14 and Table 9-15.

During Round 1 of sampling, the groundwater has a relatively strong bicarbonate signature which ranges between 226.9 – 311.2 mg/L as $CaCO_3$ within the 4 no. GWS groundwater samples, with the sample from the River Clare falling within the middle of this range at 278.8 mg/L as $CaCO_3$. This range, 226.9 - 311.2 mg/L, is considered Hard-Very Hard water.

Similarly, the calcium signature of the groundwater and the water in the River Clare is relatively high ranging between 109.6 – 161.9mg/L.

Chloride ranges between 16-20 mg/L, which is typical of a background atmospheric rate of chloride and suggests little influence from anthropogenic activities such as land spreading. Iron has a considerable range between <80-1140 µg/L, which exceeds the Drinking Water limit of 200 µg/L at Balrobuckbeg GWS (378 µg/L), Biggermore GWS (µg/L) and in the River Clare (372 µg/L).

Magnesium was below all threshold limit of 50mg/L, ranging between 4.9 – 16.6 mg/L. Manganese was below the detection limit of <1 µg/L in 3 of the 5 no. samples. In the other 2 no. samples Manganese measured 38 µg/L in the River Clare and was 75 µg/L in Biggeramore GWS, the latter being above the threshold value of 50 µg/L.

Nitrate levels were low, ranging between 4-16 mg/L as NO_3 in the 5 no. samples, below the EPA guideline value of 25 mg/L. Nitrites were also low, at or below the detection limit of 0.001 mg/L in all samples.

The pH levels ranged between 7.17 – 8.28 in the 4 no. groundwater samples, with the sample from the River Clare falling within this range also at 7.79.

Potassium, Phosphate, Sodium and Sulphate returned reported values which were all below their respective thresholds. Total Dissolved solids ranged between 363-441 mg/L and were highest in the River Clare. Total Suspended Solids was below the detection limit of 2 mg/L in 4 of the 5 no. samples, while Biggeramore returned a TSS value of 38 mg/L. This may be due to the water storage in the pressure vessel, which might explain the high Iron and Manganese at this location, rather than it being a function of the groundwater itself.

Table 9-14: Round 1 Groundwater Sampling

Parameter	EQS	Sample ID				
		Cluide Cahermorris (16/8/23)	Balrobuckbeg (16/8/23)	Biggeramore (16/8/23)	Anbally (16/8/23)	R.Clare (16/8/23)
Bicarbonate (mg/L as $CaCO_3$)	_	311.2	325.6	302.6	226.9	278.8
Calcium (mg/L)	_	116.4	122.7	161.9	125.5	109.6
Chloride (mg/L)	250*	20	19	18	17	16
Iron (µg/L)	200*	<80	378	1140	26	372
Magnesium (mg/L)	50$^+$	6.7	6.4	16.6	7.3	4.9
Manganese (µg/L)	50*	<1	<1	75	<1	38
Nitrate (mg/L as N)	50*/25$^+$	16	8	12	8	4
Nitrite (mg/L as N)	0.5*/0.1$^+$	<0.01	0.01	<0.01	<0.01	<0.01
pH	6.5-9.5	7.47	7.17	7.84	8.28	7.79
Phosphate (mg/L as P)	0.03$^+$	0.01	0.02	<0.01	0.02	0.01
Potassium (mg/L)	200*	3	3	4	2.2	2.1
Sodium (mg/L)	250*	10.6	11.4	10.8	9.5	9
TDS (mg/L)	2500	396	394	363	399	441
TSS (mg/L)	_	<2	<2	38	<2	<2
Sulphate (mg/L)	200*	7	10	7	8	12

(*) S.I. No. 122/2014 – Drinking Water Regulations
(+) EPA Interim Guideline Values

The second round of sampling was conducted on 05th December 2023. During Round 2 of sampling, the groundwater has a relatively strong bicarbonate signature which ranges between 321.8 – 363.5 mg/L as $CaCO_3$ within the 4 no. GWS groundwater samples, with the sample from the River Clare falling slightly lower than this range at 315.4 mg/L as $CaCO_3$. This range is classified as Hard-Very Hard water.

Similarly, the calcium signature of the groundwater and the water in the River Clare is relatively high ranging between 123.8 – 139 mg/L.

Chloride ranges between 17-21 mg/L, similar to the results from Round 1. Iron levels range between <8 – 140 µg/L in the 4 no. groundwater samples and 375 µg/L in the River Clare.

Magnesium was again below all threshold limit of 50mg/L during Round 2, ranging between 5.2-11mg/L. Manganese was below the detection limit of <1 µg/L in 3 of the 5 no. samples. In the other 2 no. samples Manganese measured 8 µg/L in the Biggeramore GWS sample and 42 µg/L in the sample from the River Clare.

Nitrate levels were low, ranging between 2-4 mg/L as NO_3 in the 5 no. samples, below the EPA guideline value of 25 mg/L. Nitrites were also low, at or below the detection limit of 0.001 mg/L in all samples. The highest recorded value (4 mg/L at Biggeramore) is considerably less than the highest recorded value during Round1 (16 mg/L at Cluide Cahermorris GWS).

The pH levels ranged between 6.9–7.66, slightly lower than the values reported during Round 1. This may be due to increase inputs from recent rainfall, which would tend to lower the pH due its shorter residence time in the ground.

Potassium, Phosphate, Sodium and Sulphate returned reported values which were all below their respective thresholds. Total Dissolved solids ranged between 376-433 mg/L e. Total Suspended Solids was below the detection limit of 2 mg/L in all 5 no. samples.

Table 9-15: Round 2 Groundwater Sampling

Parameter	EQS	Sample ID				
		Cluide Cahermorris (05/12/23)	Balrobuckbeg (05/12/23)	Biggeramore (05/12/23)	Anbally (05/12/23)	R.Clare (05/12/23)
Bicarbonate (mg/L as $CaCO_3$)	_	342.4	354.9	321.8	363.5	315.4
Calcium (mg/L)	_	139	136.2	125.7	138.8	123.8
Chloride (mg/L)	250*	21	18	22	17	17
Iron (µg/L)	200*	<8	<8	140	31	375
Magnesium (mg/L)	50^{+}	6.3	6.1	11	7.9	5.2
Manganese (µg/L)	50*	<1	<1	8	1	42
Nitrate (mg/L as N)	$50^{*}/25^{+}$	3	2	4	2	2

Parameter	EQS	Sample ID				
		Cluide Cahermorris (05/12/23)	Balrobuckbeg (05/12/23)	Biggeramore (05/12/23)	Anbally (05/12/23)	R.Clare (05/12/23)
Nitrite (mg/L as N)	0.5*/0.1⁺	<0.01	<0.01	<0.01	<0.01	<0.01
pH	6.5-9.5	7.07	6.97	7.66	7.12	7.61
Phosphate (mg/L as P)	0.03⁺	0.02	0.02	<0.01	0.02	0.02
Potassium (mg/L)	200*	2.9	3.4	3.9	2.1	2.4
Sodium (mg/L)	250*	12.1	11.2	11.4	9.8	9.9
TDS (mg/L)	2500	409	385	376	433	427
TSS (mg/L)	_	<2	<2	<2	<2	<2
Sulphate (mg/L)	200*	11	10	7	13	12

(*) S.I. No. 122/2014 – Drinking Water Regulations
(+) EPA Interim Guideline Values

9.3.9 Groundwater Body Status

The Proposed Project is located in the Clare Corrib Groundwater body. The Clare Corrib GWB (GWB: IE_WE_G_0020) is assigned 'Good Status' under the 2016-2021 WFD cycle, which is defined based on the quantitative status and chemical status of the GWB. This GWB is considered "Not at Risk" (see Table 9-16 below).

Table 9-16: Summary of groundwater body status.

GWB	Risk 2nd Cycle	Overall Status (2013-2018)	Risk 3rd Cycle	Overall Status (2016-2021)	Pressures
Clare-Corrib	At risk	Good	Not at risk	Good	-

9.3.10 Surface Water Body Status

As outlined in Section 9.3.3, the Proposed Wind Farm site is situated within the River Clare catchment, the Cross River catchment. Local Surface water Body status and WFD risk classification are available from (www.catchments.ie) and are summarised in Table 9-17.

The Site is located in the WFD river sub basins of the Ballinduff Stream_010, which has a 2016-2021 WFD Status of "Good" and is deemed to be "Not at risk" of missing out on the 2027 WFD objectives, and the Clare (Galway_060), which has a 2016-2021 Status of "Poor" and is deemed to be "At risk" of not meeting the WFDs 2027 objectives.

The Clare (Galway)_070 has a WFD 2016-2021 Status of “Good” and is deemed to be “Not at risk” of missing out on the WFDs 2027 objectives. The Clare (Galway)_080 has a WFD 2016-2021 Status of “Moderate” and is deemed to be “At risk” of missing out on the WFDs 2027 objectives. The Clare (Galway)_090 has a WFD 2016-2021 Status of “Moderate” and is deemed to be “At risk” of missing out on the WFDs 2027 objectives. The Clare (Galway)_100 has a WFD 2016-2021 Status of “Moderate” and is deemed to be “Under Review”. The Corrib Lower lake body has a WFD 2016-2021 Status of “Good” and is deemed to be “Not at risk” of missing the WFDs 2027 objectives.

Table 9-17: Summary of surface water body status.

SWB	Overall Status (2013-2018)	Overall Status (2016-2021)	Risk 3rd Cycle	Pressures
Ballinduff Stream_010	Good	Good	Not at risk	-
Clare (Galway)_060	Moderate	Poor	At risk	Hydromorphology
Clare (Galway)_070	Good	Good	Not at risk	-
Clare (Galway)_080	Moderate	Moderate	At risk	Hydromorphology
Clare (Galway)_090	Moderate	Moderate	At risk	Hydromorphology
Clare (Galway)_100	Moderate	Moderate	Under review	-
Corrib Lower	Good	Good	Not at risk	-

9.3.11 Designated Sites & Habitats

Designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The Site is not located within any designated conservation-site. Designated sites in proximity to the Site are shown in Figure 9-12.

The nearest SAC is the Lough Corrib SAC which is located ~4.3km west of the Site and ~5.1km east of the Site also. East of the Site, the boundaries of the Corrib SAC extend up the River Clare.

Wind Farm site

There are several turloughs, which are listed as pNHA's located to the north and northwest of the Proposed Wind Farm site. Belclare and Killower turlough as well as Turlough O'Gall are situated between 5-7km north of the Wind Farm site, while Turlough Monaghan, Turlough Cor and Lough Hackett are mapped between 3-7km west/northwest. Designated sites located near the Proposed Wind Farm site are listed in Table 9-18. A designated sites map is included as Figure 9-12.

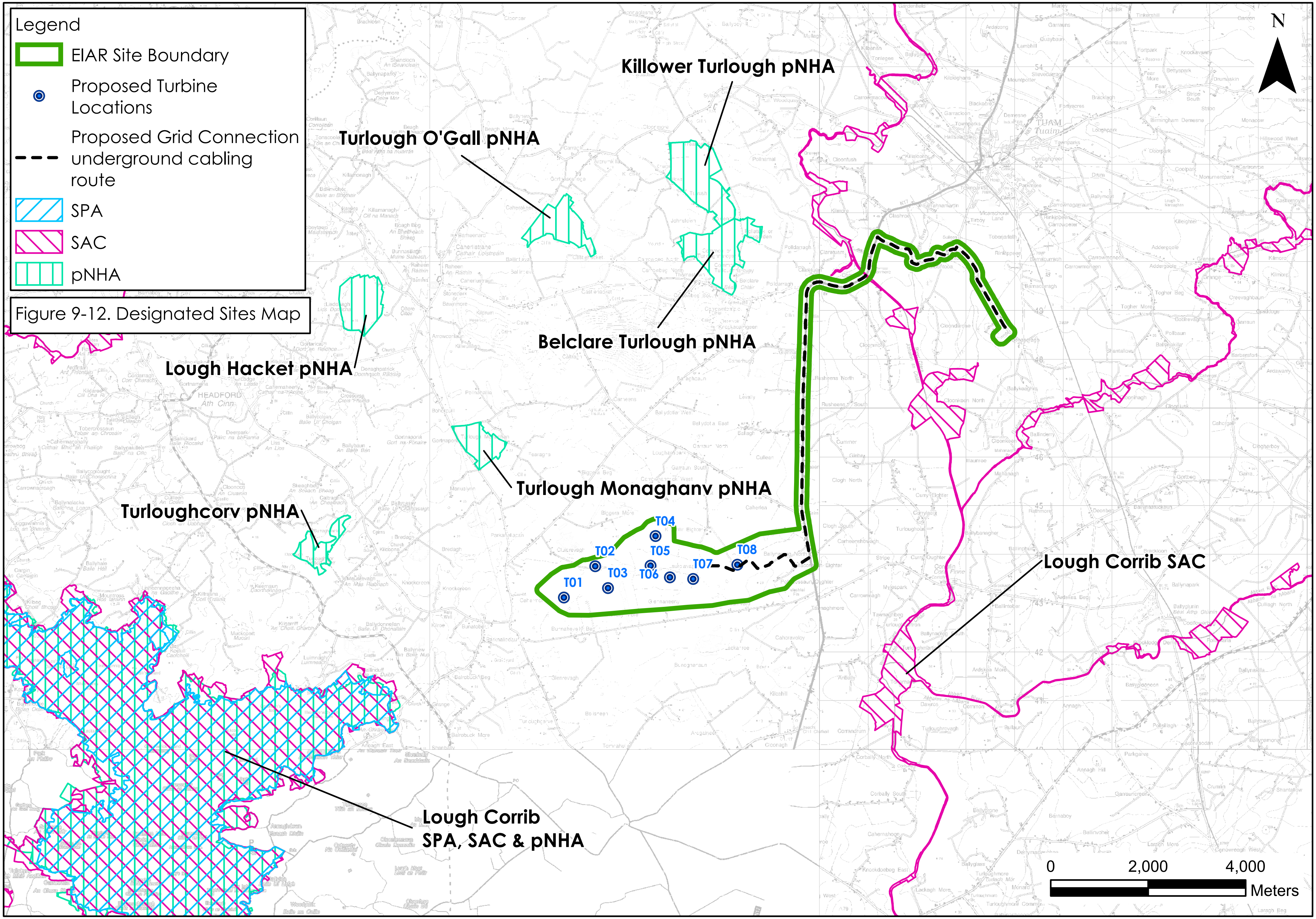
Table 9-18: Designated sites near the Proposed Wind Farm

Site	Designations	Distance from Proposed Wind Farm site
Lough Corrib	SAC pNHA SPA	4.3km west
Belclare Turlough	pNHA	5km north
Killower Turlough	pNHA	6.5km north

Site	Designations	Distance from Proposed Wind Farm site
Turlough O'Gall	pNHA	6.5km north
Turlough Monaghan	pNHA	3.5km northwest
Turloughcor	pNHA	5.5km west
Lough Hackett	pNHA	6.9km northwest

Proposed Grid Connection

The Proposed Grid Connection underground cabling route passes over the River Clare at an existing bridge. The River Clare is mapped as part of the Lough Corrib SAC at this location.



Legend
EIAR Site Boundary
Proposed Turbine Locations
Proposed Grid Connection underground cabling route
SPA
SAC
pNHA
Figure 9-12. Designated Sites Map
N
Killower Turlough pNHA
Turlough O'Gall pNHA
Belclare Turlough pNHA
Lough Hacket pNHA
Turlough Monaghanv pNHA
Turloughcorv pNHA
Lough Corrib SAC
Lough Corrib SPA, SAC & pNHA
T01
T02
T03
T04
T05
T06
T07
T08
0
2,000
4,000
Meters

9.3.12 Receptor Sensitivity

Due to the nature of wind farm developments, being primarily near surface construction activities, effects on groundwater are generally negligible and surface water is the main sensitive receptor assessed during impact assessments. However, given the lack of surface water features at the Proposed Wind Farm site, meaning that all rainfall will infiltrate to ground rather than runoff to surface watercourses, and the mapping of the bedrock aquifer as regionally karstified, the hydrogeology of the area has been extensively monitored and synthesised using site investigation data acquired between 2021-2023, consisting of groundwater level data, rotary core borehole logs, monitoring well borehole logs, trial pit data, geophysics and infiltration test data. The primary risk to groundwater at the Site would be from cementitious materials, hydrocarbon spillage and leakages and the potential for the turbine foundations to intercept and interfere with groundwater recharge and flows.

Based on criteria set out in Table 9-1, groundwater at the Site can be classed as Very Sensitive to pollution as the aquifer is mapped as a Regionally Important Karstified aquifer and groundwater vulnerability is mapped as High to Extreme. The Site-specific data for the areas of infrastructure indicate that the groundwater aquifer is not locally karstified and that the proposed turbine locations are underlain by Hard, competent Limestone. Notwithstanding this, and based on the precautionary principle, groundwater is regarded as Very Sensitive.

Surface waters such as the River Clare are Sensitive to potential contamination. These rivers and associated lakes are known to be of trout potential and are important locally for fishing (see Biodiversity, Chapter 6).

There are no designated sites that are directly hydraulically connected by surface water paths to the Proposed Wind Farm site. Any potential hydraulic connections are indirect and will be via groundwater flow over a generally long distance (kilometres), i.e the regional groundwater flow towards the Lough Corrib SAC/SPA/pNHA. The designated sites listed in Section 9.3.11 can be considered Very Sensitive in terms of potential effects (see Chapter 6 of the EIAR).

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downgradient waterbodies (lakes, rivers and turloughs). Mitigation measures will ensure that surface runoff from the developed areas of the Site will be of a high quality. Runoff from the Site will percolate to ground based on the underlying site permeability. The mitigation measures outlined to protect surface water during the construction, operational and decommissioning phases will ensure that waters infiltrating to the underlying aquifer will be of a high quality and will therefore not impact on the quality of downstream water bodies. Any introduced drainage works at the Site will mimic the existing hydrological regime thereby avoiding any significant changes to recharge patterns.

9.3.13 Characteristics of the Proposed Project

For the purposes of this EIAR:

- The 'Proposed Wind Farm' refers to the 8 no. turbines and supporting infrastructure which is the subject of this Section 37E application.
- The 'Proposed Grid Connection' refers to the 110kV substation and supporting infrastructure which will be the subject of a separate Section 182A application.
- The 'Proposed Project' comprises the Proposed Wind Farm and the Proposed Grid Connection, all of which are located within the EIAR Site Boundary (the 'Site') and assessed together within this EIAR.

A detailed description of the Proposed Project is provided in Chapter 4 of this EIAR

9.3.13.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against effects on the underlying groundwater aquifer. Two distinct methods will be employed to manage drainage water within the Proposed Project. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage and recharge patterns. The second method involves collecting any drainage/runoff waters from works areas within the Wind Farm site that might carry silt or sediment, and nutrients, to route them along collector drains within which recharge can occur, and outfall to infiltration areas and subsequent infiltration through the subsoil. As per the prevailing natural conditions at the Wind Farm site, there will be no direct discharges to surface waters. During the construction phase all runoff from works areas (i.e., potential dirty water) will be attenuated and treated to a high quality prior to being allowed to slowly percolate to ground.

Further means of drainage management include:

- No surface water will leave the Proposed Wind Farm site. All drainage measures will incorporate water infiltrating back to ground;
- Where it is required to pump water from turbine foundation excavations, the pumping rate will be limited to greenfield runoff rates;
- Excavations are to be limited as much as possible in order to minimise the volume of spoil generated;
- Sand blinding, DPM and concrete blinding are to be provided at formation level to create a vertical cut-off barrier and to mitigate the risk of concrete leakage into the ground below; and,
- Hardstands will be lined with Terram geotextile to limit direct discharge to the subsoil/bedrock.

A detailed drainage plan showing the layout of the proposed drainage design elements for the Proposed Wind Farm is attached in Drainage Design Drawings (HES, 2023) attached in Appendix 4-6).

9.4 Likely and Significant Effects and Mitigation Measures

The potential effects of the Proposed Project and mitigation measures that will be put in place to eliminate or reduce them are set out below. The assessment considers the Proposed Project as a whole i.e. both the Proposed Wind Farm and the Proposed Grid Connection. Where this is required to be assessed separately, this is noted in the text.

9.4.1 Do Nothing Scenario

If the Proposed Project were not to proceed, the existing uses of small-scale agriculture would continue. The opportunity to harness the wind energy resource of County Galway would be lost, as would the opportunity to contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate local employment and investment would also be lost.

9.4.2 Construction Phase – Likely Significant Effects

The assessment considers the Proposed Project as a whole i.e. both the Proposed Wind Farm and the Proposed Grid Connection. Where this is required to be assessed separately, this is noted in the text.

9.4.2.1 Earthworks (Removal of Vegetation Cover, Excavations and Stock Piling) Resulting in Suspended Solids Entrainment in Drainage Recharge

Construction phase activities that will require earthworks resulting in the removal of vegetation cover and excavation of mineral subsoil (where present), and bedrock in certain areas, are detailed in Chapter 4: Description of the Proposed Project. Excess soil/subsoil will be accommodated at the 4 no. proposed spoil management areas.

Potential sources of sediment laden water include:

- Drainage and seepage water resulting from infrastructure excavations;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the Grid Connection underground cabling trench including small amounts of peat soils, resulting in entrainment of sediment from the excavations during construction; and,
- Erosion of sediment from emplaced site drainage channels (although these are limited in scale and channel length).

These activities can result in the generation of suspended solids in drainage water, and as there are no drainage outlets (other than recharge to ground) across the Wind Farm site, there is a risk that sediment laden recharge water can enter the underlying aquifer. To reiterate, there are no recorded surface water features within the Proposed Wind Farm site.

Along the Proposed Grid Connection underground cabling route, there are 4 no. surface water crossing points. The 2 no. primary crossings exist along existing bridges over the River Clare and a smaller tributary of the River Clare, while there are a further 2 no. crossings further east at small streams along a local road. The Proposed Grid Connection underground cabling will be emplaced along the road carriageway, therefore no instream works will occur.

Surface water runoff that will occur at Proposed Wind Farm infrastructure will be recharged locally into subsoils. This recharge water will occur close to source and can migrate vertically to groundwater below the Site. The potential effects on groundwater quality are assessed separately below at 9.4.2.5, 9.4.2.6 and 9.4.2.8.

Pathways: Drainage and surface water discharge routes – these are absent across the Proposed Wind Farm site. This is primarily related to the permeability of the soil/subsoil.

Receptors: Down-gradient rivers, lakes and water dependant ecosystems near the Proposed Wind Farm site which include:

- Lakes – Lough Corrib (SAC, SPA and pNHA)
- Rivers – Ballinduff stream

Down gradient rivers and dependant ecosystems along the Proposed Grid Connection underground cabling route which include:

- Rivers – River Clare

Pre-Mitigation Potential Impact:

Indirect, negative, slight, temporary, highly unlikely impact within the Proposed Wind Farm site (receptors listed above).

Indirect, negative, significant, temporary, unlikely impact along the Proposed Grid Connection underground cabling route (receptors listed above).

Proposed Mitigation Measures

Proposed Wind Farm site

The key mitigation measures typically employed during the construction phase of Wind Farms is the avoidance of sensitive aquatic areas where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). At the Proposed Wind Farm site, the nearest surface watercourse is situated 2.6km away. Therefore, self-imposed buffer zones are not required at the Site.

Spoil management areas for excess soil/subsoil will be localised to 4 no. spoil management areas and will be designed and constructed with the minimal amount of surface area exposed. In these spoil management areas, the vegetative top-soil layer will be removed and re-instated or reseeded directly after construction, allowing for re-vegetation which will mitigate against erosion.

Proposed Grid Connection underground cabling route

More than 95% of the underground electrical cabling connection route is >50m from any nearby watercourse, sections within 50m of the route are confined to existing watercourse crossings at bridges. It is proposed to limit any works in any areas located within 50m of any watercourse/waterbody including the stockpiling of excavated soils and subsoils.

No in-stream works are required at any of these crossings, however due to the proximity of the streams to the construction work at the crossing locations, there is a potential for surface water quality impacts during trench excavation work. Mitigation measures are outlined below.

A constraint/buffer zone will be maintained for all crossing locations where possible . In addition, measures which are outlined below will be implemented to ensure that silt laden or contaminated surface water runoff from the excavation work does not discharge directly to the watercourse.

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

- Avoid physical damage to watercourses, and associated release of sediment;
- Avoid excavations within close proximity to surface watercourses; and,
- Avoid the entry of suspended sediment from earthworks into watercourses.

Mitigation by Avoidance:

A key mitigation measure adopted during the design phase is the avoidance of infrastructure close to surface water features across the Proposed Wind Farm site. From Figure 9-2 it can be seen that the Proposed Wind Farm site is significantly distal from any surface water course, the nearest being the Ballinduff stream located 2.1km west of the Site.

The Proposed Grid Connection underground cabling route crosses over 4 no. watercourses. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

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

- Avoid physical damage to watercourses, and associated release of sediment;
- Avoid excavations within close proximity to surface watercourses (again, absent from the Wind Farm site);
- 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, by allowing all surface water/recent rainfall to infiltrate to ground at the Proposed Wind Farm site (refer to Appendix 4-6, Drainage Design drawings).

Mitigation by Design:

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

Silt Fences

Silt fencing will be emplaced downgradient of turbines, to prevent any runoff of sediment laden water. Silt fences are effective at removing heavy settleable solids. Inspection and maintenance of these structures will be carried out during construction phase. They will remain in place throughout the entire construction phase.

Silt fences will also be emplaced where the Proposed Grid Connection is near sensitive areas (*i.e.* watercourse crossing over River Clare).

Silt Bags

Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through. The discharge from the silt bags will be directed to the settlement ponds, where the water will be allowed to naturally infiltrate to ground.

Pre-emptive Site Drainage Management

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

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

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

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

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

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

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

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

Management of Runoff from Spoil Management Areas

It is proposed that excavated subsoil will be used for landscaping throughout the Site and any excess will be accommodated at 4 no. spoil management areas across the Proposed Wind Farm site.

Proposed surface water quality protection measures regarding the spoil management areas are as follows:

- During the initial emplacement of spoil at the storage area, silt fences, straw bales and biodegradable matting will be used to control surface water runoff from the enclosure.
- Drainage from the storage areas will be directed to settlement ponds as required or will overflow through controlled overflow pipes.
- Discharge from the spoil management areas will be intermittent and will depend on preceding rainfall amounts.
- Once the storage areas have been seeded and vegetation is established the risk to downstream surface water is significantly reduced.

Therefore, at each stage of the spoil management area development the above mitigation measures will be deployed to ensure protection of downstream water quality.

Timing of Site Construction Works

Construction of the 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. Construction of the drainage system during this period will also ensure that attenuation features associated with the drainage system will be in place and operational for all subsequent construction works.

Monitoring

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

Any excess build-up of silt levels at infiltration outfall points or within the short drainage channels, that may decrease the effectiveness of the drainage feature, will be removed.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs should be undertaken at drainage outfall locations, and specifically following heavy rainfall events (as per the CEMP, included as Appendix 4-5 to this EIAR). The inspections will include ensuring that all surface water is infiltrating to ground as per the Drainage Design, with no surface water runoff from the Wind Farm site.

Residual Effect:

Following the implementation of the mitigation by avoidance measures, which has involved an iterative process of optimising the design and layout of the Proposed Project to minimise the potential for effects due to earthworks, as well as the mitigation by design measures which involves the detailed and site-specific drainage management plan, the residual impact is considered to be - Negative, indirect, imperceptible, short term, unlikely impact on:

Underlying groundwater systems, down-gradient rivers and dependant ecosystems near the Proposed Wind Farm site which include:

- Lakes – Lough Corrib
- Rivers – Ballinduff stream

Down gradient rivers and dependant ecosystems along the Proposed Grid Connection underground cabling route which include:

- Rivers –River Clare

Significance of Effects: No significant effects on the aforementioned receptors will occur.

9.4.2.2 Potential Effects on Groundwater Flows and Levels due to alteration of recharge (including activation of potential karst)

<u>Proposed Wind Farm</u>

Groundwater flow within a recognised karst environment is difficult to fully quantity without significant datasets, as spatial variations in the degree of karstification can alter the permeability and transmissivity (essentially the volume of groundwater flowing through a particular unit of rock) by orders of magnitude.

For the Proposed Wind Farm site, a comprehensive site investigation dataset has been accrued between 2021-2023. The collated site investigation dataset for the Site has not identified any significant karst features within the underlying bedrock, following 230m of drilling within the bedrock, along with an extensive data from trial pitting in these areas.

Groundwater bearing bedrock formations (aquifers) were encountered between 19.5 – 41mbgl at the Proposed Wind Farm site, within the 3 no. deep groundwater monitoring wells. No water bearing formations were recorded during the drilling of the 10-10.5m deep rotary core boreholes The data from the rotary core drilling shows that the bedrock is generally medium hard to hard Limestone. The inflow of groundwater into the monitoring wells was encountered at depths >20m, and data from the GWS wells indicates groundwater strikes were similarly deep within the Limestone aquifer. There were no groundwater strikes recorded during the drilling of the 10 no. rotary core boreholes drilled across the Proposed Wind Farm site. The ~20m of competent Limestone bedrock below the Proposed Wind Farm site does not contain any evidence of karst flow systems.

Groundwater levels have been monitored extensively. Groundwater levels within the Proposed Wind Farm site are below the formation levels for the proposed turbine foundations. Groundwater levels in the deep water bearing aquifers (>20m depth) occasionally rise to near ground levels, however unless an excavation penetrates these deep aquifers this will not be observed in the overlying hard, competent limestone. As the proposed excavations are shallow in nature (typically 3-4m), groundwater strikes will not occur (as evidenced from the drilling of RC01-RC09 and RC-11) and as such the excavations will remain relatively dry (apart from managing rainfall). Groundwater levels may be affected by any change in recharge within a groundwater catchment. A reduction in recharge, which would be accompanied by an increase in surface water drainage, would clearly reduce the volume of water infiltrating to the bedrock aquifers and therefore lead to a reduction in groundwater levels. The drainage management design of the Proposed Wind Farm site has been optimised to ensure the volume of rainfall infiltrating through the subsoils to the groundwater aquifer will not change.

<u>Proposed Grid Connection</u>

Changes in the permeability of the ground along the Proposed Grid Connection underground cabling route can impact on groundwater recharge to the underlying aquifer. As the cable trench will be shallow (~1.3m) and within an existing road carriageway, the trench will be excavated within the soil/subsoil layer. Following the excavation of the trench, the cable will be laid and the soil/subsoil removed will be backfilled within the excavation (in the same order as it was removed). As such, the overall permeability of the ground along the Proposed Grid Connection underground cabling route will not be altered to a significant degree. Where tarmacadam or other hardstanding is removed, this will be reinstated and as such the permeability will not change as a result of the Proposed Grid Connection underground cabling route.

Pathways:

Groundwater Flow - Groundwater flow paths (typically slow, non-karstic)

Groundwater levels – Rainfall Infiltration (recharge)

Receptors: Downgradient groundwater (flows and levels with the underlying Clare-Corrib GWB) and downgradient connected waterbodies (Lough Corrib).

Pre-Mitigation Potential Effects: Indirect, negative, moderate, medium term, very unlikely impact.

Mitigation by Avoidance - Groundwater Flows:

Proposed Wind Farm site

The construction of the turbines, met mast, access roads and other ancillary features of the Proposed Project could impact groundwater flows within the Proposed Wind Farm site, if a particular pathway *e.g.* karst conduit, existed near the development, however based on all the available site investigation data no reasonable pathways have been identified. The identification and avoidance of any potential karst features has been a key aim of the intrusive and extrusive site investigations, through iterative geophysical surveys, drilling and trial pit excavations and is considered to be the most rational method of mitigating against effecting flow paths, by avoiding any potential karst areas.

The Proposed Wind Farm site data outlined within Section 9.3.6.2 and 9.3.6.3 and outlined in more detail within Chapter 8 provides sufficient scientific data to say, with a high degree of certainty, that the construction of the turbine foundations, met mast, site access roads, and other relatively near surface constructs, will not interact with or alter the existing groundwater recharge, and underlying groundwater flow, regimes.

Proposed Grid Connection

The Proposed Grid Connection underground cabling route will be routed along an existing road carriageway. The trench will be excavated to a depth of 1.3m with the soil/subsoil removed and backfilled in place. As such there will be no significant change in the permeability of the lands occupied by the Proposed Grid Connection underground cabling route.

Mitigation by Design - Groundwater Levels:

As mentioned above, the critical driver of groundwater levels and the potential to affect them is through groundwater recharge. The drainage design of the Proposed Wind Farm site has been designed to mimic the existing hydrological regime within the Site, whereby surface water runoff pathways are generally short and rainfall readily percolates to ground. and level spreaders to allow water to infiltrate to ground.

The net effect of the drainage design will be that all rainfall falling within the Proposed Wind Farm site will remain on the Site and infiltrate to ground and will not exit the Site as runoff to surface watercourses.

Residual Effects: Due to the siting of the Wind Farm site infrastructure guided by the knowledge accrued through the various phases of site investigations and the iterative design process, as well as the design measures incorporated within the drainage management plan, the residual effects are considered to be - No effects on groundwater flows or groundwater levels.

Due to the nature and extent of the Proposed Grid Connection underground cabling route, along an existing road carriageway, the residual effects are considered to be – No effects on groundwater flows or groundwater levels.

Significance of Effects: No significant effects on groundwater flows and groundwater levels will occur.

9.4.2.3 Potential Effects on Groundwater Levels and Local Groundwater Well Supplies During Excavation works

Temporary dewatering of turbine foundations during construction has the potential to impact on local groundwater levels. The local groundwater levels which have been monitored over a 24-month period and a full understanding of local prevailing hydrogeological conditions has been gained. Groundwater level effects are not anticipated to be significant due the known local hydrogeological regime, and due to the proposed excavation method as outlined below. Groundwater levels across the Proposed Wind Farm site are well defined through monitoring of numerous groundwater wells and site investigation boreholes.

The known groundwater levels within the Proposed Wind Farm site are summarised in Section 9.3.6.6. Briefly, they range between 8.2 – 30.8 mOD across the Proposed Wind Farm site. Ground elevations and typical Winter groundwater levels are included in the Groundwater Contour Map, Appendix 9-6. Known winter groundwater levels are below the proposed formation levels of all turbines, the drilling of the rotary core boreholes has confirmed that no groundwater strikes were met in the underlying 10-10.5m of bedrock and as such we can confirm there will be no groundwater dewatering requirements during turbine base construction.

No groundwater level effects are anticipated from the construction of the Proposed Grid Connection underground cabling trench due to the shallow nature of the excavation (i.e. ~1.3m), the excavation of the trench within the road carriageway and the unsaturated nature of the subsoil/bedrock to be excavated.

Pathway: Groundwater recharge and groundwater flowpaths.

Receptor: Groundwater levels in the underlying bedrock aquifer (Clare-Corrib GWB) surrounding the Proposed Wind Farm site and the associated groundwater levels in mapped and unmapped wells near the Proposed Wind Farm site which source groundwater from the aquifer. And groundwater levels along the Proposed Grid Connection underground cabling route.

Pre-Mitigation Potential Effects: Indirect, slight, short term, unlikely impact on groundwater levels and local groundwater well supplies near the Proposed Wind Farm site and the Proposed Grid Connection underground cabling route.

Indirect, slight, short term, very unlikely impact on groundwater levels and local groundwater well supplies along the Proposed Grid Connection underground cabling route.

Impact Assessment – Proposed Wind Farm

Based on the engineering design, bedrock may be exposed where road and hardstand area excavations are proposed . Elsewhere, the proposed turbine base excavations will be within the subsoil strata and do not involve excavation into bedrock. The bedrock has been classified as a Regionally Important aquifer by the GSI, however the Site data from HES boreholes and site investigation boreholes indicates that groundwater is not met within the 0-10mgbl and was met first in borehole MW21-02 at 19.5mbgl *i.e.* very low permeability in the bedrock underlying the turbine locations. As outlined above, no groundwater dewatering will be required during the construction phase in any element of the Proposed Wind Farm.

The topographical and hydrogeological setting of turbine locations means no groundwater dewatering will be required. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management. For the avoidance of doubt, dewatering is defined 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 (the quarry example) is very different in scale and operation from the proposed operation of a temporary shallow excavations (3-4m), where the groundwater aquifer units (water strikes) are known to exist at depth (>19.5m). In order to explain this thoroughly we will outline our reasoning in a series of bullet points as follows:

- Firstly, the turbine locations are located on lands where the ground elevations are between ~35 and 60m OD;
- The elevations of the turbine foundations are above the elevations of groundwater levels recorded in monitoring wells and local domestic/farm wells, and therefore of the known groundwater levels within the Proposed Wind Farm site. Groundwater strikes were not met in any of the rotary core boreholes drilled to 10-10.5m at the turbine locations. Groundwater was only met in the deeper monitoring boreholes at depths greater than 19.5m. The turbine foundations will be excavated to 3-4mbgl and as such will not intercept any aquifer units, but will be excavated within the overlying subsoil and near-surface Limestone bedrock;
- The local bedrock comprises medium hard to hard Limestone and has been shown to be generally unfractured and unproductive (not water bearing) during site investigations. This means that groundwater flows at depth, beneath the turbine foundations, will be relatively minor;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations (as proven by the Site investigation drilling);
- Therefore, shallow inflows will be fed by recent rainfall, and possibly by limited seepage from localised permeable subsoils;
- As such any shallow groundwater seepage (within the subsoils) will be small in comparison to the expected surface water flows following any heavy rainfall events; and,
- Hence, it is considered that the management of surface water will form the largest proportion of water to be managed and treated, although where permeable subsoils are encountered, rainfall may infiltrate to ground rather than ponding at any excavation.

Any potential dewatering of excavations will take place above the local groundwater level, within excavations with ponded surface water. The water will be pumped a short distance to settlement ponds where it will recharge to ground. There will be no net change in runoff/recharge, other than the displacement of the recharge by a short distance (10's of metres).

In terms of the local well supplies (GWS and domestic wells) included in Section 9.3.6.5, as well as any potentially unmapped wells the implementation of the drainage design measures, ensures that recharge to the aquifer will not be altered, thus downgradient water levels will not be altered. As such, there are no well supplies down-gradient of the Proposed Wind Farm site that can be affected by temporary dewatering during turbine base construction.

Impact Assessment – Proposed Grid Connection

The Grid Connection underground cabling trench depth will only be approximately 1.3 m in depth, the excavation will be temporary and transient, and the cable trench will be backfilled with excavated material and/or hardcore material, depending on site conditions. Therefore, there will be no net loss of permeability across the 1.3m depth. As a result, and given the shallow depth, there will be very limited potential for groundwater level effects to occur.

Residual Effect: *Proposed Wind Farm:* Based on the underlying groundwater levels (above the level of excavations), the requirement for groundwater dewatering of groundwater will not exist. There may be an occasional requirement for dewatering of surface water which may pond within the excavation bases. Any pumped water will be directed (by temporary pumping) to a settlement pond to infiltrate to ground slightly downgradient of the excavation, thus recharge rates will not be altered. The residual effects are considered to be - No effects on groundwater quantity or levels reaching local domestic wells. Groundwater quality leaving the Site is dealt with in Sections 9.4.2.5, 9.4.2.6 and 9.4.2.7.

Proposed Grid Connection: Based on the typical depth of grid excavation trenches, the lack of interaction with groundwater levels, the short-term nature of the works and the spatial extent of the trench, the residual impact is considered to be: Indirect, imperceptible, temporary, very low probability impact on local groundwater levels.

Significance of Effects: No significant effects.

9.4.2.4 Potential Effects on Surface Water and topographically downgradient Surface Water bodies

Surface water draining from an active construction site can contain elevated levels of suspended sediment, which can impact on downstream surface water bodies. The surface water can also contain cementitious runoff and/or hydrocarbons depending on the nature of the construction activity. Any alteration in the drainage regime within a site can impact on the volume of runoff which leaves the Site. These effects can affect the quantity and quality of downstream surface waterbodies (where a flow path exists between the Site and the waterbody).

As noted above, no direct surface water pathways exist between the Proposed Wind Farm site and downgradient watercourses, and all pathways are via groundwater recharge and groundwater flow.

There are 4 no. watercourse crossings along the Proposed Grid Connection underground cabling route. Potential sources of suspended sediment include runoff from spoil excavated from the cabling trench. The mitigation measures outlined in Section 9.4.2.1 will ensure that there are no effects on downgradient surface waterbodies.

Pathway: Surfacewater recharge, and groundwater flow

Receptor: Downgradient surface waterbodies such as the Ballinduff stream, River Clare and Lough Corrib

Pre-Mitigation Potential Effects:

Proposed Wind Farm - As no direct surface water pathways exist between the Proposed Wind Farm and these watercourses - Indirect, slight, short term, unlikely impact.

Proposed Grid Connection - Indirect, negative, significant, temporary, unlikely impact along the Proposed Grid Connection underground cabling route.

Mitigation by Avoidance:

The primary mitigating factor in relation to downgradient surface water bodies is the distinct lack of surface water courses across the Proposed Wind Farm site and the surrounding area. The rainfall falling on the Proposed Wind Farm site recharges to the underlying groundwater aquifer. The closest mapped watercourse, the Ballinduff stream is situated 2.1 km west of the Proposed Wind Farm site.

Along the Proposed Grid Connection underground cabling route, the cabling will be emplaced within existing road carriageways and existing bridges. The utilisation of the existing roadways and bridges avoids any in-stream works.

Mitigation by Design:

Proposed Wind Farm - To ensure the continuation of the existing hydrological regime, whereby rainfall percolates to ground and does not discharge as surface water runoff, the drainage design has incorporated natural attenuation of flows and allows for collected rainwater to be recharged back into the underlying aquifer rather than leaving the Site through man-made drains. The drainage design also includes mitigation measures to ensure that any collected surface water is treated prior to discharge/recharge back into the ground, and therefore will not contain suspended sediment. The drainage design which was developed for the Proposed Wind Farm site is included in Appendix 9-7 and summarised in Section 9.3.13.

Proposed Grid Connection – The mitigation measures outlined in Section 9.4.2.1 will ensure that surface water leaving the Site will be of a high quality and control measures such as double silt fencing at watercourse crossings will protect downgradient surface water bodies.

Residual Effect:

Proposed Wind Farm - Due to the lack of surface water drainage from the Site, as well as the proposed drainage management plan which ensures the continuation of the existing hydrological/hydrogeological regime (groundwater recharge, with no runoff), along with the in-line treatment such as check dams, settlement ponds and Terrastop silt fencing - the residual effect is considered to be: No impact on downgradient surface waterbodies.

Proposed Grid Connection – With the implementation of the mitigation measures outlined in Section 9.4.2.1, the residual effect is – No residual effect on downgradient surface waterbodies.

Significance of Effects: No significant effects.

9.4.2.5 Potential Release of Hydrocarbons during Construction and Storage

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

The pathways for the rapid transport of any potential spilt chemicals are limited at this site, due to the absence of any surface water drainage routes (rivers, streams *etc*). The primary pathway is through infiltration through the subsoil and bedrock and eventually reaching the underlying groundwater aquifer.

The potential release of hydrocarbons can occur during the works within the Proposed Wind Farm site and during works along the Proposed Grid Connection underground cabling route. As stated previously, the Proposed Wind Farm site does not directly interact with any surface watercourses. There are 4 no. surface watercourse crossings along the Proposed Grid Connection underground cabling route.

Pathway: Groundwater flowpaths and site drainage network within the Proposed Wind Farm. Groundwater flowpaths and surface water drainage network along the Proposed Grid Connection underground cabling route.

Receptor: *Proposed Wind Farm:* Groundwater within the Clare-Corrib GWB.

Proposed Grid Connection: Surface watercourses downgradient of the Grid Connection underground cabling route (River Clare) and the underlying groundwater aquifer (Clare-Corrib GWB).

Pre-Mitigation Potential Impact: Due to the nature and depth of subsoils across the Proposed Wind Farm site and the ability of subsoils to attenuate pollutants - Indirect, negative, slight, short term, unlikely effect on local groundwater quality.

Due to the proximity of surface watercourses to the Proposed Grid Connection underground cabling route - Indirect, negative, slight, short term, possible impact on local surface water quality and groundwater quality.

Proposed Mitigation Measures:

Mitigation measures proposed to avoid release of hydrocarbons at the Proposed Wind Farm site and along the Proposed Grid Connection underground cabling route are as follows:

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station;
- On site re-fuelling of machinery will be carried out using a mobile double skinned refuelling truck
    - A refuelling truck will be used to refuel construction equipment used on site.
    - The refuelling truck will also carry fuel absorbent material and pads in the event of any accidental spillages.
    - The fuel truck will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site.
    - Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Onsite refuelling will be carried out by trained personnel only;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- Surface water runoff from temporary construction compounds will be collected and drained via silt traps and hydrocarbon interceptors prior to recharge to ground;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Construction and Environmental Management Plan (Appendix 4.5. Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

Residual Effect: *Proposed Wind Farm:* Based on the mitigation measures outlined, such as refuelling off site, the appropriate safe use and handling of hydrocarbons on-site where necessary including fuel bunds and the inclusion of hydrocarbon interceptors, the residual effects within the Wind Farm Site are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact on groundwater (and downgradient surface water where they are groundwater fed – Ballinduff stream).

Proposed Grid Connection: Based on the mitigation measures outlined, such as refuelling off site, the appropriate safe use and handling of hydrocarbons along the Proposed Grid Connection underground cabling route where necessary including fuel bunds, the residual effects along the Proposed Grid Connection underground cabling route are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact on surface water and groundwater.

Significance of Effects: For the reasons outlined above, and with the application of the listed mitigation measures, no significant effects on surface water and groundwater quality will occur.

9.4.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from wastewater treatment systems has the potential to impact on groundwater and surface waters if site conditions are not suitable for an on-site percolation unit. There are 2 no. construction compounds proposed for the Proposed Project.

The construction compounds will be used as a base during the construction phase of the Proposed Wind Farm and the Proposed Grid Connection works.

Pathway: *Proposed Wind Farm:* Groundwater flowpaths and site drainage network.

Proposed Grid Connection underground cabling *route:* Groundwater flowpaths and drainage network.

Receptor: Down-gradient well supplies, groundwater quality and surface water quality within the Proposed Wind Farm site and along the Proposed Grid Connection underground cabling route.

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

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

Proposed Mitigation by Avoidance:

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

Residual Effect: Based on the fact that there will be no discharge of wastewater to either the Proposed Wind Farm or along the Proposed Grid Connection underground cabling route and that wastewater will be managed by an appropriately licensed waste contractor, there will be no effect.

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

9.4.2.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative effects on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ±0.5 of a pH unit. Entry of cement-based products into surface watercourses represent a risk to freshwater ecology along the Proposed Grid Connection underground cabling route.

At the Proposed Wind Farm site, this pathway (to surface waters) is not present, however, the release of cement-based products to the Site drainage system will percolate to ground. 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 to the underlying groundwater system. Mitigation measures will be put in place to protect groundwater.

Pathway: *Proposed Wind Farm:* Site drainage network/ recharge to groundwater.

Proposed Grid Connection : Nearby surface watercourses

Receptor: *Proposed Wind Farm:* Groundwater within the underlying Clare-Corrib GWB.

Proposed Grid Connection: Downgradient surface water bodies – River Clare and its tributaries

Pre-Mitigation Potential Impact: *Proposed Wind Farm:* Indirect, negative, moderate, short term, very unlikely impact to groundwater within the Wind Farm Site.

Proposed Grid Connection: Indirect, negative, moderate, short term, likely impact to surface water along/near the Grid Connection underground cabling route (i.e., the River Clare and its tributaries).

Proposed Mitigation by Avoidance:

The following mitigation measures are proposed for the Proposed Wind Farm site and the Proposed Grid Connection underground cabling route:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and emplacement of pre-cast elements, will take place;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water will be undertaken at lined cement washout ponds;
- Weather forecasting will be used to plan dry days for pouring concrete;
- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event; and,
- Sand blinding, DPM and concrete blinding are to be provided at turbine formation level to create a vertical cut-off barrier and to mitigate the risk of concrete leakage into the ground below the turbine foundations.

Proposed Mitigation by Design:

The following mitigation measures are proposed:

- No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing locations;
- Where the proposed underground cabling route crosses a natural surface watercourse, the cable will pass over or below the existing culvert within the access road;
- Any guidance/mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites", 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); and
- 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.

Residual Impact: Based on the lack of surface watercourses at the Proposed Wind Farm site, as well as the mitigation measures to reduce the potential for concrete leakage and the use of pre-cast elements, the residual effect is considered to be - Negative, indirect, imperceptible, short term, very unlikely impact on groundwater quality in the Clare-Corrib GWB.

Based on the lack of in stream works at watercourse crossing (using existing bridges) and the mitigation measures to prevent the release of concrete runoff, the residual impact along the Proposed Grid Connection underground cabling route is considered to be - negative, indirect, imperceptible, short term, low probability impact to surface water along/near the Proposed Grid Connection underground cabling route (i.e., the River Clare and its tributaries).

Significance of the Effect: For the reasons outlined above, and with the implementation of the listed mitigation measures, no significant effects on groundwater quality, and no significant effects on stream morphology or stream water quality will occur at crossing locations along the Proposed Grid Connection underground cabling route.

9.4.2.8 Potential Effects on Turloughs

Nearby turloughs and their respective distance to the Proposed Wind Farm site turbines are outlined in Section 9.3.6.4.2. Turlough Monaghan is the only turlough which is a designated site (pNHA) and is situated 3.5km north of the Proposed Wind Farm site.

Groundwater levels have been plotted across the Proposed Wind Farm site and groundwater level contours have been derived from these levels. Groundwater flow is considered to be perpendicular to groundwater contours, however some local variation will likely occur across the Site based on topography and on the wide spread of groundwater levels. Based on these groundwater contours/flowpaths, turloughs which are considered to be downgradient of excavations (turbine hardstands/substation) are:

- Undesignated small scale turloughs near Balrobuckbeg GWS;

Turlough Monaghan (pNHA) and the turlough situated in the townland of Fearagha are not considered downgradient of any Proposed Wind Farm infrastructure.

230m of borehole drilling has been completed within the Proposed Wind Farm site, with no identified near surface karst features present across this drilling.

There is no potential for surface water to drain towards or reach any identified turlough.

Source: Excavation of roads and turbine foundations and emplacement of roads/concrete, and hardstanding areas at the 8 no. locations across the Proposed Wind Farm site, and drainage associated with these works.

Pathway(s):

- Alteration of groundwater volumes through alterations of recharge patterns;
- Alteration of groundwater flowpaths which feed the turloughs through excavation / emplacement works; and,
- Alteration of groundwater quality due to cementitious material/hydrocarbons etc.

Receptor: Turlough water levels (volume), and water quality.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, highly unlikely impact to groundwater fed turloughs.

Proposed Mitigation Measures:

The following mitigation measures are proposed:

- Proposed Wind Farm site drainage management will be put in place (as outlined in Section 9.4.2.1) in order to prevent any surface water runoff from leaving the Site and ensuring that all surface waters infiltrate to ground following short flowpaths (10's of metres) and,
- Mitigation measures relating to hydrocarbons, cementitious materials and wastewater disposal, as outlined in Sections 9.4.2.5, 9.4.2.6 and 9.4.2.7 will provide adequate protection to groundwater and surface water quality and ensure that groundwater quality will not be impacted, thus protecting the groundwater quality of any hydraulically downgradient turloughs.

Residual Effect: Due to the expansive data on subsoils and bedrock within the Proposed Wind Farm site, the data on groundwater levels and flow which have informed the groundwater contour maps and conceptual models, coupled with the distance to the turloughs near Balrobuckbeg and the mitigation measures associated with drainage management and the protection of water quality, the residual effect is considered to be - No effect on turloughs.

Significance of the Effect: No significant effects will occur on turloughs.

9.4.2.9 Potential Effects on Water Dependent Habitats

9.4.2.9.1 *Groundwater dependent pNHA's*

Primarily groundwater dependent designated sites near the Proposed Wind Farm and the Proposed Grid Connection are:

Turlough Monaghan pNHA

As outlined in Section 9.4.2.8, groundwater levels and contours have been derived for the Proposed Wind Farm site and groundwater flow directions towards turloughs have been identified where the data suggests so. Groundwater from the Proposed Wind Farm does not flow towards Turlough Monaghan pNHA, which is situated 3.5km north of the Site, but rather flows west/southwest towards Lough Corrib.

Source(s): Excavation of roads and turbine foundations, Emplacement of roads/concrete hardstandings within the Site.

Pathway (s):

There is no identified pathway between the Proposed Wind Farm site and any groundwater dependent designated site.
There is no identified pathway between the Proposed Grid Connection underground cabling route and any groundwater dependent designated site.

Receptor: Groundwater dependent pNHA's (turloughs) – turlough water levels (volume) and water quality within these turloughs.

Residual Impact: There is no potential for effects on groundwater dependent designated sites as a result of the Proposed Project.

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

9.4.2.9.2 *Surface Water Dependent SAC's, SPA's and pNHA's*

Primarily Surface water dependent designated sites near the Proposed Wind Farm and the Proposed Grid Connection underground cabling route are:

- Lough Corrib SAC (which includes the River Clare), SPA and pNHA

The Lough Corrib SAC/SPA/pNHA is principally fed by flow from Lough Mask, as well as multiple rivers from the Connemara region and north of Headford. The River Clare also discharges to Lough Corrib approximately 4km west of Claregalway. Lough Corrib is situated 4.3km west of the Proposed Wind Farm site. Groundwater will also inflow into the lake around its margins, as evident by the groundwater hydraulic gradient which flows towards the lake. Water levels in Lough Corrib are generally at ~8 mOD. The catchment to Lough Corrib (Corrib Catchment) measures ~3,100 km^2. There are no surface waterbodies which drain from the Proposed Wind Farm. The Ballinduff stream situated 2.1km west of the Proposed Wind Farm site, discharges to Lough Corrib near the townland of Balrobuckbeg.

Mitigation by Design:

Proposed Wind Farm site

There will be no net change in runoff from the Wind Farm site due to the drainage design. All water will recharge to ground. Any "dirty" surface water generated on site will be collected within a downstream collector drain, be attenuated with the collector drain and allowed to infiltrated to ground along the collector drain and within an end of drain infiltration area.

Proposed Grid Connection

The mitigation measures outlined in Section 9.4.2.1 relating to earthworks along the Grid Connection underground cabling route will ensure that surface water quality within the River Clare (part of the Lough Corrib SAC) remains unchanged.

Residual Effect: Due to the separation distances involved, the knowledge of the ground conditions (subsoil and bedrock competency) groundwater levels, gradients and flow directions as well as the mitigation measures provided to ensure the protection of water quality and water quantity (recharge), the residual effects on surface water ecosystems is considered to be – No effect on surface water ecosystems, including Lough Corrib SAC/SPA/pNHA and the associated stretches of the River Clare which form part of the Lough Corrib SAC.

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

9.4.2.10 Potential Effects on Public Water Supplies

Proposed Grid Connection

Due to the shallow nature of the Proposed Grid Connection underground cabling route, which is essentially a shallow trench excavated to allow for cable ducting, there are no potential effects on nearby public water supplies. As such, only potential effects from the construction stage activities within the Wind Farm site are considered in this section, apart from 1 no. 320m section of road which intersects with the Rusheens GWS SPA (discussed below).

Proposed Wind Farm site

The public water supplies near the Site are outlined in Section 9.3.6.5 and include the following GWS, in order of proximity to the Proposed Wind Farm site:

- Biggeramore GWS – 0.5km

- Caherlea GWS – 1.0km
- Cahermorris Glenreevagh GWS – 1.35km
- Cluide Cahermorris GWS – 1.4km
- Rusheens GWS – 2.1km
- Anbally & District GWS – 2.4km
- Balrobuckbeg GWS – 2.7km
- Claretuam-Belclare GWS – 4.8km
- Kilcoona Caherlistrane GWS – 4.9km

The quality and quantity of water being abstracted from these locations is critically important to these schemes. There is a risk of poor quality or contaminated water entering the groundwater system below the Proposed Wind Farm site and flowing towards the existing GWS water sources.

The following terms are used within this section, relating to the mapping of groundwater source protection areas:

- Source Protection Area (SPA) - The catchment area around a groundwater source which contributes water to that source (Zone of Contribution), divided into two areas;
  - The Inner Protection Area (SI) and the. The SI is designed to protect the source against the effects of human activities that may have an immediate effect on the source, in particular in relation to microbiological pollution. It is defined by a 100-day time of travel (TOT) from any point below the water table to the source.
  - The Outer Protection Area (SO)The SO covers the remainder of the zone of contribution of the groundwater source.
- Zone of Contribution (ZOC) - The area surrounding a pumped well that encompasses all areas or features that supply groundwater recharge to the well. It is defined as the area required to support an abstraction from long-term groundwater recharge.

The Biggeramore GWS is a small supply which feeds ~6-7 houses along a local road. The well is situated 0.5km from the Proposed Wind Farm site boundary, and 1.0km from the nearest proposed turbine (T4). The well is more than 40m deep and is situated within a small block built pump house. A Source Protection Area has not been mapped for the scheme and there is limited information available on the supply. Based on the number of connections to the scheme, the supply volume is estimated at only 4.5 m^3/day. With an effective rainfall rate of 717 mm/year, the zone of contribution to the Biggeramore GWS is an area of ~0.29km^2, with ~70% of this area falling within the already mapped SPA of the Cluide Cahermorris GWS. The Cluide Cahermorris GWS is located 2.4km southwest of Biggeramore. The Source Protection Area to the Biggeramore GWS does not extend to the Proposed Wind Farm site.

The Source Protection Area to the Caherlea GWS has been mapped by the GSI which encompasses an area of 0.07km^2. The boundary of the SPA is situated 0.85km north of the Proposed Wind Farm site and the nearest point of infrastructure to this SPA is Turbine No. 8, situated 1.5km from the SPA boundary. Groundwater flow direction has also been shown to follow the regional west/southwest direction, which means groundwater flow from the Wind Farm site will not flow towards the Caherlea GWS source.

The Cluide Cahermorris GWS well is situated in the townland of Cahermorris, located west of the Proposed Wind Farm site. The SPA for the source has been mapped, and extends to an area of ~7.11km^2. The SPA is ovaloid in shape, and its shape and orientation infer that groundwater flows in a southwest direction towards the well, broadly in line with the regional groundwater flow.

There is a small section (0.11km^2) of the Proposed Wind Farm site which is situated within the area of the Cluide Cahermorris GWS, towards the western edge of the Proposed Wind Farm site. There are no turbines situated within this 0.11km^2 area which intersects with the SPA, while there is 190m of roadways within this zone.

The Cahermorris Glenreevagh GWS has been audited by the GSI and a Source Protection Area is mapped. The Source Protection Area measures 3.1km2 and extends its eastern boundary in Bunnavehelly More towards the source well in the townland of Cahermorris. Again, the orientation of the SPA indicates that groundwater is flowing in a westerly direction towards the source well. There is an area of 0.72km^2 of the Proposed Wind Farm site which is situated within the Cahermorris Glenreevagh GWS SPA. Within this area, the proposed turbine T1 is situated 76m inside of the SPA boundary. A 270m section of roadway is also proposed within this area mapped as the SPA. Soil, subsoil and bedrock excavations have the potential to affect surface water quality runoff which will infiltrate to ground and may reach the GWS well. Mitigation measures are required to ensure groundwater quality in the form of groundwater recharge is maintained.

The Rusheens GWS SPA is situated 2.1km north of the Proposed Wind Farm site. The SPA forms a long rectangle which stretches east between the townlands of Ballydotia East and Moneen. The eastern section of the SPA includes the N83 road carriageway, which forms part of the Proposed Grid Connection underground cabling route. An area of 0.07km^2 of the SPA is situated within the boundary of the Proposed Grid Connection underground cabling route, along a 320m stretch of the road carriageway.

The Anbally GWS SPA is mapped 1.1km south of the Proposed Wind Farm site. The SPA measures 0.1km^2. The area encompassed by the SPA does not interact with any element of the Proposed Project and this GWS well and SPA is considered distal and not hydraulically downgradient of the Proposed Project.

The Balrobuckbeg GWS SPA is situated 1.3km west of the Proposed Wind Farm site. The SPA measures 0.31km^2 situated between the townland of Balrobuckbeg and Parknaliddaun. The Balrobuckbeg GWS is situated hydraulically downgradient of the Proposed Project, however the Source Protection Area is relatively small, given the small volume of water required. The area encompassed by the SPA does not interact with any element of the Proposed Project. Mitigation measures will be implemented during the construction and operational phases of the Proposed Project which will ensure that upgradient groundwater recharge quality is maintained.

The Claretuam-Belclare GWS SPA has been mapped by the GSI and is situated 5km north of the Proposed Wind Farm site. The GWS well and SPA is considered distal to the Proposed Wind Farm site and is hydraulically upgradient.

The Kilcoona Caherlistrane GWS Source Protection Area is situated 3.9km west of the Proposed Wind Farm site. The GWS SPA is situated downgradient of both the Balrobuckbeg and Cahermorris Glenreevagh Group Water Schemes. The area encompassed by the SPA does not interact with any element of the Proposed Project and this GWS well and SPA is considered distal to the Proposed Project. Mitigation measures to maintain high quality surface waters, and therefore groundwater recharge, will be implemented at the Site. This will protect the water quality of the underlying Clare-Corrib GWB and any groundwater flow which may reach the Kilcoona Caherlistrane GWS.

Receptor: Groundwater quality and/or quantity at the GWS production wells.

Pathway: Surface waters infiltrating to the underlying groundwater aquifer. Groundwater Flowpaths from the Proposed Project towards the GWS wells.

Pre-Mitigation potential Impact: Indirect, negative, moderate, long term, unlikely impact on groundwater quality and quantity in the SPA's listed above.

Impact Assessment & Proposed Mitigation Measures:

Proposed Wind Farm site

The Source Protection Areas (SPA's) to the nearby GWS wells have been mapped. There are no areas of the Biggeramore GWS, Caherlea GWS, Claretuam Belclare GWS, Balrobuckbeg, Kilcoona Caherlistrane or Anbally GWS SPA's situated within the Site.

There are small areas of the Cahermorris Glenreevagh and Cluide Cahermorris GWS SPA's situated within the Proposed Wind Farm site. The area of the Proposed Wind Farm site which includes the Cluide Cahermorris GWS SPA includes a short section of proposed access track (190m). The access track consists of the emplacement of new access track and the upgrade/widening of the existing farm roadway. Surface water mitigation measures will be put in place as outlined in Section 9.4.2.1 which will ensure that any surface water in this area during the construction process will be attenuated and will be of a high quality before being allowed to recharge to ground within a short distance (10's of metres). The quantity and quality of recharge to the groundwater system will be maintained.

The area of the Wind Farm site which includes the Cahermorris Glenreevagh GWS includes the proposed turbine T1 and a 270m section of proposed access road. The access track consists of the emplacement of new roadway to turbine T1. Surface water mitigation measures will be put in place as outlined in Section 9.4.2.1 which will ensure that any surface water in this area during the construction process of the roadway will be attenuated and will be of a high quality before being allowed to recharge to ground within a short distance (10's of metres). The quantity and quality of recharge to the groundwater system will be maintained. In terms of the turbine T1, there were no groundwater strikes encountered during the drilling of RC03, located at the Site of the proposed Turbine T1. The monitoring well MW21-03, drilled 850m west of turbine T1 did not encounter a water strike until 34mbgl. The Limestone bedrock underlying the turbine site is competent Limestone without any signs of karstification. The primary risk to the GWS SPA is therefore considered to be surface waters arising during the construction phase, before recharging to ground. During the construction phase, mitigation measures outlined in Section 9.4.2.1 such as interceptor drains, silt fences, swales and settlement ponds will ensure that the recharge to the underlying groundwater aquifer remains at a high standard.

Proposed Grid Connection

In terms of the Proposed Grid Connection underground cabling route, a small area of the Rusheens GWS Source Protection Area, overlaps with the underground cabling route, within a 0.07km^2 area, which contains ~320m of roadway. The underground cabling trench (1.3m deep) will be excavated along the road carriageway in sections, before being backfilled once the underground cabling has been installed. This excavation work can lead to sediment laden runoff from the excavation, following rainfall events. Typically, surface water effects are the primary concern during the Proposed Grid Connection underground cabling route works, rather than groundwater effects. However, as there are few nearby surface watercourses to drain towards, all surface water is expected to infiltrate to ground and to the underlying aquifer. The management of sediment from runoff along the construction areas is detailed in Section 9.4.2.1 which will be implemented along the Proposed Grid Connection underground cabling route. Hydrocarbon controls and controls on cement-based products will also be implemented to ensure any surface water along the Proposed Grid Connection underground cabling route is of a high quality, before it recharges to ground.

Residual Impact:

Cahermorris Glenreevagh GWS – Based on the small volume of works within the Cahermorris Glenreevagh GWS Source Protection Area, the mitigation measures which will be implemented to ensure surface water quality, and thus groundwater recharge is maintained to a high quality, as well as the Site investigation indicating competent Limestone underlying turbine T1 thus eliminating any subsurface connection to the GWS well, the residual effects are considered to be - Indirect, negative, imperceptible, short term, unlikely impact on groundwater quality and quantity in the Cahermorris Glenreevagh GWS well.

Cluide Cahermorris GWS – Based on the limited volumes of work within the GWS source protection area, the types of works which are near surface roadway construction over a distance of 190m and the overall distance to the GWS well, the residual effect, after the mitigation measures to protect surface water quality have been put in place are considered to be - Indirect, negative, imperceptible, short term, unlikely impact on groundwater quality and quantity in the Cluide Cahermorris GWS well.

Rusheens GWS – Based on the limited works within the Rusheens SPA within an existing roadway at a depth of ~1.3m, as well as the temporal nature of the works and the mitigation measures to ensure surface water quality and thus groundwater quality is protected. The residual effect is considered to be - Indirect, negative, imperceptible, short term, very unlikely impact on groundwater quality and quantity in the Rusheens GWS well.

Based on the separation distances and the Site being situated outside of the remaining mapped Source Protection Area, the detailed site investigation data detailing competent (not karstified) Limestone underlying the turbines at the Proposed Wind Farm site, the proposed mitigation measures in relation to suspended sediment, hydrocarbons and cement based products (outlined in Sections 9.4.2.1 - 9.4.2.7), as well as the information gathered on the hydrogeological regimen including groundwater flow directions and groundwater levels, the residual effect on the remaining GWS wells, namely Biggeramore GWS, Caherlea GWS, Claretuam Belclare GWS, Balrobuckbeg, Kilcoona Caherlistrane or Anbally GWS, , is considered to be – Indirect, negative, imperceptible, medium term, very unlikely impact on groundwater quality and quantity in the Source Protection Areas and thus to the GWS groundwater wells.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigations measures, no significant effects on the GWS wells mapped in the area surrounding the Proposed Project will occur.

9.4.2.11 Potential Effects on Domestic Water Supplies

Due to the prevalence of local GWS wells within the area and their associated connection numbers, the number of domestic wells present in the area surrounding the Site is very low. HES have gained access to 3 no. domestic wells which are known in the area (DW1-DW3) which have been monitored during the period December 2021-December 2023 outlined in Section 9.3.6.3.2.

Potential effects on domestic groundwater wells are similar to those in relation to GWS wells and include a reduction in groundwater quality in the aquifer underlying the Site through poor quality water recharging to ground. Due to the knowledge of competent Limestone underlying the Proposed Wind Farm site at the turbine and major infrastructure locations and the level of groundwater strikes at below 19.5m, and the shallow and transient nature of the excavated trench along the Proposed Grid Connection underground cabling route there is no potential to affect groundwater pathways during the construction phase.

Receptors: Local unmapped downgradient groundwater wells (west and southwest of the Proposed Project due to groundwater flow direction).

Pre-mitigation Potential Effects: Indirect, negative, moderate, long term, unlikely impact on groundwater quality and quantity in unmapped local domestic wells.

Mitigation Measures:

Surface water mitigation measures will be put in place as outlined in Section 9.4.2.1 which will ensure that any surface water arising at the Site during the construction process of the Proposed Project will be attenuated and will be of a high quality before being allowed to recharge to ground within a short distance (10's of metres). The quantity and quality of recharge to the groundwater system will be maintained. Measures to protect the water environment from cement based products and hydrocarbons (as outlined in Sections 9.4.2.7 and 9.4.2.5) will ensure that the water recharging to ground is of a high quality.

The Limestone bedrock underlying the proposed turbine locations is competent Limestone without any signs of karstification. The primary risk to unmapped domestic wells is therefore considered to be surface waters arising during the construction phase, before recharging to ground. During the construction phase, mitigation measures outlined in Section 9.4.2.1 such as interceptor drains, silt fences, swales and settlement ponds along with mitigation measures to protect against effects from hydrocarbons and cement based products will ensure that the recharge to the underlying groundwater aquifer remains at a high standard.

Based on the separation distances involved, the detailed site investigation data detailing competent (not karstified) Limestone underlying the turbines at the Proposed Wind Farm site, the proposed mitigation measures in relation to suspended sediment, hydrocarbons and cement based products, as well as the information gathered on the hydrogeological regimen including groundwater flow directions and groundwater levels, the residual effect on unmapped domestic wells is considered to be – Indirect, negative, imperceptible, medium term, very unlikely impact on groundwater quality and quantity.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigations measures, no significant effects on unmapped domestic wells mapped in the area surrounding the Proposed Project will occur.

9.4.2.12 Potential Effects on Water Framework Directive Status

Construction phase activities will require earthworks resulting in removal of vegetation cover and excavation of soil and subsoils.

The main risk will be from surface water runoff from bare soil and spoil management areas during construction works, however as outlined several times in the above text, surface water pathways are very short and any surface water will readily infiltrate to ground.

Hydrocarbons and cement-based compounds will also be used during the construction phase.

These activities can result in the release of suspended solids and pollutants in runoff water and could result in an increase in the suspended sediment load, resulting in increased turbidity, increased pH and contamination which in turn could affect the water quality and fish stocks of downstream water bodies such as the Ballinduff (Stream)_010 and the Clare (Galway)_060.

These Surface Water Bodies (SWB's) are relatively distal in relation to the Site. However, there is the possibility of these contaminants having the potential to cause a deterioration in the overall status of the Ballinduff (Stream)_010, Clare (Galway)_050 and the Clare (Galway)_060 river waterbodies. Further downstream the status of the Clare (Galway)_070 to the Clare (Galway)_100 river waterbodies are unlikely to be impacted even in an unmitigated scenario due to the distal location of the SWB from the Proposed Project and the large volume of water within the river. However, they are included into the WFD Impact Assessment for precautionary measures.

In terms of groundwater bodies, accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a major pollution risk to groundwater. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Chemicals such as cement-based compounds also pose a threat to the groundwater environment. Runoff from concrete works can impact on groundwater quality. These sources of contamination have the potential to impact on groundwater quality in the underlying groundwater Clare-Corrib GWB in the area of the Proposed Project.

Receptors

- Surface water bodies listed in Table 9-19
- Groundwater bodies listed in Table 9-20

Pre-mitigation Potential Effects:

A summary of potential status change to WFD SWBs arising from surface water quality effects from earthworks during the construction phase of the Proposed Project in the unmitigated scenario are outlined in Table 9-19.

Table 9-19: Potential Surface Water Body effects during the Proposed Project

SWB	WFD Code	Current Status	Potential Status Change
Ballinduff (Stream)_010	IE_WE_30B050100	Not assigned	Not assigned (reduced quality)
Clare (Galway)_050	IE_WE_30C010700	Moderate	Poor
Clare (Galway)_060	IE_WE_30C010800	Moderate	Poor
Clare (Galway)_070	IE_WE_30C011000	Good	Good
Clare (Galway)_080	IE_WE_30C011100	Moderate	Moderate
Clare (Galway)_090	IE_WE_30C011200	Moderate	Moderate
Clare (Galway)_100	IE_WE_30C011300	Not assigned	Not assigned

Table 9-20: Potential Groundwater body status effects during the Proposed Project

GWB	WFD Code	Current Status	Potential Status Change
Clare-Corrib	IE_WE_G_0020	Good	Moderate

Mitigation Measures

The mitigation measures outlined in Section 9.4.2.1 including avoidance of surface watercourses, along with source controls (interceptor drains, sandbags, silt fences), amongst others, will ensure that any surface water generated at the Proposed Wind Farm, will be of a high quality in terms of suspended sediments, while it is noted that runoff from the Proposed Wind Farm will not occur as surface water will infiltrate to ground.

In terms of cement-based materials, the mitigation measures outlined above in Section 9.4.2.7 relating to cement products will be implemented and will break the pathway between the source and receptor.

Mitigation measures in relation to the use of hydrocarbons including off-site refuelling, hydrocarbon interceptors and an emergency plan to deal with accidental spillages are outlined in Section 9.4.2.5.

Residual Effect:

Proposed Wind Farm site: Based on the mitigation measures outlined in relation to sediment control (Section 9.4.2.1), cement based products (Section 9.4.2.7) and hydrocarbons (Section 9.4.2.5, the residual effects within the Proposed Wind Farm site on the WFD status of the SWB's and GWB are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact.

Grid Connection underground cabling route: Based on the mitigation measures outlined in relation to sediment control (Section 9.4.2.1), cement based products (Section 9.4.2.7) and hydrocarbons (Section 9.4.2.5, the residual effects along the Proposed Grid Connection underground cabling route on the WFD status of the SWB's and GWB are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact.

Significance of Effects: For the reasons outlined above, and with the application of the listed mitigation measures, no significant effects on the WFD status of the Surface water bodies and Groundwater bodies listed in Table 9-19 and Table 9-20 will occur.

9.4.2.13 Potential Effects of the Proposed Turbine Delivery Route

No effects on the water environment along the turbine delivery route will occur as no earthworks are required.

9.4.3 Operational Phase – Likely Significant Effects

The assessment considers the Proposed Project as a whole i.e. both the Proposed Wind Farm and the Proposed Grid Connection. Where this is required to be assessed separately, this is noted in the text.

9.4.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Proposed Wind Farm

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network, if the drainage design included surface water runoff leaving the Site. However, at this site, the drainage design has been optimised to allow for all rainfall which may fall on impermeable surfaces (such as at turbine hardstands) to recharge to ground as would normally occur at the Site. The Proposed Wind Farm site footprint comprises an area of 11.9 ha.

Proposed Grid Connection

The Proposed Grid Connection underground cabling route comprises an area of 1.9Ha. Along the Proposed Grid Connection underground cabling route, a trench will be excavated for the emplacement of the grid connection cabling. Once installed, this trench will be backfilled and the road surface reinstated. As such, there will be no change in the permeability along this route.

Pathway: Proposed Wind Farm site drainage network and recharge to underlying groundwater in the Clare-Corrib GWB.

Proposed Grid Connection underground cabling route – excavate and reinstate.

Receptor: Underlying groundwater aquifer.

Pre-Mitigation Potential Impact: Indirect, negative, slight, permanent, unlikely effect on groundwater quality and quantity within the Clare-Corrib GWB.

Impact Assessment/Mitigation Measures

As summarised in Section 9.3.13 and outlined in detail in Appendix 9-7, the drainage design for the Proposed Wind Farm includes for the release of any surface water captured within the interceptor drains to recharge back to ground, with a very nominal spatial diversion of the water (10's of metres). In doing so, all rainfall which falls on the Site will still infiltrate to ground. There will be no net increase in runoff from the Proposed Wind Farm site or along the Proposed Grid Connection underground cabling route.

Proposed Mitigation by Design:

Proposed Wind Farm site

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

- Interceptor drains will be installed up-gradient of 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 slowly re-distributed over the ground surface and infiltrate through the soil and subsoils;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the Proposed Wind Farm site, likely to have entrained suspended sediment, and channel it to infiltration areas for sediment settling; and,
- Check dams will be used along sections of access road drains to attenuate flows and intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock.

Proposed Grid Connection:

The trench associated with the Proposed Grid Connection underground cabling route will be backfilled and reinstated following the laying of the cable. As such, the permeability of the ground will remain unchanged.

Residual Impact:

Proposed Wind Farm site

Due to the retention of groundwater recharge regime, with no surface water drainage from the Proposed Wind Farm site, as well as the relative short displacement of any surface water before natural infiltration occurs and the mitigation measures to ensure the quality of the surface water, the residual effect is considered to be - indirect, negative, imperceptible, permanent, very unlikely effect on groundwater quality and quantity within the Clare-Corrib GWB.

Proposed Grid Connection

Due to the temporary and transient nature of the works along the grid route and the reinstatement of the ground following completion of the cable laying, the residual effect is considered to be – no effect on groundwater quality and quantity.

Significance of Effects: No significant effects on surface water and groundwater quality or quantity are anticipated during the operational phase of the Proposed Project.

9.4.3.2 Potential Hydrological and Hydrogeological Effects on Turloughs

Proposed Wind Farm site

Nearby turloughs, and their respective distance to the Proposed Wind Farm site are outlined in Section 9.3.6.4.2. The closest turloughs are situated ~2km west of the Proposed Wind Farm site in the townland of Balrobuckbeg.

The potential effects and effects on the turloughs during the construction phase has been considered and outlined in Section 9.4.2.8. The construction phase is the most disruptive element of the Proposed Project, in terms of soil/subsoil excavation and movements and general groundworks. During the operational phase, the potential for effects are more limited as there is no further excavation/movement of soil/subsoil and the drainage system is fully constructed and operational.

Proposed Grid Connection

Due to the shallow nature of the Proposed Grid Connection underground cabling route trench (~1.3m), the temporary and transient nature of the works and the reinstatement of the trench after the cable has been laid, there are no reasonable pathways for effects on turloughs. As such, the Proposed Grid Connection underground cabling route is not carried forward in this section for assessment.

Source: Groundwater quantity and quality leaving the Wind Farm site draining in the direction of turloughs.

Pathway (s): Infiltration of rainfall to ground (including any rainfall directed through interceptor drains and settlement ponds).

Receptor: Turlough water quantity and quality

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, unlikely impact to groundwater fed turloughs.

Impact Assessment:

As outlined above, the potential for effects during the operational phase of the Proposed Project is reduced as there are no further construction activities along with the associated potential sources such as hydrocarbons/cement/ exposure of subsoils/bedrock.

During the operational phase of the Proposed Project, the only plant which will be required on site will be maintenance/inspection vehicles (Light Goods vehicles). These will be refuelled off site, thus reducing the potential for effects due to hydrocarbon spills. There will be no discharge of wastewater during the operational phase. Mitigation measures relating to hydrocarbons, cementitious materials and wastewater disposal, as outlined in Sections 9.4.2.5, 9.4.2.6 and 9.4.2.7 will continue to provide adequate protection to groundwater and surface water quality during the operational phase and ensure that groundwater quality will not be impacted, thus protecting the groundwater quality of any hydraulically downgradient turloughs.

Residual Effect: Due to the expansive data on subsoils and bedrock within the Proposed Wind Farm site, the data on groundwater levels and flow which have informed the groundwater contour maps and conceptual model, coupled with the mitigation measures associated with drainage management and the protection of water quality, combined with the lack of any construction type activities the residual effect during the operational phase of the Proposed Project is considered to be - No effect on downgradient turloughs.

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

9.4.3.3 Potential Hydrological and Hydrogeological Effects on Designated Sites

The potential water environment effects on designated sites from the Proposed Project are principally related to the construction process, through potential sources such as sediment generation, cement-based materials and hydrocarbon spillages and potential pathways created during the excavation and movement of soils/subsoils and in some cases bedrock.

During the operational phase of the Proposed Project, these potential sources and pathways no longer exist. Any potential effects then on designated sites are related to the operational maintenance of the wind farm infrastructure.

Pathway: Rainfall infiltration through soils/subsoils and groundwater flow towards designated sites

Receptor(s): Groundwater and surface water dependent SAC's (as listed in Section 9.4.2.9.1 and 9.4.2.9.2).

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, unlikely impact to designated sites.

Mitigation Measures:

Mitigation measures to protect designated sites during the operational phase of the Proposed Project include:

- Regular maintenance of the on-site drainage system. The maintenance schedule will be reduced once natural vegetation is re-established, which will provide consistent filtration through the soil/subsoil;
- The use of fuel storage bunds for any hydrocarbons (fuel/oils) and the ongoing maintenance of the bund structures; and,
- Any maintenance works which may involve soil movement (such as the removal of sediment from the settlement ponds) will take place during the dry months of the year (May - September).

Residual Effect: Based on the considerable reduction in the potential sources of effects during the operational phase, as well as the ongoing mitigation measures the residual effect is considered to be – No effect.

Significance of Effects: None.

9.4.3.4 Potential Effects on Water Framework Directive Status

During the operational phase of the Proposed Project, the progressive replacement of the soil or vegetated surfaces with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff at the Proposed Wind Farm site (this will not occur along the Proposed Grid Connection underground cabling route as the trench will be backfilled and the road reinstated, and permeability will be unchanged). This could potentially increase runoff from the Proposed Wind Farm site, however as noted all surface water will infiltrate to ground within the Proposed Wind Farm site. An increase in surface water runoff leaving the Site would have an effect on the groundwater recharge to the underlying groundwater body, however due to the drainage design proposed at the Proposed Wind Farm site, this will not occur.

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 and hardstand areas. These works are of a very minor scale and are 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.

Receptors
Surface water bodies listed in

- Table 9-21
- Groundwater bodies listed in Table 9-22

Pre-mitigation Potential Effects:

Table 9-21: Potential Surface Water Body effects during the Proposed Project

SWB	WFD Code	Current Status	Potential Status Change
Ballinduff (Stream)_010	IE_WE_30B050100	Not assigned	Not assigned (reduced quality)
Clare (Galway)_050	IE_WE_30C010700	Moderate	Poor
Clare (Galway)_060	IE_WE_30C010800	Moderate	Poor
Clare (Galway)_070	IE_WE_30C011000	Good	Good
Clare (Galway)_080	IE_WE_30C011100	Moderate	Moderate
Clare (Galway)_090	IE_WE_30C011200	Moderate	Moderate
Clare (Galway)_100	IE_WE_30C011300	Not assigned	Not assigned

Table 9-22: Potential Groundwater body status effects during the Proposed Project

GWB	WFD Code	Current Status	Potential Status Change
Clare-Corrib	IE_WE_G_0020	Good	Moderate

Mitigation Measures

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

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road-side drains will be used to collect runoff from access roads and turbine hardstanding areas of the Proposed Wind Farm site, likely to have entrained suspended sediment, and channel it to infiltration areas for sediment settling and recharge to ground;
- 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; and,
- Infiltration areas, emplaced downstream of road swale sections and at end of the downstream collector drains, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall and allow the rainfall to recharge to ground effectively.

The mitigation measures to protect against poor quality runoff during the operational phase of the Proposed Project are the same as those outlined in Section 9.4.2.1 above.

Mitigation measures for oils and fuels during the operational phase of the Proposed Project are the same as those outlined in 9.4.2.5 above.

Residual Effect:

Proposed Wind Farm: Based on the mitigation measures outlined in relation to drainage/sediment controls (Section 9.4.2.1), wastewater (Section 9.4.2.6), cement based products (Section 9.4.2.7) and hydrocarbons (Section 9.4.2.5), the residual effects within the Wind Farm Site on the WFD status of the

SWB's and GWB are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact.

Proposed Grid Connection: Based on the mitigation measures outlined in relation to drainage/sediment control (Section 9.4.2.1), cement based products (Section 9.4.2.7) and hydrocarbons (Section 9.4.2.5), the residual effects along the Proposed Grid Connection underground cabling route on the WFD status of the SWB's and GWB are considered to be - Indirect, negative, imperceptible, short term, very unlikely impact.

Significance of Effects: For the reasons outlined above, and with the application of the listed mitigation measures, no significant effects on the WFD status of the Surface water bodies and Groundwater bodies listed in

Table 9-21 and Table 9-22 will occur.

9.4.4 Decommissioning Phase – Likely Significant Effects

Proposed Wind Farm

In the event of decommissioning of the Proposed Wind Farm site, similar activities to the construction phase are carried out.

Potential effects will be similar to the construction phase but to a lesser degree. There may be increased trafficking and an increased risk of disturbance to underlying soils at the Proposed Wind Farm site, during the decommissioning phase. Any such potential effects will be less than during the construction stage as the drainage system will be fully mature and will provide additional filtration of runoff. Any diesel or fuel oils stored on site will be bunded. In the event of decommissioning of the Proposed Wind Farm, the proposed access tracks may be used in the decommissioning process.

Following decommissioning of the Proposed Wind Farm site; the turbine foundation areas will be rehabilitated, i.e. left in place, covered over with local soils/subsoils and allowed to re-vegetate naturally, if required. The internal site access tracks will be left in place. It is considered that leaving these areas in-situ will cause less environmental damage than removing and recycling them.

The removal of this infrastructure (hardstanding areas, foundations *etc.*) would result in disturbance to the local environment in terms of disturbance to underlying soils and an increase in erosion, sedimentation, dust, noise, traffic and an increased possibility of contamination of the local water table. As such, these areas will be left in place and there will be no effects from a decommissioning process.

The Proposed Grid Connection underground cabling route infrastructure to the on-site 110kV substation will be removed, while the ducting itself will remain in-situ rather than excavating and removing it, as this is considered to have less of a potential environmental impact, in terms of soil exposure, and thus on the possibility of the generation of suspended sediment which could enter nearby watercourses.

The residual effect on the water environment as a result of the decommissioning phase is considered to be: Negative, indirect, imperceptible, long-term, unlikely effect on groundwater quality and groundwater quantity in the Clare-Corrib GWB.

Proposed Grid Connection

The onsite 110kV substation will remain in place as it will be under the ownership/ control of the ESBN/ EirGrid. The Proposed Grid Connection underground cabling will also remain in place. As such there will be no effects associated with the Proposed Grid Connection during the decommissioning stage of the Proposed Project.

The potential for effects during the decommissioning phase of the Proposed Grid Connection underground cabling route is considered to be - No effect.

An outline decommissioning plan is contained in the CEMP in Appendix 4-5 of this EIAR for the decommissioning of the Proposed Project, the detail of which will be agreed with the local authority prior to any decommissioning.

9.4.5 Cumulative Assessment

9.4.5.1 Proposed Project

Construction Phase

A detailed cumulative assessment has been carried out for all planning applications (granted and awaiting decisions) within a combined river sub-basin zone within the vicinity of the Site defined within Appendix 2-3. This combined sub basin area encompasses an area of 184.43km^2 and includes river sub-basins within the Clare[Galway]_SC_040 sub-catchment as well as the southern half of Lough Corrib.. There will be no potential for cumulative effects beyond the southern edge of the cumulative boundary are due to increases in flow volume (as the catchment area increases) and increasing distance from the Proposed Project.

A total of 520 planning applications have been identified within the sub-basin zone. 380 no. of these applications are for new dwellings or renovations of existing dwellings, as well as a further 52 no. applications for erection of farm buildings and 44 no. for commercial units. 10 no. applications have been identified as energy related developments. Of these, 2 no. applications refer to solar farm PV developments; PL 191315, a 43Ha solar farm development at Cloonascragh, Tuam (0.5km south of Proposed grid Connection underground cabling route) and PL22647, a 2100 m^2 solar energy development at Knocknacarigeen (2.5km north of Wind Farm site).

The remaining energy related developments are associated with upgrade works to grid connections. There are no other Wind energy developments proposed or granted within the cumulative boundary area.

Based on the scale of the works, their proximity to the Proposed Project and the temporal period of likely works, no cumulative effects will occur as a result of the Proposed Project.

Operational Phase

During the operational phase of the Proposed Project, the main sources of potential environmental effects will not exist. There will be no exposed excavations and spoil management areas will not be in operation. There will be no sources of sediment to reach watercourses. There will be no use of cementitious materials. Fuels/oil will be kept to a minimum at the Site. Any oils for turbine maintenance will be stored within bunded areas.

The underground connection cabling route will be reinstated at the end of the construction phase and will remain in-situ during the operational phase. No maintenance of the underground cabling route is envisaged, however any minor maintenance will be completed from inspection points along the route.

During the operational phase of the project, there will be no cumulative effects with other planned projects (as listed in Section 2.13 of Chapter 2) within the sub-basin catchment zone).

Decommissioning

During the decommissioning phase, the potential cumulative effects are similar to the construction phase, but to a lesser degree with less ground disturbance. The onsite 110kV substation and underground cabling route will remain in-situ and will not be decommissioned. There will be increased trafficking and an increased risk of disturbance to underlying soils at the Proposed Wind Farm site, during the decommissioning phase. Any potential effects would be likely to be less than during the construction stage as the drainage system will be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site will be bunded. During the decommissioning phase of the Proposed Project, the proposed access tracks may be used in the decommissioning process.

During the decommissioning phase, there will be no cumulative effects within the sub-basin zone.

The hydrological impact assessment undertaken above in this chapter outlines that significant effects will not occur during the construction, operational and decommissioning works.

No significant cumulative effects on the hydrology and hydrogeology environment will occur as a result of the Proposed Project within the Proposed Wind Farm site and the associated Proposed Grid Connection underground cabling route