NIS APPENDIX 3

EIAR CHAPTER 9 – HYDROLOGY AND HYDROGEOLOGY

9. HYDROLOGY AND HYDROGEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential likely and significant effects of the proposed Clonberne Wind Farm and Grid Connection (Proposed Project), Co. Galway on water aspects (hydrology and hydrogeology) of the receiving environment.

The Proposed Project (Wind Farm site and Grid Connection) is described in full in Chapter 4 of this EIAR.

Where 'the Site' is referred to, this relates to the primary study area for the Proposed Project EIAR, as delineated by the EIAR Site Boundary and includes both the Wind Farm site and Grid Connection.

Where the 'Wind Farm site' is referred to, this refers to the 11 no. turbines and associated foundations and hard-standing areas, turbine delivery route (TDR) accommodation works, access roads, 2 no. temporary construction compounds, underground cabling, peat, spoil and overburden repositories, wind farm drainage, tree felling, 1 no. borrow pit, peatland enhancement area, and all ancillary works.

The "Grid Connection" relates to the ~2.8km underground 220kV Cabling Route, on-site 220kV substation, proposed access road, 2 no. new interface/end mast towers and all associated infrastructure.

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater natural resources) in the area of the Proposed Project;
- Identify likely significant effects of the Proposed Project on surface water and groundwater natural resources during the construction, operational and decommissioning phases of the project;
- Identify mitigation measures to avoid, reduce or offset significant negative effects;
- Assess significant residual effects; and,
- Assess the cumulative effects of the Proposed Project itself as well as other local developments (as described in Chapter 2 of this EIAR).

The Water Study Area for assessing the potential zone of impact and cumulative effects assessment is the Clare River catchment. The Clare River catchment is shown on Figure 9-1 below (Regional Hydrology Map).

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 wetland hydrology and wind farm drainage design. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by David Broderick and Michael Gill.

David Broderick (P. Geo., BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with over 17 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment, karst hydrology and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed over 25 Source Protection Assessments for the GSI/NFGWSs, and for Irish Water and for private developments across the country in a wide variety of hydrogeological settings. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Ardderroo Wind Farm, Knockalough Wind Farm, and Oweninny Wind Farm, and over 60 other wind farm related projects across the country. David worked on his first wind energy project in 2010, and he has continued to work on similar projects since then.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Civil/Environmental Engineer and Hydrogeologist with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. Michael has completed over 30 Source Protection Assessments for the GSI/NFGWSs, and for Irish Water, and for private developments across the country in a wide variety of hydrogeological settings. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, karst hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Slievecallan Wind Farm, Seven Hills Wind Farm, Carrownagowan Wind Farm, and over 100 other wind farm related projects across the country. Michael worked on his first wind energy project in 2003, and he has continued to work on similar projects since then.

9.1.3 Scoping and Consultation

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

Due to the long duration of the Proposed Project pre-planning stage and alterations of the proposed layout over that period, scoping and consultation was carried out in 2020 and again in 2023.

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

Consultee	Matters Raised - Description	Addressed in Sections
Geological Survey of Ireland (2020 & 2023)	"*There are groundwater drinking water abstractions for which there are zones of contribution/source protection areas: Gurteen Cloonmore Group Water Scheme, is located within the area of the proposed wind farm development. Additionally, Gallagh Group Water Scheme and Dunmore Glenamaddy water supply scheme are located close by*". "*Key to groundwater protection in general, and protection of specific drinking water supplies, is preventing ingress of runoff to the aquifer. Design of wind farm drainage will need to be cognisant of the group water scheme and the interactions between surface water and groundwater as well as run-off*".	9.3.4, 9.3.8, 9.3.9, 9.3.10, 9.3.15, 9.4.1, 9.5.2.1 and 9.5.2.11

Consultee	Matters Raised - Description	Addressed in Sections
	"Appropriate design should be undertaken by qualified and competent persons to include mitigation measures as necessary, such as SUDs or other drainage mitigation measures". *"Also, any excavation/cuttings required should ensure that groundwater flow within the zones of contribution to the groundwater abstraction points is not disrupted, resulting in diminished yields. Note that there could be other groundwater abstractions in the locality for which Geological Survey Ireland has not undertaken studies, and a robust assessment should be undertaken by qualified and competent persons".* *"Given the nearby drinking water sources (Group Water Scheme and numerous boreholes and domestic wells), the effects of any potential contamination / dewatering as a result of the wind farm development would need to be assessed".*	
Department of Agriculture, Food and the Marine (2020 & 2023)	*"The interaction of these proposed works with the environment locally and more widely, in addition to potential direct and indirect impacts on designated sites and water, is assessed. Consultation with relevant environmental and planning authorities may be required where specific sensitivities arise (e.g. local authorities, National Parks & Wildlife Service, Inland Fisheries Ireland, and the National Monuments Service)".*	9.3.14
DAU (2020 & 2023)	*"Wetlands are important areas for biodiversity and ground and surface water quality should be protected during construction and operation of the proposed development. The EIAR should include a detailed assessment of the hydrological impacts on wetlands from the proposed development".* *"Flood plains, if present, should be identified in the EIAR and left undeveloped to allow for the protection of these valuable habitats and provide areas for flood water retention (green infrastructure). If applicable the EIAR should take account of the guidelines for Planning Authorities entitled "The Planning System and Flood Risk Management" published by the Department of the Environment, Heritage and Local Government In November 2009".*	9.5.2.17 9.3.6
Uisce Éireann (2020 & 2023)	*"At present, Uisce Éireann does not have the capacity to advise on the scoping of individual projects. However, in general the following*	9.3.15

Consultee	Matters Raised - Description	Addressed in Sections
	aspects of Water Services should be considered in the scope of an EIA where relevant *Where the development proposal has the potential to impact an Uisce Éireann Drinking Water Source(s), the applicant shall provide details of measures to be taken to ensure that there will be no negative impact to Uisce Éireann's Drinking Water Source(s) during the construction and operational phases of the development. Hydrological / hydrogeological pathways between the applicant's site and receiving waters should be identified as part of the report".*	

9.1.4 Relevant Legislation

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

The requirements of the following legislation are complied with:

- Planning and Development Act 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296/2018: 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 and S.I. No. 722/2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it replaced a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;
- S.I. No. 41/1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 294/1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 74/440/EEC concerning the quality required of

surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);

- S.I. No. S.I. No. 99/2023: European Communities Environmental Objectives (Drinking Water) (Amendment) Regulations 2023;
- S.I. No. 287/2022: European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2016;
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Water) Regulations 2009; and,
- S.I. No. 77/2019: European Communities Environmental Objectives (Surface Water) (Amendment) Regulations 2019.

9.1.5 Relevant Guidance

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

- Environmental Protection Agency (2022): Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- European Commission (2017): Environmental Impact Assessment of Projects – Guidance on the Preparation of the Environmental Impact Assessment Report;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Watercourses;
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- 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);
- DOE/NIEA (2015): Wind Farms and Groundwater Impacts – A guide to EIA and Planning Considerations; and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.2 Methodology

9.2.1 Desk Study

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

- Environmental Protection Agency databases (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks and Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 14 (Geology of Galway Bay). Geological Survey of Ireland (GSI, 2004);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 12 (Geology of Longford/Roscommon). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland (2003) – Clare-Corrib Groundwater Body Initial Characterization Reports;
- OPW Past Flood Event Mapping (www.floodinfo.ie); and,
- OPW Flood Extents Mapping and National Indicative Fluvial Mapping (www.floodinfo.ie/map/floodmaps).

9.2.2 Baseline Monitoring and Site Investigations

Geological/hydrological/hydrogeological baseline monitoring and site investigations of the Site were undertaken by David Broderick of HES (refer to Section 9.1.2 above for qualifications and experience) on 5th March, 10th & 11th May, 21st & 22nd June, 10th August, 21st December 2021, on 19th January and 6th April 2022 and on 28th March 2023. No site visits were carried out in 2024 as sufficient monitoring was carried out between 2021 and 2023.

A Peat Stability Risk Assessment and Peat Management Plan were undertaken by Gavin and Doherty GeoSolutions (GDG, March 2024) for the Proposed Project.

The Peat Stability Risk Assessment Report and Peat Management Plan prepared by GDG are included as Appendix 8-1 and Appendix 4-3 of this EIAR, respectively.

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

- Walkover surveys and hydrological mapping of the Site area was undertaken by HES whereby water flow directions and drainage patterns in local watercourses were recorded;
- A total of 194 no. peat probes were undertaken by HES, MKO, and GDG to determine the thickness and geomorphology of peat overlying parts of the Site;
- Trial pitting (15 no.) by GDG and gouge cores (10 no.) by HES to investigate soil, peat and mineral subsoil lithology;
- Investigation drilling (5 no. boreholes under supervision of HES) to determine the full geological profile of the Site (i.e. peat, mineral subsoil, and top of bedrock profile) and groundwater conditions;
- Continuous groundwater level monitoring at the 5 no. investigation boreholes and 1 no. private well within the Site by means of in-situ data loggers (pressure transducers) between June 2021 and March 2023;
- Continuous groundwater level monitoring at Gurteen/Cloonmore GWS source spring sump;

- A Peat Stability Risk Assessment was undertaken by GDG (March 2024) for the Site;
- Field hydrochemistry measurements (electrical conductivity, pH, dissolved oxygen and temperature) were taken to determine the origin of surface water flows;
- Surface water (3 no. rounds) and groundwater sampling (2 no. rounds) for baseline and hydrological/hydrogeological characterisation purposes; and,
- Surface water flow measurements of the primary streams that drain the Site.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, 2022) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e., negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment are those set out in the EPA (2022) Glossary of effects as shown in Chapter 1 of this EIAR.

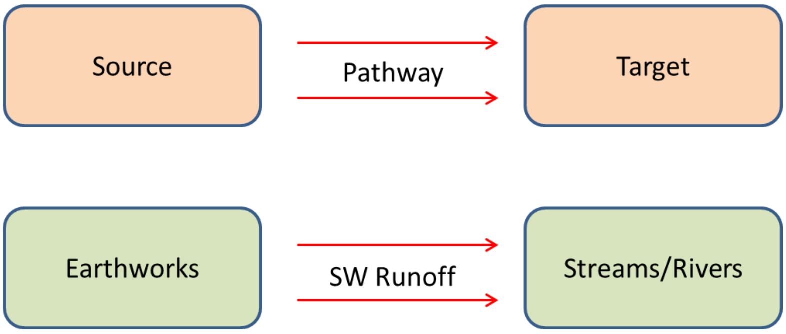
In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are used to assess the potential effect that the Proposed Project may have on them.

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 which are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability “Low” – “Medium” classification and “Poor” aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. Surface water quality classified by EPA as A2. Salmonid species may be present and may be locally important for fisheries. Abstractions for private water supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability “High” classification and “Locally” important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value i.e. NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability “Extreme” classification and “Regionally” important aquifer

9.2.4 Overview of Impact Assessment Process

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



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

- Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (2022).

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.5), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

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

Step 1	Identification and Description of Potential Impact Source: This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 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 1	Identification and Description of Potential Impact Source: This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to this type of development, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Hydrology and Hydrogeology Chapter of the EIAR. The site investigations and seasonal monitoring carried out were detailed and comprehensive.

9.3 Receiving Environment

9.3.1 Site Description and Topography

The Wind Farm site, which is 353ha in area, comprises areas of cutover bog, forestry, and agricultural grassland, and is located approximately 0.7km to the west of Clonberne Village, Co. Galway.

Approximately 46% of the Wind Farm site is agricultural land, 40% bog, and 14% coniferous forestry. The majority of the northern half of the Wind Farm site is grassland while the southern half is mainly bog. It's likely a large proportion of the agricultural land was also originally bog. The forestry areas occur as small, fragmented plantations across the Wind Farm site.

Peat cutting in the form of private turbary plots is widespread across the bog areas along with some peat harvesting of the bogs at the west and southeast of the Wind Farm site. There are also several separate farmsteads within the Wind Farm site.

The topography of the Wind Farm site is undulating with gentle to moderate slopes typical of a low-lying raised bog setting with local hills. The elevation of the Wind Farm site ranges from approximately 65mOD to 80mOD, with the overall slope to the west /southwest. The lower parts of the Wind Farm site are on the west and the southwest and this is also where most of the bog coverage is. The higher elevated part of the Wind farm site on the north /northeast is mainly undulating grassland.

The Wind Farm site is currently accessible via a network of local public roads, bog roads and farm tracks. The proposed entrance to the Wind Farm site is off the R328 which borders the Site to the north.

Approximately 1km of existing bog roads and farm tracks will be upgraded as part of the Proposed Project.

With regard to the main elements of the proposed Wind Farm site infrastructure, proposed turbine locations T6, T7, T10, and T11 are located on cutover bog, proposed turbine locations T1, T2, T4, T5 and T9 are located on grassland, while turbines T3 and T8 are in forestry (with underlying peat). The proposed 1 no. borrow pit is in an area of grassland on the far west of the Wind Farm site. The proposed temporary construction compounds (2 no.), located on the north and south of the Site are in grassland and on bog respectively. The proposed 4 no. peat repositories are located on cutover bog while the 1 no. spoil storage area is located on grassland.

The underground Grid Connection cabling route, which measures approximately 2.8km in length, will connect into the existing Cashla – Flagford 220kV overhead line at Laughil, located 1.7km to the southeast of the Wind Farm site. The proposed on-site 220kV substation is located near the edge of the bog on the far south of the Wind Farm site.

On leaving the proposed substation location, the cabling route crosses cutover bog for approximately 1.1km before exiting the Wind Farm site. The route then follows public roads for 1.4km before reaching the proposed 2 no. end mast locations within grassland areas at Laughil townland.

The proposed Peatland Enhancement area is a ~11.6ha portion of a raised bog on the south of the Wind Farm site that has been drained (high level drains) and cutaway along its western and northern edges. This area of drained bog is proposed for drain blocking and rewetting as part of the Proposed Project.

TDR road upgrade works are required at 3 no. locations that are situated approximately 4.5km to the northwest of the Wind Farm site. Junction works are required on the N83, the R328, and the L6466 local road junction.

9.3.2 Water Balance

Long term Average Annual Rainfall (AAR) and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (1980 - 2010) recorded at Dunmore G.S. rainfall station, located 5.5km northwest of the Site, are presented in Table 9-3. This is the most appropriate station to use with respect to distance (from the Wind Farm site) and elevation.

Met Éireann also provide a grid of average annual rainfall for the entire country for the period of 1991 to 2020. Based on this more site-specific modelled rainfall values, the average annual rainfall at the Proposed Project site ranges from 1,190 to 1,199mm/year. The average annual rainfall is 1,194mm/year (this is considered to be the most accurate estimate of average annual rainfall from the available sources).

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

Station		X-Coord		Y-Coord		Ht (MAOD)		Year Start		Year End		
Dunmore G.S.		151500		263500		61		1981		2010		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
123	91	100	71	73	76	73	97	90	123	117	123	1157

The closest synoptic[1] station where the average potential evapotranspiration (PE) is recorded is at Claremorris, approximately 25km northwest of the Site. The long-term average PE for this station is 408mm/year. This value is used as a best estimate of the Site PE. Actual Evaporation (AE) at the Site is estimated as 388mm/year (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 1,194 mm/year – 388mm/year

ER = 806mm/year

According to the GSI subsoil permeability mapping, the Site is mapped mainly as "*low permeability*" subsoils.

Based on recharge coefficient estimates from the GSI, an estimate of 4% recharge is assigned for a large proportion (43%) of the Site (mapped as "*low vulnerability - basin peat*"), while areas mapped as "*low vulnerability – low permeability subsoil"* (24% of site area) and "*moderate vulnerability – low permeability subsoil"* (30% of site area) are assigned a recharge coefficient of 7.5% and 15% respectively. Areas mapped as "*high" to "extreme"* only account for 3% of the Site.

The weighted average recharge coefficient for the Site is calculated to be 6%. The Site hydrology is therefore characterised by naturally high surface water runoff rates (94%) and very low groundwater recharge rates. The high drainage density across the Site, including in areas of grassland and forestry, is reflective of the low groundwater recharge rates.

Therefore, annual recharge and runoff rates for the Site are estimated to be 48mm/year and 758mm/year respectively.

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 Proposed Project site is -4% under the medium-low emission scenario and -2% under the high emissions scenario.

In addition to average rainfall data, extreme value rainfall depths are available from Met Éireann. Table 9-4 below presents return period rainfall depths for the area 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, 10-year, 30-year and 100-year). The 10-year rainfall depths are the basis of the Proposed Project drainage hydraulic design as described further below.

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

Table 9-4: Return Period Rainfall Depths (mm) for the Proposed Project site

Return Period (Years)				
Storm Duration	1	10	30	100
5 mins	3.6	7.6	10.6	14.9
15 mins	5.8	12.5	17.4	24.5
30 mins	7.6	15.9	21.8	30.3
1 hour	9.9	20.1	27.2	37.4
6 hours	19.7	37.2	48.7	64.7
12 hours	25.7	47.1	61	80
24 hours	33.5	59.7	76.4	98.9
2 days	42.2	70.6	88	110.8

9.3.3 Regional and Local Hydrology

The Site is located in the regional Lough Corrib (Corrib_030) surface water catchment within Hydrometric Area 30 of the Western River Basin District (WRBD). A regional hydrology map is shown as Figure 9-1.

On a more local scale the Site is located in the River Clare catchment wherein it exists within two surface water sub-catchments. The majority (80%) of the Wind Farm site which includes all 11 no. turbine locations, 1 no. temporary construction compound, borrow pit, peat repositories (4 no.) and spoil storage area (1 no.) are located in the Clare[Galway]_SC_040. The Wind Farm site drains to the River Clare, which is located approximately 23km downstream (southwest) of the Site, via the Grange River.

The northern portion of the Wind Farm site (20%) is located in the Sinking River sub-catchment (Sinking_SC_010). The Sinking River is located to the northwest and approximately 5.5km downstream of the Wind Farm site. Proposed infrastructure within the Sinking River sub-catchment is limited to the Wind Farm site entrance, ~1.6km of access road and 1 no. construction compound. The Sinking River drains into the River Clare approximately 22km downstream of the Site.

The downstream distance to Lough Corrib in the Clare[Galway]_SC_040 is approximately 50km while in the Sinking_SC_010 sub-catchment it is approximately 67km.

The portion of the Wind Farm site within the Clare[Galway]_SC_040 sub-catchment drains locally to the Levally Stream (Levally Stream_010 sub-basin) which has several tributaries that drain the Site (discussed in Section 9.3.4 below). The portion of the Wind Farm site within the Sinking River sub-catchment drains locally to a headwater stream of the Sinking River (Sinking_020).

The proposed Grid Connection (including the substation and 2 no. end masts) is located in the Clare[Galway]_SC_040 sub-catchment and is also drained locally by the Levally Stream.

With regard the TDR accommodation works areas, 2 no. of these areas are located in the Clare[Galway]_SC_030 and 1 no. accommodation area located in the Sinking_SC_010 sub-catchment.

A local hydrology map is shown as Figure 9-2.

9.3.4 Project Site Existing Drainage

9.3.4.1 Drainage Regime

The portion of the Wind Farm Site within the Clare[Galway]_SC_040 sub-catchment is drained by a network of 3 no. tributary streams (1st/2nd order) that merge together at the western boundary of the Wind Farm site to form the Levally Stream which then flows southerly along the south-western and southern Site boundary. Refer to Figure 9-3 below for a Site drainage map.

The larger of the 3 no. tributary streams (referred to as Stream A) draining the Wind Farm site rises to the northeast of the Site and flows in a south-westerly direction through the central area of the Site forming the main drainage artery of the Wind Farm site.

The majority of the proposed Wind Farm infrastructure (including turbine locations T1, T2, T3, T4, T5, T6, T8 and T11, southern construction compound along with 3 no. peat repositories) drain towards Stream A via various man-made bog drains and forestry and field drainage networks. There are 6 no. existing bridge/culvert crossings along Stream A as it flows through the Wind Farm site. This includes public road, bog road, and farm track crossings.

The second of the tributary streams (Stream B) emerges just outside the northwestern boundary of the Wind Farm site and then flows southerly along the western boundary of the Site before merging with Stream A at the existing road entrance to the bog immediately west of the Wind Farm site. The flow in Stream B largely comprises groundwater discharge from the Gurteen/Cloonmore Group Water Scheme (GWS) source spring which is discussed in detail in Section 9.3.15 below. Proposed turbine location T7 drains in a westerly direction towards Stream B.

A notable feature of both Stream A and Stream B is that the bed of the streams in the vicinity of the bogs comprises white shell marl. Shell marl is a pale brown-whitish coloured calcareous deposit formed in freshwater lakes and composed largely of uncemented mollusc shells and precipitated calcium carbonate and is commonly found below basin peat.

Shell marl, which has a low permeability, underlies the raised peat in this area with thicknesses of up to 1.3m having been recorded during site investigations. Shell marl underlies the peat at turbine locations T6, T7, T10, and T11 which are located on cutover bog (refer to Land, Soils and Geology Chapter 8).

The third stream, Stream C emerges at the location of Gortagarraun Turlough, which is situated 1.5km to the northwest and upstream of the Wind Farm site. Stream C flows in a south-easterly direction prior to merging with the Levally Stream immediately downstream of the Stream A/Stream B confluence on the west of the Wind Farm site. The proposed borrow pit area, which is located on the west of the Wind Farm site, drains to Stream C via a field drain that starts close to the eastern boundary of the proposed borrow pit location. Gortagarraun Turlough is only typically present over the winter period when groundwater levels are highest.

The proposed Grid Connection (including the substation) drains directly to the Levally Stream as it flows nearby along the southern boundary of the Site. There are several bog drains that run in a southerly direction, which intercepts the proposed substation area and cable route, before flowing into the Levally Stream. There is 1 no. existing bridge crossing on a tributary of the Levally Stream (Stream E) where the Grid Connection cable route follows the public road.

The portion of the Wind Farm site within the Sinking River sub-catchment is drained by a headwater stream (Stream D) of the Sinking River main channel which flows 3.1km to the north of the Site. Stream D emerges from an area of cutaway bog located on the northwest of the Wind Farm site. There is 1 no. proposed watercourse crossing on Stream D where the proposed site entrance access road crosses a section of cutover bog on the north of the Site.

Aside from main streams draining the Wind Farm site as described above, there is also a high density of man-made drains located within the cutover bog, grassland, and forestry areas. The grassland and forestry areas typically comprise peaty or poorly draining soil (underlain by deep SILT and CLAY-dominated/low permeability glacial tills). Refer to Land, Soils and Geology Chapter 8 and summarised in Section 9.3.9.2 further below also.

The grassland area on the northeast of the Wind Farm site (i.e. in the area of proposed turbines T1, T2, T3, T4, and T5) has extensive land drainage that drains towards Stream A. The forestry areas, which area also heavily drained, have at least 0.5m of peat overlying the mineral subsoils.

The cutaway bogs are also extensively drained, with parallel running drains on the high bog along with regular bog outfall channels along the cutaway fringes and turbary plots that drain into the local streams. The proposed Peatland Enhancement area is heavily drained by a systematic, parallel running, man-made drainage network.

According to the GSI source protection report[2] for Gurteen/Cloonmore GWS spring, Stream A is reported to have a losing reach ("losing Stream") upstream of the Wind Farm site. A losing Stream is when surface water flow is lost/drains down into the underlying aquifer through the bed of the stream/river. Losing Streams normally only occur in areas of karst bedrock geology and act as point groundwater recharge zones.

The location of the losing reach (as identified in Figure 2 of the GSI report) is located approximately 500m to the northeast and upstream of the Wind Farm site boundary. The losing reach is mapped as a "*swallow hole*" in the GSI karst database (www.gsi.ie). The losing reach/swallow hole is also shown on the GSI database as well as indicated on the site drainage map below (Figure 9-3).

Surface water lost along the section of the losing Stream is reported by the GSI (2015) to contribute flow to the overall Gurteen/Cloonmore GWS spring discharge. The linkage was reported to be accidentally discovered when the spreading of slurry on lands around the losing stream contaminated the spring source. No standard dye tracing test was subsequently undertaken to confirm this potential linkage. The losing stream is located on private lands and therefore has not been visited by HES as part of this hydrological assessment.

9.3.4.2 Surface Water Flow Measurements

To investigate the possibility of additional losing reaches along Stream A further downstream within the Site, surface water flows measurements were taken in Stream A upstream (@FML_2) and downstream (@FML_1) of the proposed Site development areas. Losing streams within the Site is an important potential pathway to investigate with regard flow contribution to the overall Gurteen/Cloonmore GWS spring discharge.

Flow Monitoring Location (FML) details and flow measurements for Streams A, B, C and D are shown in Table 9-5 below. The FML locations are shown in Figure 9-4.

Flows were measured on 3 no. occasions (dates and flows shown in Table 9-5 below) and all measurements for Stream A show an increase in flow at the downstream location (@FML_1) which suggests there are no detectable losing reaches along Stream A within the Wind Farm site.

Also, mentioned above, Stream A is underlain by shell marl where it flows adjacent to the raised bog within the Wind Farm site. Shell marl has very low permeability and this natural barrier would prevent any surface water leakage from the stream into the underlying glacial deposits/bedrock aquifer.

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[2] *Geological Survey of Ireland (2015) Establishment of Groundwater Zones of Contribution - Gurteen/Cloonmore Group Water Scheme.*

In addition to the shell marl, the investigation drilling carried out at the Wind Farm site (refer to Chapter 8 Land, Soils and Geology and also Section 9.3.9 below) show that Stream A is also underlain by several metres of low permeability CLAY and SILT dominated glacial tills (refer to Section 9.3.9.2 below for summary logs for BH1, BH2 and BH5 which are the closest boreholes to Stream A).

At Stream B, the flow is predominately groundwater discharge from Gurteen/Cloonmore GWS spring, located at the stream headwater. Stream B is also underlain by shell marl and deep glacial deposits. Nevertheless, losing reaches along Stream B would not pose a potential pathway to the spring, as the stream is down-gradient of the spring (i.e. the stream is located outside the groundwater zone of contribution).

The hydrogeology in the area of the Wind Farm site and Gurteen/Cloonmore GWS spring are discussed in Section 9.3.9 below along with groundwater contribution areas to the spring.

Table 9-5 Surface Water Flow Monitoring Data

Location	Watercourse	22/06/2021	19/01/2022	06/04/2022
		Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)
FML_1	Stream A	0.024	0.057	0.043
FML_2	Stream A	0.015	0.042	0.030
FML_3	Stream B*	0.028	0.052	0.030
FML_4	Stream C	0.022	0.036	0.032
FML_5	Stream D	0.053	0.085	0.066

* Gurteen/Cloonmore GWS Spring Discharge

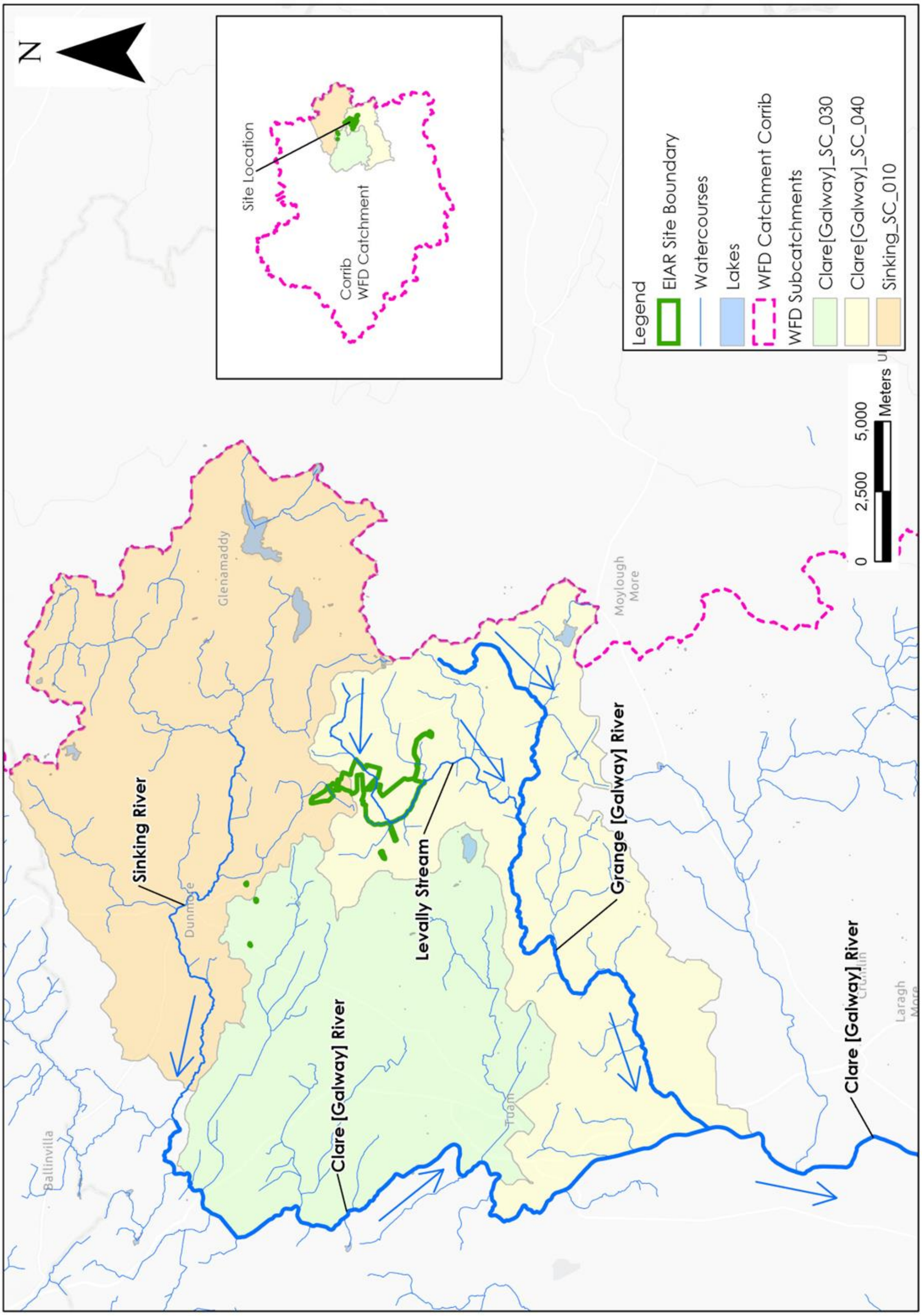

Figure 9-1 Regional Hydrology Map

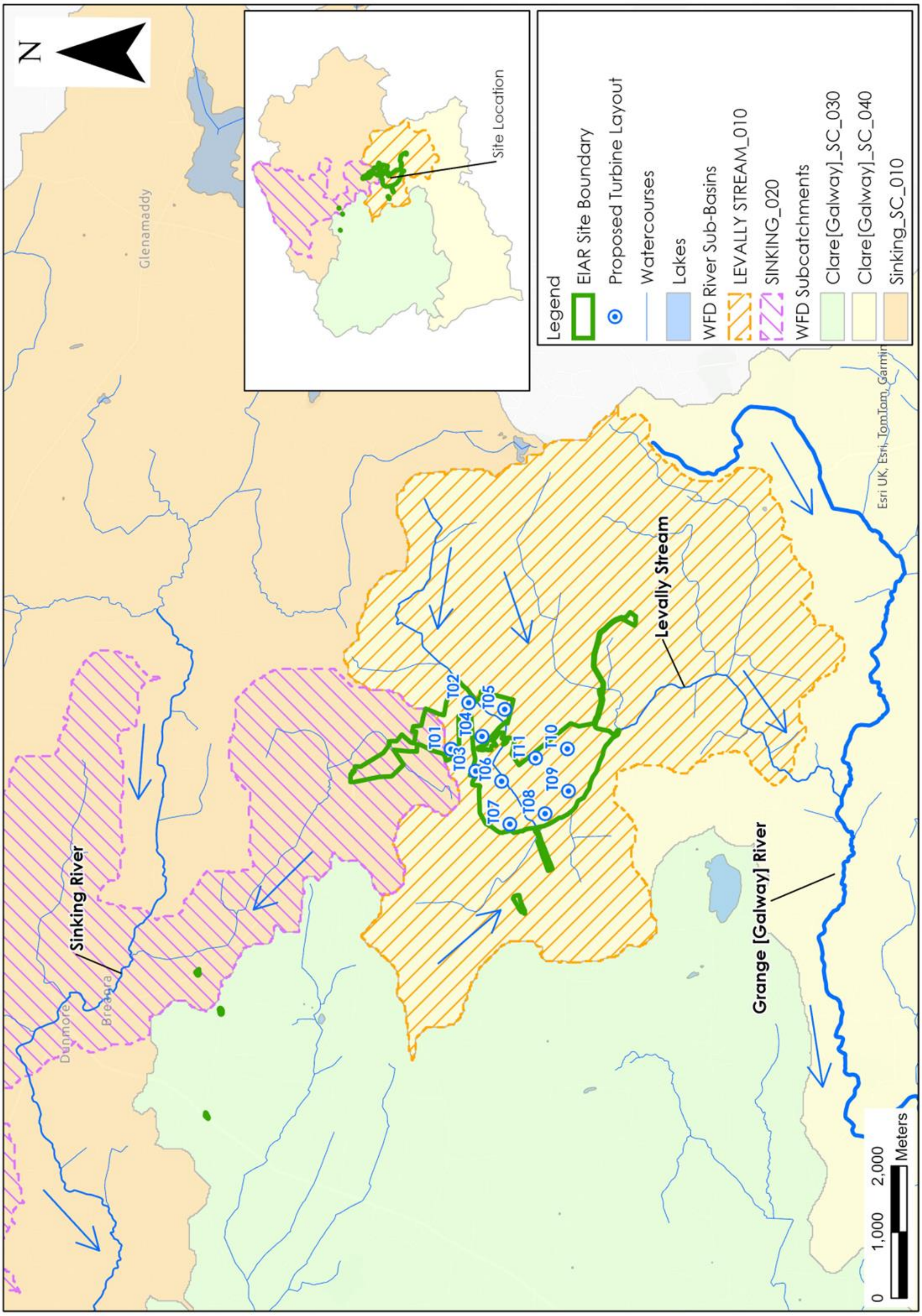

Figure 9-2 Local Hydrology Map

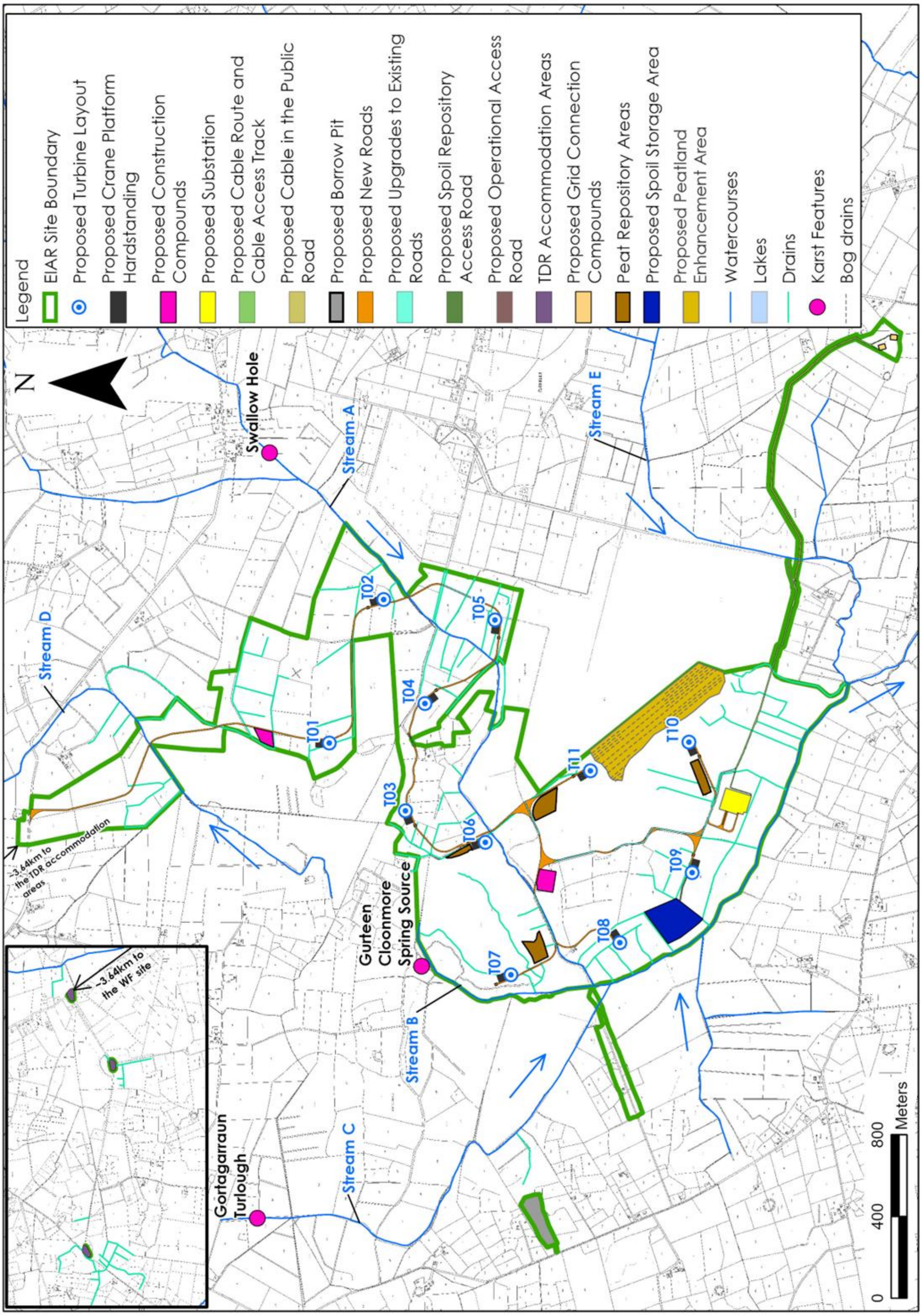

Figure 9-3 Site Drainage Map

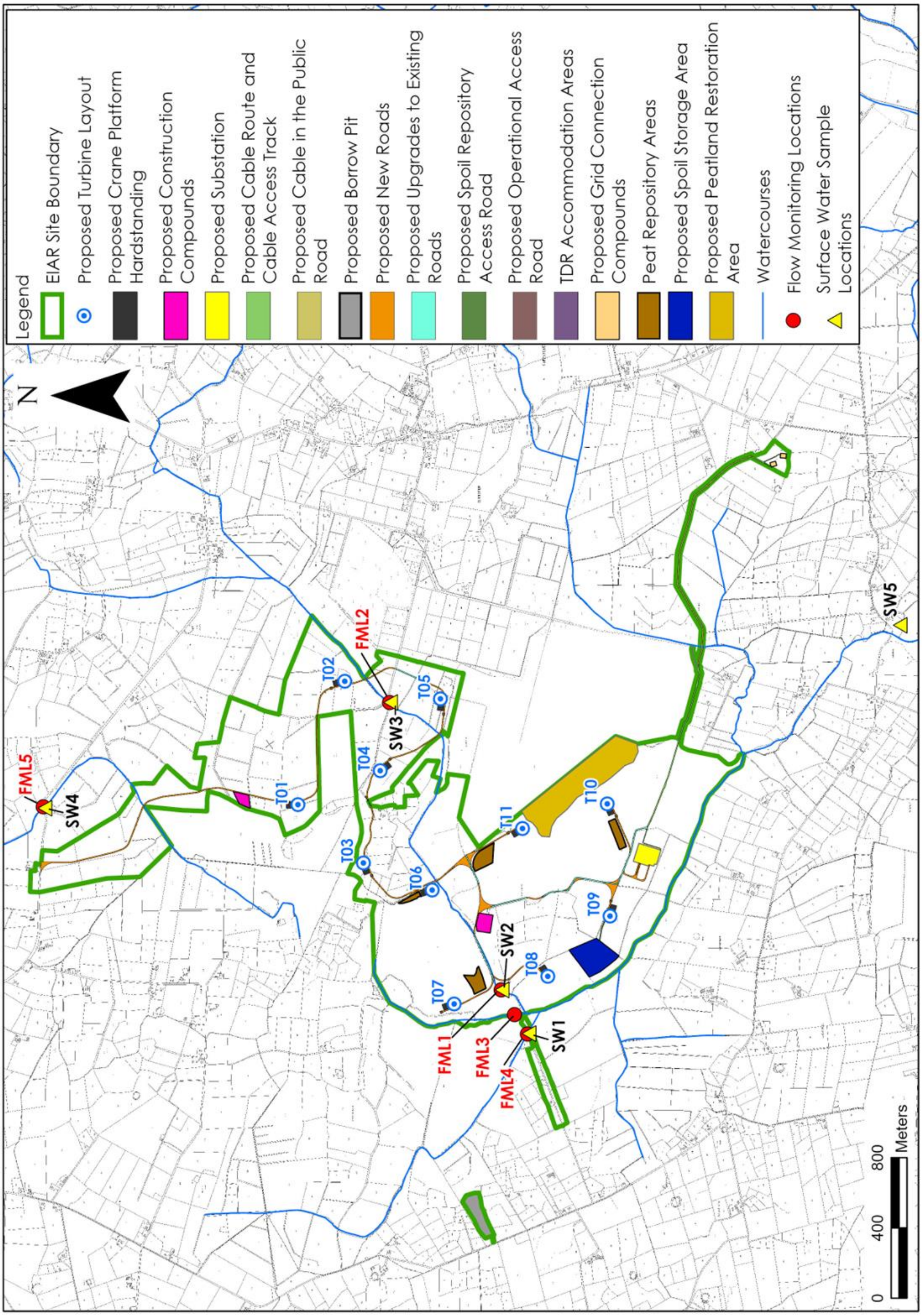

Figure 9-4 Surface Water Monitoring Map

9.3.5 Baseline Assessment of Development Site Runoff

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

The rainfall depths used in this water balance, which are long term averages, are not used in the design of the sustainable drainage system for the Proposed Project. The Site drainage design is based on the 10-year return period rainfall event as described further in Sections 9.4.1 and 9.5.2.3 below.

The water balance calculations are carried out for the month (December) with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-6).

The water balance represents the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the Site pre-development. The surface water runoff co-efficient for the Site is estimated to be 94% based on the predominant peat coverage, poorly draining mineral soils and thick, low permeability glacial deposits (refer to Section 9.3.2 above).

The highest long-term average monthly rainfall recorded at Dunmore over 30 years occurred was 123mm over December. The average monthly evapotranspiration for the synoptic station at Claremorris over the same period in December was 3.1mm. The water balance presented in Table 9-7 indicates that a conservative estimate of surface water runoff for the Site during the highest rainfall month is 398,516m^3/month or 12,855m^3/day for the Site.

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

Water Balance Component	Depth (m)
Average Highest Monthly Rainfall (R)	0.123
Average Potential Evapotranspiration (PE)	0.0031
Average Actual Evapotranspiration (AE = PE x 0.95)	0.0029
Effective Rainfall (ER = R - AE)	0.1201
Recharge (6% of ER)	0.0072
Runoff (94% of ER)	0.1128

Table 9-7: Baseline Runoff for the Proposed Project Site

Wate Balance Area	Approx. Area (ha)	Baseline Runoff per Wettest month (m^3)	Baseline Runoff per day (m^3) in wettest month
Proposed Project Site	353	398,516	12,855

9.3.6 Flood Risk Assessment

This section is a summary of a site-specific flood risk assessment (FRA) undertaken for the Site. The full FRA report is attached Appendix 9-1.

The FRA was carried out at the early design stage of the Proposed Project in order to ensure as much of the proposed infrastructure was placed outside of mapped flood zones.

OPW's River Flood Extents Mapping, National Indicative Fluvial Mapping, Past Flood Event mapping (https://www.floodinfo.ie/map/floodmaps/), historical mapping (i.e. 6" & 25" base maps) and GSI Groundwater/Surface Water Flood Maps were consulted to identify those areas of the Site as being potentially at risk of fluvial, pluvial and surface water flooding. Several walkover surveys were also conducted as part of the site-specific FRA.

No recurring flood incidents within the Site boundary were identified from OPW's Past Flood Event Mapping (Refer to Figure 9-5).

One of the closest mapped recurring flood events is at the location of Gortagarraun Turlough, 1.5km to the northwest of the Wind Farm site where "*low lying land floods after heavy rain every year*". The flooding is caused by rising groundwater levels over the winter period.

There are no mapped recurring fluvial flood events downstream of the Proposed Project along the Levally Stream or the tributary of the Sinking River within 10km of the Site.

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

There is no OPW River Flood Extents Mapping available for the area of the Site and therefore the National Indicative Fluvial Mapping (NIFM) was consulted which has estimated current and future scenario 100-year and 1000-year fluvial flood zones for the Levally Stream at the location of the Site.

Based on the National Indicative Fluvial Mapping (NIFM) as shown in Figure 9-6 below, the 100-year and 1000-year flood zones of Stream A (tributary of Levally Stream) extends into localised low-lying cutaway bog areas mainly in the central area of the Wind Farm site. The most extensive mapped fluvial flooding occurs along Stream A between proposed turbine locations T6 and T7 within the bog. The flooding on the grasslands on the north of the Wind Farm just affects localised areas close to the watercourse channel.

These flood zone constraints were considered during the early stages of the Wind Farm site layout design and therefore no turbines or associated hardstand areas are located inside an NIFM flood zones.

However, watercourse crossings were unavoidable and along this stretch of Stream A there is 1 no. existing bridge associated with bog roads that will be utilised by the Proposed Project. Approximately 0.26km of existing bog roads (proposed for upgrade as part of the Proposed Project) are also located within the mapped 1000-year fluvial flood zone.

Also located within 1000-year mapped fluvial flood zone in this same general area is approximately 100m of proposed access road and 1 no. proposed watercourse on Stream A that will allow access to proposed turbine location T6, located north of Stream A.

Further upstream there is 1 no. proposed watercourse crossing near proposed turbine T2 and 1 no. near T5 where the proposed access roads will encroach on mapped fluvial flood zones. The proposed total length of these new access roads only amounts to ~110m.

The GSI Groundwater Flood Maps and Winter 2015/2016 Surface Water Flooding Maps have no groundwater flood zones mapped within the Site.

All potential vulnerable Wind Farm and Grid Connection infrastructure, including all 11 no. turbines, the substation, end masts, construction compounds, peat repositories, spoil storage area, and borrow pit are located above the mapped 1000-year flood level and therefore all this infrastructure is located in Flood Zone C (Low Risk).

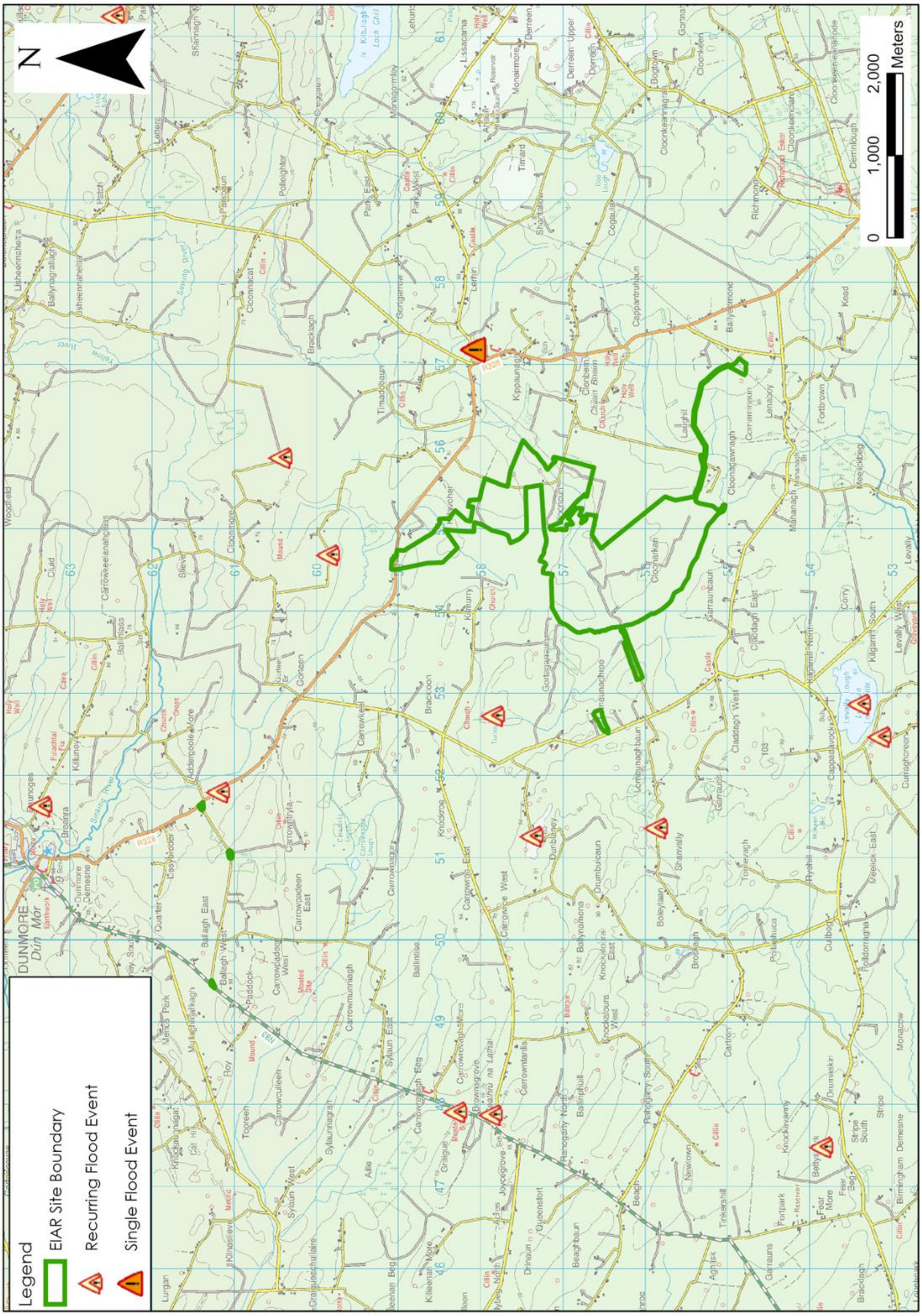

Figure 9-5 OPW Past Flood Event Mapping

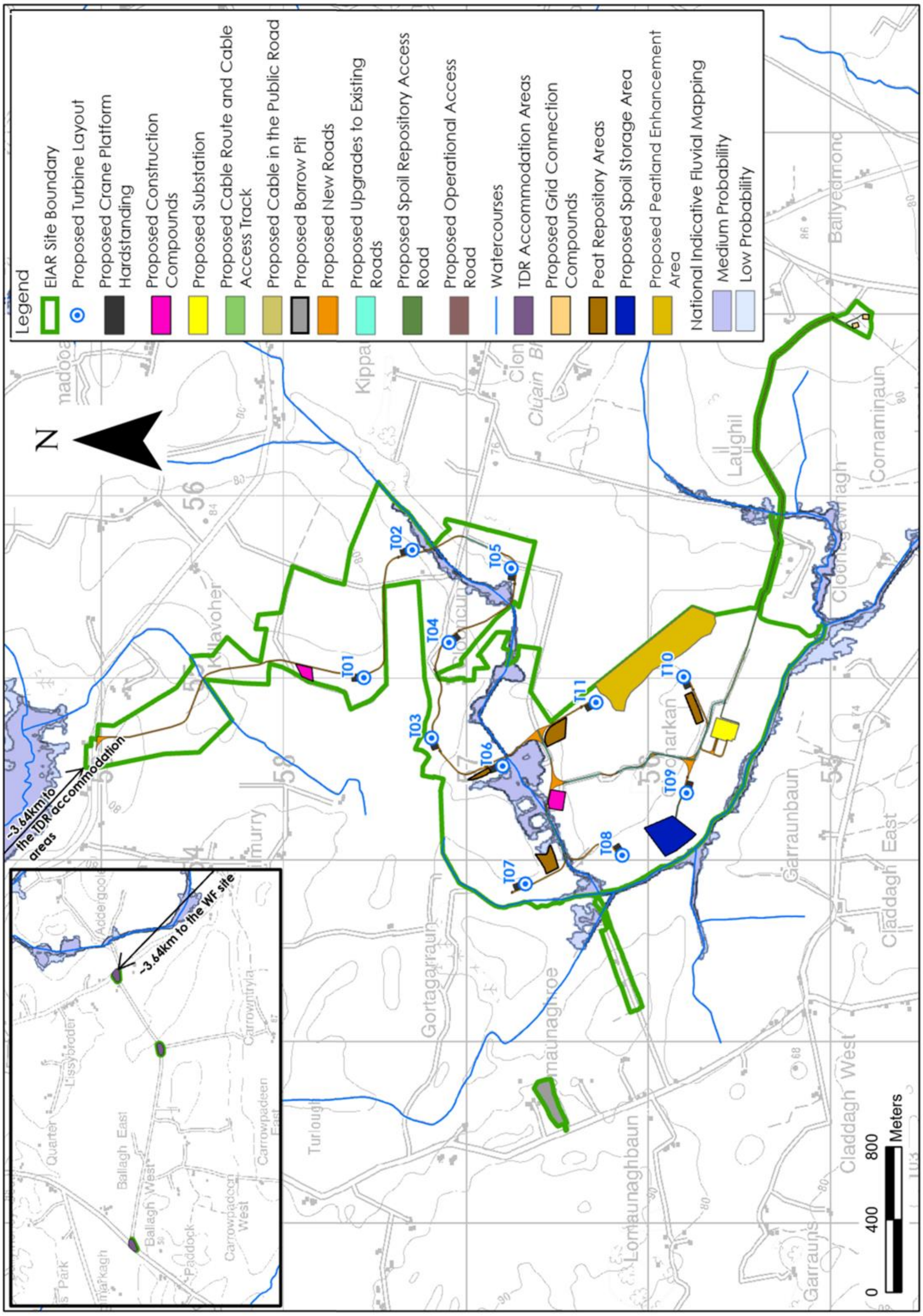

Figure 9-6 OPW NIFM Mapping

9.3.7 Surface Water Quality

EPA Q-rating data[3] (https://www.catchments.ie/data) is available for the Levally Stream, the Grange River, and the Sinking River. Most recent data (from 2018) shows that the downstream EPA monitoring point on the Levally Stream has a Q3 rating (Poor Status) while further downstream the Grange River has a Q4 rating (Good Status). Monitoring points on the Sinking River immediately upstream of the Site have a 3-4 rating (Moderate Status) and then the rating improves to Q4 downstream of the Site.

Surface water sampling, flow monitoring and field hydrochemistry (measurements of electrical conductivity (µS/cm), pH (pH units), and dissolved oxygen (%)) were taken at 5 no. locations (SW1 – SW5) within surface watercourses downstream of the Proposed Project site on 22nd June 2021, 7th April 2022, and 9th June 2023 (refer to Figure 9-4 for locations). Field hydrochemistry results are presented in Table 9-8 below.

Electrical conductivity values for the local streams ranged between 580µS/cm and 650µS/cm which would be typical of streams in a catchment underlain pure bedded limestones. pH values which were all slightly basic ranged from 7.3 to 7.7 which is also typical for this setting.

Dissolved oxygen saturation ranged between 82 and 105%. The dissolved oxygen levels would be normal for a Good to High Status and exceed the required dissolved lower limit of 80% (Surface Water Regulations S.I. No. 77/2019).

Table 9-8:Field Hydrochemistry Data

Location	EC (µS/cm)			pH [H^+]			Dissolved Oxygen %		
	22/06/2021	07/04/2022	09/06/2023	22/06/2021	07/04/2022	09/06/2023	22/06/2021	07/04/2022	09/06/2023
SW1	650	627	620	7.5	7.5	7.3	98	102	103
SW2	663	584	583	7.7	7.6	7.5	104	98	100
SW3*	620	580	610	7.6	7.4	7.4	82	85	83
SW4	650	610	608	7.3	7.5	7.4	101	99	103
SW5	630	600	590	7.3	7.5	7.3	102	105	97

* Gurteen/Cloonmore GWS Spring Discharge Watercourse

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

Surface water grab sampling was also conducted at monitoring locations SW1 – SW5 on the dates referred to above.

Results of analysis are show in Table 9-9, Table 9-10 and Table 9-11 below alongside relevant Environmental Quality Standards (EQS) values for surface water. Laboratory reports are presented in Appendix 9-2.

Table 9-9: Analytical Results of HES Surface Water Samples (22/06/2021)

Parameter	EQS	Sample ID				
		SW1	SW2	SW3	SW4	SW5
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5	<5
Ammonia (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	0.03	0.04	0.02	<0.02	0.05
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	0.03	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	6	<5	<5	<5	<5
Phosphorus (mg/L)	-	<0.1	<0.1	<0.1	0.46	<0.1
Chloride (mg/L)	-	15.9	15.6	16.2	15.3	14.8
BOD	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	<1	1	1	<1	1

(+) S.I. No. 293 of 1988: Quality of Salmon Water Regulations.
(*) S.I. No. 77/2019: European Communities Environmental Objectives (Surface Waters) Regulations 2019.

Table 9-10: Analytical Results of HES Surface Water Samples (07/04/2022)

Parameter	EQS	Sample ID				
		SW1	SW2	SW3	SW4	SW5
Total Suspended Solids (mg/L)	25(+)	<5	<5	<5	<5	<5
Ammonia (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	0.03	0.07	0.02	0.02	0.04
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	10	5.9	6.9	7.3	<5.0
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride (mg/L)	-	18.2	18.4	19.2	18.1	19.2
BOD	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	<5	2	1	<2	<2

(+) S.I. No. 293/1988: Quality of Salmon Water Regulations.
(*) S.I. No. 77/2019: European Communities Environmental Objectives (Surface Waters) Regulations 2019.

Table 9-11: Analytical Results of HES Surface Water Samples (09/06/2023)

Parameter	EQS	Sample ID				
		SW1	SW2	SW3	SW4	SW5
Total Suspended Solids (mg/L)	25(+)	6	3	<5	<5	9
Ammonia (mg/L)	Good Status: ≤0.065 High Status ≤ 0.04(*)	0.06	0.06	0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)	-	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	Good Status ≤ 0.035 to High Status: ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5	<5	<5	<5	<5
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride (mg/L)	-	15	19.6	18.3	13.8	13.3
BOD	Good Status: ≤ 1.5 High Status: ≤ 1.3(*)	3	3	2	2	2

(+) S.I. No. 293/1988: Quality of Salmon Water Regulations.
(*) S.I. No. 77/2019: European Communities Environmental Objectives (Surface Waters) Regulations 2019.

Total suspended solids ranged between 3mg/L and 9mg/L for the three sampling rounds which is below the 25mg/l standard set out in S.I. 293/1988.

Levels of nitrate, nitrite and phosphorus were low with all the results for nitrite and phosphorus below the laboratory detection limit. Most results for nitrate were also below the laboratory detection limit apart for the second round of sampling (07/04/2022) where reported levels ranged between <5 – 10mg/L.

For ammonia, 11 no. of the 15 no. samples were below "High Status", 3 no. were below "Good Status", while 1 no. sample exceeded the "Good Status" threshold value with respect of the Surface Water Regulations (S.I. 77/2019).

With the exception of SW1 in the first round of sampling (22/06/2021), Orthophosphate was reported as <0.02mg/L in all other samples which is below the "High Status" threshold. SW1 in the first round of sampling was below the "Good Status" threshold.

Biological Oxygen Demand (BOD) was reported as between <1 and <5mg/L over the three sampling rounds. All results in the first round of sampling (22/06/2021) were below the "High Status" threshold, while in round 2 (07/04/2022) all samples except 1 no. exceeded the "Good Status" threshold value. All results in the third round of sampling exceeded the "Good Status" threshold value.

9.3.8 Regional & Local Hydrogeology

The Proposed Project site is located in the Clare-Corrib Groundwater Body (IE_WE_G_0020) which has a mapped surface area of 1,344km^2.

The bedrock type of the Clare-Corrib GWB is predominantly Dinantian Pure Bedded Limestone (Burren Formation) which also underlies the Site. The Burren Formation is classified by the GSI as a Regionally Important Karstified Aquifer which is dominated by conduit flow (Rkc).

These pure limestone rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are sometimes enlarged by karstification, which significantly enhances the permeability of the rock.

Karstification can be accentuated along structural features such as fold axes and faults. Groundwater flow directions through karst areas can be very variable due to the heterogenous nature of karstification/weathering within a rock that is otherwise devoid of groundwater. Groundwater flows through a network of solutional enlarged bedding planes, fissures and conduits. Overall, groundwater flow directions within the GWB are reported to be to the southwest, with all groundwater flowing towards and discharging to Lough Corrib (GSI, 2004).

Both point recharge and diffuse recharge occur in this GWB. Diffuse recharge occurs over the GWB via rainfall percolating through the permeable subsoil. In areas of peat and low permeability till [such as the Proposed Project site], recharge to the underlying aquifer is limited to point recharge such as swallow holes, collapse features/dolines, and losing streams (GSI, 2004).

There are 3 no. GSI mapped groundwater Source Protection Areas (SPAs) within ~5km of the Site relating to Group Water Scheme (GWS) and Public Water Supply (PWS) sources. Refer to Figure 9-7 below.

These schemes are Gurteen/Cloonmore GWS, Gallagh GWS, and Dunmore/Glenamaddy PWS and all these supplies have karst spring sources. The mapped SPAs are based on estimated groundwater Zones of Contributions (ZoCs) for each source and the alignment of the individual SPAs suggests some variability in groundwater flow directions in the region of the Site.

The closest SPA to the Site is the Gurteen/Cloonmore GWS which has a karst spring source. As stated above, the spring is located at Gortagarraun townland and is situated just outside the western boundary of the Site. The northern and central portions of the Wind Farm site are mapped inside this SPA (Source Protection Area). The orientation of the SPA suggests a general westerly groundwater flow direction in the area of the Site.

The Gallagh GWS SPA (karst spring source situated 4km to the southwest of the Site), which is located immediately west/southwest of the Wind Farm site, suggests a south-westerly groundwater flow direction. The proposed Wind Farm borrow pit is mapped to be located just inside the northeastern edge of the Gallagh GWS SPA.

The Dunmore/Glenamaddy PWS SPA (karst spring/groundwater source located 1.5km to the east/northeast of the Site) suggests a north-westerly groundwater flow direction. The Dunmore/Glenamaddy PWS SPA was mapped using dye tracing which is a reliable method for determining groundwater flow direction and Zone of Contribution (ZoC) to a source. The tracer lines all suggest north-westerly flow directions. The Proposed Project site is not located inside the Dunmore/Glenamaddy PWS SPA.

The Gallagh GWS and Gurteen/Cloonmore GWS SPAs, which overlap the Site, are delineated based on a conceptual understanding of groundwater flow and recharge patterns and therefore there is a larger element of unknown with regard the ZoC and SPA to these two sources. The SPAs are mapped as "Preliminary" according to the GSI online datasets.

As mentioned in Section 9.3.4 above, Stream A is reported by the GSI source report to have a losing reach ("losing Stream") to the northeast and upstream of the Site which is reportedly linked to the Gurteen/Cloonmore GWS spring. The linkage was accidentally discovered when the spreading of slurry on lands around the losing stream reportedly contaminated the spring at Gortagarraun. The evidence is anecdotal (and not scientifically proven), but this at least suggests a westerly/south-westerly groundwater flowpath direction between the losing stream and spring across the northern portion of the Wind Farm site.

The Gallagh GWS and Gurteen/Cloonmore GWS are discussed further in Section 9.3.15 below.

It is also worth noting that the overall surface water drainage pattern of the Levally Stream and its tributaries in the area of the Site is in a southerly direction. Also, the hydrochemistry of the surface water (high relatively electrical conductivity) suggests that there is a significant groundwater component to the flow in the tributaries of the Levally Stream sub-basin in which the Site is located.

This suggests there is groundwater discharge (baseflow) from the underlying bedrock aquifer/mineral subsoils to the Levally Stream and therefore surface water flow patterns (i.e. surface water catchments) are likely to influence groundwater flow directions to some extent.

However, the surface water/bedrock aquifer hydraulic connection within the Wind Farm itself is very limited due to underlying deposits of clays/marls and thick glacial deposits. This is discussed further in Section 9.3.9 below.

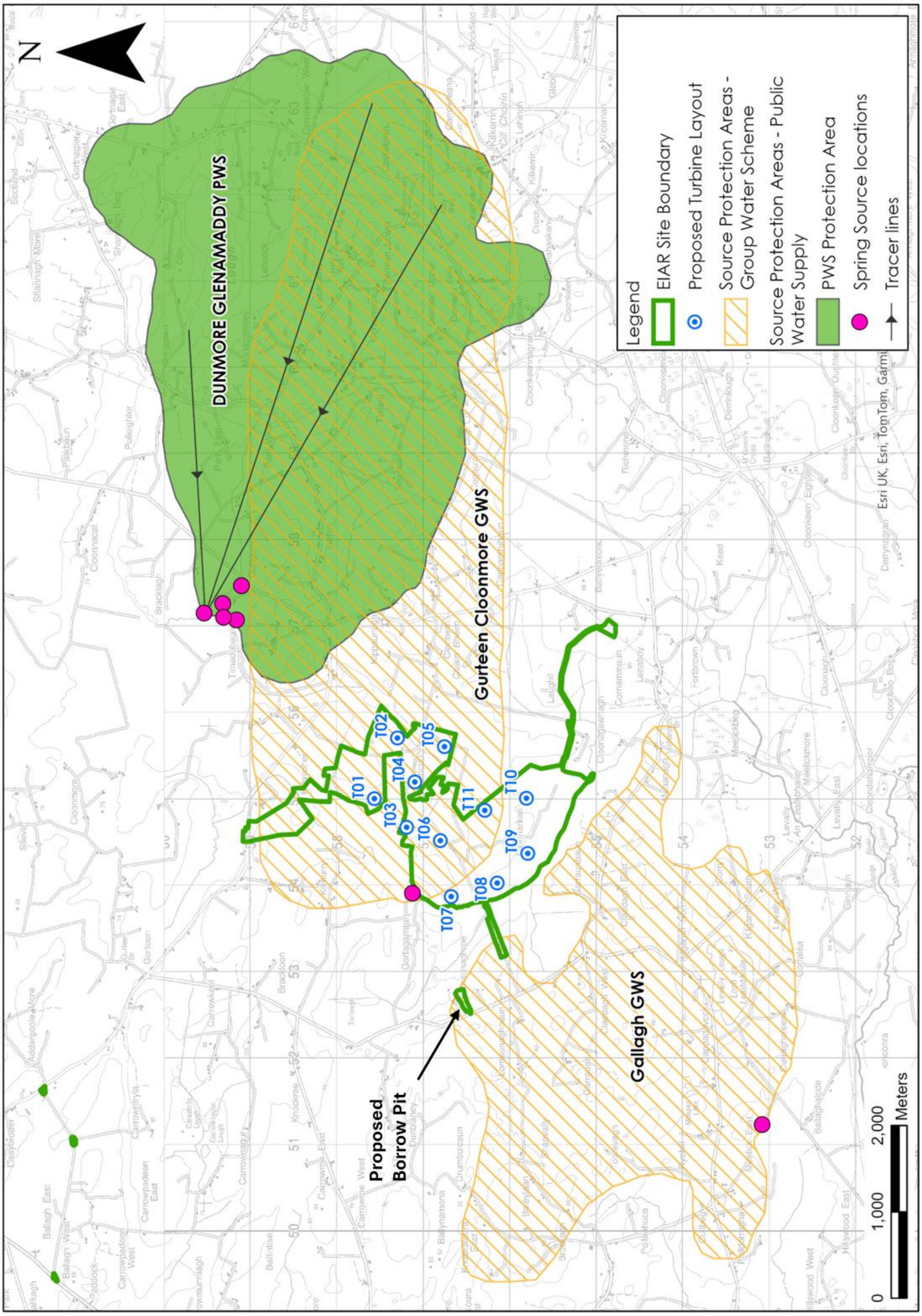

Figure 9-7 GSI Source Protection Mapping

9.3.9 Site Hydrogeology

9.3.9.1 Introduction

Extensive ground investigations were carried out in 2021 and 2022 to determine the geological and hydrogeological setting of the Wind Farm site. The investigations and seasonal monitoring carried out were detailed and comprehensive.

The drilling investigations were targeted around the area where the Gurteen/Cloonmore GWS SPA/ZoC overlaps with the Wind Farm Site.

In order to determine the full geological profile (soil/peat, subsoil, and bedrock) below the Site, particularly around the area of the mapped SPA, peat probing, 10 no. gouge cores, 15 no. trial pits, and 5 no. bedrock boreholes (BHs) were carried out at the Site. The boreholes were finished as monitoring wells to allow seasonal water level monitoring to be completed.

Following the drilling investigations, groundwater levels were continuously monitored between June 2021 and March 2023 by in-situ data loggers (pressure transducers) installed in the 5 no. boreholes, and in 1 no. farm well. Groundwater levels were also regularly measured at 2 no. existing investigation boreholes located near the proposed borrow pit location (EH1 & EH3).

Refer to Figure 9-8 below for the borehole and groundwater level monitoring locations. Refer to Figure 9-9 below for the groundwater level monitoring plots (hydrographs).

A data logger was also placed in the Gurteen/Cloonmore spring source sump for a shorter period after consultation with Gurteen/Cloonmore GWS management for permission to carry out this monitoring.

Also, when flooded above ground level, spot water levels were also surveyed in Gortagarraun Turlough located 1.5km to the northwest of the Wind Farm site.

The 5 no. BHs were strategically located topographically at upslope, downslope and across slope locations to the Gurteen/Cloonmore GWS spring, while also being positioned as close as possible to proposed turbine locations that are located close to or inside the GSI mapped SPA for the Gurteen/Cloonmore GWS source. For example:

- BH1 – 530m downslope of spring / 120m to the southwest of proposed turbine T7;
- BH2 – 690m downslope of spring / 130m to the southwest proposed turbine T6;
- BH3 – 1km downslope of spring /on local topographic divide on south of the Wind farm site;
- BH4 – 570m across slope to spring / 200m to the west of proposed turbine T3; and,
- BH5 – 1.7km upslope of spring / At the location of proposed turbine T2 foundation.

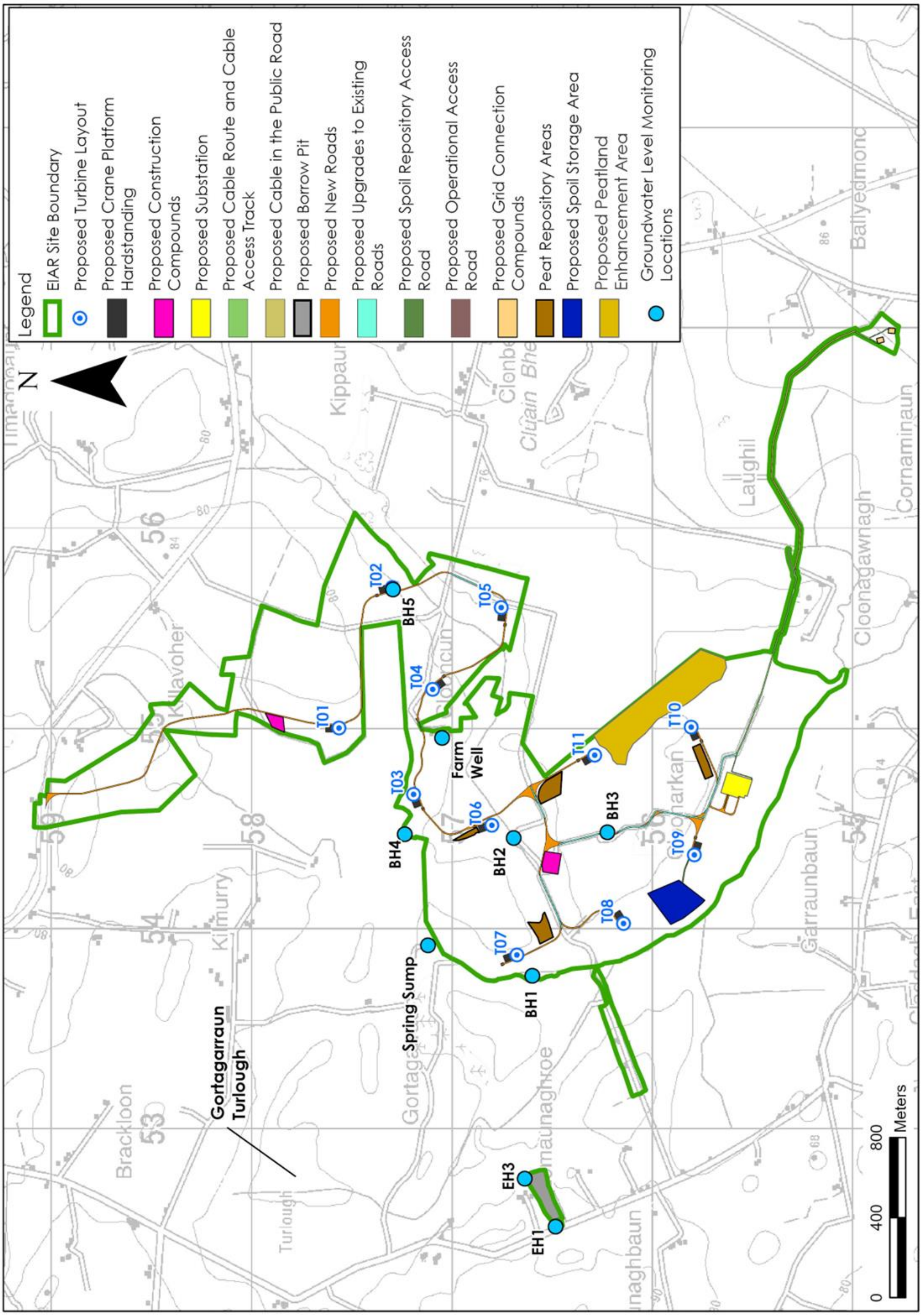

Figure 9-8 Groundwater Level Monitoring Locations

9.3.9.2 Site Investigation Summary

Refer to the Land, Soils, and Geology (Chapter 8) for more comprehensive information relating to the intrusive site investigations conducted at the Site.

For background information, the Site has a large coverage of cutaway/cutover peat which is both underlain and surrounded predominately by deep glacial (limestone) tills.

Geomorphologically, the peat at the Site is mainly raised bog, also known as basin peat. The underlying bedrock at the Wind Farm Site is mapped by the GSI as the Burren Formation which is a pure bedded limestone (karstified limestone). Peat depths in cutover areas were typically less than 2m, but also exceeded 6m in areas of intact peat.

In the peatland/bog areas of the Site, the peat was found to be directly underlain by up to 1.3m of shell marl which in turn is underlain by deep glacial deposits as summarised in Table 9-12 below.

Outside of the peat bog areas limestone glacial till deposits are dominant over the rest of the Site (i.e. grassland/forestry areas) which comprises mainly stiff sandy gravelly CLAYS/SILTS with some isolated SAND and GRAVEL layers.

One of the most notable findings of the intrusive investigations is the large depths of overburden/glacial tills present at the Wind Farm site. This is consistent with the GSI groundwater vulnerability rating of the Wind Farm site which is mainly Low followed by Moderate at the proposed infrastructure locations. A summary of the Wind Farm investigation drilling is shown in Table 9-12 below.

The significant depth of overburden present at the Wind Farm site is important from a groundwater recharge and groundwater vulnerability perspective and these are discussed further in Section 9.3.10 and Section 9.3.15 below.

Table 9-12: Summary BH Drilling Data for Wind Farm site

Location	Ground Level (m OD)	Depth to Bedrock (m)	Peat Thickness & Marl (m)	Glacial Till Thickness (m)	Glacial Till Description
BH1	66.425	13.2	3.5	9.7	Silty CLAY
BH2	66.298	15.3	3.2	12.1	Silty sandy CLAY
BH3	74.551	16.5	1	15.5	Gravelly SILT/CLAY
BH4	74.558	14.6	0	13.8	S&G, SILT & CLAY
BH5	70.540	6.0	0	5.7	SAND & CLAY

Investigation drilling in the area of the cutover bog encountered between 9.7m (BH1) and 15.5m (BH3) of mainly CLAYs and SILTs (glacial till deposits) below the peat and shell marl layers.

The confirmed depth of glacial till in the grassland areas on the north of the Wind Farm site is between 5.7m (BH5) and 13.8m (BH4).

BH3 is the most southerly positioned borehole and as stated above 15.5m of glacial deposits were encountered at that location. BH3 is located on the edge of the bog where there is a transition into grassland.

Bedrock was not confirmed in any of the 15 no. trial pits carried out at the Wind Farm site (excavation depths of trial pits were up to 3.5mbgl – metres below ground level).

The drilling shows the limestone bedrock below the glacial tills varies from strong competent limestone to very weathered limestone, with some clay infilled fractures. Bedrock heterogeneity is a typical feature of karstified limestone, however, a pattern in bedrock quality did emerge from the 5 no. drilling locations.

The bedrock at the boreholes carried out in the bog areas (BH1, BH2, and BH3) was notably more weathered and karstified than the boreholes carried out in grassland areas (i.e. BH4 and BH5). Large water strikes were also encountered in the bedrock below the bog, while in BH4 no groundwater strikes were recorded, and in BH5 water strikes were very minor as the bedrock was noted to be very competent. The northern portion of the Site, which is more elevated than the southern portion appears to be underlain by very competent limestone (unweathered) based on the completed drilling investigations.

There are drilling logs available for 2 no. existing investigation holes located in the area of the proposed borrow pit (EH1 and EH3 as shown on Figure 9-8 above) which is situated on slightly elevated grassland (80 – 85m OD) on the west of the Wind Farm site. Overburden depths up to 5.6m were reported in the driller's logs.

The proposed depth of the borrow pit is between 7 and 13m below ground level (mbgl) to put the findings of the investigation holes into context.

The drilling logs show solid, competent, dry limestone down to a depth of approximately 25mbgl. Some isolated fractures with small to moderate groundwater inflows (0.025 – 1.5L/s) were recorded below 25mbgl. Overburden depths of between 2.5 and 5.6m were recorded in this area.

There is no recorded confining layer between the glacial till deposits and the underlying weathered bedrock/competent bedrock layers. As such it is our interpretation that the bedrock and glacial till deposits are connected, albeit that connection is limited by the low permeability characteristics recorded in the glacial till deposits.

9.3.9.3 Groundwater Levels and Flows

As mentioned above, a groundwater level monitoring network was established at the Wind Farm site in June 2021 to facilitate continuous seasonal monitoring of groundwater levels, groundwater flow patterns, and groundwater gradients across the Site, particularly in the area of the Gurteen/Cloonmore GWS and Gallagh GWS SPAs (i.e. Source Protection Areas).

The monitoring wells (BH1 – BH5) were drilled into bedrock and therefore facilitate the measurement of the groundwater pressure head/level in the bedrock aquifer. The Farm Well and existing investigation wells/boreholes near the proposed borrow pit (EH1 and EH3) are also drilled into bedrock. Summary groundwater levels for the period June 2021 to March 2023 are shown in Table 9-13 below.

Groundwater level monitoring shows the glacial till deposits below the bog/peatland areas are saturated (i.e. contain groundwater) all year round which would be typical for a low-lying basin peat setting. The seasonal groundwater level variation below the bog is between 0.5 -1m which is also typical of deposits below peatland/bog settings.

The monitoring also shows that the deeper groundwater level/pressure rises high enough to occur at an elevation within the upper peat layer. This means that the groundwater in the glacial tills below the bog is confined by the overlying low-permeability shell marl and peat deposits. Notably, there are no recorded artesian groundwater pressures above the level of the ground surface (i.e. there is no potential for groundwater to flow onto the bog surface).

Groundwater level monitoring carried out in the lowest bogland areas (i.e. BH1 at approximately 66.4m OD) indicates a groundwater level of between approximately 0.76mbgl (65.64m OD) and 1.73mbgl (64.67m OD) over the monitoring period.

Groundwater level data for the boreholes located in grassland on the north of the Site (i.e. BH4 and BH5) shows groundwater level of between 1.4mbgl (73.151m OD) and 4.4mbgl (70.08m OD) at BH4, while at BH5 groundwater levels were between 0.01mbgl (70.53m OD) and 1.15mbgl (69.38m OD). Groundwater level data for the BH3, the most southerly borehole at the Site, show levels of between 1.6mbgl (72.9m OD) and 2.5mbgl (71.94m OD) over the monitoring period. The groundwater levels outside the bog areas are unconfined.

We summarise as follows:

- Water levels within the peat areas are perched and are isolated from the underlying groundwater system;
- No artesian groundwater pressures were recorded at Wind Farm site;
- There is a high density of manmade drains and natural watercourses draining the ground surface of the Wind Farm site;
- There are significant depths of overburden (peat/shell marl and glacial tills) recorded above the bedrock across Wind Farm site;
- groundwater levels below the peat/shell marl areas and below the grassland areas remain high throughout the year; and,
- if there was significant underground drainage occurring because of deeper karstified bedrock, these observed conditions would not exist at the Wind Farm site.

In addition, this indicates that there is limited recharge/vertical groundwater flow from the glacial deposits down into the underlying bedrock aquifer at the Wind Farm site. This is also confirmed by the high stream density and man-made drainage density at the Site. The presence of these implies there is a need to drain surface water, as it cannot recharge/drain readily to the underlying regionally important karstified groundwater system.

Therefore, the majority (94% based on GSI recharge rates) of the rainfall that infiltrates into the glacial tills at the Site is more likely to move laterally and discharge into the local streams that flow through the Site (i.e. Streams A – D) rather than recharge vertically into the underlying bedrock aquifer.

The saturated state of the glacial tills all year round, as shown by >1.5 years of monitoring data implies that the bulk permeability/ transmissivity of the limestone bedrock aquifer directly below the Wind Farm site is low and as a result, the combination of the overburden/till cover (thickness) and the competent bedrock provides significant natural protection to any deeper conduits that feed groundwater towards the nearby spring.

Table 9-13: Groundwater Level Summary Data

Location	Ground Level (m OD)	Min WL (m OD)	Max WL (m OD)
BH1	66.425	64.677	65.646
BH2	66.298	65.628	66.145
BH3	74.551	71.947	72.903
BH4	74.558	70.080	73.151
BH5	70.540	69.389	70.534
Farm Well	75.447	68.812	72.722
Borrow Pit Well (EH1)	80.085	-	77.315
Borrow Pit Well (EH3)	73.503	68.823	72.733
Gurteen/Cloonmore Spring	66.8	65.811	66.371
Gortagarraun Turlough	68 - 70	-	68.85

Notes:-Borehole EH1 and Gortagarraun Turlough dry up during the summer months.

The highest groundwater levels around the main Wind Farm site (borrow pit groundwater levels are discussed separately below) were recorded in BH4 and the lowest levels were recorded in BH1. BH1 is located 530m south of the spring, while BH4 is located 570m to the northeast. There was a 5 - 7m groundwater level difference between BH1 and BH4 over the monitoring period.

Using spot groundwater levels from the monitoring well network, groundwater level contour maps were produced for winter (Figure 9-10) and summer (Figure 9-11) seasons. The mapping shows that there is little variation in the groundwater level contouring (i.e. groundwater gradients/flow direction) between the winter and summer seasons which would be expected given the relatively small variation in seasonal groundwater level fluctuations recorded.

The groundwater level contours show an overall southerly/south-westerly flow direction at the northern and central portions of the Wind Farm site. Groundwater flows appear to be towards the Levally Stream, which flows to the west and south of the Wind Farm site. The groundwater contours also appear to strongly mimic the local topographic of the northern portion of the Wind Farm site. This would be expected given the very low groundwater recharge characteristics of the Site which maintains a relatively high groundwater level (i.e. similar in a Locally Important or Poor bedrock aquifer setting).

Groundwater flows at the southern portion of the Site appear to follow a more localised pattern which is likely to be influenced by the local topography and underlying geology. The southern portion of the Site features a prominent hill, comprising silts and clays (refer to BH3 log) with groundwater gradients in this area appearing to mimic the local topography of the hill. Groundwater contours suggest a westerly flow towards the Levally Stream and also a northerly flow towards Stream A.

Groundwater levels at the far west of the Site (proposed borrow pit location) show an opposing groundwater flow pattern compared to the main Site, and this is easterly towards the Levally Stream. The proposed borrow pit is located to the west of the Levelly Stream valley while the main Site is located to the east of the Levelly Stream. The proposed borrow pit is located immediately east of a surface water catchment divide where the ground slopes easterly towards the Levelly Stream.

The groundwater levels across the borrow pit location range between approximately 73 and 77m OD (over winter) with the gradient to the east in the direction of the Levally Stream. This is also consistent with the surface water catchment mapping and topography. The groundwater levels in the area of the borrow pit also suggest a relatively localised flow pattern with a steep gradient across the borrow pit footprint also being an indication of this localised flow pattern.

The opposing easterly/westerly groundwater flow patterns also suggest that the Levally Stream is a discharge zone for the underlying limestone aquifer in this area. The Levally Stream flows in a valley to the west of the Site which originates at Gortagarraun Turlough to the northwest of the Site. The presence of the valley and the groundwater flow patterns may suggest the presence of a geological feature such as a fault or contact zone that is likely connected to Gortagarraun Turlough.

The groundwater level in the Gurteen/Cloonmore GWS spring sump ranged between 65.811m and 66.371m OD over the monitoring period. Given the groundwater flow direction in the area of the spring is from the northeast, the northern portion of the Site is potentially up-gradient of the spring, while all of the Site area to the south of the spring is downgradient of the spring.

The Gurteen/Cloonmore GWS spring is discussed further in Section 9.3.15 below with regard its groundwater zone of contribution within the Site.

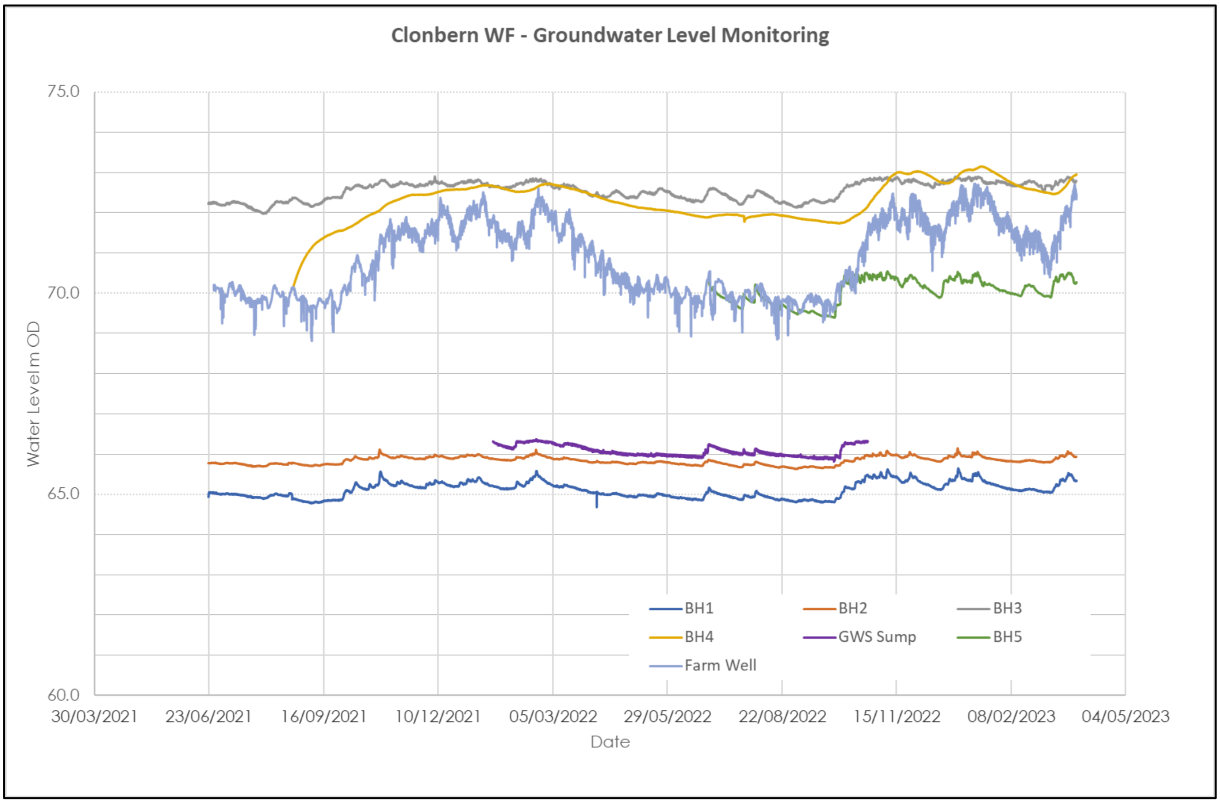

Figure 9-9: Groundwater Level Plots

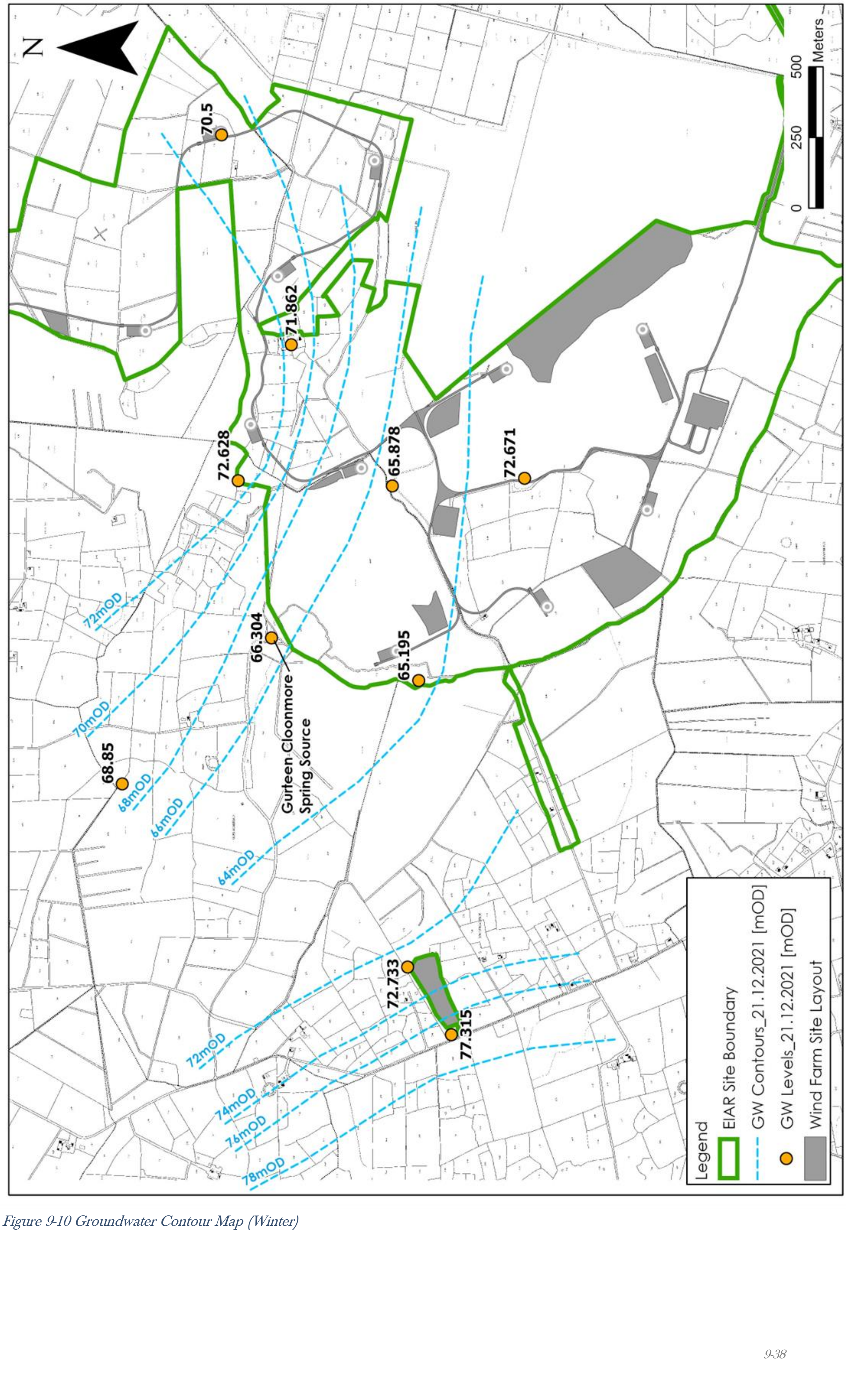

Figure 9-10 Groundwater Contour Map (Winter)

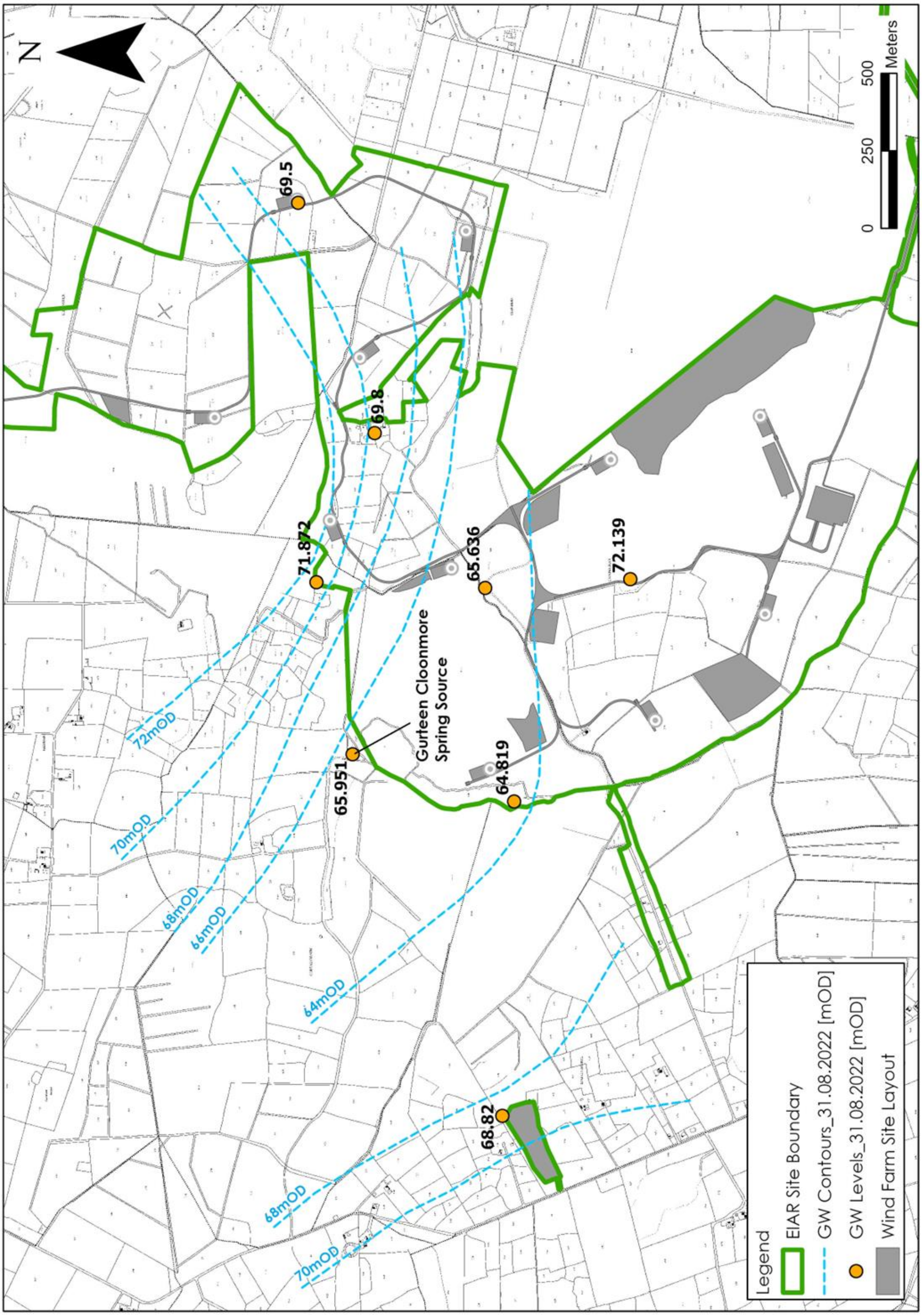

Figure 9-11 Groundwater Contour Map (Summer)

9.3.10 Groundwater Vulnerability

The groundwater vulnerability of the limestone aquifer underlying the Site is classified as predominately "Low" by the GSI (www.gsi.ie) and this accounts for 67% of the Site area. 30% is mapped ass "Moderate" while "*High" to "Extreme"* combined account for 3% of the Site.

The "Low" rating largely represents the basin peat/cutover bog which covers a large portion of the Site. The agricultural and forestry areas on the south of the Site are also mapped as "Low" and this is consistent with the total depth of overburden (peat and mineral subsoils) at BH3, the most southerly borehole, which is 16.5m.

The GSI subsoil permeability mapping has "low permeability" subsoils mapped across 97% of the Site, including the agricultural and forestry areas as well as the bogs, and this is the basis of their vulnerability classification along with overburden depths. The findings of the site investigation conducted at the Site are consistent with the GSI groundwater vulnerability rating.

Based on the GSI mapping, proposed turbine locations T1, T6, T7, T8, T9, T10, T11, 2 no. construction compounds, 4 no. peat repository areas and the spoil deposition area are mapped in "Low" groundwater vulnerability rating areas. The vulnerability rating at these locations is consistent with the site investigation findings.

The "Moderate" vulnerability rating is associated with the agricultural lands on the north of the Wind Farm site where a subsoil depth of 5.7m was encountered at BH5 (located at turbine T2 location) which is consistent with the GSI rating.

Proposed turbine locations T2, T3, T4, and T5 are mapped in "Moderate" groundwater vulnerability areas according to the GSI. The vulnerability rating at these locations is consistent with the site investigation findings with the exception of turbine T3 where a low vulnerability rating is also likely to be most appropriate based on an overburden depth of 14.6m at BH4 (located 200m to the west of T3).

The mapped groundwater vulnerability rating in the area of the proposed borrow pit is "Moderate" to "High". A very localised area of "Extreme" groundwater vulnerability is mapped to the south of proposed turbine T3 but there is no proposed infrastructure in this area. The investigation drilling indicates the "Extreme" groundwater vulnerability mapping in not correct.

In addition, all watercourses which flow through the Site as described in Section 9.3.4 above are assigned an "Extreme" vulnerability rating. In karst areas, potential point recharge zones such as swallow holes, dolines, and losing streams are assigned an "Extreme" vulnerability rating which is applied using a 30m buffer around the feature.

Apart from the Gurteen/Cloonmore GWS karst spring, there are no other visible surface karst features within the Site. As discussed in Section 9.3.4, the main streams that flow through the Site do not have losing reaches within the Site as demonstrated by surface water flow monitoring. In addition, the sections of streams close to the bogs within the Site are also underlined by low permeability shell marl and deep glacial deposits which would prevent surface water losses to the underlying bedrock groundwater system.

Therefore, due to thick deposits of low permeability subsoils, groundwater recharge will be very low (estimated at 6% for the overall Site) and surface water runoff to local streams will dominate. The groundwater contouring also suggests a localised groundwater flow pattern at the Site which closely follows topography.

Groundwater level hydrographs show responses to rainfall events, but these are subdued and small in comparison to what would be expected in karst aquifers with conduit flow.

Groundwater flowpaths in the overlying glacial till deposits will be short and localised, with recharge emerging close by at seeps and surface water streams that flow through the Site. This means there is a very low potential for groundwater dispersion and downward movement into the limestone bedrock aquifer, therefore making surface water bodies such as streams more vulnerable than groundwater at the Site.

9.3.11 Groundwater Quality Hydrochemistry

Groundwater sampling of BH1, BH2, the Farm Well, and the Gurteen/Cloonmore GWS spring was carried out by HES on 7th April 2022 and on 29th March 2023.

Tabulated groundwater quality data are attached as Appendix 9-3. Results of the analysis are shown alongside relevant groundwater regulation and drinking water regulation values (S.I. No. 366/2016 of 2016 and S.I. No. 99 of 2023). Laboratory certificates are shown in Appendix 9-4.

Commonly elevated metals in groundwater such as iron and manganese were elevated above drinking water regulation threshold values in the well samples (i.e. BH1, BH2, and Farm Well). Iron and manganese were not elevated in the Gurteen/Cloonmore GWS spring samples.

Nutrients such as nitrate, nitrite, phosphorus, and ammonia were also low with results being close to the laboratory detection limit in all samples.

Ranges for electrical conductivity (545 - 680µS/cm), pH (7.1 – 7.4) and hardness 311 – 520mg/L) values are typical for a limestone aquifer in all samples.

There were detections of microbial presence (i.e. coliforms and E.coli) in all the Farm Well and Gurteen/Cloonmore GWS spring samples but not in the well samples.

Overall, the groundwater hydrochemistry of the Gurteen/Cloonmore GWS spring is similar to the groundwater from the wells.

9.3.12 Groundwater Body Status

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

The Clare Corrib GWB (GWB: IE_WE_G_0020) underlies the Site and it is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB. The assigned risk status (WFD 3rd Cycle) is At Risk. The main groundwater pressures are reportedly due to agriculture.

9.3.13 River Water Body Status

Local River Waterbody status and WFD risk classification are available from (www.catchments.ie) and are summarised in Table 9-14 below.

Table 9-14 below gives summary details of the river waterbodies in which the Proposed Project are directly located. Please refer to the WFD Assessment report (attached as Appendix 9-5) for details and status of all river waterbodies in the Site Water Study Area.

The proposed Wind Farm site is mainly located within the Levally Stream_010 sub-basin with the northern portion of the Wind Farm site extending into the Sinking_020 sub-basin. The Grid Connection is located in the Levally Stream_010 sub-basin only.

The proposed TDR works located to the northwest of the Site are located in the Sinking_020 and Clare(Galway)_020 sub-basins.

Table 9-14: River Waterbody Status and Risk

European Code	SWB Name	Ecological Status	Overall Status	Risk Status	Pressure Category
IE_WE_30L070100	Levally Stream_010	Good	Good	Not at Risk	Hydromorphology
IE_WE_30S010300	Sinking_020	Good	Good	Not at Risk	n/a
IE_WE_30C010300	Clare(Galway)_020	Good	Good	Not at Risk	n/a

9.3.14 Designated Sites and Habitats

Within the Republic of Ireland designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). A map of designated sites in the local area is shown as Figure 9-12 below.

The closest designated site to the Site is Lough Corrib SAC (Site Code: 000297) which includes sections of the Levally Stream and Sinking River immediately downstream of the Site. The proposed Grid Connection briefly intercepts Lough Corrib SAC where it follows a public road after leaving the Wind Farm site on the southeast. The Grid Connection cable route intercepts the SAC for about 160m as the route goes over an existing bridge crossing on the Levally Stream. The closest turbine to the SAC (T10) is 0.6km away.

Levally Lough SAC/pNHA (Site Code: 000295) is located ~2km southwest of the Proposed Project site. The Site Synopsis (NPWS, 2013) description of Levalley Lough is as follows:

> *"Levally Lough is a fluctuating lake, or turlough, situated 9 km east of Tuam and to the north of the Grange River in Co. Galway. It is overlooked by a low rise on the north side, with some esker or drift mound to the south. The land is flat at the eastern and western ends. A stream enters the turlough from the north-east corner".*

There is no surface water connection between the Site and Levally Lough. However, given that the general groundwater flow direction in the area of the Site is to the south/southwest, it has to be assumed that Levally Lough is potentially down-gradient of the Site with respect to groundwater flow.

Drumbulcaun Lough pNHA is located 1km to the west of the site, where it exists in a separate surface water and groundwater catchment to that of the Site.

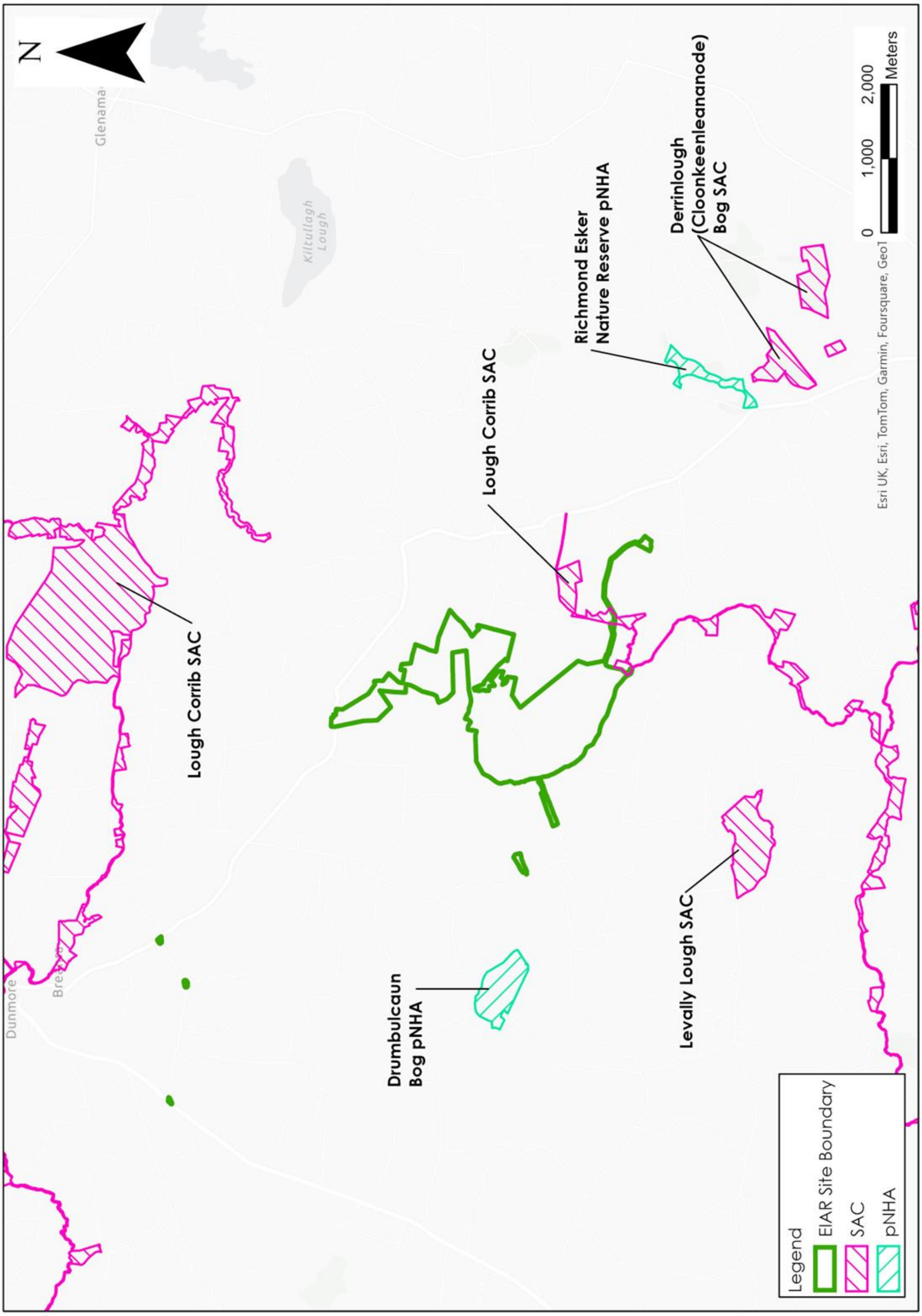

Figure 9-12 Local Designated Sites

9.3.15 Water Resources

9.3.15.1 Public/Group Water Schemes

There are 3 no. GSI mapped groundwater Source Protection Areas (SPAs) within ~5km of the Wind Farm site relating to Group Water Scheme (GWS) and Public Water Supply (PWS) sources. Refer to Figure 9-7 above.

These schemes are Gurteen/Cloonmore GWS, Gallagh GWS, and Dunmore/Glenamaddy PWS.

The Dunmore/Glenamaddy PWS SPA (karst spring/groundwater source located 1.5km to the east/northeast of the Site) suggests a north-westerly groundwater flow direction. The Dunmore/Glenamaddy PWS SPA was mapped using dye tracing which is a reliable method for determining groundwater flow direction and Zone of Contribution (ZoC) to a source. The tracer lines all suggest north-westerly flow directions. The Proposed Project site is not located inside the Dunmore/Glenamaddy PWS SPA.

Preliminary Source Protection Areas (SPAs) for 2 no. Group Water Scheme (GWS) spring sources are mapped to include parts of the proposed Wind Farm site. The Grid Connection is not mapped inside the SPAs.

The Gallagh GWS SPA is located immediately west/southwest of the Wind Farm site and includes a small area of the Site where a borrow pit is proposed. The Gallagh GWS karst spring source is located 4km to the southwest of the Site.

The following summary details were taken from the GSI source protection report for Gallagh GWS (GSI, 2014):

- The source serves 1,200 no. meter connections, which are mainly domestic and farms;
- The preliminary source groundwater protection report and SPA was prepared by the GSI/NFGWS in 2014, this report defines the ZoC/SPA for the spring;
- The total SPA area is mapped to be 15km^2;
- According to the GSI report the spring is fed predominantly through a network of enlarged bedrock conduits within the underlying karstified bedrock aquifer;
- The total flow from the spring was measured on two occasions by the GSI on 26th June 2014 (11,600m^3/day) and 12th August 2014 (12,000m^3/day), but major seasonal fluctuations (in flow) are reported;
- Current GWS abstraction rate is between 380 and 600m^3/day; and,
- Following chlorination, filtration and UV treatment water from the spring is pumped directly to the GWS network.

The proposed borrow pit is located inside the northeastern edge of the mapped SPA for Gallagh GWS. However, groundwater level monitoring carried out at 2 no. boreholes (EH1 and EH3) located adjacent to the proposed borrow pit location indicates there is an easterly gradient towards the Levally Stream and away from the source location to the southwest. These groundwater levels demonstrate that the proposed borrow pit is not located inside the Gallagh GWS SPA.

The Gurteen/Cloonmore GWS spring source itself is located immediately outside the western boundary of the Site (Gortagarraun townland). The following summary details were taken from the GSI source protection report (GSI, 2015):

- The Gurteen/Cloonmore GWS source is located in Gortagarraun townland, approximately 3km west of Clonberne, Co. Galway;
- The source serves 80 no. connections, 7 – 8 of which are farms, the rest are domestic;
- The daily demand of the GWS is reported by the GSI to be between 180 and 230m^3/day;

- Preliminary Source Protection Area (SPA) mapping for the Gurteen/Cloonmore GWS exists on GSI online databases;
- The SPA defines the land zone within which recharge to the underlying groundwater system occurs and contributes groundwater towards the spring (i.e. Zone of Contribution = total SPA);
- The Gurteen/Cloonmore GWS preliminary source groundwater protection report and SPA was prepared by the GSI/NFGWS in 2015, this report defines the ZoC/SPA for the spring;
- The total SPA area is mapped to be 25km^2;
- The GSI preliminary ZoC mapping is largely based on desk study information and other assumptions as acknowledged in the GSI report;
- According to the GSI report the spring is fed predominantly through a network of enlarged bedrock conduits within the underlying karstified bedrock aquifer (5 – 10m below the ground surface);
- The total flow from the spring was measured on one occasion by the GSI on 26th June 2014 (5,010m^3/day), but major seasonal fluctuations (in flow) are reported;
- Following chlorination and UV treatment, water from the spring is pumped directly to the GWS network;
- The GSI report states that the spring is possibly linked to a losing stream (surface water sink) located in Kippaunagh townland to the northeast of the Site; and,
- The losing stream is mapped as a swallow hole in the GSI karst database.

The Preliminary Gurteen/Cloonmore GWS SPA mapping by the GSI shows that the northern and central portions of the Site are located inside the SPA. Approximately 220ha of the Site (~60% of the Site) is located inside the GSI mapped SPA. Therefore, the Wind Farm site area accounts for ~9% of the total SPA which is 25km^2.

The area of the Site inside the GSI mapped SPA includes 7 no. of the proposed 11 no. turbine locations. The proposed turbine locations mapped within the SPA include: T1, T2, T3, T4, T5, T6 & T11. The proposed 2 no. temporary construction compounds are also located inside the GSI mapped SPA. The closest turbine to the spring is T7 which is located ~440m from the spring at a down-gradient location and outside the SPA.

The EIAR acknowledges that the Gurteen/Cloonmore GWS spring is a very important local water supply that serves a wide population in the area, and that it is classified as an extremely sensitive water supply source. Considering the springs importance and potential sensitivity to impacts from the Proposed Project detailed hydrogeological investigations/monitoring was undertaken (as described above) that further advances the knowledge of the ZoC to the Gurteen/Cloonmore GWS spring.

This groundwater level monitoring data allowed accurate mapping of groundwater flow directions and gradients in the area of the proposed Site and the GWS spring. The groundwater level monitoring data is presented in Section 9.3.9.3 above and an interpretation of groundwater levels and flows is presented in the form of detailed groundwater level contour mapping.

The groundwater level contour mapping shows that the groundwater flow direction is in a southerly/south-westerly direction in the area of the spring and Site. this is slightly different to the assumptions made by the GSI during the preliminary SPA which is dominantly westerly. There is also an element of northerly groundwater flow towards the spring based on the GSI assumptions.

Given the measured southerly groundwater flow direction and the location of the spring with regard the Wind Farm infrastructure, all proposed Wind Farm infrastructure located to the north of the spring is potentially up-gradient of the spring and within the ZoC.

To the south of the spring groundwater flow/gradient is measured to be in a southerly direction (away from spring). Therefore, the areas to the south and southeast of the spring cannot contribute groundwater flow to the source and are therefore outside the spring ZoC. Therefore, all proposed Wind Farm infrastructure located to the south of the spring cannot be inside the ZoC.

Using the groundwater level and contour mapping a refined version of the ZoC was delineated in the area of the proposed Wind Farm site as shown in Figure 9-13 below. The ZoC was only refined for the area inside the Site as there is not sufficient data to refine the ZoC in the wider area.

The refined (worst-case scenario as explained below) ZoC mapping shows that 4 no. proposed turbine locations are potentially (as a worst-case scenario) located within the refined SPA. Turbines potentially located inside the refined ZoC include T1, T2, T3 & T4.

The preliminary GSI SPA show proposed turbine location T5, T6 and T11 inside the SPA/ZoC which is not the case based on the groundwater level monitoring. It's also worth noting that all the peat repositories and the southern temporary construction compound are now located outside the refined ZoC.

Even though the groundwater level monitoring suggests a localised groundwater flow regime at the Site (i.e. groundwater contours strongly mimic the local topography with groundwater discharge to local streams), in a worst-case scenario we are assuming that anywhere on the northern portion the Wind Farm site where the groundwater level is higher than the water level in spring (@BH4, BH5 and Farm Well) is potentially located within the ZoC to the spring (this only includes turbine locations T1, T2, T3 and T4).

This worst-case approach is taken due to the karst nature of the underlying limestone bedrock and the potential for groundwater flowpaths in bedrock conduits that do not conform with the overall southerly groundwater flow direction/gradient in the area. For example, the potential link between the losing stream and spring does not conform with the mapped groundwater contours as it is more westerly. The groundwater flow in this possible link appears to preferentially follow a structural feature in the deeper bedrock such as a fracture/conduit.

However, the groundwater level contours at the Wind Farm site suggests that shallow groundwater flow patterns are strongly influenced by local topography. This is not surprising given the very low recharge characterises (due to thick deposits of low permeability glacial sitting on competent limestone bedrock with low bulk permeability) which drives shallow, localised groundwater flow patterns towards the nearby streams that flow through the Site.

In other words, the geology of the Wind Farm site results in shallow groundwater flow patterns that would typically be observed in a Locally Important or Poor Aquifer (i.e. groundwater flow directions mimic topography).

The groundwater contours in the grasslands on the north of the Wind Farm site (particularly in the area of proposed turbine locations T2, T3 and T4) indicates groundwater flow closely mimics topography which is sloping steadily to the south towards Stream A.

Proposed turbine T1 location on the other hand is located more upslope of the spring location and the local topography here would potentially permit localised groundwater recharge to flow south-westerly towards the spring. Thereby, including proposed turbine locations T2, T3 and T4 in the refined ZoC is considered worst case, but a prudent decision nonetheless due to the importance of the spring.

However, considering the low groundwater vulnerability rating, thick deposits of low permeability peat and glacial till coverage along with high density surface water drainage, there is very little groundwater recharge contributing to the spring discharge from anywhere on the northern portion of the Wind Farm site (within the refined ZoC).

Any bedrock conduits/fractures in the bedrock underlying the Wind Farm site that contributes flow to the spring are most likely to be recharged at locations remote from the Wind Farm itself (i.e. lands to the north/northeast of the Wind Farm site or losing streams further up the Levally Stream catchment).

Nevertheless, the impact assessment and mitigation measures specific to the spring source assume that the northern portion of the Wind Farm (including turbines, T1, T2, T3 and T4 locations) forms part of the refined ZoC.

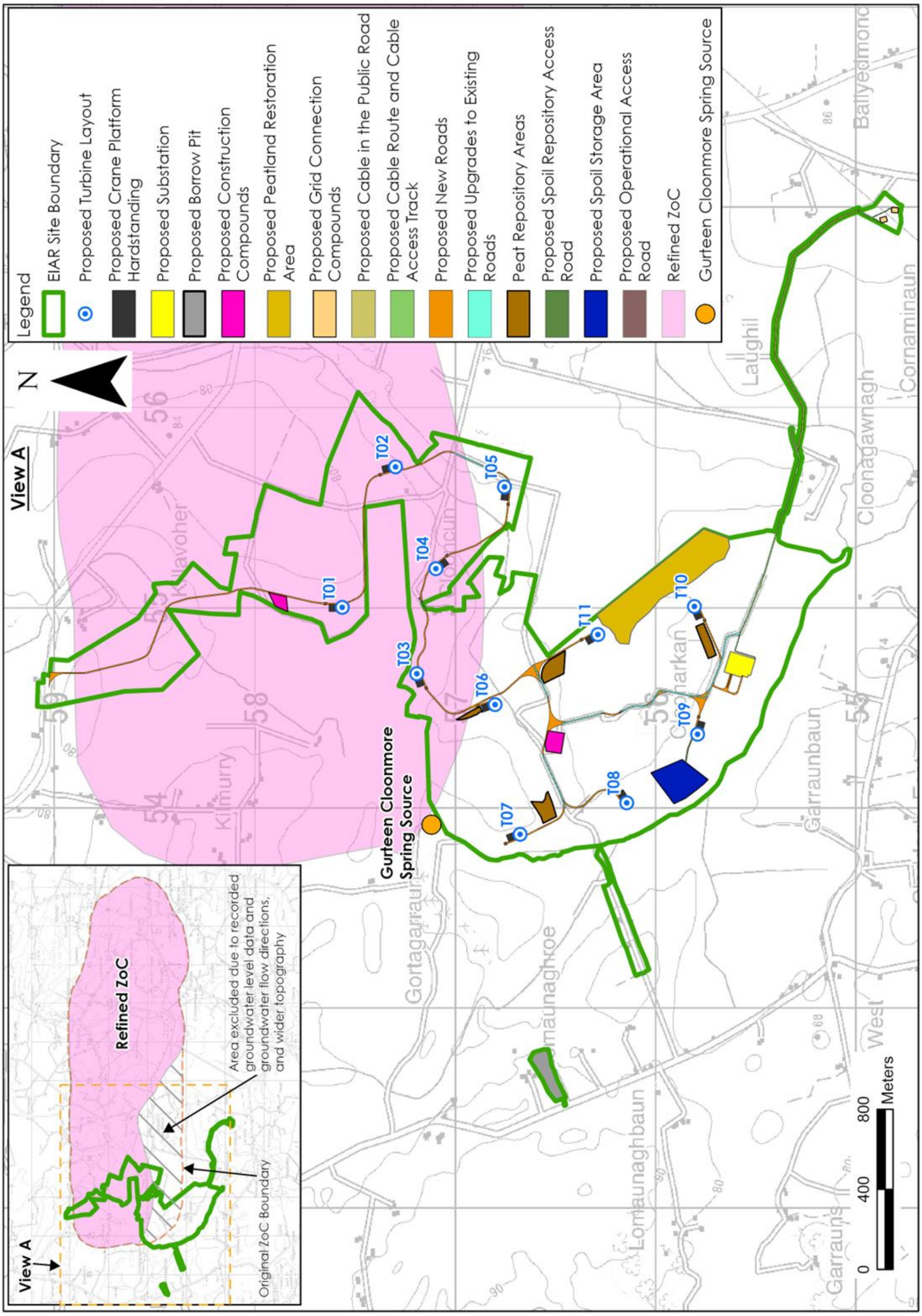

Figure 9-13 Refined ZoC Mapping for Gurteen/Cloonmore GWS Source

9.3.15.2 Private Domestic Wells

A search of private well locations on GSI well database (www.gsi.ie) reveal no mapped private wells within 2km of the Site.

We have completed an assessment below of private wells in the lands surrounding the Site (Section 9.5.2.11 below). In order to be conservative and following the worst case assumption, we have assumed that all dwellings in the surrounding lands have a private groundwater well. A number of private dwelling houses were identified along the local roads to the southwest (i.e. down-gradient) of the Site.

GSI mapped wells and private dwelling houses are shown on Figure 9-14 below.

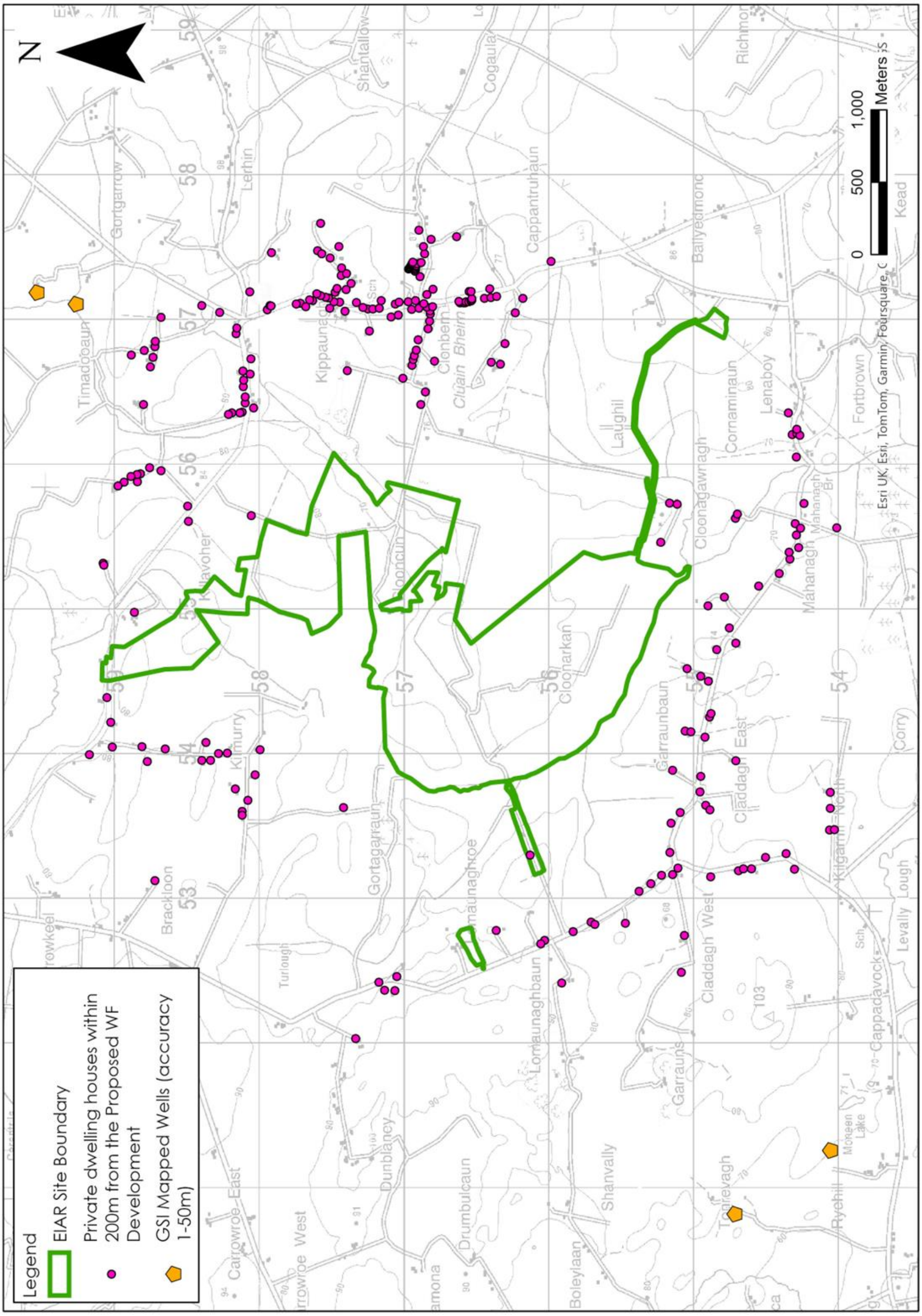

Figure 9-14 GSI Mapped Private Wells and Private Dwellings

9.3.15.3 Surface Water Resources

There are no river waterbodies in the vicinity of the Site which are identified as Drinking Water Protected Areas (DWPAs). Downstream of the Site, the Clare(Galway)_020 SWB is listed as a DWPA in Article 7 – Abstraction for Drinking Water. Only the furthest north portion of the Site (portion inside the Sinking River catchments) drains to Clare(Galway)_020. Development in this area of the Site is limited to the Wind Farm site entrance road and proposed northern construction compound.

The mapped DWPA is located approximately 20km downstream of the Wind Farm site.

9.3.16 Receptor Sensitivity

Due to the nature of Wind Farm and Grid Connection developments being near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the Site would be from hydrocarbon spillage and leakages at the borrow pit and turbine base excavations.

These are common potential impacts to all construction sites (such as road works and industrial sites). These potential contamination sources are to be carefully managed at the Site during the construction and operational phases of the development and mitigation measures are proposed below to deal with these potential minor impacts.

It is acknowledged that the Site is underlain by a Regionally Important Aquifer, however due to the basin peat geological setting, the groundwater vulnerability rating of the Site is mainly Low to Moderate. This is because the majority of the Site is covered by low permeability peat as well as deep glacial deposits, which act as a protective cover to the underlying aquifer. The low vulnerability rating means groundwater is much less vulnerable to potential effects.

Any contaminants which may be accidentally released on-site are more likely to travel to nearby streams within surface runoff. The deep and relatively low permeability of the glacial deposits means contaminants are unlikely to reach the bedrock and will instead disperse with the glacial deposits and would remain localised to the source or would be removed as runoff during wet periods.

The EIAR acknowledges that the Gurteen/Cloonmore GWS spring is a very important local water supply that serves a wide population in the area, and that it is classified as an extremely sensitive water supply source. Considering the springs importance and potential sensitivity to impacts from the Proposed Project detailed hydrogeological investigations/monitoring was undertaken that further advances the knowledge of the ZoC/SPA to the Gurteen/Cloonmore GWS spring.

This new knowledge with regard the ZoC/SPA along with our understanding of the geological/hydrogeological setting of the Site means this important local water supply can be managed and protected.

Dunmore/Glenamaddy PWS is screened out for further assessment for the following reasons:

- The proposed Wind Farm site is not located inside the GSI mapped Dunmore/Glenamaddy PWS SPA;
- The nearest proposed turbine location (i.e. T2) is >2km from the PWS. The recorded geology on the north of the Wind Farm site shows between 6m to 14.6m of overburden over bedrock;

- Available groundwater level data for Dunmore/Glenamaddy PWS spring[4] shows the lowest water level (73.4m OD at Gortgarrow spring) is higher than the groundwater levels recorded at the Wind Farm site, therefore there is no potential for groundwater flow towards the PWS from the Wind Farm site;
- Surface water drainage in the area of Dunmore/Glenamaddy PWS is to the southeast, in an area that is upstream of the proposed Wind Farm site;
- The tracer lines within the SPA to the Dunmore/Glenamaddy PWS all suggest north-westerly flow directions which are remote and upgradient of the Wind Farm site;
- The measured groundwater flow direction at the Wind Farm site is south-westerly and away from the location of the Dunmore/Glenamaddy PWS source springs (to the northeast of the Site);
- Any drawdown associated with the operation of the Dunmore/Glenamaddy PWS will be localised to each source location and will not extend over the >2km separation distance between the source locations and the proposed Wind Farm infrastructure. In any event, those Wind Farm elements will not cause a drawdown or interruption to groundwater flow due to their shallow extent; and,
- Therefore, there are no hydraulic pathways between the Site and PWS source springs along which impacts could occur or be transferred.

Gallagh GWS is screened out for further assessment for the following reasons:

- The proposed Site (i.e. borrow pit location) is located inside the northeastern edge of the mapped SPA. Groundwater level monitoring carried out at the proposed borrow pit location indicates there is an easterly flow gradient towards the Levally Stream and away from the spring source location to the southwest;
- These groundwater levels demonstrate that the proposed borrow pit is not located inside the SPA; and,
- Therefore, there are no hydraulic pathways between the Site and source spring for effects to occur.

Surface waters such as the downstream Levally Stream, Grange River, Sinking River and River Clare are all very sensitive to potential contamination as these rivers downstream of the Site form part of the Lough Corrib SAC.

Mitigation measures will ensure that surface runoff from the developed areas of the Site will be of a high quality and will therefore not impact on the quality of downstream surface water bodies. Any introduced drainage works at the Site will mimic the existing hydrological regime thereby avoiding changes to flow volumes leaving the Site.

A surface water hydrological constraints map for the Site is shown as Figure 9-15. The map shows that the majority of Proposed Project development areas (with the exception of watercourse crossings and some sections of existing road upgrades) are located away from areas on the Site that have been determined to be hydrologically sensitive (a 50m buffer has been applied to watercourses).

The large setback distance from sensitive hydrological features means they will not be impacted by excavations/drains etc. It also allows adequate room for the proposed drainage mitigation measures (discussed below) to be properly installed up-gradient of primary drainage features. This will allow attenuation of surface runoff to be more effective.

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[4] *Geological Survey of Ireland (2008) Dunmore/Glenamaddy Water Supply Scheme – Gortgarrow Spring – Groundwater Source Protection Zones.*

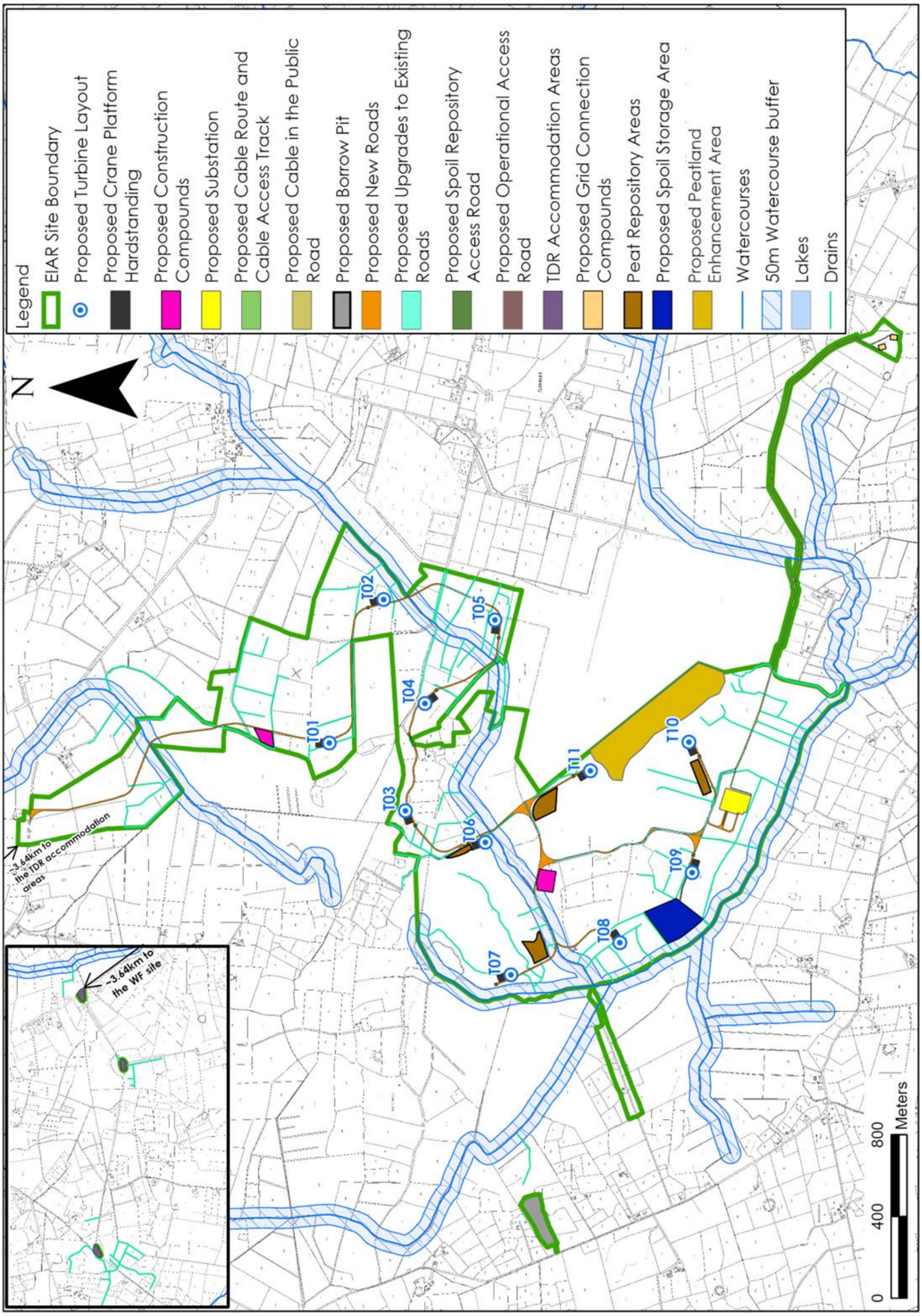

Figure 9-15 Hydrological Constraints Map

9.4 Characteristics of the Proposed Project

Please refer to Section 4.1 of the EIAR for a description of the Proposed Project (i.e. Proposed Wind Farm and Proposed Grid Connection).

The main characteristics of the Wind Farm that could impact on hydrology and hydrogeology are:

- Establishment of 2 no. temporary construction compounds, which will involve minor regrading of peat/soil/subsoil and the emplacement of hardstand. Welfare facilities will be provided at the primary temporary construction compounds. Wastewater effluent will be collected in a wastewater holding tank and periodically emptied by a licenced contractor;
- Construction of the site access tracks will use the floating technique as well as the excavate and replace technique. This will involve the use of aggregate from the 1 no. proposed borrow pit and imported from local quarries where required;
- Construction of the crane hardstand areas and turbine assemblage areas will utilise ground bearing foundations;
- Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning;
- Grey water will be supplied by rainwater harvesting and water tankered to site where required. Bottled water will be used for potable supply;
- Construction of 11 no. turbine foundations, which will be a combination of piled foundation and gravity foundation design;
- Due to deep peat at turbine T7, piling is likely to be required as an alternative option to gravity base;
- At turbine locations T1, T2, T3 & T4, which are located inside the refined ZoC to the Gurteen/Cloonmore GWS spring, only a gravity base foundation or precast piling is being considered;
- Cabling between turbine locations and the on-site substation will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling;
- Opening of 1 no. temporary borrow pit;
- Construction of 5 no. new watercourse crossing (clear span bridge design) and upgrade of 1 no. bridge crossing on Stream A (tributary of the Levally Stream);
- Tree felling (10.3ha) for the purposes of turbine and access road construction clearance which will be carried out under felling licence;
- Establishment of 4 no. peat repositories and 1 no. spoil repository area;
- The enhancement of 11.6ha of cutover bog for biodiversity enhancement; and,
- Turbine haul route upgrade works at 3 no. locations.

The main characteristics of the Grid Connection that could impact on hydrology and hydrogeology are:

- Approx 2.8km of an underground cabling route between the proposed 220kV substation and the existing Cashla – Flagford 220kV OHL at Laughil involving the excavation of a double shallow trench (approximately 1.2m deep), placement of ducting and backfilling with aggregate, lean-mix concrete, and excavated material, as appropriate (depending on the location of the cable trench);
- Construction of 2 no. end masts, cable compounds and associated foundations at the Cashla – Flagford OHL connection;
- Construction of the on-site 220kV substation with a subsoil bearing foundation. Welfare facilities will be provided at the substation along with a temporary construction compound;
- New 1.2km access road along off-road section over bog at the Wind Farm site; and,
- Horizontal Directional Drilling under 1 no. existing bridge crossing on a tributary of the Levally Stream.

9.4.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Site. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas.

The second method involves collecting any drainage waters from works areas within the Site that might carry silt or sediment, and nutrients, to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters.

During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as Figure 9-16 below.

Due to the low groundwater vulnerability rating of the Site and the poor surface water and bedrock aquifer interaction, no special design requirements are needed to prevent the ingress of Wind Farm surface water drainage into the karst groundwater system where works inside the refined Gurteen/Cloonmore GWS ZoC are proposed (i.e. turbine locations T1, T2, T3 and T4). Refer to Section 9.5.2.1 below for impact assessment relating to the source.

A detailed drainage plan showing the layout of the proposed construction and operational drainage design elements as shown in Figure 9-16 and in Appendix 4-5.

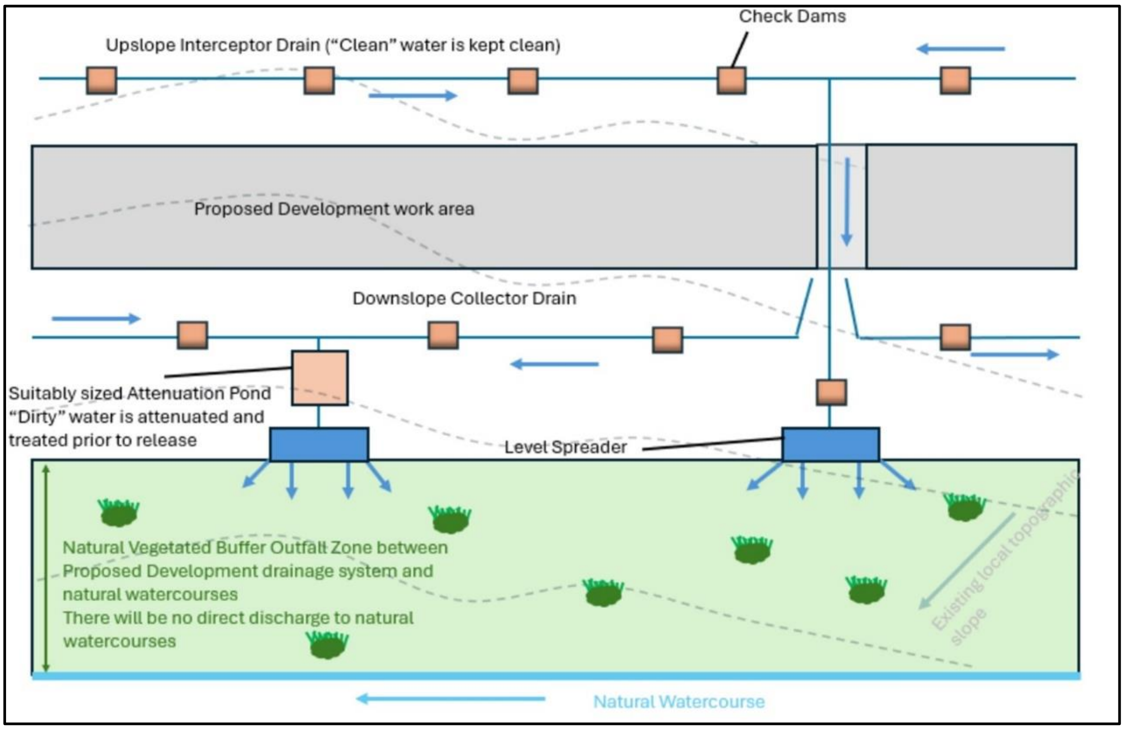

Figure 9-16 Schematic of the Proposed Drainage Management

9.5 Likely Significant Effects and Mitigation Measures

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

9.5.1 Do Nothing Scenario

If the Proposed Project were not to proceed, the existing land use practices including forestry, peat cutting and agricultural activities will continue at the Site. Forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with coniferous plantation is likely to occur. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas.

If the Proposed Project were not to proceed, the opportunity to generate renewable energy and electrical supply to the national grid would be lost, as would the opportunity to further contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions.

9.5.2 Construction Phase – Likely Significant Effects and Mitigation Measures

9.5.2.1 Potential Effects on the Gurteen/Cloonmore GWS Spring Source (Wind Farm)

Only the Wind Farm element is located inside the refined ZoC (Zone of Contribution) to the Gurteen/Cloonmore GWS. Only the Wind Farm is assessed herein. The Grid Connection is located outside of the mapped Gurteen/Cloonmore GWS ZoC.

The groundwater level contour mapping shows that 4 no. proposed turbine locations are potentially (as a worst-case scenario) located within the refined ZoC to the source.

Turbines potentially located inside the refined ZoC include T1, T2, T3 & T4. As stated above, only proposed turbine T1 is located upslope of the spring. The proposed northern temporary construction compound is also inside the refined ZoC. Anywhere to the south of the spring is located outside the refined ZoC. This includes all the remaining Wind Farm site area (including borrow pit and peat/spoil repositories) and Grid Connection (including substation).

Potential effects on the spring include groundwater quality with regard to contaminants such oils, fuels, cement and sediments (i.e. from rock breaking, piling, and excavation works).

Quantity effects (i.e. flows/spring discharge volumes) could potentially arise due to deep excavations, dewatering, grouting etc in the bedrock aquifer that supplies groundwater to the spring. Due to the nature of the groundwater flows to the spring (i.e. deep bedrock conduit flow), significantly deep excavations, for example turbine base constructed below the top of bedrock or borrow pits, would only have the potential to significantly affect flows to the spring.

There is negligible diffuse groundwater recharge contributing to the spring discharge from anywhere on the northern portion of the Wind Farm site due to very low recharge rates, therefore replacement of natural ground with less permeable hardstand areas within the refined ZoC will have no potential to affect recharge to the spring. This is due to the cover of low permeability overburden over the bedrock aquifer.

The significant depth of overburden at the Wind Farm site would also ensure that access road construction, trenching for electrical cabling, temporary construction compounds and roadside drainage and attenuation (i.e. settlement ponds) would have no potential to disrupt groundwater flowpaths to the spring. Trenching or drains will typically extend no more than 1.2m below ground level.

Also, the large depth of low permeability glacial overburden below the development footprint would prevent any surface water runoff /discharge from the proposed Wind Farm drainage system getting into the karst groundwater system. No point recharge features such as swallow holes, dolines etc are present at the ground surface on the Wind Farm site.

Discharge from proposed Wind Farm drainage system will be on natural undisturbed ground and into the existing farm/bog/forestry drains as currently is the case. The surface water flow monitoring carried out at the Wind Farm site has ruled out any direct recharge links between the spring and the Wind Farm site surface water courses via losing reaches (i.e. point recharge).

Pathways: Groundwater flowpaths and recharge (quality effects). Alteration/disruption of groundwater conduits/flowpaths in the bedrock aquifer (quantity and quality effects).

Receptors: Gurteen/Cloonmore GWS spring.

Pre-Mitigation Potential Impact: Negative, slight, indirect, long term, unlikely effect on Gurteen/Cloonmore GWS spring quality and quantity

Impact Assessment/Proposed Mitigation Measures:

Assessment of Quantitative Effect (i.e. flow volumes to the spring) and Proposed Mitigation Measures

The spring is reportedly fed predominantly through a network of enlarged conduits within the underlying bedrock aquifer. These conduits transmit water from the entire ZoC (estimated by the GSI to be 25km^2) to the spring. However, any conduits present in the underlying bedrock at the Wind Farm site are most likely to be fed by recharge to the aquifer which occurs remote from the Wind Farm site itself. There are no point sources of groundwater recharge within the Wind Farm site due to the thickness and coverage of peat and glacial tills.

The volume of diffuse recharge occurring within the Wind farm Site itself that contributes flow to the overall spring discharge is negligible. This is again due to the peat coverage and significant depth of glacial tills at the Wind Farm site. The glacial till deposits do not directly supply groundwater to the spring (i.e. there are no groundwater flowpaths in the glacial till deposits that transmit flows directly to the spring).

Therefore, unless a bedrock conduit is disrupted/intercepted during turbine foundation works there is no for the proposed Wind Farm development to effect groundwater flowpaths to the spring.

There is a potential that any weathered layer at the top of bedrock may contribute flow to the spring and therefore care needs to be taken that this upper bedrock layer is also not removed during excavation works.

The following proposed construction design measures will ensure the bedrock aquifer below the Wind Farm is not disrupted during works:

- The proposed construction method for turbine bases located inside the refined ZoC (i.e. T1, T2, T3, and T4) will either be a gravity foundation or pre-cast piling;
- The gravity foundation option will seek a suitable founding in the glacial tills at a maximum depth of 3 - 3.5mblg and therefore excavations will only require the removal of overburden to the final base level which will be within the overburden layer and above the top of bedrock;
- A considerable protective layer of overburden will be left in place above the bedrock;

- Gravity foundation is the preferred option unless further site investigations deem it unsuitable. If a gravity foundation is not suitable at a depth of 3 - 3.5m or above, driven precast piling will be the approach;
- Pre-cast piling will involve driving/hammering imported concrete piles down onto the top of bedrock below the glacial tills. The piles will not be drilled into the underlying bedrock aquifer nor will they grouted in place;
- The gravity foundation or pre-cast piling approach will not require excavations or grouting down into the bedrock aquifer and therefore there will be no risk of intercepting potential underlying bedrock conduits/fractures that transmit groundwater to the spring;
- Short term pumping/dewatering of turbine base excavations is likely to be required in the gravity base scenario only, but this will only be seepage from the overlying glacial overburden; and,
- Therefore, with both approaches there will be no potential whatsoever to disrupt underlying groundwater flowpaths (conduits/fractures) in the bedrock aquifer that feeds the GWS spring.

The proposed borrow pit location on the west of the Wind Farm site is neither located inside the GSI SPA/ZoC or the refined ZoC. The borrow pit location is 1.2km away from the spring source on the opposite side of the Levally Stream valley.

The proposed borrow pit location and the spring source is separated by the Levally Stream valley which appears to be a local groundwater discharge zone (i.e. there is no potential for groundwater flow from the proposed borrow pit towards the spring).

As a precautionary design measure, the extraction depth of the borrow pit will not go deeper than 67m OD which means the borrow pit floor will always be above the water level in the spring source sump (65.811m to 66.371m OD over the monitoring period).

There is a shallow road cutting (<2m in cut depth) required on the north of the Wind Farm site that is located on the northern edge of the GSI SPA/ZoC. The proposed cut is required to achieve the required road slope along the site entrance road. The cut will not extend into the underlying bedrock.

Assessment of Quality Effect and Proposed Mitigation Measures

In order for potential contaminants (i.e. oils, fuels, cements, sediments etc) to reach the spring from the Wind Farm construction areas, a groundwater flowpath (pathway) must be present.

The proposed turbine base construction design outlined above (which avoids bedrock excavations) removes the risk of intercepting/disrupting potential bedrock conduit/fractures that directly transmit groundwater to the spring. A protective layer of overburden will be left in place above the bedrock to prevent ingress of construction water down into the bedrock aquifer.

Intercepting/unearthing a bedrock conduit/fracture during the construction works would potentially create a direct pathway between the construction work area (i.e. turbine base) and the spring. This risk can be entirely eliminated by the proposed construction methods outlined above.

Therefore, the only potential pathway that exists between the proposed construction areas and the spring is indirectly via recharge through the overlying glacial tills and down into the bedrock aquifer. As described above, the glacial till deposits themselves do not directly transmit water to the spring.

The groundwater level monitoring data indicates that the majority of the recharge water in the glacial tills actually discharges to local streams that flow through the site. Therefore, only a very small portion of the recharge water in the glacial tills actually passes down to recharge the bedrock aquifer. Therefore, the total volume of recharge occurring within the Wind Farm site itself that contributes flow to the overall spring discharge is negligible. Therefore, the potential diffuse recharge pathways between the proposed construction works areas and the spring are extremely limited.

Furthermore, the likelihood of any significant diffuse recharge pathway between the more remote proposed turbine locations T2, T3 and T4 is even further diminished (hence we consider the refined ZoC conservative). Albeit the groundwater levels at these turbine locations are higher than the spring, the groundwater level contours strongly suggest that flows in the glacial tills is more southerly and not in the direction of the spring. The groundwater flow direction in the area of T2, T3 and T4 appear to strongly mimic topography which is sloping steadily to the south towards Stream A. Any potential spills or leaks that might occur in the area of T2, T3 and T4 will preferentially drain to Stream A.

Proposed turbine T1 is located upslope of the spring and therefore there is a higher risk of leaks and spills reaching the location spring via flows in the glacial deposition.

The following mitigation is proposed at all construction works areas and all 4 no. turbines inside the refined ZoC:

- No storage of fuels, oils, cements, or chemicals will be permitted within the refined ZoC;
- Refuelling of mobile plant (i.e. diggers, dumpers etc) will only be permitted outside the refined ZoC;
- Refuelling of large immobile plant (i.e. cranes) will only be carried out with a double skinned fuel bowser that will be removed from ZoC immediately after use;
- Spill kit stations will be present at each turbine location (T1, T2, T3 and T4);
- There will be no long term storage of peat/spoil inside the ZoC;
- A geotextile liner will be placed below the founding layer (lean mix concrete) where concrete is to be poured. These both prevent vertical loss of wet concrete at turbine bases;
- Use of perimeter shuttering at turbine basis to prevent lateral loss of wet concrete;
- All cement washout lagoons will be located outside the ZoC;
- A protective layer of in-situ overburden (2 -3m) will remain above the top of bedrock where gravity foundation excavations are required for groundwater quality protection; and,
- There will be clear signage in place inside the refined ZoC to remind construction workers that the area is inside a drinking water protection area.

Residual Impact: Due to the local groundwater flow patterns, the natural protection afforded by the deep overburden geology along with the proposed design measures, the residual effect of the Proposed Project will be negative, imperceptible, indirect, short-term, unlikely effect on Gurteen/Cloonmore GWS spring.

Significance of Effects: With the application of the mitigation outlined above, no significant effects on the Gurteen/Cloonmore GWS spring source will occur.

9.5.2.2 Clear Felling of Coniferous Plantation and Potential Surface Water Quality Effects (Wind Farm)

Felling works only relate to the Wind Farm element and not the Grid Connection. Only the Wind Farm is assessed herein.

Tree felling is a minor component of the proposed Wind Farm works with approx. 10.3ha felling proposed around the area of proposed turbine locations T3 and T8 and associated infrastructure.

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

Potential impacts during tree felling occur mainly from:

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

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters (Levally Stream, Grange River and River Clare) and associated dependent ecosystems.

Pre-Mitigation Potential Effect: Indirect, negative, slight, temporary, likely effect on surface water quality.

Proposed Mitigation Measures:

All felling operations will conform to current best practice Forest Service regulations, policies and strategic guidance documents as well as Coillte and DAFM guidance documents, including the specific guidelines listed below, to ensure that felling, planting and other forestry operations result in minimal potential negative effects to the receiving environment.

- Forestry Standards Manual (Forest Service, 2015)
- Environmental Requirements for Afforestation (Forest Service, 2016a)
- Land Types for Afforestation (Forest Service, 2016b)
- Forest Protection Guidelines (Forest Service, 2002)
- Forest Operations and Water Protection Guidelines (Coillte, 2013)
- Forestry and Water Quality Guidelines (Forest Service, 2000b)
- Forestry and the Landscape Guidelines (Forest Service, 2000c)
- Forestry and Archaeology Guidelines (Forest Service, 2000d)
- Forest Biodiversity Guidelines (Forest Service, 2000e)
- Forests and Water, Achieving Objectives under Ireland's River Basin Management Plan 2018-2021 (DAFM, 2018)
- Coillte Planting Guideline SOP
- A Guide to Forest Tree Species Selection and Silviculture in Ireland (Horgan et al., 2003)
- Management Guidelines for Ireland's Native Woodlands. Jointly published by the National Parks & Wildlife Service (Cross and Collins, 2017)
- Native Woodland Scheme Framework (Forest Service, 2018)
- Code of Best Forest Practice (Forest Service, 2000)

Mitigation by Avoidance:

There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document *"Forestry and Water Quality Guidelines"* are shown in Table 9-15.

Table 9-15 : Minimum Buffer Zone Widths (Forest Service, 2000)

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

During the Wind Farm construction phase a self-imposed buffer zone of 50 metres will be maintained for all streams where possible. These buffer zones are shown on Figure 9-15. No tree felling is required inside a 50m buffer zone.

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

Mitigation by Design:

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

- Machine combinations (i.e., handheld or mechanical) will be chosen which are most suitable for ground conditions and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and will avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- All drainage channels will taper out before entering the 50m buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction will be suspended during periods of high rainfall;

- Timber will be stacked in dry areas, and outside a local 50 metre watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- A permit to refuel system will be adopted;
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors;
- Crossing of streams will not be permitted;
- Trees will be cut manually from along streams and using machinery to extract whole tree; and,
- Travel only perpendicular to and away from stream.

Silt Traps:

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

Drain Inspection and Maintenance:

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

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

Surface Water Quality Monitoring:

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

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

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

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

Residual Effect: The potential for the release of suspended solids to watercourse receptors during tree felling is a risk to water quality and the aquatic quality of the receptor. Proven forestry best practice measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effect of the Proposed Project will be negative, imperceptible, indirect, temporary, likely effect on downstream water quality and aquatic habitats.

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

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

There will be earthworks required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

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

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Levally Stream, Sinking River, Grange River & Clare River) and dependent ecosystems.

Pre-Mitigation Potential Effect: Indirect, negative, significant, long-term, likely effect on surface water quality.

Mitigation by Avoidance:

The key mitigation measure during the construction phase of the Proposed Project is the avoidance of sensitive aquatic areas where possible From Figure 9-15 it can be seen that all of the key areas of the Proposed Project infrastructure are actually significantly away from the 50m delineated buffer zones with the exception of existing road upgrades, new roads, proposed stream crossings and existing stream crossings requiring upgrading. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

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

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

Mitigation by Design:

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

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system, there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the

Proposed Project drainage into the existing site drainage network. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works / tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- Runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through stilling ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site; and,
- Drains running parallel to the existing roads requiring widening will be upgraded, widening will be targeted to the opposite side of the road. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

Pre-commencement Temporary Drainage Works

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

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

Water Treatment Train:

A final line of defence will be provided by a water treatment train such as a “Siltbuster”. If the discharge water from construction areas fails to be of a high quality during regular inspections, then a filtration treatment system (such as a ‘Siltbuster’ or similar equivalent treatment train (sequence of water treatment processes) will be used to filter and treat all surface discharge water collected in the dirty water drainage system. This will apply for all of the construction phase.

Silt Fences:

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

Silt Bags:

Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, the majority of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters or sedimats Sediment entrapment mats, consisting of coir or jute matting, will be placed at the silt bag location to provide further treatment of the water outfall from the silt bag. Sedimats will be secured to the ground surface using stakes/pegs. The sedimat will extend to the full width of the outfall to ensure all water passes through this additional treatment measure.

Settlement Ponds:
The Proposed Project footprint has been divided into drainage catchments (based on topography, outfall locations, and catchment size) and stormwater runoff rates based on the 10-year return period rainfall event were calculated for various catchment areas in order to size the settlement ponds as shown in Table 9-16 below.

Table 9-16 : Settlement Pond Design

Pond Size W [m] x L [m] x D [m]			Track/Hardstand Catchment Size (m^2)		
Return Period	*10 yrs*	Storm Duration	500	1000	2000
6hr retention for coarse silt		6 hrs	3.4 x 10.6 x 1 m	4.8 x 15.0 x 1 m	6.9 x 21.0 x 1 m
11hr retention for medium silt		12 hrs	3.8 x 12.0 x 1 m	5.5 x 16.5 x 1 m	7.5 x 24.2 x 1 m
24hr retention for fine silt		24 hrs	4.2 x 13.8 x 1 m	6.2 x 18.6 x 1 m	8.6 x 27.0 x 1 m

Level Spreaders and Vegetation Filters:
The purpose of level spreaders is to release treated drainage flow in a diffuse manner, and to prevent the concentration of flows at any one location thereby avoiding erosion. Level spreaders are not intended to be a primary treatment component for development surface water runoff. They are not stand-alone but occur as part of a treatment train of systems that will reduce the velocity of runoff prior to be released at the level spreader. In the absence of levelspreaders, the potential for ground erosion is significantly greater than not using them.

Vegetation filters are essentially end-of-line polishing filters that are located at the end of the treatment train. In fact, vegetation filters are ultimately a positive consequence of not discharging directly into watercourses which is one of the mitigation components of the drainage philosophy. This makes use of the natural vegetation of the Site to provide a polishing filter for the Wind Farm drainage prior to reaching the downstream watercourses.

Again, vegetation filters are not intended to be a single or primary treatment component for treatment of works area runoff. They are not sand alone but are intended as part of a treatment train of water quality improvement/control systems (i.e. source controls→check dams→silt traps→settlement ponds→level spreaders →silt fences→vegetation filters).

Pre-emptive Site Drainage Management

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

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

- General Forecasts: Available on a national, regional and county level from the Met Eireann website (www.met.ie/forecasts). These provide general information on weather patterns including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;

- 3-hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;
- Rainfall Radar Images: Images covering the entire country are freely available from the Met Eireann website (www.met.ie/latest/rainfall_radar.asp). The images are a composite of radar data from Shannon and Dublin airports and give a picture of current rainfall extent and intensity. Images show a quantitative measure of recent rainfall. A 3-hour record is given and is updated every 15 minutes. Radar images are not predictive; and,
- Consultancy Service: Met Eireann provides a 24-hour telephone consultancy service. The forecaster will provide an interpretation of weather data and give the best available forecast for the area of interest.

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

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

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

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

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

Management of Runoff from Peat and Spoil Repository Areas:
It is proposed that excavated spoil and peat will be used for landscaping where required. The excess material will then be placed in 4 no. dedicated Peat Repository Areas (PRA) and 1 no. Spoil Deposition Area (SDA). All proposed PRAs and the SDA are located outside of 50m watercourse buffers and also outside of OPW mapped fluvial flood zones.

During the initial construction of repository/deposition areas, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from works areas.

Where applicable, the vegetative top-soil layer of the peat and spoil management areas will be rolled back to facilitate placement of excavated spoil, following which the vegetative-top soils layer will be reinstated. Where reinstatement is not possible, spoil and peat management areas will be sealed with a digger bucket and seeded as soon possible to reduce sediment entrainment in runoff.

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

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

Timing of Site Construction Works:

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

Monitoring:

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

Any excess build-up of silt levels at dams, the settlement pond, or any other drainage features that may decrease the effectiveness of the drainage feature, will be removed. Checks will be carried out on a daily basis.

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

Residual Effect: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effects of the Proposed Project will be negative, imperceptible, indirect, short-term, likely effect on down-gradient rivers, water quality, and dependent ecosystems.

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

9.5.2.4 Potential Impacts on Groundwater Levels During Excavations (Proposed Project)

There will be excavations required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

Dewatering of the borrow pit (as required) and other deep excavations (i.e., turbine bases) have the potential to impact on local groundwater levels temporarily during construction works.

However, groundwater level impacts will not be significant due to the local geological and hydrogeological regime as outlined below. Piling, which will likely be undertaken at some turbine locations, does not require active dewatering (albeit some temporary displacement of local groundwater is likely to occur) and therefore has no potential to significantly affect groundwater levels during construction.

Pathway: Groundwater flowpaths.

Receptor: Groundwater levels (Clare Corrib GWB and local bedrock aquifers).

Pre-Mitigation Potential Effect: Direct, negative, slight, brief, likely effect on local bedrock aquifers. No significant effects on the Clare Corrib GWB will occur due to the small dewatering requirements.

Impact Assessment:

No groundwater level impacts are predicted from the construction of the Proposed Grid Connection (including substation and 2 no. end masts) infrastructure due to the shallow nature of the excavations (i.e. 0 -~3m). The deepest excavations will be required at the substation, 3m, but these excavations will progress in a more horizontal manner rather than vertical deepening.

Turbine foundations will either be gravity base or piled. Due to the relatively shallow depth of the gravity foundations (3 – 3.5m deep) and the low permeability nature of the glacial till overburden, significant groundwater inflows into turbine excavations will not occur. In addition, any effects on groundwater levels will only be for a temporary basis during the foundation construction work. Groundwater level effects are unlikely to be significant beyond 10m from the turbine base excavation. Gravity foundations are proposed at all turbine locations unless further site investigation deem the option unsuitable.

Any potential piling at turbine locations T1, T2, T3 and T4 will be restricted to imported precast piles which will be driven down to the top of bedrock without the requirement for any pumping or dewatering.

Standard bored piling will be an option at all other turbine locations outside of the Gurteen/Cloonmore GWS refined ZoC, if gravity foundations are deemed unsuitable. Bored piling does not require active dewatering/pumping (albeit some displacement of groundwater is likely to occur during drilling and placement of grout) and therefore has no potential to significantly affect groundwater levels.

The proposed borrow pit is located on elevated ground (west side of Levally Stream valley) on the west of the Wind Farm site. The proposed depth of the borrow pit is between 7 and 13m below ground level (mbgl).

The drilling logs for the existing boreholes located in the area of the proposed borrow pit show solid, competent, dry limestone down to a depth of approximately 25mbgl.

The groundwater level monitoring carried out in the area of the borrow pit show steep groundwater gradients across the footprint of the borrow pit location, indicating competent low permeability bedrock with localised groundwater flow patterns. Groundwater flows in the bedrock of the borrow will be limited to localised flows in the upper weathered bedrock layers or localised weaknesses. No regional groundwater flows will be intercepted during the operation of the borrow pit.

Any dewatering/pumping required at the borrow pit will likely be associated with rainfall input/surface water runoff rather than groundwater inflows.

Residual Impact: Due to the prevailing geology at the Site, the local and temporary nature of the proposed works, the residual effects of the Proposed Project on groundwater levels will be negative, imperceptible, direct, brief and reversible.

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

9.5.2.5 Excavation Dewatering and Potential Impacts on Surface Water Quality (Proposed Project)

Pumping water from excavations might be required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

Some minor groundwater/surface water seepages will likely occur in turbine base excavations and borrow pit, and this will create additional volumes of water to be treated by the runoff management system. Cable trenching might require removal of water prior to backfilling.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore baseline contamination does not occur.

Pathway: Overland flow and site drainage network.

Receptor: Down-gradient surface water bodies (Levally Stream, Sinking River, Grange River & Clare River).

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

Proposed Mitigation Measures:

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

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

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect of the Proposed Project will be negative, imperceptible, indirect, short-term, likely effect on local surface water quality.

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

9.5.2.6 Potential Release of Hydrocarbons During Construction and Storage (Proposed Project)

Hydrocarbons will be required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

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

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater and surface water (Levally Stream, Sinking River, Grange River & Clare River).

Pre-Mitigation Potential Effect:

Indirect, negative, slight, short term, unlikely effect to local groundwater quality.

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

Proposed Mitigation Measures:

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

- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound (outside of Gurteen/Cloonmore GWS refined ZoC) when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Onsite refuelling will be carried out by trained personnel only;
- A permit to fuel system will be put in place;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor (outside of Gurteen/Cloonmore GWS refined ZoC);
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be included within the Construction and Environmental Management Plan (Appendix 4-4). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

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

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

9.5.2.7 Groundwater and Surface Water Contamination from Wastewater Disposal (Proposed Project)

Wastewater management will be required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

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

Pathway: Groundwater flowpaths and site drainage network.

Receptor: Groundwater quality and surface water quality (Levally Stream, Sinking River, Grange River & Clare River).

Pre mitigation Effect:

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

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

Proposed Mitigation Measures:

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

Residual Effect: No residual effects of the Proposed Project.

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

9.5.2.8 Release of Cement-Based Products

Cement will be required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

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

Pathway: Site drainage network.

Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Impact: Indirect, negative, moderate, short term, likely impact to surface waters (Levally Stream, Sinking River, Grange River & Clare River).

Proposed Mitigation Measures:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- Where possible pre-cast elements for culverts and concrete works will be used;
- Where concrete is delivered on site, only the chute will be cleaned, using the smallest volume of water practicable. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water will be undertaken at lined cement washout ponds located outside of Gurteen/Cloonmore GWS refined ZoC;
- Weather forecasting will be used to plan dry days for pouring concrete; and,
- The pour site will be kept free of standing water and plastic covers will be ready in case of a sudden rainfall event.

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

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

9.5.2.9 Morphological and Hydrological Effects due to Watercourse Crossing Works (Wind Farm).

New watercourse crossings (i.e. bridges/culverts) or upgrades of existing crossings will only be required at the Wind Farm site and not the Grid Connection. Only the Wind Farm is assessed herein.

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

Construction of 5 no. new watercourse crossing (clear span bridge design) and upgrade of 1 no. bridge crossing on Stream A (tributary of the Levally Stream) will be required to facilitate the Wind Farm Site development infrastructure.

Pathway: Site drainage network.

Receptor: Surface water flows (Levally Stream, Sinking River, Grange River & Clare River), stream morphology and water quality.

Pre-Mitigation Potential Impact: Negative, direct, slight, long term, likely effect on surface water flows and drainage patterns.

Proposed Mitigation Measures :

- All proposed new stream crossings will be bottomless or clear span culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed

and therefore there will be no direct impact on the stream at the proposed crossing location;
- Where the proposed cable route follows an existing road or road proposed for upgrade, the cable will pass over or below the culvert within the access road;
- All guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland[5] is incorporated into the design of the proposed crossings;
- As a further precaution, near stream construction work, will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites", i.e., May to September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses (any deviation from this will be done in discussion with the IFI);
- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas; and,
- All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Residual Impact: With the application of the best practice mitigation outlined above, the residual effect will be negative, imperceptible, direct, long-term, unlikely impact on stream flows, stream morphology and surface water quality.

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

9.5.2.10 Potential Hydrological Effects on Designated Sites (Proposed Project)

Designated sites are located downstream to both the Wind Farm and Grid Connection. Therefore, both are assessed herein.

The closest designated site to the Proposed Project site is Lough Corrib SAC (Site Code: 000297) which includes sections of the Levally Stream and Sinking River immediately downstream (north and south) of the Site.

The proposed Grid Connection cable route briefly intercepts Lough Corrib SAC where it follows a public road after leaving the Wind Farm site on the southeast. However, the Grid Connection grid cable will be contained with the carriageway of the public road at this location.

Levally Lough SAC/pNHA (Site Code: 000295) is located ~2km southwest of the Site. There is no surface water connection between the Site and Levally Lough. However, given that the measured groundwater flow direction in the area of the Site is southerly/south-westerly, Levally Lough is potentially down-gradient of the Site with respect to groundwater flow.

The groundwater flow direction in the area of the Site (i.e. south/south-westerly) means designated sites such as Williamstown Turlough SAC (to the north) and Drumbulcaun Bog (to the west) have been screened out.

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

Pathway: Surface water and groundwater flowpaths.

Receptor: Down-gradient water quality and designated sites (Lough Corrib SAC and Levally Lough SAC).

Pre-Mitigation Potential Effect: Indirect, negative, moderate, short-term, likely effect on Lough Corrib SAC and Indirect, negative, slight, short-term, unlikely effect on Levally Lough SAC.

Impact Assessment & Proposed Mitigation Measures:

Drainage mitigation measures for surface water quality protection during the construction phase are summarised again below: (Please refer to Sections 9.5.2.2, 9.5.2.3 & 9.5.2.5 above for the full description of these measures and how they will be applied).

- The proposed mitigation measures which will include 50m buffer zones for avoidance of sensitive hydrological features (streams and rivers);
- Pre-construction drainage control measures;
- Robust drainage control measures (i.e. interceptor drains, swales, settlement ponds and treatment trains such as Siltbuster) will ensure that the quality of runoff from Proposed Project areas will be very high; and,
- Best practice measures with regard use of oils, fuels (Section 9.5.2.6) and cement based compounds (Section 9.5.2.8).

As stated in Section 9.5.2.2 above, there could potentially be a residual "imperceptible, short term, likely effect" on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on the downstream Lough Corrib SAC will not occur.

Levally Lough SAC is located approximately 2km to the south of the Site and in the direction of groundwater flow (i.e. southerly/south-westerly) with regard the Site location. The Levally Stream flows between the Site and Levally Lough.

The groundwater level monitoring carried at the Site suggests that the Levally Stream is a local discharge zone for groundwater in the area of the Site. The fact that the Levally Stream separates the Site and Levally Lough, groundwater flows arising from the Site (especially shallow groundwater flows in the glacial deposits) are more likely to discharge into the Levally Stream rather than travel further south towards Levally Lough.

Also, due to the large coverage of peat, the presence of deep glacial till deposits, and poorly draining soils across the Site, the risk to groundwater quality in the deeper karst limestone is low. Considering these factors in addition to the proposed mitigation measures for groundwater protection, no effects on Levally Lough SAC are likely to occur.

Residual Impact: No effects on local designated sites from the Proposed Project.

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

9.5.2.11 Potential Effects on Local Groundwater Well Supplies from Excavations (Proposed Project)

There will be excavations required for both the Wind Farm and Grid Connection (Proposed Project) and therefore both are assessed herein.

In the area of the Proposed Project site, private dwelling houses (potential well locations) are mainly located along public roads to the southwest and south of the Site which is also the measured direction of groundwater flow in the area of the Wind Farm site (i.e. southerly/south-westerly).

The biggest risk to potential down-gradient wells will be from where deep excavations are required such as the borrow pits and turbines bases. Construction of the Grid Connection will not have the potential to effect local wells due to the shallow nature of the works at the substation, cable route and end mast locations.

The closest distance between a proposed turbine location and a downstream dwelling house (potential well) is approximately 0.85km (i.e. turbine T10). In order to be conservative and following the worst-case assumption, we have assumed that all dwellings in the surrounding lands have a private groundwater well.

Based on the groundwater level monitoring carried out in the area of the borrow pit (i.e. easterly flow towards the Levally Stream), there are no dwelling houses located either up gradient or downgradient of the proposed borrow pit location.

Pathway: Groundwater flowpaths.

Receptor: Private Groundwater Supplies.

Pre-Mitigation Potential Impact: Negative, imperceptible, indirect, short-term, unlikely effect on local wells.

Impact Assessment:

We are satisfied that the Proposed Project site will not impact in any significant way on any potential down-gradient private wells for the following reasons:

- The large set back distances between turbine locations and downstream potential well locations (>0.85km);
- The proposed project will involve relatively shallow excavations (3 – 3.5mbgl), other than at borrow pit;
- The low permeability of the glacial deposits in which the turbine gravity base foundations will be constructed;
- The large depths of peat and glacial deposits that protect the underlying limestone bedrock aquifer (i.e. the majority of the Site has a low groundwater vulnerability rating);
- Localised groundwater flow patterns in the glacial deposits which is towards local streams that flow through the Site;
- The Levally Stream acting as a hydraulic boundary between the Site and the dwellings to the southwest and south;
- The absence of dwelling houses at down-gradient or up-gradient locations with regard the proposed borrow pit location;
- The competent nature of the bedrock in the area of the proposed borrow pit with only shallow localised groundwater flowpaths; and,
- The shallow excavation depths required for Grid Connection cable and End Masts.

Residual Effects: For the reasons outlined in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), It has been assessed the Proposed Project has no potential to impact on local groundwater wells.

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

9.5.2.12 Turbine Delivery Route Works (Wind Farm)

TDR works will only be required at the Wind Farm site and not the Grid Connection. Only the Wind Farm is assessed herein.

Minor earthworks are required for the TDR. These include for temporary widening of existing road junctions at 3 no. locations along the proposed route. These TDR works are described in Section 4.4 of the EIAR.

Pathway: Surface water flowpaths.

Receptor: Down-gradient surface water quality (Sinking River and Clare River).

Pre-Mitigation Potential Impact: Indirect, negative, slight, short term, likely effect on surface water quality.

Proposed Mitigation Measures:

- All works are minor and localised and cover very small areas;
- These works are distributed over a wide area;
- All works are temporary in nature; and,
- Application of the Pre-Construction Drainage Measures (see Section 9.5.2.3) for surface water quality protection.

Residual Impact: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect of the Proposed Project will be negative, imperceptible, indirect, short-term, unlikely effect on down gradient rivers, water quality, and dependent ecosystems.

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

9.5.2.13 Effects of Construction Works on the WFD Status of Downstream Waterbodies (Proposed Project)

Both the Wind Farm and Grid Connection and the potential to effect WFD status. Therefore, both are assessed herein.

WFD status and Risk Results for downstream river waterbodies and the underlying Clare-Corrib GWB are presented in Sections 9.3.12 & 9.3.13 above.

Due to the low groundwater vulnerability rating of the Proposed Project site (thick deposits of peat and glacial tills), the potential to negatively affect the WFD status of the Clare-Corrib GWB is very low, even in the absence of mitigation.

Without mitigation the proposed construction works do have the potential to adversely impact on surface water quality which may negatively impact on the WFD status of these downstream surface waterbodies.

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

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters (Levally Stream, Sinking River, Grange River & Clare River) and associated dependent ecosystems.

Pre-Mitigation Potential Impact: Indirect, negative, slight, temporary, unlikely effect on river waterbody status. No effects Clare-Corrib GWB WFD status will occur.

Proposed Mitigation Measures:

Comprehensive surface water mitigation and drainage controls are outlined in Section 9.5.2.2 (Felling of Coniferous Plantations), Section 9.5.2.3 (Earthworks), Section 9.5.2.5 (Excavation Dewatering), Section 9.5.2.6 (Hydrocarbons), Section 9.5.2.8 (Cement-based Products) and Section 9.5.2.9 (Morphological Changes to Watercourses). These will ensure the protection of surface water quality and flows in all downstream receiving watercourses.

Residual Impact: The potential for the release of suspended solids, hydrocarbons, cement-based products or altered flows to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigation measures have been proposed and will break the pathway between the potential pollutant sources and the receptor. The mitigation measures will ensure that surface water runoff from the site will be equivalent to baseline conditions and will therefore have no potential impact on the status, ecology or hydromorphology of downstream waters. The residual effect of the Proposed Project is negative, imperceptible, indirect, short-term, unlikely impact on down gradient rivers, water quality, and dependent ecosystems. No effects on the status of the Clare-Corrib GWB will occur.

Significance of Effects: For the reasons outlined above, and with the implementation of the proposed mitigation, no significant effects on waterbody WFD status will occur.

9.5.2.14 Use of Siltbuster and Impacts on Downstream Surface Water Quality (Proposed Project)

Both the Wind Farm and Grid Connection could benefit from the use of a siltbuster. Therefore, both are assessed herein.

Siltbusters are regularly used to remove suspended sediments on construction sites by means of chemical dosing and sedimentation (i.e. use of coagulants and flocculants to accelerate the settlement process). The benefits of using enhanced settlement systems on downstream surface water quality are widely known and are a positive effect. However, potential overdosing with chemical agents means there is a perceived risk of chemical carryover in post treatment water which could result in negative effects on downstream water quality.

Proposed Project construction water (i.e. surface water runoff or pumped groundwater) has sometimes very fine particles, particularly clays and peat, with slow settling velocities which do not settle out efficiently, even in a lamella clarifier at normal flow rates. In these cases, chemical dosing can be used to aggregate the particles (i.e. force them to combine and become heavier), increasing the particle settling rate and cleaning the water via gravity separation techniques. Agents commonly used include poly aluminium chloride (PAC), aluminium sulphate, ferric iron and ferrous iron. These agents are commonly used in drinking water treatment plants. So their use is widespread, and there is significant scientific knowledge about their use and control.

The benefits of using a Siltbuster system in emergency scenarios where all other water treatment systems have proven ineffective are considerable. An example of treatment capability of siltbuster systems from northwest Mayo is provided in Figure 9-17. This is a duration curve of downstream water quality data post siltbuster treatment. The system was setup so that any water not meeting discharge criteria was recycled back to the settlement ponds. The graph shows all data, and only 24 data points out of 1194 records were above 20 mg/L (i.e. recycling, and repeat treatment occurred at these times to ensure compliance at the discharge location).

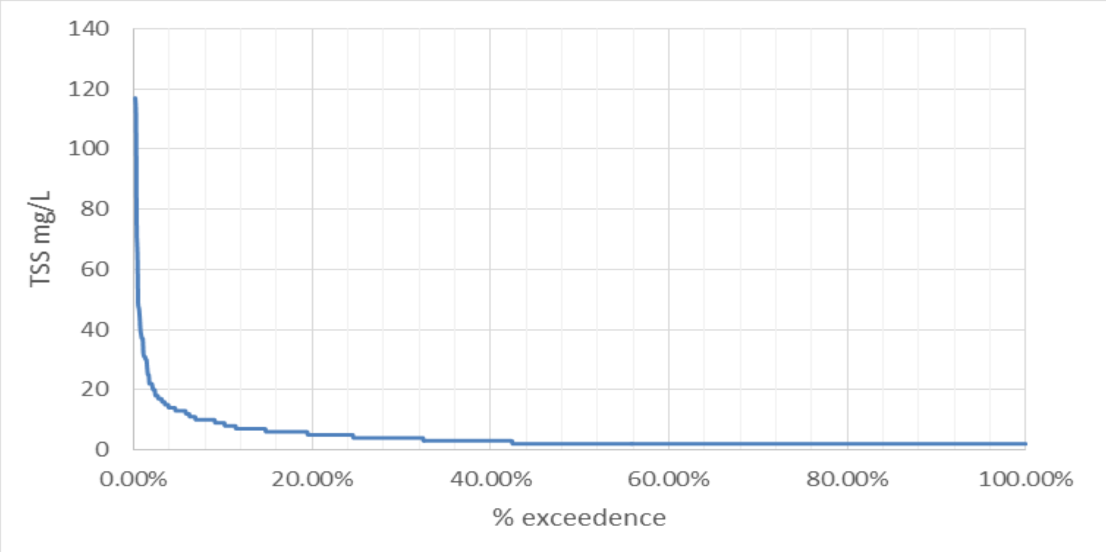

Figure 9-17 TSS treatment data using Siltbuster systems (with chemical dosing)

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Levally Stream, Sinking River, Grange River & Clare River) and designated sites and associated dependent ecosystems.

Pre-Mitigation Potential Effects: Negative, slight, indirect, temporary, likely effect on surface water quality.

Mitigation Measures:

Measures employed to prevent overdosing and potential chemical carryover:

- The siltbuster system comprises an electronic in-line dosing system which provides an accurate means of adding reagents, so overdosing cannot occur;
- Continued monitoring and water analysis of pre and post treated water by means of an inhouse lab and dedicated staff, means the correct amount of chemical is added by the dosing system;
- Dosing rates of chemical to initiate settlement is small, being in the order of 2-10 mg/L and the vast majority of the chemical is removed in the deposited sediment;
- Final effluent not meeting the discharge criteria is recycled and retreated, which has a secondary positive effect of reducing carryover; and,
- Use of biodegradable chemical agents can be used at very sensitive sites (i.e. upstream of SACs).

Residual Effects: With the implementation of the dosing technology and the continual monitoring of pre and post treatment water, the appropriate volume of chemical agent can be added to ensure that chemical carryover concentrations are present only in tiny trace amounts which will not cause any effects to receiving waters or associated aquatic ecology. The residual effect will be negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality.

Significance of Effects: For the reasons outlined above, no significant effects on the surface water quality will occur. In fact, we consider that the use of siltbuster systems has a significant positive effect in respect of surface water quality.

9.5.2.15 Potential Surface Water Quality Effects of the Proposed Grid Connection Earthworks Works and Watercourse Crossings (Grid Connection)

The Proposed Grid Connection comprises a proposed 220kV on-site substation, approximately ~2.6km of underground cabling route, ~1.17km of new access track and 2 no. end masts, 1 no. watercourse crossings on tributary of the Levally Stream (1 no. existing bridge on public road). Directional drilling will be used to cross the existing bridge on the public road.

Pathway: Surface water flowpaths/groundwater paths.

Receptor: Down-gradient water quality (Levally Stream and Grange River)

Pre-Mitigation Potential Effect: Negative, slight, indirect, temporary, likely effect to surface water quality.

Proposed Mitigation Measures:

Pre-commencement Temporary Drainage Works:

Prior to the commencement of substation, cable trenching, access road or end mast works the following key temporary drainage measures will be installed:

- All existing roadside drains (where present) that intercept the proposed works area will be temporarily blocked down-gradient of the works using check dams/silt traps;
- Culverts, manholes and other drainage inlets (where present) will also be temporarily blocked;
- A double silt fence perimeter will be placed along the road verge on the down-slope side of works areas that are located inside the watercourse 50m buffer zone on the Levally Stream tributary.

The following mitigation measures are proposed for the underground cabling watercourse crossing works:

- No stock-piling of construction materials will take place along the grid route;
- No refuelling of machinery or overnight parking of machinery is permitted in this area;
- No concrete truck chute cleaning is permitted in this area;
- Works will not take place at periods of high rainfall, and will be scaled back or suspended if heavy rain is forecast;
- Local road drainage, culverts and manholes will be temporarily blocked during the works;
- Machinery deliveries will be arranged using existing structures along the public road;
- All machinery operations will take place away from the stream and ditch banks, apart from where crossings occur. Although no instream works are proposed or will occur;
- Any excess construction material will be immediately removed from the area and sent to a licenced waste facility;
- No stockpiling of materials will be permitted in the constraint zones;
- Spill kits will be available in each item of plant required to complete the stream crossing; and,
- Silt fencing will be erected on ground sloping towards watercourses at the stream crossings if required.

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

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

Residual Effect: Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect of the Proposed Project will be negative, imperceptible, direct, long term, likely effect on surface water quality.

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

9.5.2.16 Potential Groundwater Effects Associated with Piled Turbine Foundations at Wind Farm

Turbine foundation piling works will only be required at the Wind Farm site and not the Grid Connection. Only the Wind Farm is assessed herein.

Due to the presence of deep peat and glacial tills at some of the proposed turbine locations, a range of foundation scenarios are proposed, including:

- Gravity foundations (preferred option pending further investigations);
- Pre-cast piled foundation with a configuration of up to 50 no. 300mm square concrete driven piles (potentially to be used at turbines T1 to T4 inside refined ZoC); and,
- Worst case, standard piled foundation with a configuration of up to 20 no. 900 to 1200mm cylindrical bored piles (potentially to be used at turbines T5 to T11).

The following potential scenarios arise in respect of proposed piling works:

- Creation of preferential pathways, through a low permeability subsurface layer (an aquitard such as lacustrine clay/marl/peat), to allow downward flow into the underlying aquifer;
- Creation of preferential pathways, through a low permeability subsurface layer (an aquitard such as lacustrine clay/marl/peat), to allow upward migration alkaline groundwater to the acidic bog surface, thus potentially altering local hydrochemistry and therefore vegetation at the bog surface; and,
- Creation of a blockage to regional groundwater flow within the underlying aquifer due to placement of pile clusters.

These pathways are analogous to pathways described for piling works associated with contaminated land sites, as detailed in Environment Agency (2001).

Pathways: Groundwater flowpaths (upward and/or downward pathways, and regional groundwater flows).

Receptors: Groundwater quality in the underlying Clare-Corrib GWB and groundwater hydrochemistry at the surface and within the peat bog.

Pre-Mitigation Potential Effects: Negative, moderate, direct, short term, likely effect on groundwater quality/hydrochemistry.

Proposed Mitigation Measures:

The proposed mitigation measures designed for the protection of downstream surface water quality and groundwater quality within the peat bog will be implemented at all construction work areas.

Proposed mitigation measures relative to piling works will comprise:

- Strict QA/QC procedures for piling works will be followed;
- Piles will be kept vertical during piling works;
- Good workmanship will be employed during all piling works; and,
- Where required use bentonite seal to prevent upward/downward movement of surface water/groundwater.

Impact Assessment:
The ground conditions at the Wind Farm site can be typically categorised into the following deposits (based on data presented in Chapter 8):

- **Basin Peat** – Typically described as spongy, dark brown, pseudo fibrous cutover peat (turbine locations T6, T7, T8, T10 and T11);
- **Shell Marl** – Located at turbines T6, T7, T10 & T11;
- **Glacial Tills** – Mainly CLAYs and SILTs (glacial tills derived from limestone). The confirmed thickness of the layer is variable across the proposed Site ranging between 5.7m and 15.5m at borehole locations;
- **Limestone Bedrock** – Limestone bedrock was encountered in boreholes at depths between 6 and 16.5mbgl; and,
- **Groundwater** – levels are typically less than 2mbgl with no up-welling potential onto ground surface.

Proposed piles will penetrate through peat deposits, lacustrine clay/marl deposits (where they occur), and then into underlying glacial tills or bedrock. Where present the marl layer is likely to act as an aquitard/low permeability layer, through which only very small amounts of water can flow.

Peat water is perched above the regional groundwater table. Peat water occurs in the bog basins, while regional groundwater flow will occur in the underlying bedrock aquifer. Glacial tills that occur between the base of the peat/lacustrine clays can be permeable in local zones, but in general will have a low permeability. Therefore, the two main groundwater systems are the upper acidic peat water, and the lower regional bedrock groundwater water. As the underlying bedrock is mainly limestone, the groundwater occurring within this aquifer will be alkaline.

For the driven piles the clay/marl and also the glacial tills are likely to 'self-seal' around the piles, meaning that a long term pathway between the upper peat/bog water and the lower bedrock aquifer will not be sustained.

Research indicates that provided the aquitard layer is of a reasonable thickness and the piles driven through have a cross section without re-entrant angles, the likelihood of creating preferential flowpaths for downward migration of leachate (i.e. peat water) is very low. This hypothesis is consistent with the results obtained by Hayman et al (1993) and Boutwell et al (2000).

For bored piles, as the temporary steel casing is removed, a steel reinforcement cage is added to the pile column and then concrete is added to the toe of the pile using a tremie pipe. Vermiculite is used to create a plug between the concrete and the displaced water, therefore the concrete seals the entire pile column and pushes the vermiculite plug to the surface as concrete is added. The temporary steel casing is removed carefully as the concreting works are being completed. This concreting process is similar to that used when grouting a water supply production well (IGI (2007), and EPA (2013)). This means that a long-term pathway between the upper peat/bog water and the lower bedrock aquifer will not be sustained.

Scenario 1: Creating a Pathway for Downward Flow
To ensure downward flow of peat water and/or pollutants from the piling works does not occur, a bentonite seal will be used in a starter pit for each driven pile, and the mitigation measures outlined above will be implemented. The concrete added to the bored pile will seal the pile annulus. As a result, the potential for either piling work option to create pathways for downward flow of peat water or pollutants that could affect groundwater quality in the underlying aquifer is imperceptible.

Scenario 2: Creating a Pathway for Upward Flow
No upwelling of groundwater to the peat surface water recorded in any of the site investigation boreholes at the Wind Farm site.

Notwithstanding this, to ensure upward flow of underlying groundwater via potential pathways created by piling works does not occur, a bentonite seal will be used in a starter pit for each driven pile, and the mitigation measures outlined above will be implemented. The concrete added to the bored pile will seal the pile annulus. As a result, the potential for piling works to create pathways for upward flow of alkaline groundwater to the bog surface is imperceptible.

Scenario 3: Blocking Regional Groundwater Flow
For example, worst case, if a piling array of 50 no. 300mm square piles is applied at each of the 11 no. turbine bases (as piling Option 2), this combined area of piling footprint amounts to ~49.5m^2, or 4.5m^2 per turbine base. Each turbine base is 500m – 800m apart. The area of the piles driven into the ground is distributed over a very large area, and that area only amounts to <0.03% of the development footprint, or <0.0005% of the proposed Site area. Also, none of the proposed piles would penetrate any great distance into the underlying bedrock aquifer, as they will find sufficient resistance, either in the over lying glacial tills/mineral subsoils or upon reaching the top of bedrock. At such wide separation distance, the ability of clusters of piles, with a plan area of ~4.5m^2 per turbine, to alter or affect regional groundwater flow is imperceptible.

Post-Mitigation Residual Effects: Should piling works be required at any of the proposed turbine locations, they potentially pose a threat to groundwater quality in the underlying regional groundwater system, and also could potentially create a pathway for upward migration of alkaline groundwater to the peat surface. These potential effects will not arise at the proposed site due to a combination of the prevailing ground conditions, groundwater conditions, and proposed mitigation measures, outlined above, that will ensure the potential pathways for interaction of shallow (acidic peat water) and deeper (alkaline) groundwater are prevented from occurring. In addition, due to the small footprint of proposed pile clusters, and the significant spacing between turbine bases where pile clusters are proposed, the potential for such pile clusters to block regional groundwater flow is imperceptible at that scale. The proposed piled foundations therefore have no potential to change the WFD status or impact the WFD objectives of the underlying Clare-Corrib GWB. The residual effect of the Proposed Project will be a negative, imperceptible, indirect, long term, likely effect on groundwater flow, and ground quality/peat water hydrochemistry.

Significance of Effects: For the reasons given above, no significant effects on regional groundwater and the Clare-Corrib GWB will occur, and no significant effects on peat water hydrochemistry will occur from proposed piling works.

9.5.2.17 Potential Effects on Wetland Hydrology (Proposed Project)

Construction phase activities such as excavations, dewatering, drainage installation and peat/spoil storage have the potential to affect wetland hydrology if not designed or laid out in an appropriate matter.

Proposed turbine locations T6, T7, T10 and T11 are located on cutover bog including the associated spoil/peat storage areas. There is no development proposed in areas of intact bog. The proposed Grid Connection also intercepts areas of cutover bog.

Due to the already cutover nature and existing extensive drainage at the Proposed Project areas on cutover bog, no significance effects on remaining areas of intact bog are expected. Also, the areas of intact bog closest to the Proposed Project, are already affected by the presence of drainage on the high bog surface.

Pathways: Surface Water and Groundwater flowpaths.

Receptors: Intact bog wetland hydrology.

Pre-Mitigation Potential Effects: Negative, slight, indirect, long-term, likely effect on intact bog wetland hydrology.

Impact Assessment/Proposed Mitigation Measures:

The main mitigation with regard the safeguard of existing peatland hydrology was the avoidance of areas of intact bog. Proposed turbine locations T6, T7, T10 and T11 as well as the Grid Connection are at least 50m away from areas of intact bog.

As assessed in Section 9.5.2.4 above (groundwater level effects), no significant effects or long-term effects on groundwater levels will occur due to the relatively shallow depth of the gravity foundations (3 – 3.5m deep) and the low permeability nature of the peat and glacial till overburden to be excavated. Significant groundwater inflows into turbine excavations will not occur for these reasons.

Any effects on groundwater levels will only be for a temporary basis during the construction work. Groundwater level effects are unlikely to be perceptible beyond 10m from the turbine base excavation. Once construction is completed and the works area reinstated, the local groundwater levels and peat waters levels will return to baseline conditions.

Residual Impact: Due to avoidance of intact bog, the prevailing hydrogeology/wetland hydrology at the Site as well as the local and temporary nature of the proposed works, residual effects of the Proposed Project on wetland hydrology will be negative, imperceptible, direct/indirect and short term.

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

9.5.2.18 Hydrological Effects Peatland Enhancement (Wind Farm)

The proposed Peatland Enhancement is associated with the Wind Farm element and not the Grid Connection. Only the Wind Farm is assessed herein.

The purpose of this Peatland Enhancement process is to establish a hydrological regime, which will allow for the regeneration of an area of raised bog. The overall aim of the peatland enhancement plan is to put the selected bog area at the Site on a trajectory towards becoming naturally functioning peatland by rewetting the surface of the bog by raising the water table in the drains, and in adjacent areas primarily through drain blocking in order to reduce run-off rates and carbon losses.

Pathway: Rewetting measures and targeted revegetation.

Receptor: Peat

Pre-Mitigation Potential Impact: Positive, slight, direct, permanent likely effect of Peatland Enhancement.

Mitigation Measures:
To maximise the effectiveness of the re-wetting proposal and to increase the chances of future success, any works undertaken as part of the enhancement plan will be based on approaches and methods that were successful at other peatland sites in Ireland.

Peat water level monitoring, by means proposed piezometer installs, will also be carried out to monitor the effectiveness of the bog re-wetting. The monitoring will continue through the lifetime of the Proposed Project.

Likely Residual Effect: The likely residual effect of the Proposed Project on peat following the implementation of the Peatland Enhancement plan is a moderate, positive, direct, permanent effect on peat as it will be wetter and closer to its natural condition with increases in vegetation cover across all bogs.

9.5.3 Operational Phase – Likely Significant Effects and Mitigation Measures

9.5.3.1 Removal of Vegetation Cover and Progressive Replacement of Natural Surface with Low Permeability Surfaces (Proposed Project)

Hardstand emplacement will be required at both the Wind Farm site and Grid Connection. Both assessed herein.

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

Progressive replacement of the vegetated surface with impermeable surfaces will decrease the permeability of the ground within the Site footprint (i.e., turbine bases, hardstandings, and to a lesser extent the new access roads) and substation. It should be noted that approximately 2km of the proposed Site roads already exist and are proposed for upgrade. The permeability along the internal underground cabling route through the Site will not be significantly altered, as the fill material will not be compacted.

The emplacement of the Proposed Project footprint, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials as a worst-case scenario) could result in an average total site increase in surface water runoff of approximately 1,261m^3/month (Table 9-17). This represents a potential increase of approximately 0.3% in the average daily/monthly volume of runoff from the Site area in comparison to the baseline pre-development site runoff conditions.

This is a very small increase in average runoff and results from a relatively small area of the overall Proposed Project site being developed. Specifically, the Proposed Project footprint is approximately 17.5ha, representing 5% of the total EIAR Study Area of 353ha.

The additional volume is low due to the fact that the runoff potential from the Site is naturally high (94%). Also, this calculation assumes that all hardstanding areas will be impermeable which considered to be a worst-case scenario. The increase in runoff from most of the development catchment will therefore be imperceptible and this is before mitigation measures will be put in place. This water balance assessment demonstrates that even in the absence of mitigation, the potential to alter the water balance of the Site or downstream hydrology/morphology is imperceptible.

Table 9-17: Baseline Site Runoff V Development Runoff

Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Footprint Area (m^2)	Footprint Area 100% Runoff (m3) (m^3)	Footprint Area 95% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m^3)	% Increase from Baseline Conditions (m^3)
398,516	12,855	175,000	21,018	19,756	1,261	41	0.316

Pathway: Site drainage network.

Receptor: Surface waters (Levally Stream, Sinking River, Grange River & Clare River) and dependent ecosystems.

Pre-Mitigation Potential Impact: Negative, imperceptible, indirect, long-term, likely effect on all downstream surface water bodies.

Proposed Mitigation by Design:

The proposed drainage philosophy outlined in Section 9.4.1 states that runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Project. The first being 'keeping clean water clean' and the second involving the collection of any drainage waters from work area and to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. The second method relates to proposed design measures that will prevent road surface and other hardstand areas acting as preferential flowpaths. All development site runoff will be collected, attenuated, treated and then released in a diffuse and regular manner that does not significantly change the natural drainage regime/hydrology of the site.

The operational phase drainage system of the Proposed Project will be installed and constructed in conjunction with the road and hardstanding construction work as described below and as shown on the drainage drawings (Appendix 4-5) submitted with this planning application:

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

- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in consideration of the greenfield runoff rate.

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

Residual Impact: Direct, negative, neutral, long term, likely effect of the Proposed Project on surface waters.

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

9.5.3.2 Runoff Resulting in Suspended Solids Entrainment in Surface Waters

Site runoff will occur at both the Wind Farm site and Grid Connection. Both assessed herein.

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 are likely to be completed, such as maintenance of site entrances, internal roads and hardstand areas. These works will be of a very minor scale and will be very infrequent. Potential sources of sediment laden water will only arise from surface water runoff from small areas where new material is added during maintenance works.

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Levally Stream, Sinking River, Grange River & Clare River) and associated dependent ecosystems.

Pre-Mitigation Potential Effect: Negative, slight, indirect, temporary, likely effect on surface water quality.

Proposed Mitigation Measures:

The mitigation measures outlined in Sections 9.5.2.3 & 9.5.3.1 will ensure all surface water runoff from upgraded roads and new road surfaces (including hardstand and turbine base areas) will be captured and treated prior to discharge/release. Settlement ponds, checks dams and buffered outfalls will prevent roads acting as preferential flowpaths by providing attenuation and water quality treatment.

It is proposed that bedrock won from the on-site borrow pit (i.e. limestone) will be used to construct the sub-base layer of proposed upgraded and new access roads, hardstand areas and turbine base areas.

Once installed the subbase layer will be overlain by a clean capping layer of high-grade stone material which will be sourced from the borrow pit or local quarries.

Post-Mitigation Residual Effects: With the implementation of the proposed drainage measures as outlined above, and based on the post-mitigation assessment of runoff, residual effects are - Negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality.

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

9.5.3.3 Potential Effects on the Gurteen/Cloonmore GWS Spring Source during Operational Phase (Wind Farm)

Only the Wind Farm element is located inside the refined ZoC to the Gurteen/Cloonmore GWS. Only the Wind Farm is assessed herein. The Grid Connection is located outside the Gurteen/Cloonmore GWS ZoC.

Turbines located inside the refined ZoC include T1, T2, T3 & T4. As stated above, only proposed turbine T1 is located upslope of the spring. Anywhere to the south of the spring is not located inside the refined ZoC. This includes all the remaining Wind Farm site area (including borrow pit and peat/spoil storage areas) as well as the Grid Connection (including substation).

During the operational phase, the potential for effects is much more limited than those associated with the construction phases as there is no further excavation/movement of soil/subsoil and the drainage system is fully constructed and operational.

Potential effects on the spring mainly include groundwater quality with regard contaminants such oils and fuels.

Source: Oils, fuels and Chemicals

Pathway (s): Recharge and shallow groundwater flowpaths.

Receptor: Gurteen/Cloonmore GWS

Pre-Mitigation Potential Impact: Indirect, negative, imperceptible, long term, unlikely impact to Gurteen/Cloonmore GWS.

Impact Assessment:

As outlined above, the potential for effects during the operational phase of the Proposed Project is much 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 regular plant which will be required on site will be maintenance/inspection vehicles (jeeps/vans/quads) and these will not be refuelled on-site.

Any hydrocarbons (oil) present within the turbine generator and gear box will be enclosed within a bund with 110% capacity.

There will be no storage of fuels, oils and chemicals inside any of the turbines.

Automated oil leak detectors will be placed in each of the turbines which will allow early detection of even the smallest leaks of oil or hydraulic fluid that may arise from components such as the transformer or gearbox.

Automated oil leak detectors will be placed in each of the turbines which will allow early detection of even the smallest leaks of oil or hydraulic fluid that may arise from components such as the transformer or gearbox.

The automated detection system will then rapidly notify the wind farm operator by cloud-based systems. This early detection system will prevent large leaks of oil or hydraulic fluid.

Residual Effect: Due to the low groundwater vulnerability rating coupled with the mitigation measures associated with drainage management and the protection of water quality, combined with the lack of any construction type activities no residual effect of the Proposed Project will occur. No residual effect on Gurteen/Cloonmore GWS.

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

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures (Proposed Project)

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

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

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

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

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

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

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

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

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

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

9.5.5 Risk of Major Accidents and Disasters (Proposed Project)

The main risk of Major Accidents and Disasters (MADs) at peatland sites is related to peat stability. A peat stability risk assessment (Appendix 8-1) has been completed for the Proposed Project Site and it concludes that due to the gentle sloping topography of the Site, and with the implementation of the proposed mitigation measures, that the risk of a peat failure at the Proposed Project site is low.

Flooding can also result in downstream MADs. However, due to the small scale of the Proposed Project footprint with regard the overall Site, the naturally high runoff rates, the avoidance of fluvial flood zones (see Section 9.3.6) and with the implementation of the proposed mitigation measures, the increased flood risk associated with the Proposed Project is imperceptible.

9.5.6 Assessment of Potential Health Effects (Proposed Project)

Potential health effects arise mainly through the potential for surface and groundwater contamination which can have negative effects on public and private water supplies. A portion of the Wind Farm site is located inside the Gurteen/Cloonmore GWS refined ZoC, but extensive investigations have been carried out to assess the risk (see Section 9.5.2.1) posed by the proposed Wind Farm. Notwithstanding this, the Proposed Project design and mitigation measures ensures that the potential for effects on the water environment will not be significant.

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues.

A detailed Flood Risk Assessment (Appendix 9-1) has been caried out for the Proposed Project, summarised in Section 9.3.6. This Flood Risk Assessment, combined with the assessment of changes in permeable surfaces (Section 9.5.3.1) demonstrates that the risk of the Proposed Project contributing to downstream flooding is imperceptible. On-site (construction and operation phase) drainage control measures will ensure no downstream increase in local flood risk.

9.5.7 Cumulative Effects (Proposed Project)

This section presents an assessment of the potential cumulative effects associated with the Proposed Project and other developments (existing and/or proposed) on the hydrological and hydrogeological environment.

The main likelihood of cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater). Due to the local hydrogeological setting (i.e. low permeability peat and glacial tills) and the near-surface nature of construction activities, cumulative effects with regard groundwater quality or quantity arising from the Proposed Project are assessed as not likely.

The primary potential for cumulative effects will occur during the construction phase of the Proposed Project as this is when earthworks and excavations will be undertaken at the Site. The potential for cumulative effects during the operational phase of the Proposed Project will be significantly reduced as there will be no exposed excavations, there will be no sources of sediment to reach watercourses, there will be no use of cementitious materials and fuels/oil will be kept to a minimum at the site. During the decommissioning phase, the potential cumulative effects are similar to the construction phase, but to a much lesser degree with less ground disturbance.

The cumulative Water Study area is delineated by the catchment of the Clare River which has an area of ~1,000km^2. Downstream of the Clare River catchment (i.e. Lough Corrib itself) no cumulative hydrological effects are likely due to the large upstream catchment area of Lough Corrib (i.e. ~3,100km^2) and the very high dilution effects afforded by such a large regional catchment, subsequent large surface water flows and the natural attenuation afforded by Lough Corrib itself.

- The cumulative study area for assessing other wind farms is the Clare River catchment;
- The cumulative study area for assessing small projects (i.e. agricultural, forestry and smaller planning applications) include the Levally Stream_010, Sinking_020 and Clare(Galway)_020 sub-basins.

A hydrological cumulative impact assessment is carried out on a regional catchment scale for other large projects such as other wind farm developments and large-scale infrastructure developments located inside the Clare River catchment. Other smaller developments have been excluded at this regional scale as cumulative effects are likely to be less than perceptible at this (regional) scale.

A hydrological cumulative impact assessment is then undertaken on a more local scale using WFD sub-basins (in which the proposed Project is located) as the cumulative study area.

9.5.7.1 Cumulative Effects with Agriculture

According to Corine land cover mapping (www.epa.ie) (2018) the Clare River catchment is a largely agricultural catchment.

Agricultural practices such as the movement of soil and the addition of fertilizers and pesticides can lead to nutrient losses and the entrainment of suspended solids in local surface watercourses. This can have a negative effect on local and downstream surface water quality.

In an unmitigated scenario the Proposed Project would have the potential to interact with these agricultural activities and contribute to a deterioration of downstream surface water quality through the emissions of elevated concentrations of suspended solids and ammonia.

However, the mitigation measures detailed in Section 9.5 for the construction, operation and decommissioning phases of the Proposed Project will ensure the protection of downstream surface water quality.

For these reasons, we consider that there will not be a significant cumulative effect associated with agricultural activities.

9.5.7.2 Cumulative Effects with Commercial Forestry

The most common water quality problems arising from forestry relate to the release of sediment and nutrients to the aquatic environment, and impacts from acidification. Forestry works can also give rise to modified stream flow regimes caused by associated land drainage.

Given that most of the main forestry plantations are located a significant distance from the Proposed Project site, the likelihood of significant potential effects occurring is very small.

However the mitigation measures detailed for the construction, operation and decommissioning phases of the Proposed Project will ensure the protection of downstream surface water quality.

For these reasons we consider that there will not be a significant cumulative effect associated with commercial forestry activities.

9.5.7.3 Cumulative Effects with Turbary Peat Cutting Activities

Private peat cutting on turbary plots will likely continue in the vicinity of the Proposed Project site and in the wider cumulative area. The construction phase of the Proposed Project is likely to interact with these turbary activities and result in a deterioration of downstream surface water quality through the emissions of elevated concentrations of suspended solids and ammonia.

However, the areas of private peat cutting will be small, significantly limiting the potential for cumulative effects to arise with the Proposed Project. Nevertheless, the mitigation measures detailed for the construction, operational, and decommissioning phases of the Proposed Project will ensure the protection of downstream surface water quality.

For these reasons outlined above we consider that there will not be a significant cumulative effect associated with turbary activities.

9.5.7.4 Cumulative Effects with One Off Housing Developments

A detailed cumulative assessment has been carried out for all planning applications (granted and awaiting decisions) within the cumulative assessment area described above.

There are applications are for new dwellings or renovations of existing dwellings, as well as for the erection of farm buildings. Based on the scale of the works, their proximity to the Site and the temporal period of likely works, no cumulative effects will occur as a result of the Proposed Project (construction, operation and decommissioning phases).

9.5.7.5 Cumulative Effects with Other Wind Farms

In addition to the proposed Clonberne Wind Farm, 4 no. other wind farms have been identified within the Clare River catchment/cumulative study area (refer to Table 9-18). Within these existing and proposed wind farms there are a total of 13 no. turbines potentially situated within the Clare River catchment/ cumulative study area.

The total number of wind turbines that could potentially be operating in the cumulative study area is 24 no. (11 no. from Clonberne Wind Farm site and 13 no. turbines from the other wind farms.

The total area of the Clare River catchment is c. 1000km^2 which equates to 1 no. turbine per ~42km^2 which is considered not significant in terms of likely cumulative hydrological effects on the Clare River.

The EIARs for the above wind farm developments will be required to detail potential hydrological and hydrogeological issues relating to the construction, operation and decommissioning phases of these developments and propose a suite of best practice mitigation measures designed to ensure that the developments do not in any way have a negative effect on downstream surface water quality and quantity. Similarly, the mitigation and best practice measures proposed in this EIAR chapter will ensure that the Proposed Development does not have the potential to result in significant effects on the hydrological/hydrogeological environment.

Therefore, due to the dispersed nature/setback distance of the other wind farms along with the implementation of the proposed mitigation measures for the Proposed Project (listed in Table 9-18) there will be no cumulative effects associated with the construction, operational or decommissioning phases of the Proposed Project and other wind farms within the cumulative study area.

Table 9-18:: List of Other Wind Farm Developments Assessed for Hydrological Cumulative Effects

Catchment	Wind Energy Development (Status)	Total Turbine No.	Turbine No. in Clare Catchment
Clare River	Cooloo WF (future proposal)	9	9
	Laurclavagh WF (future proposal)	8	1
	Clonlusk WF (existing)	2	2
	Cloonascragh WF (Permitted)	1	1
Totals		**20**	**13**