APPENDIX 3

HYDROLOGICAL ASSESSMENT

9. WATER

9.1 Introduction

9.1.1 Background and Objectives

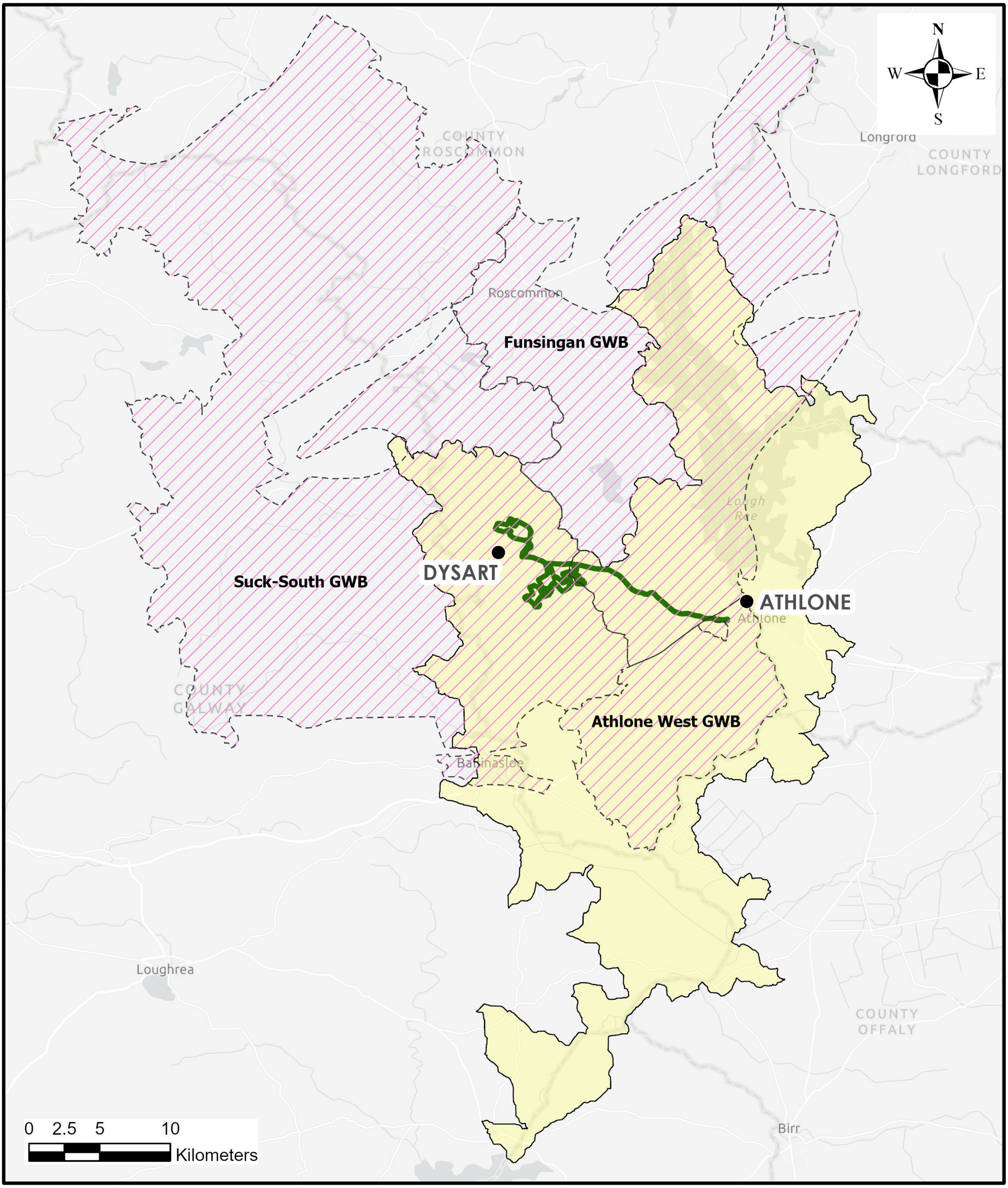
Hydro-Environmental Services (HES) was engaged by MKO Ireland (MKO) to carry out an assessment of the potential effects of the Proposed Development (as defined in Chapter 4). The Northern Cluster of the Proposed Development includes 7 no. turbines and is situated ~1.6km northeast of Dysart, Co. Roscommon, while the Southern Cluster of the Proposed Development includes a further 13 no. turbines and is located ~3.3km southeast of Dysart.

The objectives of this assessment are to:

- provides a baseline study of the existing water environment (surface and groundwater) in the area of the Proposed Development;
- Identifies likely positive and negative impacts of the Proposed Development on surface and groundwater during construction, operational, and decommissioning phases of the Proposed Development;
- Identifies mitigation measures to avoid, remediate or reduce significant negative effects; and,
- Assesses the significant residual effects and cumulative effects of the Proposed Development along with other permitted and proposed projects and plans.

Please note, for the purposes of this chapter, where:

- The 'Proposed Development', is referred to, this relates to all the project components described in detail in Chapter 4 of this EIAR.
- The 'Wind Farm' is referred to, this relates to all infrastructure for the wind farm as detailed in Chapter 4 in both the Northern and Southern Clusters. In some instances, the Northern and Southern Clusters are differentiated for ease of baseline description assessment.
- The 'Grid Connection' is referred to, this relates to all grid infrastructure, as detailed within Chapter 4, outside the Wind Farm site, within the local road network to Athlone 110 kV substation in Monksland.
- Where 'the site' is referred to, this relates to the EIAR Site Boundary as shown on all associated figures. Other elements of the Project are referenced accordingly (i.e. the turbine delivery route etc).
- A Water Study Area is also defined in Figure 9-1, and this includes all surface water bodies and groundwater bodies that can potentially interact with the Proposed Development (excluding the TDR).



Legend

- EIAR Site Boundary
- Water Study Area (SWBs)
- Water Study Area (GWBs)

Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Water Study Area Map	
Figure No: 9-1	
Drawing No: P1500-0-422-A4-901-00A	Scale: 1:350,000
Drawn By: GD	
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9.1.2 Statement of Authority

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

Our core areas of expertise and experience include hydrology, hydrogeology and karst hydrogeology and wind farm drainage design and management. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types including wind farm and grid connection developments.

This chapter of the EIAR was prepared by Michael Gill and Adam Keegan, with assistance from Conor McGettigan.

Michael Gill P.Geo (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in karst hydrogeology and also in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 100 other wind farm-related projects. Michael has also worked on karst related projects in South and Mid Galway, Roscommon, Tipperary, Laois, Kilkenny, Limerick, Clare, Cork and Waterford.

Adam Keegan (BSc, MSc) is a hydrogeologist with two years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF. Adam has also worked on water supply projects and karst related projects in Galway, Clare, Tipperary and Waterford.

Conor McGettigan (BSc, MSc) is a recent graduate, holding an M.Sc. in Applied Environmental Science (2020) from University College Dublin, graduating with a First-Class Honours degree. Conor has also completed a B.Sc. in Geology (2016) from University College Dublin (First Class Honours). In recent times Conor has assisted in the preparation of the geology and water sections of various developments including wind farms and quarries.

9.1.3 Scoping and Consultation

The scope for this chapter of the EIAR has been informed by the previous reasons for refusal in respect of a historic project, and by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.4 of this EIAR. Issues and concerns highlighted with respect to the water environment are summarised in Table 9-1 below.

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

Degree/Nature	Description	Addressed in Section
Roscommon County Council Heritage Officer	› Potential for impact on two identified sites of County Geological importance,	Section 9.3.6 and Section 9.5.2.7

Degree/Nature	Description	Addressed in Section
	1) Killeglan Karst Landscape and 2) Castlesampson Esker	

Geological Survey of Ireland (GSI)	- Potential for impact on two identified sites of County Geological importance, 1) Killeglan Karst Landscape and 2) Castlesampson Esker
	- Potential for impact on groundwater resources as the Wind Farm Site is underlain by a Regionally Important Karstified (conduit) Aquifer with areas of Extreme and High groundwater vulnerability.
	- Potential for impact on groundwater resources (flow and quality) within the mapped contribution/source areas for Killeglan Public Water Supply - Tobermore Spring, and potential impacts to other local domestic and agricultural groundwater users.
	- The area is known for groundwater flooding and indicates GWFlood Project is mapping and monitoring groundwater related flooding in the area. Parts of the northern cluster is located close to a mapped turlough.
	- Indicates that various datasets are available on the GSI website:
	  - Groundwater level monitoring.
	  - Geological Mapping
	  - Geohazards
	  - Natural Resources
		Section 9.3.6 and Section 9.5.2.7.
		
		Sections 9.3.7 and 9.3.8 and Section 9.4.2.2.
		
		Section 9.3.7 and 9.3.7.7 and Section 9.4.2.10.
		
		Sections 9.3.5 and 9.3.7. and Sections 9.4.2.8 and 9.4.2.9. [the specific groundwater flooding area being referred to at the Northern Cluster is Gortaphuill turlough].
		
		Noted, and all datasets were used.

Inland Fisheries Ireland (IFI)	- Mapping of all watercourses and drainage pathways required to be assessed. - Detailed baseline description of aquatic habitats required (watercourses, lakes and turloughs). Assessment of any impacts on river hydromorphology. - Site geology and slope stability/geohazards - Site hydrology and drainage management during construction and operational phases. - Site access roads should not become a focal point for the concentration of runoff. - Control measures for cement material, hydrocarbons, silt, and toxic poisonous materials should be outlined. - Describe and assess proposed watercourse crossings. - Liaise with IFI where instream works are proposed.	Section 9.3.4 Section 9.3 Section 9.4.2.1 Chapter 8. Section 9.3.14/Appendix 4-2. Section 9.3.14 Sections 9.4.2.5, 9.4.2.7 & 9.4.2.6

Degree/Nature	Description	Addressed in Section
	› Proposals for monitoring of watercourses and groundwater during and after the construction phase should be presented. › Transfer of surface water from one catchment to another should be avoided.	
Irish Water (IW)	a) In relation to the management of surface water; the potential impact of surface water discharges to combined sewer networks & potential measures to minimise/stop surface waters from combined sewers e) Any physical impact on IW assets – reservoir, drinking water source, treatment works, pipes, pumping stations, discharges outfalls etc. including any relocation of assets g) Any potential impacts on the assimilative capacity of receiving waters in relation to IW discharge outfalls including changes in dispersion /circulation characterises h) Any potential impact on the contributing catchment of water sources either in terms of water abstraction for the development (and resultant potential impact on the capacity of the source) or the potential of the development to influence/ present a risk to the quality of the water abstracted by IW for public supply. j) Mitigation measures in relation to any of the above	There are no connections to IW services proposed. Assessment of impacts on existing assets such as Killeglan Public Water Supply (Tobermore Spring Source) and Mount Talbot PWS is completed at Sections 9.3.7 and 9.3.7.7 and Section 9.4.2.10.

9.1.3.1 Planning History Review Relevant to the Water Environment

Prior to embarking on the current EIAR, HES completed a thorough hydrological and hydrogeological review the previous planning files (previous applications: 10/541 and 11/273) with respect to geology, hydrogeology and hydrology. This review informed our professional opinion with respect to the scope and approach of the assessment of the current Proposed Development.

Arising from that review, the following items informed the methodology (refer to Section 9.2 below) of this assessment:

- The impact assessment shall be underpinned by site-specific geological and hydrogeological dataset, desk study information should be backed up by site data;
- Any site investigation works should to be iterative;
- Seasonal water level monitoring in local turloughs is required, and this shall be coupled with groundwater level monitoring in as many local domestic wells and groundwater monitoring wells as possible, and contemporary rainfall monitoring to be undertaken. All recorded water levels should to be relative to Ordnance Datum (m OD);
- Site investigations to be scoped from a hydrogeological (impact) assessment perspective, and from an engineering geology/design and site drainage perspective. Subsoil composition, subsoil permeability and density, and subsoil variability should be understood;
- There should be no Wind Turbine Generator (WTG) proposed over known or suspected karst anomalies;

- The drainage proposals for the Wind Farm site layout should be bespoke, and complementary to the prevailing geological, hydrological and hydrogeological environment;
- A clearly defined and robust design for the Proposed Development should be presented for the purposes of this environmental assessment, with no gaps or postponement of design elements to post consent phase; and,
- The findings of the Environmental Assessment should be clear and unambiguous.

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;
- EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and Directive 2009/147/EC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293/1988: Quality of Salmon Water Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722/2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for the implementation of 'daughter' Groundwater Directive (2006/118/EC);
- S.I. No. 684/2007: Waste Water Discharge (Authorisation) Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249/1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (as amended by 2000/60/EC in 2007);
- S.I. No. 122/2014: European Union (Drinking Water) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010, as amended; and,
- S.I. No. 296/2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009, as amended.

9.1.5 Relevant Guidance

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

- Environmental Protection Agency (2022): Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements;

- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Department of Environment, Heritage and Local Government (DoEHLG); Wind Energy Development Guidelines for Planning Authorities (2006);
- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016);
- Good Practice During Wind Farm Construction (Scottish Natural Heritage, 2010);
- Scottish Natural Heritage (2010): Good Practice During Wind Farm Construction;
- 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); and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.2 Methodology

9.2.1 Desk Study & Preliminary Hydrological Assessment

A desk study and preliminary hydrological assessment of the Proposed Development site and the surrounding area was completed in advance of the site walkovers, site investigation works, and in advance of seasonal monitoring being implemented. This involved collection of all relevant geological, hydrological, hydrogeological and meteorological data for the Proposed Development site and the surrounding area (refer to Figure 9-1). This included consultation with the following sources:

- Environmental Protection Agency (EPA) database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 12 (Geology of Longford and Roscommon). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland (2004) – Suck South and Funshinagh Groundwater Body Initial Characterization Reports;
- Office of Public Works Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – “Hydrotool” Map Viewer (www.epa.ie);
- GSI Groundwater Flood mapping (www.gsi.ie);
- CFRAM flood maps (www.cfram.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie); and,
- Monthly downloads and data processing of publicly available water level data from Lough Funshinagh and other available sources (Killeglan PWS, Suck River- 2 Locations, Turrock GW Level, Lysterfield Stream, Four Roads Turlough).

9.2.2 Site Investigations & Seasonal Hydrological & Hydrogeological Monitoring

A comprehensive geological, hydrological and hydrogeological dataset has been collected as part of this EIAR study. Prior to the implementation of our seasonal monitoring programme HES completed a detailed review of the previous planning applications and associated planning files to develop an appropriate monitoring regime (see Section 9.1.3.1).

Initial walkover surveys, geological/hydrogeological mapping and baseline monitoring of water levels in nearby turloughs and private wells were conducted between 21st – 23rd January 2020. During this time observations were made on near surface geological features including exposed or visible quaternary features such as eskers/drumlins which might impact the hydrological regime. Water level monitoring equipment was also installed in the surrounding key turloughs (list provided below) and within accessible nearby farm and domestic groundwater wells (sufficient to provide a suitable geographic spread of groundwater monitoring locations around the Northern and Southern Clusters).

Water levels in the boreholes and turloughs surrounding the Northern and Southern Clusters were monitored between January 2020 – May 2021. The duration and extent of the water level monitoring are outlined in the relevant sections (Sections 9.3.7.6, and 9.3.7.8.1) In total 20 no. farm/domestic/quarry wells were monitored with in-situ Diver water level dataloggers as well, data was acquired from 1 no. EPA monitoring well and water levels were monitored at 8 no. turloughs. These data were normalised with a permanent barometer located within the area and compared with rainfall collected using an installed rain gauge. These data provide an ~18 month record of water levels in boreholes and turloughs which can be compared and correlated. To complement the collection of the water level data, water samples from 4 no. private domestic wells, from 2 no. nearby surface water courses and from 2 no. turloughs were also taken. These water samples were sent to an accredited laboratory for analysis and to provide details on the hydrochemical signature of each water source. Field hydrochemistry was also taken during the groundwater sampling.

Numerous intrusive site investigations have taken place across the Northern and Southern Clusters, to provide detail and clarity on the nature and extent of subsoils and bedrock and evidence for potential karstification of the Limestone bedrock. These include:

- 6 no. rotary core boreholes were drilled across the Northern and Southern Clusters in 2020 by Petersen Drilling Ltd., supervised by HES. These boreholes were drilled between 30.5-48.5m deep and provided a hydrogeological monitoring platform, along with the monitoring installed in farm/domestic wells and key surrounding turloughs. Although the monitoring wells were dry at the time of drilling, water level loggers were installed in these new monitoring wells to monitor any groundwater which may seep in over time.
- Following this drilling 16 no. boreholes were drilled by IGSL within the Northern Cluster, on behalf of MWP (engineering design consultants), with bedrock encountered in 6 of these 16 no. boreholes. A further 26 no. boreholes were drilled at the Southern Cluster by IGSL, with bedrock encountered in 19 of these 26 no. boreholes.
- Particle size distribution analysis was performed on 52 no. subsoil samples taken from the trial pits excavated between November – December 2020.
- Access was granted by Roadstone Ltd to monitor water levels in boreholes located at Cam Quarry, just north of the Southern Cluster. Diver water level dataloggers were installed in 3 no. boreholes around the quarry.
- In addition to the above, historic data from 25 no. trial pits completed at the Northern and Southern Clusters (previously referred to as Phase 1 & II of the historically proposed project) were completed in 2010 and 2011, and 6 no. rotary core boreholes were drilled (supervised by Jennings & O'Donovan) within the Northern and Southern Cluster in 2015.
- In total, the available geological dataset comprises:
  - 47 no boreholes, or 394.6m of borehole drilling has been completed across the Southern Cluster.
  - 22 no. boreholes, or 285.7m of borehole drilling has been completed across the Northern Cluster.
  - 112 no. trial pits.
  - 68 no. dynamic probes.
  - 45 no. Geophysical 2D resistivity profiles and 44 no. Seismic refraction profiles, and 1D MASW survey at each proposed turbine base.
  - Laboratory testing, including 82 no. PSDs (particle size distributions), 8 no. density test, and 12 no. permeability tests.

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

- 20 no. water level monitoring devices (Eijkelkamp Diver) and 1 no. barometric monitoring device installed within public/domestic/quarry groundwater wells in the areas surrounding the Northern and Southern Clusters;
- 8 no. water level monitoring devices installed within 8 no. turloughs, including;
  - Lough Croan: 21st January 2020 – 19th June 2020);
  - Thomas Street: 21st January – 26th May 2020 and 22nd October 2020 – 13th July 2021;
  - Feacle Turlough: 21st January – 18th June 2020 and 22nd October 2020 – 13th July 2021;
  - Gortaphuill: 21st January – 26th May 2020;
  - Commons: 21st January – 26th May 2020;
  - Cuilleenirwan: 21st January – 26th May 2020;

  - Ballyglass River: 21st January – 26th May 2020;
  - Dooloughan: 21st January – 26th May 2020;
- Monitored groundwater level data was acquired for;
  - Turrock groundwater well (2015-2021)
  - Four Roads Turlough (2016-2019)
  - Lisduff Turlough (2016-2018)
  - Lough Croan (2016-2018)
  - Lough Funshinagh (2016-2021)
  - Lough Ree (2017-2021)
- Monitored surface water level data was acquired for;
  - River Suck - at Derrycahill (2017-2021)
  - River Suck – at Rockwood (2017-2021)
  - Killeglan Spring/River (2001-2021)
  - Lysterfield Stream (1999-2021)
- All of the above water level monitoring data corresponds to a total of 37,398 (10,032 collected by HES) hydrological days of monitoring and 353,920 individual pieces of seasonal water level data ((~230,000 of which were collected by HES);
- Installed 1 no. rain gauge recording at 15-minute intervals (installed at the Northern Cluster. Note, given the proximity to the Southern Cluster (within 3.5km), and the availability of rainfall data from met Eireann it was not considered necessary to install a second raingauge at the Southern Cluster);
- Groundwater sampling (8 no. locations) and concurrent field chemistry monitoring; and,
- Walkover surveys and drainage mapping of the site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded.

Construction Environmental Management Plan (CEMP) included in Appendix 4-9, and Drainage design report included in Appendix 4-8.

9.2.3 Impact Assessment Methodology

Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology (Environmental Protection Agency (EPA), 2022). In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in

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

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

Sensitivity of Receptor	
Not sensitive	Receptor is of low environmental importance (e.g. surface water quality classified by EPA as A3 waters or seriously polluted), fish sporadically present or restricted). Heavily engineered or artificially modified and may dry up during summer months. Environmental equilibrium is stable and is resilient to changes that are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. GSI groundwater vulnerability "Low" – "Medium" classification and "Poor" aquifer importance.
Sensitive	Receptor is of medium environmental importance or of regional value. (e.g. surface water quality classified by EPA as A2 waters). Salmonid species may be present and may be locally important for fisheries. Abstractions for private water

Sensitivity of Receptor	
	supplies. Environmental equilibrium copes well with all natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. GSI groundwater vulnerability "High" classification and "Locally" important aquifer.
Very sensitive	Receptor is of high environmental importance or of national or international value i.e. NHA or SAC. Surface water quality classified by EPA as A1 and salmonid spawning grounds present. Abstractions for public drinking water supply. GSI groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

The conventional source-pathway-target (receptor) model (see Figure 9-2 below, top) was applied to assess potential impacts on downstream environmental receptors (see below, bottom as an example) as a result of the Proposed Development.

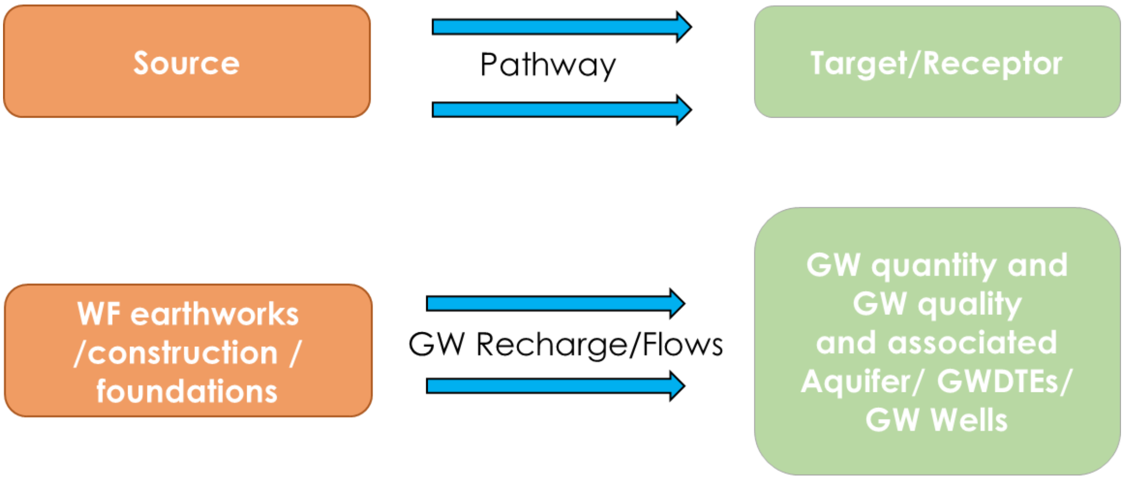


Figure 9-2: Source-Pathway-Target Model

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 EPA:

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

The description process clearly and consistently identifies the key aspects of any potential 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 9.4.2 and 9.4.3), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

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

Table 9-3 below.

Table 9-3: Stepwise impact assessment process

Step 1	Identification and Description of Potential Impact Source: This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The pre mitigation significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant negative 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.

9.2.4 Limitations and Difficulties Encountered

Some limitations were encountered during the preparation of the Water Chapter of this EIAR, namely:

- Access to Four Roads turlough could not be gained. It was hoped to monitor groundwater levels in this turlough throughout the monitoring period. However, water level data from the GSI was used in respect of this turlough.
- Available water level data for Lisduff turlough was deemed appropriate for assessment given the separation distance from the Proposed Development site to that turlough, and also given the prevailing regional drainage patterns.
- Access to Corkip turlough could not be gained. It was hoped to monitor groundwater levels in this turlough throughout the monitoring period. However, water level data from a local groundwater well was used as a surrogate/proxy for water levels in this turlough.

9.3 Receiving Environment

9.3.1 General Site Description

The Proposed Development site is located just east and south of the village of Dysart, Co. Roscommon and 11km west of Athlone, Co. Westmeath. There are two areas of Proposed Development, the Northern Cluster and the Southern Cluster of wind turbines. A site location map showing these 2 no. clusters are given in Figure 1-1 of Chapter 1.

9.3.1.1 Northern Cluster

The Northern Cluster Wind Farm site area is located ~ 1.6km northeast of Dysart and consists of 7 no. turbines within a ~2 km^2 area between the townlands of Cronin, Gortaphuill and Cornalee. The topography is slightly undulating, with elevations ranging between 70-105 m OD, with the turbine locations situated along a northwest-southeast trending ridge. The land is generally agricultural, primarily used for grazing and varies from rough ground with scrub vegetation and boulders to improved grassland. The higher ground at the Northern Cluster (i.e., the ridge) is surrounded by lower lying agricultural lands, which are generally improved and high yielding grasslands. There are a number of turloughs situated within the low-lying areas, with a number of turloughs situated within localised depressions. These surrounding (on lower lying ground) turloughs are generally situated at elevations of <65 m OD.

Access to the Wind Farm site is via a small local road from the R357, ~1.5km north of Dysart and via a second local road off the R363, ~1.4km east of Dysart.

9.3.1.2 Southern Cluster

The Southern Cluster Wind Farm site area is located ~3.3 km southeast of Dysart, Co. Roscommon and 12km west of Athlone. Co. Westmeath. The Southern Cluster consists of 13 no. proposed turbine locations over a ~5km^2 area, from the townland of Milltown towards Cuilleenoolagh and Cam Hill. Elevation ranges between 70-110 m OD, along a northwest-southeast range of small hills, which are locally steep in places. The ridgeline of these hills and the lower elevation improved grassland is evident within Site Photograph 1 of Appendix 8-1. The land above ~90m OD is generally scrub vegetation, rough grass and Blackthorn trees, strewn with glacially deposited boulders, with a considerable amount of localised depressions and variations in topography. The land is generally agricultural at elevations below ~90 m OD, used for grazing and appears well drained.

The Southern Cluster area is accessible via several small roads and farm tracks which run between the R363 and R357.

9.3.1.3 Grid Connection Route

A connection between the onsite electrical substation and the national electricity grid will be necessary to export electricity from the Wind Farm site. It is proposed to construct a 110 kV substation within the site and to connect from here via a 110 kV underground cable connection to the existing Athlone 110 kV substation in Monksland, located approximately 11.3km to the east of the Southern Cluster, via underground cabling. The majority of the Grid Connection route is located within the public road and measures approximately 12km in total. This underground cable connection will originate at the proposed electrical onsite substation, continue along the R363, transitioning to the R362 near the townland of Ballymullavill, travelling north along the L2047 before reaching the Athlone 110 kV substation at Monksland. The route is generally flat, apart from a section of the R363 which passes over Cam Hill.

A map of the proposed Grid Connection route is given in Figure 4-15 of Chapter 4.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30-year annual average rainfall (1981 - 2010) recorded at Ballyforan, Co. Roscommon, approximately 4 kilometres east of the Proposed Development Site, are presented in Table 9-4. More recent rainfall data from Leacarrow are included in Table 9-5.

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

Station		X-Coord		Y-Coord		Ht (m OD)		Opened		Closed		
Ballyforan G.S		182400		246600		50		1944		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	**Total**
99	68	75	56	68	65	59	88	88	100	95	97	**958**

Table 9-5: Monthly Rainfall Data from Leacarrow (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
2017	30	83.3	105.8	16.8	80.6	101.8	87.5	102.2	113.7	104.6	82.5	114.2	1023
2018	183.8	56.6	62.5	82.3	49.9	39.6	33.8	84	55.6	32.4	101.8	105.4	888
2019	46.5	64.5	167	62.5	41.7	102.3	50.5	235.4	110.5	95.8	90.5	121.5	1189
2020	93.2	244.2	84.5	39.5	19.7	79.3	109	143.4	80.9	162.9	113.7	97.9	1268
2021	138.6	101.5	97.6	23.6	130.6	26.4	73.9	73.8	91.3	127.4	46.8	102.2	1034
2022	52.2												-

The closest synoptic weather station where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 60 kilometres east of the site. The long-term average PE for this station is 446mm/yr. This value is used as the best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 423mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

=985mm/yr – 423mm/yr

ER = 562mm/yr

The recharge coefficient estimates from the GSI (www.gsi.ie), give an estimate of 60% recharge for the soils/subsoil near the Wind Farm Site. In reality, the recharge potential for the site is likely between 80-100%. The distinct lack of surface water features (streams/rivers) near the site would indicate that all water is infiltrating to ground (i.e., 100% recharge). A regional recharge value of 100% is assumed, based on the lack of surface water features, however, this will vary locally.

No evidence of any surface water channels/field drains are apparent within the site (Northern and Southern Clusters). Annual recharge and runoff rates for the study area (Northern and Southern Cluster) are estimated to be 562 mm/yr and 0 mm/yr respectively. Similar baseline conditions occur along the grid connection route.

This runoff rate of 0mm/year refers to the overall volume of water leaving the Wind Farm site as surface water runoff. There are no surface water features draining this Wind Farm site, therefore the site runoff is 0mm/year. However, localised runoff or brief overland flow can occur, particularly during heavy rainfall events, but this water will infiltrate down into ground and recharge to the underlying aquifer rather than reaching a stream or watercourse. Recharge and runoff conditions change approaching Athlone from the northwest along the grid connection route, as a number of watercourses are mapped, and the dominance of the underlying groundwater drainage reduces.

Table 9-6 presents return period rainfall depths for the centre of the proposed Wind Farm site, near Dysart. 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, 5-year, 10-year, 50-year, and 100-year). Similar baseline rainfall conditions occur along the grid connection route.

Table 9-6: Return Period Rainfall Depths for the Wind Farm

	Return Period				
Duration	1-year (mm)	5-year (mm)	10-year (mm)	50-Year (mm)	100-Year (mm)
15 min	5.7	9.4	11.6	17.9	21.5
1 hour	9.7	14.9	17.9	26.3	30.8
6 hour	19.1	27.2	31.6	43.1	49.0
12 hour	24.9	34.4	39.3	52.2	58.6
24 hour	32.5	43.4	49.0	63.2	70.2
48 hour	40.4	52.4	58.5	73.6	81.0

9.3.3 Regional and Local Hydrology

With respect to regional hydrology, the proposed Wind Farm site is located primarily within the Upper Shannon (26D) catchment, with a small section to the southeast of the Wind Farm site within the Upper Shannon (26G) catchment, all within Hydrometric Area 26 (Upper Shannon) of the Irish River Basin District.

On a local scale, the proposed Wind Farm site (Northern and Southern Clusters) is broadly contained within the River Suck sub-catchment (Suck_SC_090), with a small section of the Southern Cluster (T19 & T20) contained within the Cross River sub-catchment (Shannon[Upper]_SC_100). The proposed Grid Connection route is mostly located within the Cross River sub-catchment (Shannon[Upper]_SC_100), with a small section close to Athlone located in the Shannon[Upper]_SC_090 sub-catchment. These surface water catchment areas are illustrated in Figure 9-3.

The River Suck is located ~3.5km west of the Southern Cluster area, and ~3.9km west of the Northern Cluster. The River Suck flows south through the village of Ballyforan, west of Dysart, continues south through the town of Ballinasloe before turning southeast and discharging to the River Shannon at Shannonbridge, ~20km south of the Southern Cluster.

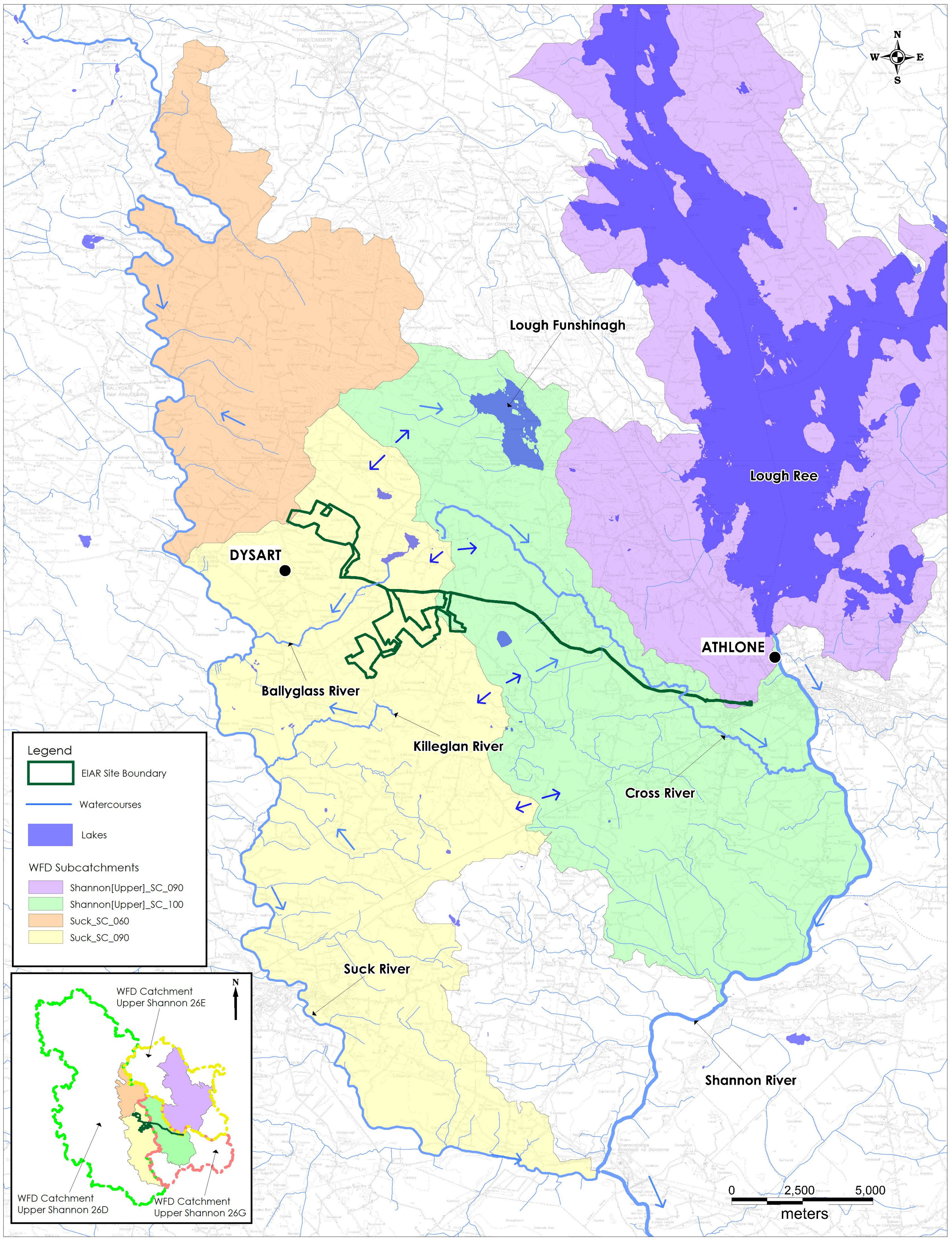
The River Suck is within the OPW Suck Drainage District. No Arterial Drainage Schemes occur within the Water Study Area defined on Figure 9-1.

The Cross River is situated ~3.2km east of the nearest Southern Cluster turbines and it drains a catchment that is located east of Lough Croan/Cuilleenirwan Lough and generally south of Lough Fuinshinagh. The headwaters of the Cross River is on the western slope of a small hill (~80m OD) in the townland of Kilcar and is mapped as a series of smaller water features near Dooloughan Lough. The most southeastern turbines of the Southern Cluster area also drain towards this river, possibly via Corkip Lough before the small tributaries of the Cross River emerge from this ephemeral water feature.

Water levels in the River Suck are measured at station 26005 and generally range in elevation between 42.6-45.4 m OD. Water levels in the River Shannon are measured in Athlone at station 26027 and range in elevation between 32.75 m OD to ~36 m OD. Water levels are not measured in the Cross River, however, the Cross River reaches a confluence with the River Shannon ~2km downstream of station 26027. Given this, and the upstream topography data, water levels in the Cross River are likely ~35 m OD near Athlone and perhaps 40-45 m OD upstream, nearer the Southern Cluster of the Wind Farm Site.

The regional area between Roscommon town and just south of Dysart is distinctively void of mapped river channels with the main drainage being provided by the Ballyglass and Cross Rivers. The surface hydrological network does increase towards the margins of this regional area, with channels emerging 1-2km east of the Suck, which then drains to the River Suck.

The orientation of the Cross River suggests that drainage to the west and northwest of this channel (*i.e.* the Northern and Southern Cluster areas) is hydraulically separated from the hydrology to the east (*i.e.* Lough Funshinagh. This point is underpinned by water level data presented in Sections 9.3.7.10 and 9.3.7.11). This is also supported by the topography, with a series of north-south orientated ridges spanning between the townlands of Eskerbaun northwest to Kilmore.



Client: Energia Renewables ROI Ltd	Drawing No: P1500-0-0422-A3-903-0A	
Job: Seven Hills WF, Co. Roscommon	Sheet Size: A3	Project No: P1500-0
Title: Regional Hydrology Map	Scale: 1:120,000	Drawn By: GD
Figure No: 9-3	Date: 20/04/2022	Checked By: MG

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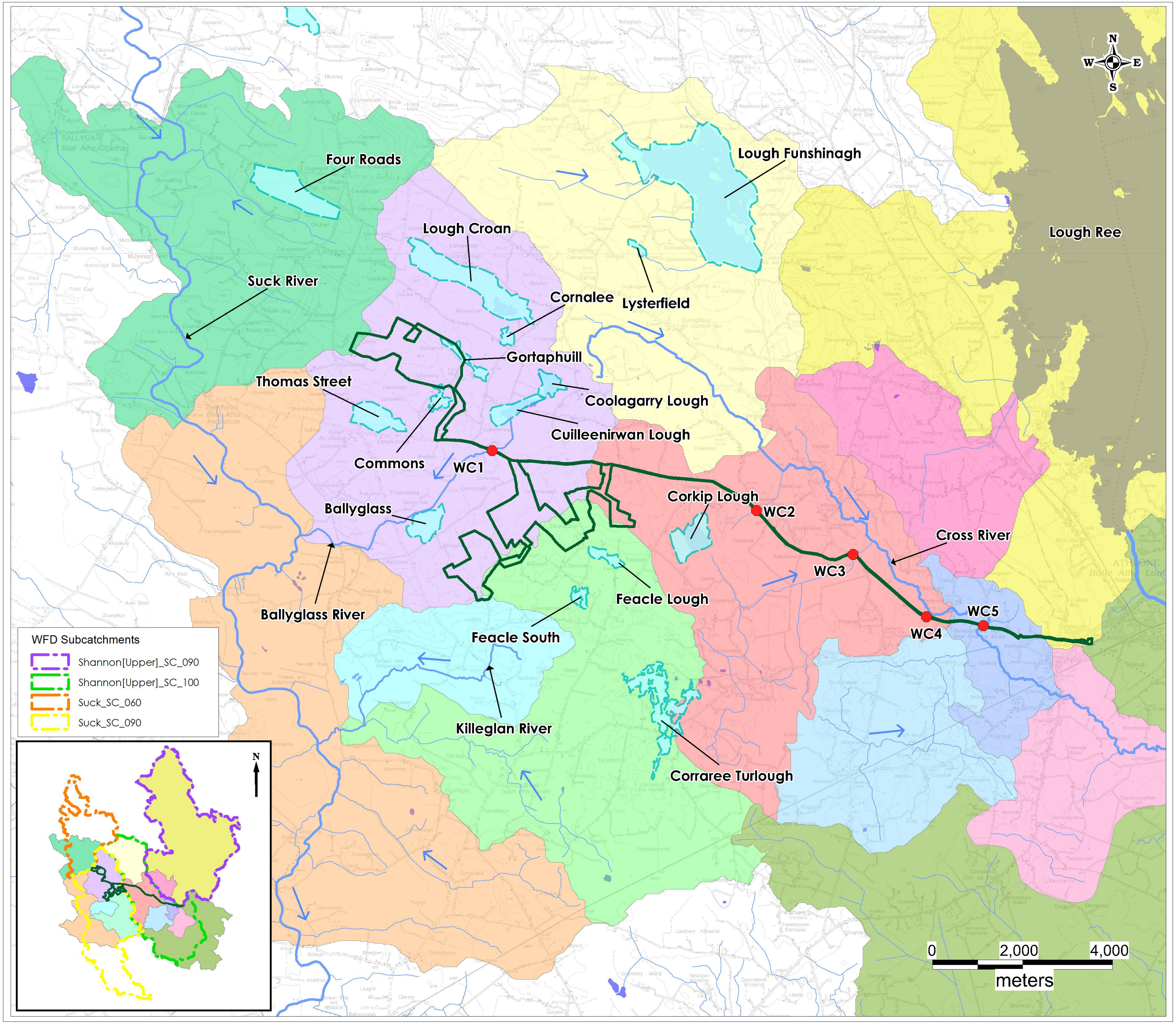
The Grid Connection route is situated along an existing road and is generally distant from any hydrological features. There are, however, 5 no. watercourse crossings along the Grid Connection route at existing bridges and culverts. The locations of these crossings are provided below in Table 9-7 and are shown in Figure 9-4. The watercourse crossing methodologies for the provision of the underground Grid Connection component at these locations is set out in Chapter 4, Section 4.8.7 and shown in the detailed design drawings in Appendix 4-1.

Table 9-7: Watercourse crossings along Grid Connection route

Crossing ID	Townland	River	Easting	Northing
WC1	Cuilleenirwan	Ballyglass	188500	245631
WC2	Brideswell	Unnamed- Trib of Cross River	194358	244307
WC3	Ballymullavill	Unnamed- Trib of Cross River	196501	243329
WC4	Cloonakille	Unnamed local drain (this watercourse is not mapped by the EPA)	198137	241942
WC5	Bellanamullia	Cross River	198781	241849



Legend

- EIAR Site Boundary
- Watercourses
- Turloughs
- Existing Watercourse Crossings (WC1-WC5)

WFD River Sub-basin

- BALLYBAY_010
- BALLYGLASS_010
- CROSS (ROSCOMMON)_010
- CROSS (ROSCOMMON)_020
- CROSS (ROSCOMMON)_030
- CROSS (ROSCOMMON)_040
- KILLEGAN TRIB NORTH_010
- KILLEGLAN_010
- MIHANBOY_010
- SHANNON (Upper)_110
- SHANNON (Upper)_120
- SUCK_120
- SUCK_130

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Local Hydrology - Grid Connection with Watercourse Crossings Map	
Figure No: 9-4	
Drawing No: P1500-0-0422-A3-904-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:80,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.4 Local & Site Drainage

There is a distinct lack of local drainage (field drains, ditches, first-order streams etc) within the areas of the Northern and Southern Clusters.

The main waterbody near the proposed Wind Farm site is the Ballyglass River, which flows southwest from Cuilleenirwan Lough (refer to Appendix 8-1, Site Photographs 6 and 7), ~1.6km southeast of the Northern Cluster and ~ 1.3km north of the Southern Cluster and reaches a confluence with the River Suck in the townland of Srahgarve. There are no other tributaries, aside from very short minor drains, mapped for the Ballyglass River, so it is likely that the majority of its emerging flow is derived from Cuilleenirwan Lough. The river channel has been modified and straightened along its course, with a series of perpendicular drains along the southern and western edge of Cuilleenirwan Lough. The Cuilleenirwan Lough is seasonal and tends to "disappear" (drain down) during the summer months, therefore flows within the Ballyglass River vary considerably throughout the year, with higher flows in the winter and lower flows (or none in the upper reaches) in Summer.

The Killeglan River is mapped ~1.5 km southwest of the Southern Cluster and ~2-3km south of the Ballyglass River. This river flows west/southwest towards the River Suck and is ~8km in total length. The headwaters of the Killeglan River form at the Killeglan spring, mapped in the townland of Rockland. There are 5-6 springs mapped over a ~0.8km stretch in this locality, one of which provides the source for the Killeglan Spring PWS. The proposed Southern Cluster turbines are located on the northern side of the topographic divide along the high ground of the Southern Cluster area. Based on the topographic data, the proposed turbines will not drain in the direction of the Killeglan River, but some turbines are in the catchment of Feacle Turlough, which connects to the Killeglan springs via underground. There are 3 no. point sources which are connected via karst conduits to the Killeglan spring, which have been mapped using tracers. These sources are Feacle Turlough, Glannanea swallow hole and Carrowduff swallow hole.

The drainage density within the Wind Farm site, and across the general area between Lough Ree and the River Suck is low, which implies that the majority of effective rainfall is infiltrating to the groundwater system, rather than creating runoff which would lead to a larger number of mapped streams/rivers.

There is a clear relationship between the topography and the mapped karst hydrology. The majority of mapped enclosed depressions, swallow holes and springs are on low lying lands which are generally under grassland. The hills in the area, generally at 70 – 100m OD are more often under rough grazing land and devoid of any hydrological or karst-type features.

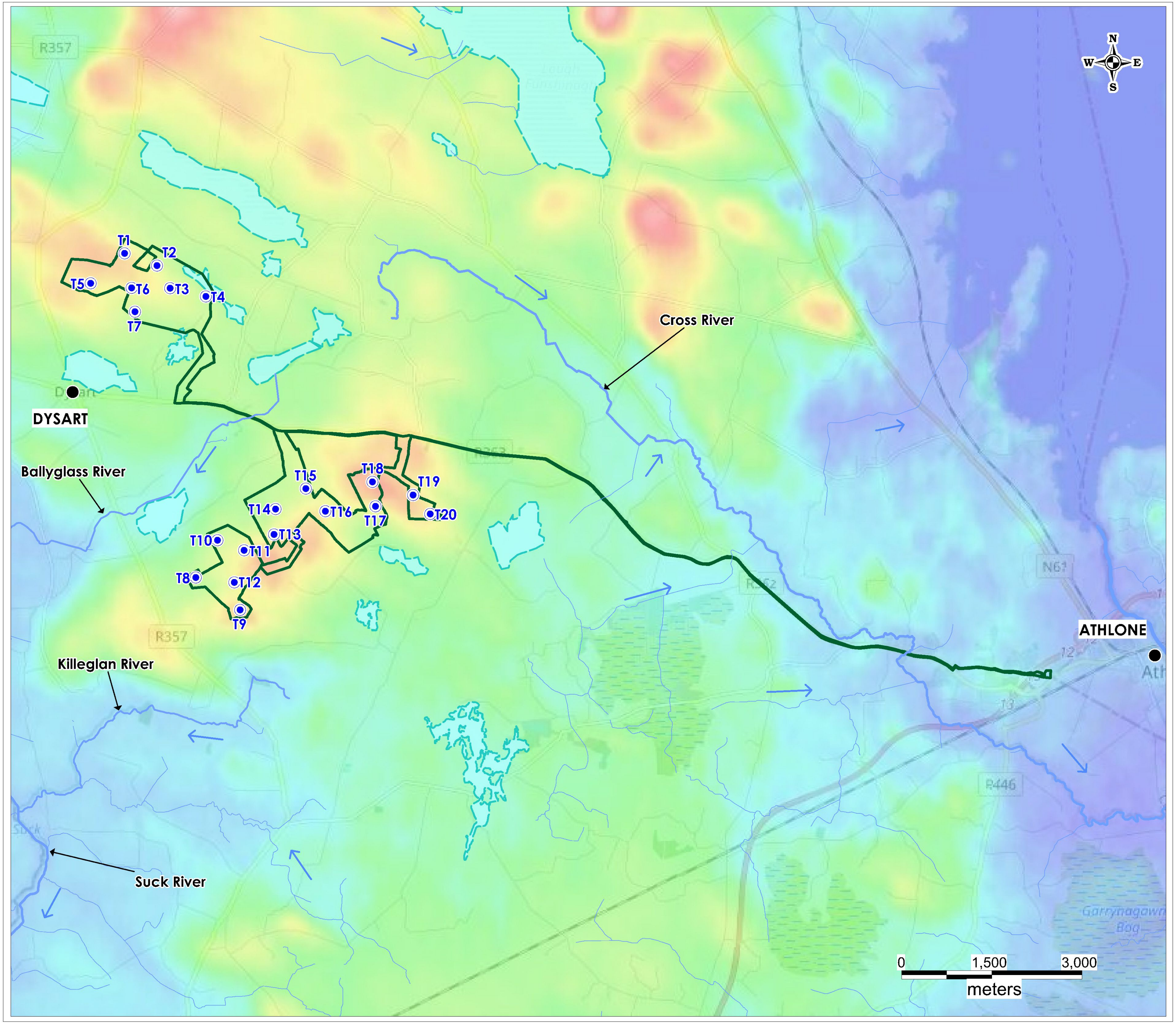
A local hydrology map is included as Figure 9-3, and separately mapped surface water features and karst features with topography is included in Figure 9-5.

A summary of the sub-catchments along with relevant Wind Farm development infrastructure, existing drainage features and points of hydrological interest are shown in Table 9-8.

Table 9-8: Summary of Regional/Local hydrology & Proposed Wind Farm Infrastructure

Regional Catchments	Sub-catchment	Main Development Infrastructure	Primary Drainage Features
Upper Shannon (26D)	Suck_SC_090	T1-T18, 3 no. soil storage areas, and 2 no. temporary construction compounds	River Suck (Ballyglass River is a secondary tributary)
Upper Shannon (26G)	Shannon[Upper]_SC_100	T19, T20, Substation	Cross River (Lower)

Drainage along the proposed Grid Connection route is broadly localised to drainage ditches along the R363/R362 between the Proposed Development site and the Athlone 110kV substation. The topography generally slopes towards the Ballyglass River in the area of the Grid Connection route west of Cam Hill, and towards the Cross River east of Cam Hill.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Watercourses
- Turloughs

Topography 35-152 mOD

152m
150m
125m
100m
75m
50m
35m

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Local Hydrology / Topography Map	
Figure No: 9-5	
Drawing No: P1500-0-0422-A3-905-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:60,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.5 Flood Risk Identification

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

No recurring flood incidents within the Wind Farm site were identified from OPW's indicative river and coastal flood map. There are several recurring flooding incidents surrounding the Wind Farm site, which relate to the turloughs in the surrounding lower-lying areas. The GSI map (GSI GWFlood Project)[1] past and recurring flood events at the following locations:

- Thomas Street (Carrownadurly) Turlough – Flood I.D-177
- Cuilleenirwan Turlough - Flood I.D-806
- Ballyglass River Flood I.D-19
- Feacle Turlough - Flood I.D-807
- Corkip Turlough - Flood I.D-808
- Lough Croan - Flood I.D-802

The Thomas Street turlough at Dysart (flood record I.D-177[2]) floods every 2-3 years, with the R357 being liable to flooding from this turlough approximately every 10 years (refer to Appendix 8-1, Site Photographs 12 and 13, taken from the R357 looking towards Thomas Street turlough).

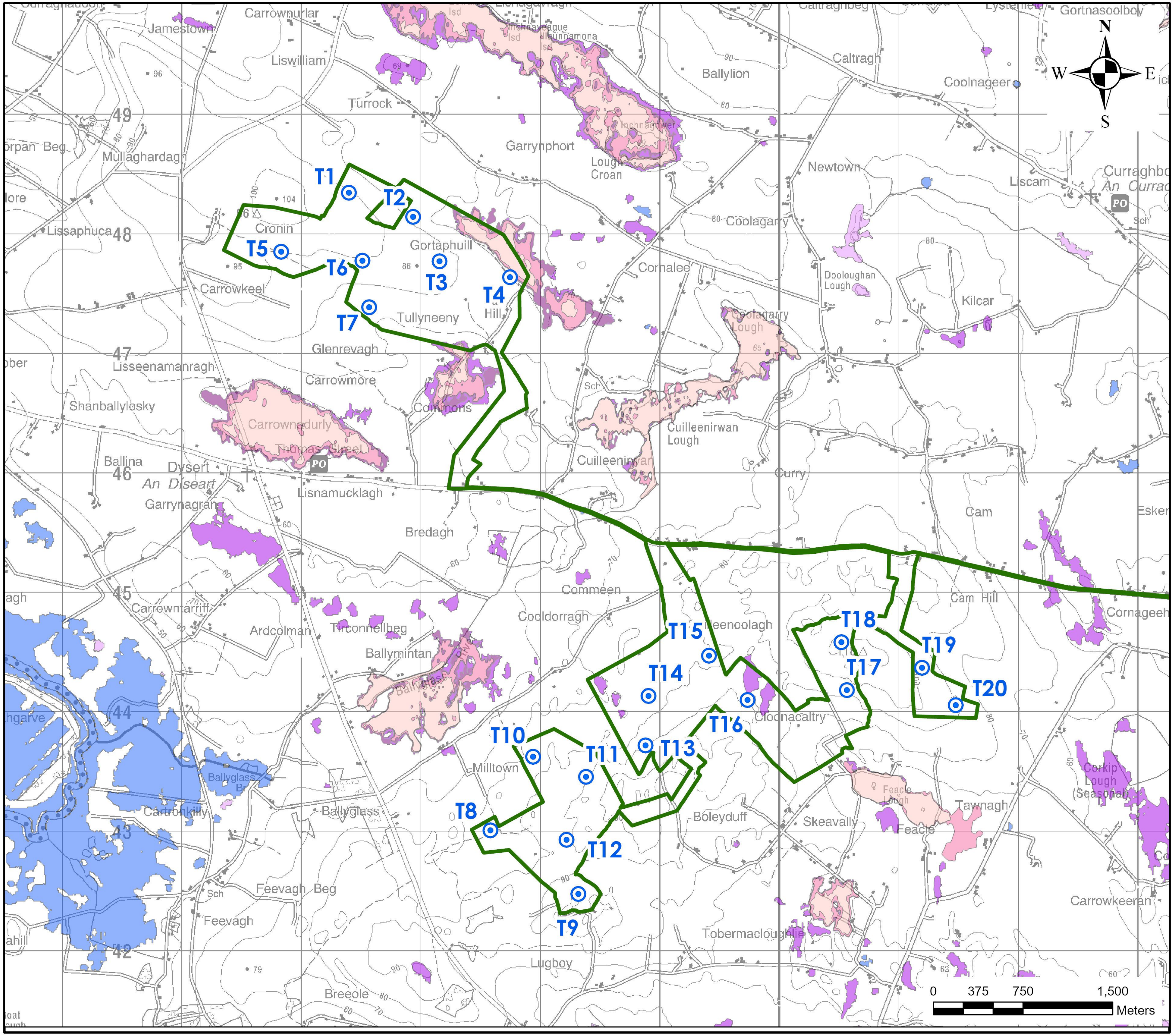
The GSI Groundwater Flooding Data Viewer was accessed to provide details on the extent of groundwater flowing in the area. The data viewer provides maximum historic groundwater flooding extents which are shown in Figure 9-6. These extents generally coincide with the known mapped turloughs, particularly the larger Lough Croan, Cuilleenirwan and Thomas Street (Carrownadurly) turloughs. The size of the groundwater flood zones ranges in the area from the smaller turloughs (0.15 ha) to Lough Croan which measures 1.3km^2 (130 ha). The proposed turbines and other Wind Farm site infrastructure are topographically upgradient of these groundwater flood zones, with the closest point of infrastructure being T4. T4 is situated ~50m upgradient of the maximum flood extent of Gortaphuill turlough.

The available PFRA mapping shows the extent of the indicative 100-year flood zone which relates to fluvial (i.e., river) and pluvial (i.e. rainfall) flood events. There are no 100-year fluvial flood zones mapped within the Wind Farm site.

All proposed turbine locations, substation, construction compounds, met mast, overburden storage areas and access roads are located at least 50m away from streams and are outside of the fluvial indicative 100-year flood zone.

A detailed flood risk assessment for the Proposed Development is attached as Appendix 9-1.

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



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- High Probability
- Medium Probability
- Low Probability
- Winter 2015/2016 Surface Water Flooding

Maximum Historic Groundwater flooding [GSI]

- Groundwater
- Groundwater/Surface water

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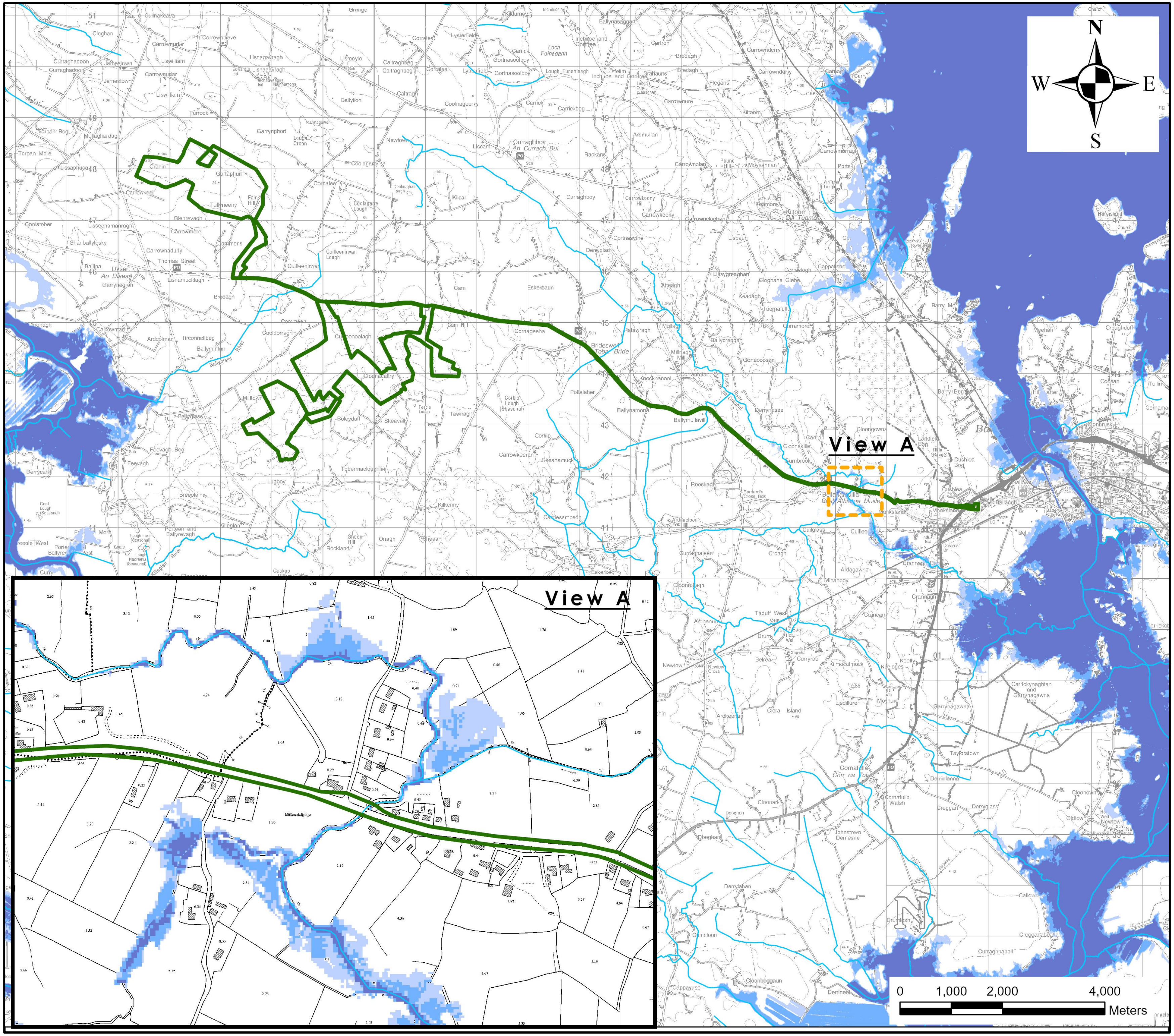
Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Groundwater Flooding Map (GSI - GW Flood)	
Figure No: 9-6	
Drawing No: P1500-0-0422-A3-906-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:30,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

There is no text on local available historical 6" or 25" mapping for the site that identifies areas that are "*prone to flooding*" within the study area, nor are there mapped benefitting lands within the Proposed Development areas.

Surface water and groundwater flooding was investigated along the proposed Grid Connection route. Flooding along the Cross River is identified on Map: S2526ATN_EXFCD_F1_11 under the OPW Shannon CFRAM Study at a 1:5000 scale (refer to Figure 9-7). Fluvial flooding is mapped ~200m north and south of the R362 road, however, it is not mapped along the road itself. The 10% AEP (Annual Exceedance Probability) flood elevations are 39.51-39.85 m OD at the modelled nodes nearest the road. There are no other areas of fluvial or pluvial flooding mapped along the Grid Connection route. The GSI Groundwater Flooding Data Viewer[3] was consulted on areas prone to groundwater flooding. There are no areas of potential groundwater flooding mapped along the Grid Connection route.

The turbine delivery route (TDR) runs along the M6, with the delivery vehicles exiting this motorway at Athlone (Junction 13). And utilising the R362/R363 for final delivery. There are no areas of flooding mapped along the turbine delivery route, as indicated by the National Indicative Fluvial Mapping (Floodinfo.ie/floodmaps). There are no past flood events mapped along the turbine delivery route. In the unlikely event of flooding along this route, the delivery of turbines will be delayed until flooding has subsided.

3 https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=848f83c85799436b808652f9c735b1cc



Legend

EIAR Site Boundary

Watercourses

OPW Fluvial Flooding Scenarios

10%AEPFluvial FloodExtent

1%AEPFluvial FloodExtent

0.1%AEPFluvial FloodExtent

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Flood Mapping - Grid Connection Route	
Figure No: 9-7	
Drawing No: P1500-0-0422-A3-907-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:30,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.6 Surface Water Hydrochemistry

Biological Q-rating data[4] for EPA monitoring points on the River Suck is available from locations approximately 4.5km west of the Northern Cluster (T1-T7) and ~5.0km west of the Southern Cluster (T8-T20). Most recent data shows that the River Suck has a Q-4 rating at Ballyforan Bridge (RS26S071100), west of T1-T7. The River Suck achieved a Q-4 rating at station RS26S071125 (west of T8-T20).

Q ratings are also available along the Ballyglass River. The river achieved a Q-4 rating at a monitoring point approximately 0.5km upstream and east of the confluence with the River Suck.

Q ratings for the River Cross are also available from 3 no. monitoring points approximately 3.8 – 5.5km east of the Southern Cluster (T8-T20) area. The Q rating at the northernmost monitoring point, RS26C100060, is Q-3, while ~1km downstream the river achieves a Q-4 rating at monitoring point RS26C100070. A Q-4 rating is maintained at station RS26C100100, ~1.2km further downstream.

The most recent Q ratings for local EPA monitoring stations are listed below in Table 9-9. These EPA monitoring locations are shown in Figure 9-8.

Table 9-9: River Q ratings

River	Station Code	Most Recent Q rating (year)	Q Value Status / WFD Biological Status
Suck	RS26S071100	4 (2020)	Good
Suck	RS26S071125	4 (2005)	Good
Killeglan	RS26K040200	4 (2020)	Good
Cross	RS26C100060	3-4 (2020)	Moderate
Cross	RS26C100070	4 (2011)	Good
Cross	RS26C100100	4 (2002)	Good

HES completed a round of 8 no. water samples on 26th March 2021. 2 no. of these samples were from nearby surface watercourses, while the remaining 6 no. samples were from wells and turloughs discussed in Section 9.3.9. The recorded field chemistry data, taken with a calibrated YSI ProDSS, are given below in Table 9-10. The laboratory data are shown in Table 9-11, the full laboratory reports are included in Appendix 9-2. Sampling locations are shown in Figure 9-8.

Table 9-10: Field Hydrochemistry of water samples taken on 26/03/2021

Location	Temp (°C)	DO (mg/L)	EC (µS/cm)	pH	ORP (mV)
Ballyglass River	8.2	10.6	419.1	7.58	318.4
Killeglan River	9.3	7.52	466.7	7.22	285.4

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

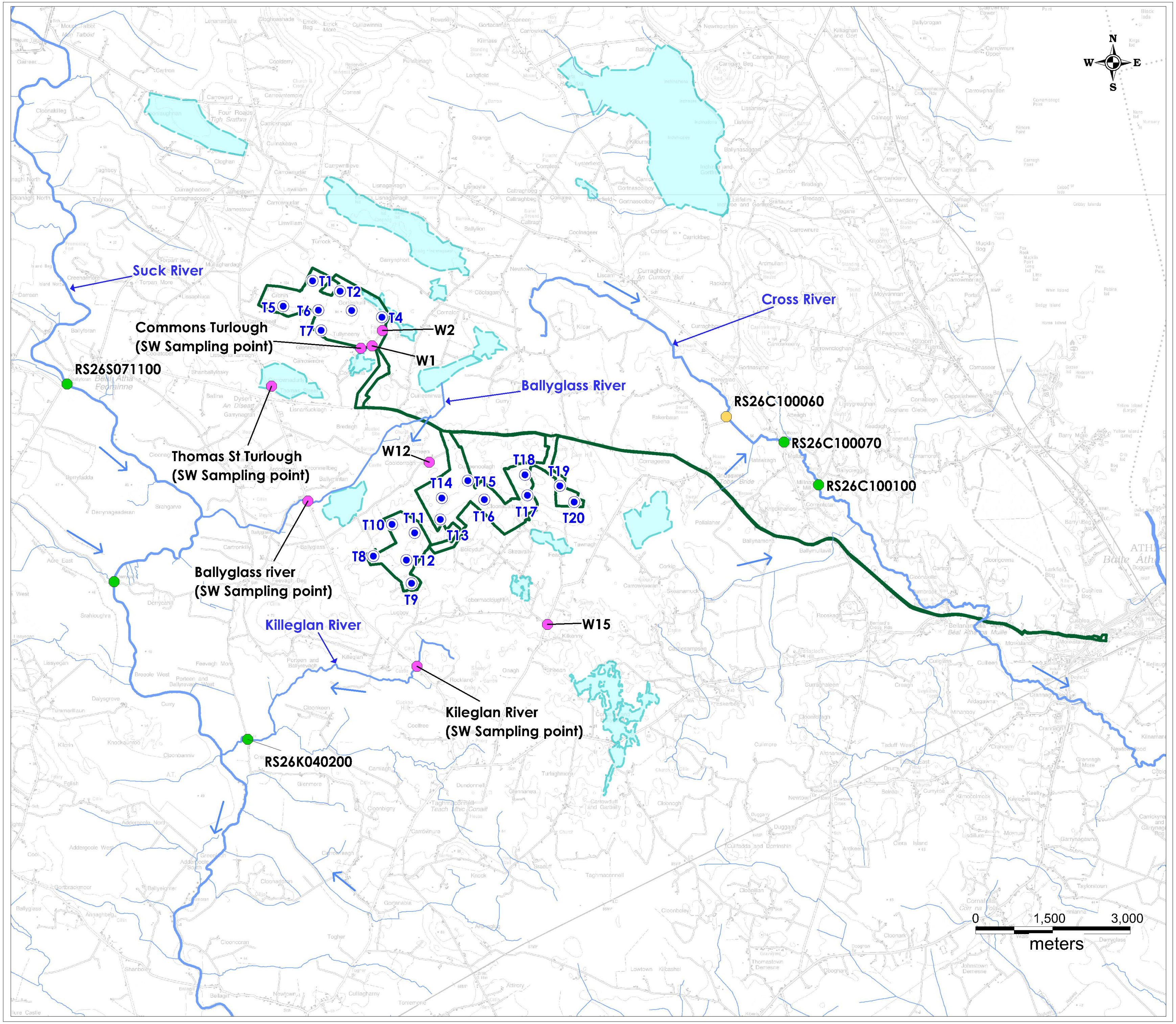
The field hydrochemistry indicates relatively healthy watercourses with pH ranging from 7.22-7.58 and a dissolved oxygen concentration of 7.52-10.6 mg/L.

Table 9-11: Summary of Laboratory Analysis results (26/03/2021)

Parameter	EQS	Sample ID	
		Killeglan River	Ballyglass River
Ammonia (mg/L)	-≤0.065 to ≤ 0.04(*)	0.006	<0.005
Nitrite – N (mg/L)		<0.05	<0.05
Ortho-Phosphate – P (mg/L)	-≤ 0.035 to ≤0.025(*)	0.008	0.007
Nitrate - NO_3 (mg/L)	-	2.1	1.0
Chloride (mg/L)		16	17
Hardness (mg/L CaCO3)		310	310

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

The laboratory results for the 2 no. surface watercourses indicated good quality water. Ammonia ranges between >0.005 and 0.006 mg/L which is below the environmental EQS for Ammonia as set out in SI 272 of 2009. Nitrate and Nitrite are within the acceptable range for surface waters at 1.0 and 2.1 mg/L respectively. Orthophosphate ranged between 0.007 to 0.008 mg/L, which is considerably below the threshold values for Orthophosphate (<0.035 to <0.025 mg/L).



Legend

EIAR Site Boundary

Proposed Turbine Layout

Watercourses

Turloughs

SW Sampling location_HES

River Q value

Good (Status 4)

Moderate (Status 3)

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Surface Water Quality Data locations (Q Rating & HES Sampling Locations)	
Figure No: 9-8	
Drawing No: P1500-0-0422-A3-908-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:70,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7 Hydrogeology

9.3.7.1 Desk Study Hydrogeological Data

Baseline geological data is available from the GSI through their online Mapviewer[5]. This bedrock mapping is completed at a broad regional scale and should be considered to be indicative of the bedrock type. However, it is superseded by the collection of site investigation data which is site-specific and completed at a much finer scale, for the purposes of the Proposed Development. The underlying bedrock at the Northern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). This undifferentiated Limestone is mapped as a 55km long block along a northeast-southwest axis, which spans from Ballinasloe, Co. Galway, to Newtown Forbes, Co. Longford. There is a considerable amount of bedrock outcrop mapped north of Dysart, towards Four Roads, while there is relatively poor coverage of mapped bedrock outcrops near and within the Northern and Southern Clusters. There are no mapped faults in the area. A bedrock aquifer map is included in Figure 9-9.

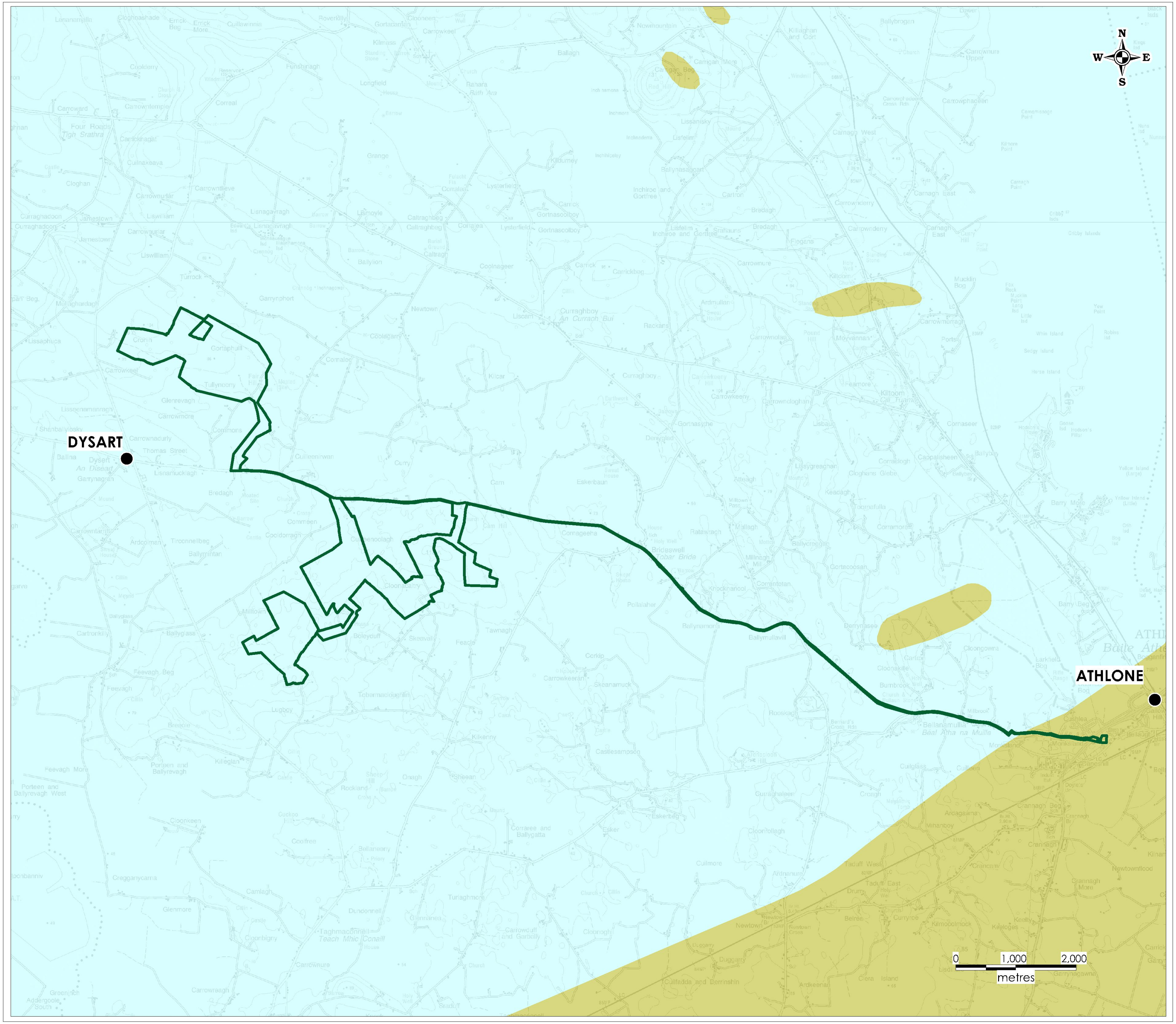
The underlying bedrock at the Southern Cluster site is also mapped by the GSI as Visean Limestones (Undifferentiated). There is no outcrop mapped near the Southern Cluster turbine locations. There are no mapped faults in the area.

The GSI has classified the Visean Limestones as a Regionally Important Aquifer – Karstified (conduit). The majority (18 of 20 no. turbines and >90% of area) of the proposed Wind Farm site is located within the Suck South Groundwater Body (GWB). Turbines T19 and T20 are located within the Funshinagh GWB. A summary of the Proposed Development infrastructure in relation to local groundwater bodies is included in Table 9-12. A description of these Groundwater Bodies along with a comparison to collected site data is included below in Section 9.3.7.11.

Table 9-12: Summary of groundwater bodies (aquifers) & proposed Wind Farm Infrastructure

Groundwater Body (GWB)	Main Development Infrastructure
Suck South GWB	T1-T18, 3 no. soil storage areas, and 2 no. temporary construction compounds
Funshinagh GWB	T19, T20, Substation

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



Legend

EIAR Site Boundary

Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones

Regionally Important Aquifer - Karstified (conduit)

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Bedrock Aquifer Map (WF and GCR)	
Figure No: 9-9	
Drawing No: P1500-0-0422-A3-909-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:50,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.2 Summary of Geological Data

A detailed description of site geology is provided at Section 8.3.4 of Chapter 8 of this EIAR. The following is a brief summary of relevant geological information that has a bearing on the hydrogeology of the study area.

9.3.7.2.1 *Northern Cluster*

Soil/Subsoil

The site investigation data on subsoil types and depths from the Northern Cluster is generally consistent across multiple instances of borehole and trial pit works between 2010-2021. The subsoils broadly consist of sandy CLAY, gravelly SAND and sandy GRAVEL, with a depth of overburden between 1.3 – 16.3m where the full profile was described (i.e. at boreholes). The mean depth of subsoil across the Northern Cluster from the borehole data is 7.41m.

The depth of subsoil cover across the site provides protection to the underlying groundwater aquifer. An aquifer with an average depth of 7.41m of subsoil cover can be categorised as being of Moderate vulnerability (refer to Section 9.3.8).

Bedrock Geology

In total 285.7m of borehole drilling has been completed within the Northern Cluster. Bedrock is identified at an average depth of 7.41mbgl and no significant karst conduit features have been logged throughout the 285.7m of drilling. In total, 157.8m of the drilling was in overburden (55.2%). The borehole drilling depths and the geographical spread of the borehole locations across the Northern Cluster provide confidence in stating that the Limestone bedrock is generally overlain by a substantial thickness of overburden and is typically a strong, dark grey bioclastic Limestone with discrete weathered zones and intermittent clay infilled fractures. The site investigation data on the bedrock geology does not refer to any significant karst features or broken/soft rock during drilling. The bedrock is described as Hard to Medium Hard bioclastic dark **grey** Limestone. The presence of weathered zones and clay-filled fractures is typical of Limestone bedrock across Ireland. The Limestone bedrock was generally unproductive in terms of water-bearing capacity as outlined by the site investigation (SI) data with very few water strikes and very slow inflows to SI wells where these strikes did occur.

9.3.7.2.2 *Southern Cluster*

Soil/Subsoil

The site investigation data on subsoil types and depths from the Southern Cluster is generally consistent across multiple instances of borehole and trial pit works between 2010-2015 (historical project) and 2019-2021 (Proposed Development). Due to the nature of geological data such as subsoil depth and bedrock lithology, that it does not change over the span of decades, the historical data (2010-2015) is deemed to be highly useful in providing further scientific data of soils, subsoils and bedrock.

The subsoils broadly consist of sandy CLAY, clayey gravelly SAND and sandy clayey GRAVEL, with a depth of overburden between 1.3 – 30m where the full profile was described. The mean depth of subsoil across the Southern Cluster from the borehole data is 7.32m.

The depth of subsoil cover across the Southern Cluster provides protection to the underlying groundwater aquifer. An aquifer with an average depth of 7.32m, of subsoil cover, similar to the Northern Cluster, can be categorised as being of Moderate vulnerability (refer to Section 9.3.8).

Bedrock Geology

In total, 394.6m of borehole drilling has been completed within the Southern Cluster. Bedrock is identified at an average depth of 7.32mbgl and no obvious karst features have been logged throughout the total depth of drilling. The bedrock at the Southern Cluster does appear to have more weathered sections of rock and clay infill at depth, however, none of these zones produced any substantial groundwater yields. The borehole drilling depths and the geographical spread of the borehole locations across the Southern Cluster provide confidence in stating that the Limestone bedrock is generally overlain by a substantial thickness of overburden and the bedrock is typically a strong, dark grey bioclastic Limestone with occasional weathered zones and intermittent clay infilled fractures, similar to the Northern Cluster.

The bedrock geology encountered during the site investigation works is similar to that observed at the Northern Cluster. The hard to medium hard, medium grey bioclastic Limestone contains discrete weathered zones but is generally not water bearing. Water strikes during the site investigation drilling were rare and where strikes occurred the aquifer was poorly productive. In several instances within the Northern and Southern Clusters, the groundwater levels within the 6 no. monitoring wells took several weeks to rise to the equilibrium groundwater level.

9.3.7.3 Wind Farm Site Field Hydrogeological Data

Rotary core drilling was undertaken at 6 no. proposed turbine locations by Petersen Drilling Ltd, supervised by HES between 19th – 22nd May 2020, with 3 no. boreholes at the Northern Cluster, drilled at the locations NT1, NT3 and NT7, which correspond to the locations of turbines WTG1, WTG3 and WTG7 respectively and 3 no. boreholes at the Southern Cluster (ST2, ST4 and ST8, located at WTG12, WT10 and WTG14 respectively). These boreholes were drilled to provide details on the depth of overburden and bedrock lithology/type and to provide groundwater monitoring points. Further rotary core boreholes were drilled at each WTG site to determine the site-specific subsoil depth and geology for the engineering design.

A summary of the borehole logs (for NT1, NT3, NT7, ST2, ST4 and ST8) and groundwater strikes met are shown in Table 9-13.

Table 9-13: Summary of rotary borehole logs from 6 no. proposed turbine locations

BH Number	Total Depth	Overburden(m)	Bedrock Geology	Karst Feature identified	Groundwater Strike
NT1	48.5mbgl (96-47.5 m OD)	0-0.1m: Firm Topsoil 0.1-1.8m: Silty gravelly SAND	1.8-22.9m Medium grey, Medium hard LIMESTONE with occasional minor fractures 22.9-32m: Medium grey, Medium soft LIMESTONE 32-32.8m: Medium grey, Medium hard LIMESTONE	None	Very minor ($0.25\ m^3/hr$) at 43.8mbgl

BH Number	Total Depth	Overburden(m)	Bedrock Geology	Karst Feature identified	Groundwater Strike
			32.8 – 48.5m: Medium grey, Medium Soft Limestone with occasional minor fractures		
NT3	33.4mbgl (87.4-54 m OD)	0-16.3m: Varying layers of sandy gravelly CLAY, clayey sandy GRAVEL and some medium brown CLAY	16.3-33.4m: Medium-dark grey, medium strong Limestone with occasional very minor fractures	None	None
NT7	30.5mbgl (75.1-44.6 m OD)	0-0.1m: Brown Sandy TOPSOIL 0.1– 3.2m: Medium brown silty gravelly SAND with cobbles and boulders 3.2-3.7m: Limestone boulder 3.8-6.4m: Medium-light brown silty, sandy, gravelly CLAY	6.4-14.1: Medium Hard – Hard LIMESTONE with occasional minor fractures 14.1-17m: Medium dense Brown CLAY 17-19.3m: Weathered LIMESTONE 19.3-21m: Medium dense brown CLAY 21-30.5m: Medium strong-Hard grey LIMESTONE	None	None
ST2	40mbgl (80.05 – 40.05 m OD)	0-0.9m: Medium brownish grey slightly gravelly SAND. 0.9 - 2: Medium brownish grey sandy GRAVEL	2 - 6.5: Hard, competent, medium grey LIMESTONE 6.5-9: Weathered LIMESTONE 9-13: Medium grey hard LIMESTONE 13-22m: Medium grey, Medium-Soft LIMESTONE. slight fracture from 20.4 - 20.6m	None	None

BH Number	Total Depth	Overburden(m)	Bedrock Geology	Karst Feature identified	Groundwater Strike
			22-40m Hard medium grey LIMESTONE		
ST4	36.8mbgl (71.05 – 34.25 m OD)	0-2.5 Light Brownish Grey Gravelly SAND. Gravels are angular to sub angular 2.5-3.7: Sandy GRAVEL.	3.7 - 4.2: Hard, competent, medium light grey LIMESTONE 4.2-4.3: Weathered LIMESTONE 4.3 - 36.8: Hard, competent medium light grey LIMESTONE	None	None
ST8	36.8mbgl	0-0.1 Sandy Topsoil 0.1-1.8 Brown silty SAND with cobbles and boulders.	1.8-11.1: Medium grey hard LIMESTONE 11.1-11.5 Slightly fractured LIMESTONE 11.5-35.2: Soft medium grey LIMESTONE 35.2-36.8: Medium grey hard LIMESTONE	None	None

The general geology of the Southern Cluster (ST2, ST4 & ST8) includes a limited depth (1.8-3.7m) of overburden which generally comprises brownish grey sandy gravel and gravelly sand, with minor amounts of silt and clay. Occasional Limestone boulders were also encountered. The bedrock below this overburden comprises generally Moderately Strong to Strong grey Limestone, which is occasionally soft and fractured/weathered in discrete intervals, but overall is considered to be competent bedrock with no observed significant below ground karst type features. This is further illustrated by the lack of water strikes or water bearing strata, despite drilling below the known groundwater level in the local lowland areas. Water level loggers were installed in boreholes ST2, ST4 and ST8 between 18th June 2020 until May/June 2021. All 3 no. wells were dry when the loggers were installed, despite drilling to a depth of 36.8 – 40m within the boreholes. The water levels eventually rose slowly over time. The Summer water level in ST-2 was ~52.8m OD, with the winter water level rising to 59.4m OD.

The geology of the Northern Cluster (NT1, NT3 & NT7) is similar to the geology encountered in the south. The overburden is slightly thicker within this section, ranging from 1.8 – 16.3m. The deepest section of overburden at NT3 includes silty sand with gravels and cobbles, sandy gravel, gravelly sand and a 0.4m layer of dense clay above the bedrock. Below the overburden, the bedrock geology is a similar light grey Limestone which is generally Moderately Strong to Strong hard grey LIMESTONE, with occasional weathered and soft LIMESTONE in discrete intervals, with minor weathering/fractured intervals/zones. A very minor water strike was observed in NT1 at 40mbgl, followed by a slightly stronger water strike at

43.8mbgl, however, flow from this well was estimated at ~0.25m^3/hr (<100mL/second). Following completion of the hole (NT1), the groundwater level rose in the borehole over 1 hour to a static level of 33.5mbgl (62.5 m OD). Following repeat site visits, minor amounts of water were found at the base of NT7 (0.27m above base of well or 44.87 m OD). Water level loggers (Divers) were installed in each of the 3 no. boreholes between 18th June 2020 and 11th May 2021. The water level in NT1 rose slowly between June to August 2020 from 61.8 to 76.1 m OD. The water level stayed between 73.2 - 76.1 m OD until May 2021, where it receded slightly to 68.7 m OD. The water level in NT3 rose very slowly from 54.75 m OD on 18th June 2020 to 69.9 m OD in early February 2021 before receding slightly. NT7 showed a similar profile with water levels rising from 60.23 m OD on 18th June 2020 to 71.24 m OD in November 2020, maintaining a relatively stable water level until a slight recession to 61.6 m OD in May 2021. The graphs of water levels within the rotary core boreholes are included in Appendix 9-3.

The actual bedrock encountered during drilling at the proposed turbine locations was typically Medium grey, Medium hard to hard Limestone, generally competent and rarely fractured. A minor water strike was only encountered in 1 no. of the 6 no. boreholes (NT1). No significant water bearing faults or fractures were encountered during the drilling of the 6 no. boreholes. In general, the boreholes were not found to be water producing.

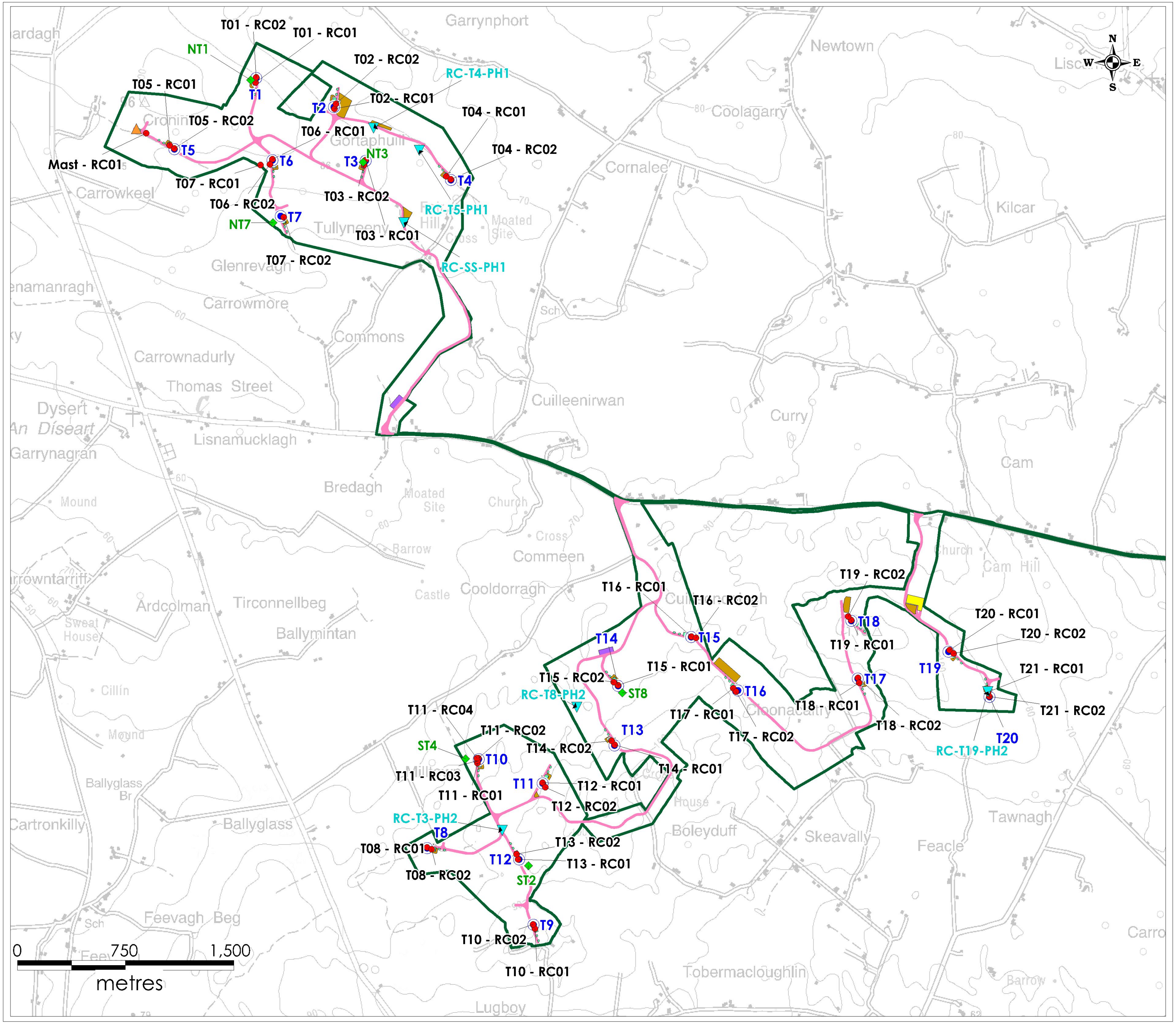
Groundwater levels and groundwater strike data are also available within the rotary core boreholes conducted by IGSL (refer to Appendix 9-4). A slow groundwater strike is noted at Turbine T4-RC01 at 9.4m, and at T7-RC-01 at a depth of 8.9m. Groundwater levels are measured and recorded also within some of the geotechnical logs. Groundwater level data for site investigation boreholes are shown in Table 9-14 below. The groundwater levels were recorded in January - March 2021, following the drilling of the rotary core (RC) boreholes. A high groundwater table at the topographic setting of the site would suggest low permeability bedrock. The locations of the boreholes with available water level data are included in

Table 9-14Table 9-14 and on Figure 9-10.

Table 9-14: Boreholes and available water level data

BH Number	Elevation (m OD)	Approx. Summer Water Level (m OD)	Approx. Winter Water Level (m OD)	Nearest Turlough
NT1	93.5	59.33	>73.6	Lough Croan – 1.4km
NT3	84.51	53.12	67.49	Gortaphuill – 0.4km
NT7	70.12	54.05	66.64	Thomas Street – 0.9km
ST2	88.0	52.8	59.4	Ballyglass – 1.4km
ST4	72.54	58.2	>60	Ballyglass – 0.8km
ST8	74.61	61.8	>65	Ballyglass – 1.6km
T04-RC01	72.47	-	64.17	Gortaphuill - 0.1km
T05-RC01	90.83	-	85.73	Thomas Street - 1.2km
T07-RC01	87.86	-	81.16	Thomas Street – 0.9km
T11-RC03	71.84	-	56.24	Ballyglass – 0.6km

BH Number	Elevation (m OD)	Approx. Summer Water Level (m OD)	Approx. Winter Water Level (m OD)	Nearest Turlough
T11-RC04	69.13	-	61.53	Ballyglass – 0.6km
T18-RC02	90.87		83.07	Feacle Turlough – 0.7km



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Me Mast
- Proposed Substation
- Proposed Temporary Construction Compounds
- Proposed Spoil Storage Areas
- Proposed Access Roads
- Proposed Hardstand
- Boreholes_HES
- Coreholes 2020/21
- Coreholes_JOD

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Site Investigation Boreholes with available Water Level data	
Figure No: 9-10	
Drawing No: P1500-0-0422-A3-910-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:25,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.4 Karst Features

Karst features are mapped by the GSI and available through the GSI online viewer. There are a large number of karst features mapped near the Proposed Development, the majority ~95% are dolines or enclosed depressions which are visible as depressions within the surrounding agricultural fields which may be 1-3m deep and typically ~100-200m^2, although their areal extent varies.

There are ~30 depressions mapped within a 3km radius of the lowlands surrounding the Northern Cluster of the Wind Farm site. Many of these depressions are located within the mapped turloughs and make up the basin topography which fills in the winter months to form the turloughs. There are 2 no. turloughs mapped within the GSI karst database near the Northern Cluster, Lough Croan and Thomas Street Turlough (Carrownadurly). The closest mapped depression to the Wind Farm site infrastructure is mapped ~0.15km southeast of proposed T4 and forms the Gortaphuill Turlough basin (although Gortaphuill is not mapped as a turlough by the GSI). There are generally no karst features mapped above 70m OD. There are no karst springs or swallow holes mapped near the Northern Cluster of the Wind Farm Site. The closest mapped spring is situated ~6.5km south of the Northern Cluster near Killeglan.

There are ~10 karst features (dolines and turloughs) mapped near the Southern Cluster of the Wind Farm site. They are all situated along the northern side of the cluster and again are generally on the lower ground. The closest mapped depression is situated ~0.45km northwest of T15. South (3-4km) of the Southern Cluster of the Wind Farm site there are a number of enclosed depressions mapped as well as several swallow holes and springs. The locations of the mapped karst features are included as Figure 9-11.

The locations of the mapped karst features align broadly with the change in topography, with the karst depressions and turloughs mapped within the low-lying ground. There are no mapped karst features on the elevated hills surrounding Dysart, which is in agreement with the site investigation data which indicates that the bedrock is medium hard to hard, medium grey Limestone which is generally competent and devoid of water bearing strata.

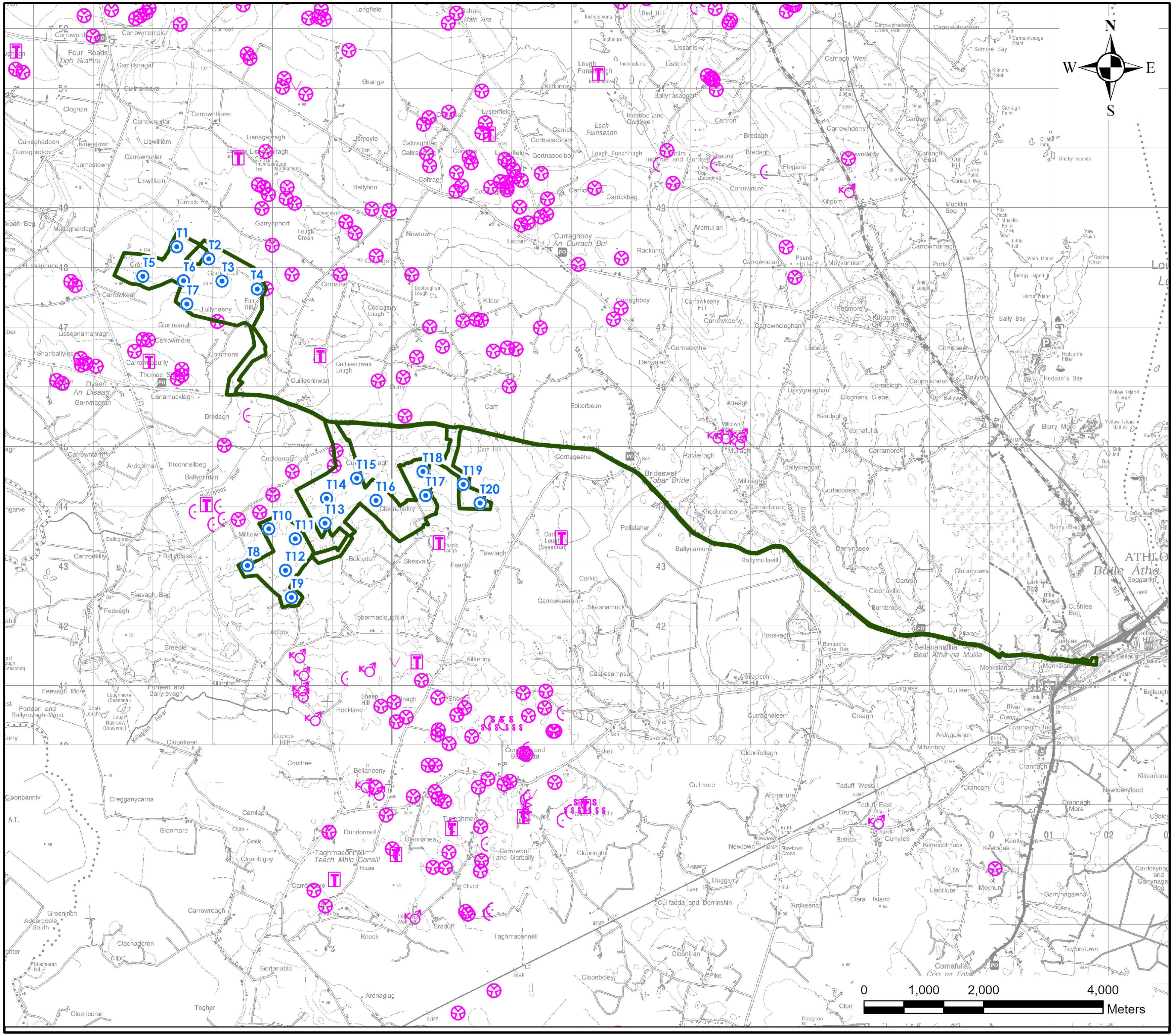
There are no mapped karst features along the Grid Connection route. The closest mapped karst feature is located in the western section of the route, where the GSI map several enclosed depressions in the surrounding lands. However, these features are all located in excess of 500m from the proposed Grid Connection route. One exception is an enclosed depression, located in the townland of Curry, which is situated ~130m north of the R363. Further east, karst features become sparse. However, there are 4 no. mapped springs in the townlands of Mullagh and Ratawragh. These mapped springs are situated ~1.4km northeast of the Grid Connection route at its closest point. These four springs are upgradient of the proposed Grid Connection route.

9.3.7.5 Tracing Studies

Tracer studies have been completed at several springs in Roscommon in order to better understand groundwater flow directions in the underlying bedrock, primarily in relation to existing public water supplies. These tracer studies were carried out by the GSI. A tracer study identified a connection between Feacle Turlough and the Killeglan Spring in the townland of Rockland. The tracer study was conducted by introducing a dye to the water in the turlough and observing any dye discharge from known local springs. The location of the Killeglan Spring and the mapped tracer lines are included in Figure 9-12.

There have been 5 no. tracer tests to establish the source of groundwater flows to the Killeglan spring. A positive trace has been confirmed between Feacle Turlough (NE of spring), Glennanea swallow hole (SE of spring) and Carrowduff swallow hole (SE of spring). The locations of these turloughs/swallow holes give a baseline idea of the size of the groundwater catchment feeding towards the spring. The public water supply scheme abstracts ~6,000-9,000 m^3/day, with an estimated total discharge at the spring of 6,000-30,000 m^3/day. The conceptual model of flow for the spring includes a shallow depth to fractured bedrock near the Tobermore source, and that surface water and groundwater are interconnected with swallow holes occurring along the course of a seasonal stream that runs through the lowland catchment. Due to the inherent difficulties in mapping groundwater flows in this system, as flows can be localised and discrete, the outer protection area (Zone of Contribution) has been delineated using topographic data, therefore the northern boundary (closest to the Southern Cluster) is the ridgeline along Cam Hill and the surrounding smaller hills.

A tracer study between the swallow hole at Lough Funshinagh completed by Drew & Burke (1996) determined a positive connection between Lough Fuinshinagh and Mullagh Spring. Mullagh Spring is located ~1.8km northeast of the Grid Connection route.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout

Karst Features

- Borehole
- Cave
- Dry Valley
- Enclosed Depression
- Spring
- Superficial Solution Features
- Swallow Hole
- Turlough

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Mapped Karst Features	
Figure No: 9-11	
Drawing No: P1500-0-0422-A3-911-0A	
Sheet Size: A3	Project No: P1500-0
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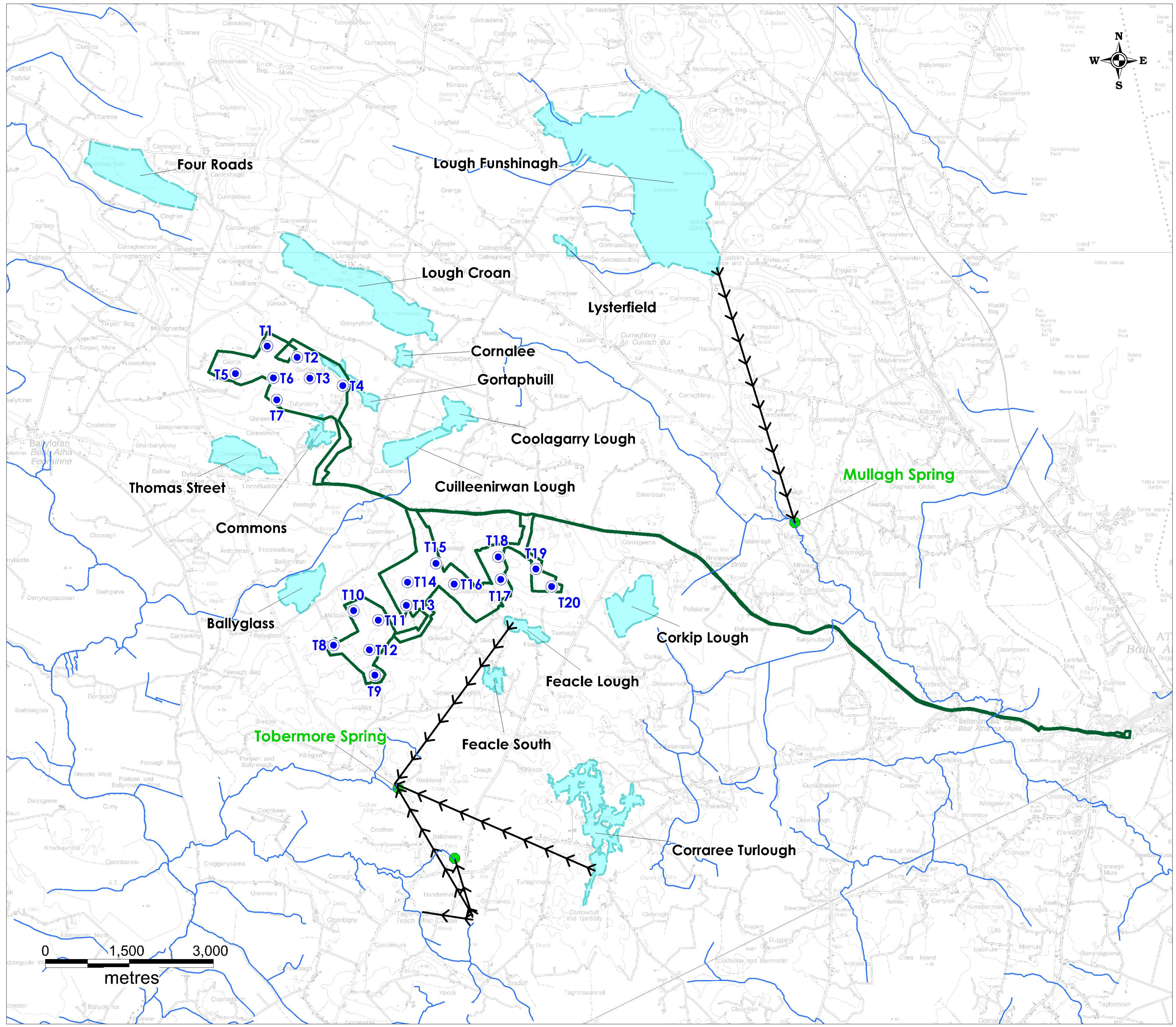
Date: 20/04/2022	Checked By: MG



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Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Title: GSI Underground Tracer line Map

Figure No: 9-12

Drawing No: P1500-0-0422-A3-912-0A

Sheet Size: A3	Project No: P1500-0
Scale: 1:65,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.6 Turloughs

There are a number of turloughs mapped locally to Dysart and the surrounding townlands (refer to Figure 9-13). The turloughs are listed below in Table 9-15. Water level monitoring (refer to Site Photograph 8 in Appendix 8-1 to see an example of how water level monitoring was undertaken in turloughs) within these turloughs has been completed by HES over the following dates:

- Lough Croan: 21st January 2020 – 19th June 2021);
- Thomas Street (Carrownadurly): 21st January – 26th May 2020 and 22nd October 2020 – 13th July 2021;
- Feacle Turlough: 21st January – 18th June 2020 and 22nd October 2020 – 13th July 2021
- Gortaphuill: 21st January – 26th May 2020;
- Commons: 21st January – 26th May 2020;
- Cuilleenirwan: 21st January – 26th May 2020;
- Ballyglass River: 21st January – 26th May 2020; and
- Dooloughan: 21st January – 26th May 2020.

Water level data for Lough Funshinagh is available from the EPA Hydronet database. The EPA water level data (m OD) for Lough Funshinagh was compared to the water levels in the 8 no. turloughs directly monitored by HES. Historical groundwater levels (2016-2019) are also available for Four Roads Turlough which indicate typical Summer and Winter groundwater levels. These data were sourced from the EPA, no access was available to Four Roads Turlough during the HES monitoring period.

The maximum recorded water level in each turlough is given in Column 3 of Table 9-15. A summary figure of water levels in the turloughs is included in Appendix 9-3. The head difference, relative to the average (mean) water level at River Suck at Derrycahill (43.8m OD) is also included as groundwater in the site area will largely flow towards the River Suck on a regional scale. This gives an indication of the relative groundwater gradients involved, i.e. the gradient from each turlough or monitoring point towards the River Suck to the west.

The turlough water levels are used in conjunction with other collected water level data to delineate groundwater contours and flow directions within the Hydrogeological Conceptual Site Model (CSM, refer to Section 9.3.7.11).

Table 9-15: Turloughs near the Proposed Development

Turlough	Distance to nearest proposed turbine	Winter water level (m OD)	Head difference to River Suck (43.8 m OD)	Turbine ground level Elevation (m OD)	Elevation difference between Turlough water level and ground level
Ballyglass	0.9 km to T8 (S)	51.5	+7.7	71	19.4m
Thomas Street	1.1km to T7(N)	57.5	+13.7	72	14.4m
Corkip Lough +	1.0km to T20(S)	~57*	+13.2	95	38m
Commons	0.9km to T7(N)	66.4	+22.6	72	5.6m

Turlough	Distance to nearest proposed turbine	Winter water level (m OD)	Head difference to River Suck (43.8 m OD)	Turbine ground level Elevation (m OD)	Elevation difference between Turlough water level and ground level
Cuilleenirwan	1.3km to T4(N)	65.1	+21.3	72	6.9m
Dooloughan	2.9km to T4(N)	70.5	+26.7	72	1.5m
Feacle Turlough+	0.7km to T18(S)	62.2	+18.4	90	27.8m
Four Roads+	2.75km to T1(N)	48.6	+4.8	93	~41m
Gortaphuill	0.1km to T4(N)	67.4	+23.6	72	4.6m
Lough Croan+	1.3km to T2(N)	68.2	+24.4	76	7.8m
Lough Funshinagh	>5km	69.04	Not in catchment	N/A	N/A

** Water levels were taken from aerial photography (not direct measurement)*
+Designated Site (SPA/SAC or NHA – proposed and designated)

The turloughs are located between 0.1 – 2.9km from the nearest proposed turbine. Water levels within the monitored turloughs (2020-2021) range between 51.6 – 70.69 m OD, with elevation differences between each turlough and its nearest proposed turbine ranging between 4.6 - ~33m. The head difference between the turloughs and the River Suck median water level ranges between 7.7- 26.7m. At Ballyglass turlough, situated along the Ballyglass river, the head difference between the maximum water level in the turlough and the River Suck is +7.7m. The Ballyglass turlough is nearest to the River Suck, being approximately 2.4km east of the river. The highest head difference between the River Suck and a monitored turlough is at Dooloughan, where the head difference was 26.7m. Dooloughan is situated 7.4km east of the River Suck but it is located in the headwaters of the Cross River. The historical data (2016-2019) for the Four Roads turlough puts the maximum winter water level at 48.6m, +4.8m above the stage of the River Suck. Water level plots for the turloughs are included in Appendix 9-3.

The turloughs can broadly be categorised into two groups, the higher elevation turloughs and the lower elevation turloughs. The water levels of the higher elevation turloughs sit between ~65-70m OD during Winter and include Lough Croan, Commons, Gortaphuill, Dooloughan, Cuilleenirwan, Cornalee and Lough Funshinagh.

The lower elevation turloughs include Feacle Turlough, Ballyglass, Thomas Street (Carrownadurly), Four Roads and Corkip.

Higher Elevation Turloughs

The closest turlough to a proposed turbine is Gortaphuill, which is located 50m northeast of proposed Turbine T4. The maximum water level recorded during the monitoring period at Gortaphuill turlough was 67.34 m OD, ~2.13m below the formation level of proposed Turbine T4. Water levels in Gortaphuill rose from early February to mid-March 2020, following 235 mm of rainfall in February 2020 and 112.8mm of rainfall in March 2020 before levelling out and reducing from late March to mid-April 2020. A summary of rainfall recorded at the proposed Wind Farm site is included below in Table 9-16.

Table 9-16: Summary of recorded rainfall (mm) at the Wind Farm Site (2020-2021)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Total
2020		235.1	112.8	39.5	19.1	72.4	101.2	126	78.2	104.2	94.4	102.6	**1085**
2021	125.8	82.6	92	15	43.8	*-	-	-	-	-	-	-	**359.2**

** raingauge removed in June 2021 (refer to Leacarrow rainfall data in Table 9-5)*

The Dooloughan turlough has a maximum measured water level of 70.69 m OD. The Dooloughan turlough displays a noticeably different response to rainfall than the other turloughs, with a highly variable hydrograph ranging between 70-70.8 m OD. The water level tends to respond quickly to rainfall with equally sharp recession curves. Its more probable, given the small area of Dooloughan and its location within a topographic hollow, that this is primarily surface water fed, by runoff from the surrounding high ground. As noted above Dooloughan turlough is located at the headwaters of the Cross River, and is hydraulically isolated from the Proposed Development.

Cuilleenirwan is located ~0.7km southwest of Dooloughan and has maximum water level of 65.17 m OD, ~5.5m lower than Dooloughan.

Water levels in Lough Croan range between 66.9-68.2 m OD. The water levels begin to rise in early February, reaching a peak in early March. Water levels gradually subside over the following months at a relatively steady rate, reaching the minimum value (base of the turlough) at the start of June. The water levels in Lough Croan are above those of Gortaphuill, with Gortaphuill turlough situated between the Northern Cluster and Lough Croan. Lough Croan has a less pronounced water level rise and recession than some of the smaller turloughs such as Gortaphuill and Commons.

Water levels in Commons turlough, which is a relatively small turlough range from 64.17 – 66.44 m OD. Again, water levels gradually increase from February to March, before levelling out slightly and gradually subsiding between mid-March to mid-April. The Commons turlough emptied several months prior to the larger turloughs (Cuilleenirwan, Croan etc.) as did Gortaphuill turlough which filled and emptied over the same shorter period. This may be due to their higher elevation.

Water levels in Cuilleenirwan range between 63.8-65.16 m OD. The water levels were at ~65 m OD when the logger was installed in January 2020. The water levels reduced slightly between January – February 2020, before rising again during February and March to the turloughs maximum water level of 65.16 m OD.

GSI/OPW groundwater monitoring data is available for Lough Funshinagh, which is situated 5.9km northeast of the Northern Cluster. Lough Funshinagh is a considerably larger waterbody than the turloughs mapped in the surrounding area of the Northern and Southern Cluster. As the volume of water stored in the turlough is large compared to the overall depth of water (~1-2m), the rise and recession of the water level tend to be more gradual. Groundwater levels in 2020 ranged between 65.23 to 68.2 m OD. The water levels began to rise in August 2019, before reaching a peak water level in early April 2020. The water level receded in 2020 back down to 67.1 m OD, approximately 1.5m above the previous groundwater minimum levels (2016-2020). The water level then rose from October 2020 to March 2021 reaching a maximum of 69.04 m OD in March.

Lower Elevation Turloughs

Water levels in Feacle Turlough range between 60-62.22 m OD. The water level was already relatively high in January 2020 when the logger was installed (~61.6 m OD). The water levels rise steadily from early February 2020 to early March 2020, before subsiding gradually over the next few months to reach their minimum level in mid-June.

Water levels were also monitored in 2021 at Feacle Turlough. The logger was placed in a deeper depression when reinstalled in 2021, as access was cut off to the previous monitoring location, hence the starting point where the water level begins to rise is lower within the 2021 data. The water level began to rise in October 2020, following a large rainfall event of 30.2mm and a general increase in daily rainfall. The rise was relatively quick between October and November from ground level at ~59.8 m OD to 60.68 m OD (0.8m above ground) by 8th November 2020. The water level then rose slowly over the following months, reaching a peak of 62.06m OD in February 2021. The water level then remained relatively steady before the water began to recede in mid-April, disappearing by late July 2021.

Water levels in Ballyglass river range between 50.8 – 51.6 m OD. The water levels rose sharply in February 2020, with a slow regression to the minimum value between March to May 2020.

Water levels in Thomas Street/Carrownadurly were measured between October 2020 – May 2021. The water levels in the Thomas Street turlough rose steadily and sharply between 22nd October – 4th November 2020, from 52.9 to 56.2 m OD before steadying out for a period and rising more slowly from 56.2 m OD to a maximum value of 57.6 m OD between 4th November 2020 to 9th February 2021. The water level then gradually decreased between February to late April, before dropping off sharply from 20th April to 11th May 2021. During the retrieval of the logger, it was noted that only very minor pockets of water remained in the deepest depressions within the turlough area.

The Four Roads turlough is situated 2.75km northwest of T1. No direct water level monitoring data is available for this turlough for the monitoring period, as access could not be granted to this private land. Historical groundwater data is available from the GSI from November 2016 to August 2019. The monitored water levels ranged between 47.8 to 48.6 m OD. The historical data shows the water level beginning to rise between September to November, reaching a peak in February. The area of the turlough has been mapped within Four Roads turlough SAC boundary and correlated with aerial photography. The Four Roads turlough is not mapped within the GSI GWFlood Map.

Corkip turlough is situated southeast of the Southern Cluster. Water levels were not directly measured by HES between 2020-2021 as access could not be gained. Maximum water levels are therefore derived from the high-water mark on aerial photography of the turlough area, which is at ~57 m OD. We have used groundwater level monitoring at well W18 (refer to Appendix 9-3) as a proxy for water levels in Corkip Lough, as this well location is a good representation of local groundwater conditions.

The difference in elevation between the turloughs over a relatively small area indicates moderate to high groundwater gradients. The elevation differences also enable mapping of the groundwater gradients between the turloughs and the general flow directions *i.e.* Gortaphuill (67.4m OD) cannot flow towards Lough Croan (68.2m OD) and Thomas Street (57.5 m OD) cannot flow towards Feacle Turlough (62.2 m OD), Thomas Street turlough flows in the general direction of the River Suck (43.8m OD).

Geographical spread of turloughs

The turloughs near the Northern Cluster of the Proposed Development in order of their maximum water level elevation are:

- Dooloughan – 70.5 m OD

- Lough Croan -68.2m OD
- Gortaphuill – 67.4m OD
- Commons – 66.4 m OD
- Cuileenirwan – 65.1 m OD
- Thomas Street – 57.5 m OD

The Four Roads turlough is geographically distal to the Northern Cluster, situated 2.75km from the nearest turbine, with a maximum water level elevation of 48.6 m OD in the Winter.

Lough Funshinagh is also considered to be geographically distal to the Northern Cluster, ~5.9km from the nearest turbine in the Northern Cluster (i.e. T4), with a maximum water level of 67.35 m OD. Lough Funshinagh is situated within a separate groundwater body (Funshinagh GWB) to the majority of the Wind Farm site (Suck South GWB). The separation is delineated by an area of elevated topography which runs northwest-southeast.

The regional groundwater gradient across the turloughs is from west/northwest (Dooloughan and Lough Croan) towards the Thomas Street Turlough. This follows the general direction of surface water features such as the River Suck and the unnamed tributaries of the Suck near Four Roads which flow in a southwest direction. While this broadly pushes groundwater away from most designated sites (Turloughs and SAC's), the potential for groundwater flows from the area of high ground near T1/T2 (where winter water levels have been measured at ~76m OD) towards the topographically downgradient turlough at Four Roads cannot be discounted, as intermediate water levels of 61.6 – 65.5 m OD are available for wells W21 and W4 which are ~1km north of T1/T2 and 1.75km south of Four Roads Turlough. The groundwater level data indicates that there are no other areas of the Northern Cluster which drain via groundwater in the direction of a turlough which is listed as a designated site.

The available groundwater levels for Lough Funshinagh show the turlough was hydraulically upgradient of the most north/northwestern turlough (Lough Croan) for ~60% of the monitoring period, notably when water levels were at their highest. These data, coupled with the elevated topography to the northwest of the Northern Cluster (i.e. between the northern cluster and Lough Funshinagh) show the prevailing hydraulic gradient is in a southwest direction towards the River Suck and Ballyglass River and it is not towards Lough Funshinagh.

The turloughs near the Southern Cluster of the proposed Wind Farm site in order of their maximum water level elevation are:

- Feacle Turlough – 62.2 m OD
- Corkip Lough - ~57 m OD
- Ballyglass – 51.5 m OD

The turlough water levels are used in conjunction with other collected water level data to delineate groundwater contours and flow directions within the Hydrogeological Conceptual Site Model (CSM, refer to Section 9.3.7.11).

Ballyglass turlough is situated along a man-made (partially at least) channel created between Cuileenirwan (nearer the Northern Cluster) and the River Suck. The turlough may have come about through the creation of the drainage channel from Cuileenirwan or may have existed prior to the drainage works. The Ballyglass turlough is situated on the northwestern side of the Southern Cluster along the Ballyglass river. The groundwater gradients identified through the incorporation of the groundwater well monitoring (refer to Section 9.3.7.8) show that groundwater at Ballyglass is linked to the turloughs near the Northern Cluster, although it is physically closer to the Southern Cluster. There is no indication that groundwater at Ballyglass is hydraulically connected to Feacle Turlough or Corkip Lough. The maximum groundwater level at Ballyglass Turlough is 51.5m OD and this turlough drains via the Ballyglass River to the River Suck.

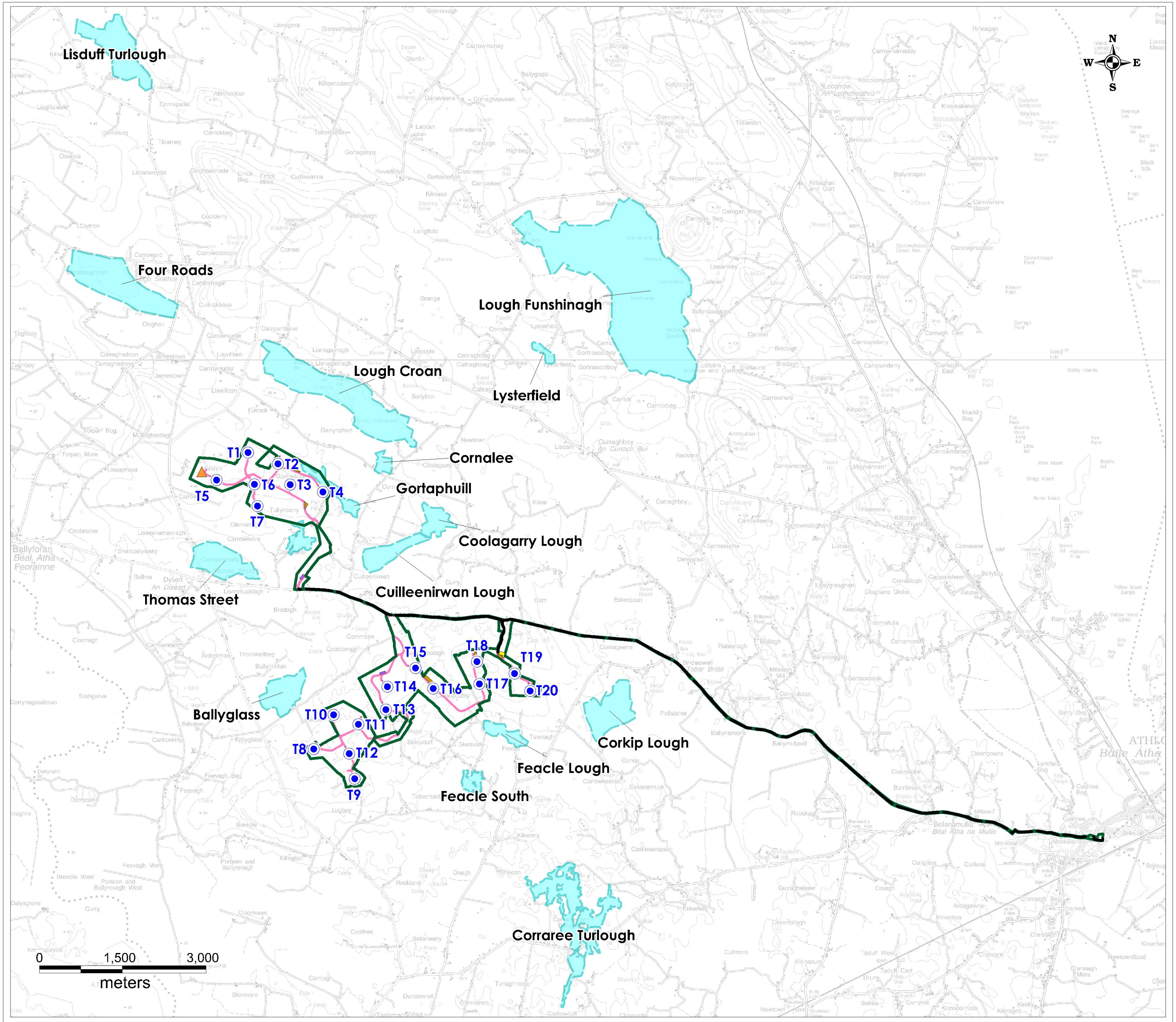
Corkip turlough is situated to the southeast of the Southern Cluster. Groundwater gradients (refer to Figure 9-18 and Figure 9-19) show that the majority of the Southern Cluster drains away from Corkip Lough. The only areas which may drain towards Corkip turlough are near Turbines T19 and T20 and the proposed onsite electrical substation. The Corkip turlough is part of the 'Corkip turlough and Ballynamona bog SAC', however, drainage from the bog is separate, given the artificial drainage channels which drain the bog to the south. Furthermore, the formation of the raised bogs requires an impermeable layer (shelly marl/clay) in order for the bog to form, which creates a disconnect between the bog hydrogeology and the regional bedrock groundwater system.

Feacle Turlough is situated to the south/southeast of the Southern Cluster. Available water level data and indicate that proposed turbines T17 and T18 are situated within the likely groundwater catchment feeding towards Feacle Turlough.

Synthetic Aperture Radar Seasonal Flood Maps

In addition to the water level data collected by HES, Synthetic Aperture Radar (SAR) seasonal flood maps are available at www.gsi.ie and show the observed peak flood extents which took place between Autumn 2015 and Summer 2021. These groundwater flood maps were produced using SAR images from the Copernicus Programme satellites and were created by SAR systems which emit radar pulses and record the return signal, with flat surface such as water returning a low signal.

As seen in Figure 9-14, the historic SAR seasonal flood zones in the vicinity of the Wind Farm Site correspond to the mapped turloughs shown in Figure 9-13. The SAR flood maps highlight the annual variability of the groundwater flood extents associated with these turloughs. The SAR maps show that the greatest recorded floods occurred during the winter 2015-2016 flood event, with these groundwater flood extents corresponding to the Maximum Historic Groundwater Flooding mapped by the GSI (Figure 9-6). During this flood event, Gortaphuill and Commons turloughs encroached upon the Wind Farm Site. Meanwhile, groundwater flood extents associated with these turloughs were significantly reduced during winter 2016-2017 whereby no flooding was recorded within the Wind Farm Site. SAR maps for the succeeding years only record groundwater flooding associated with Gortaphuill turlough to encroach upon the Wind Farm Site (i.e. the Northern Cluster). Due to the close proximity of T4 to Gortaphuill turlough a detailed site specific flood risk assessment has been completed for T4 (refer to Appendix 9-1). Meanwhile, the SAR maps do not indicate the presence of any flood zones or turloughs along the grid route.



Legend

- EIAR Site Boundary
- Proposed Grid Route
- Proposed Turbine Layout
- Proposed Me Mast
- Proposed Substation
- Proposed Temporary Construction Compounds
- Proposed Spoil Storage Areas
- Proposed Access Roads
- Proposed Hardstand
- Turloughs

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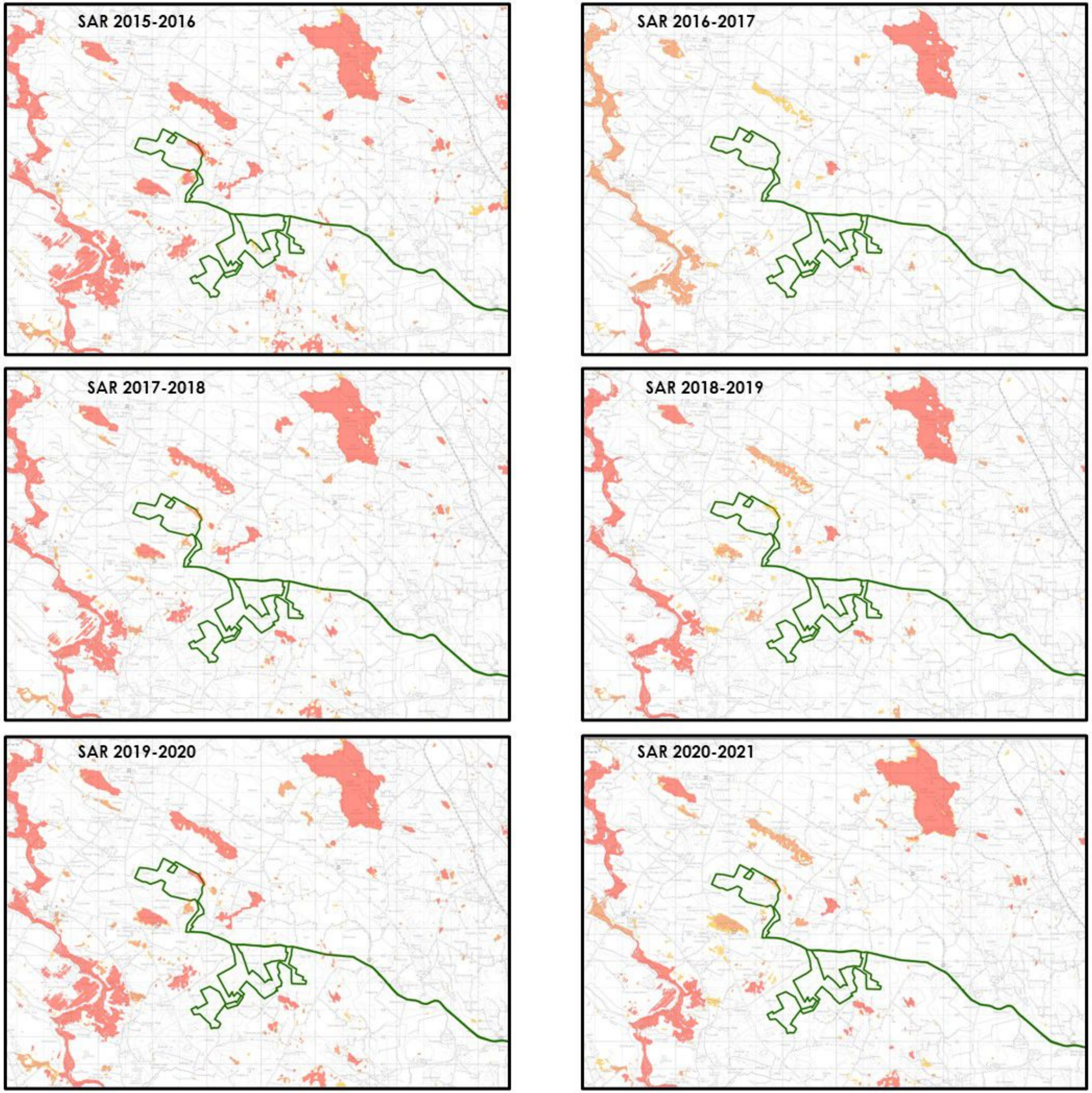
Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Mapped Turloughs near the Proposed Development	
Figure No: 9-13	
Drawing No: P1500-0-0422-A3-913-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:65,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG



Legend

EIAR Site Boundary

SAR Flood Map (GSI)

High

Medium

Low

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: SAR Flood Map	
Figure : 9-14	
Drawing : P1500-0-0422-A3-914-0A	
Sheet Size: A3	Project No.: P1500-0
Scale: As shown	Drawn By: GD
Date: 27/04/2022	Checked By: MG

9.3.7.7 Group Water Schemes and Public Water Schemes

There are no mapped group water schemes (GWS) within 5km of the Wind Farm site, nor within 3 km of the associated Grid Connection route.

There are 2 no. mapped Public Water Schemes (PWS) within 6km of the Wind Farm site (Mount Talbot PWS and Killeglan PWS (Tobermore Spring source). The Killeglan PWS is situated ~1.9km from the Southern Cluster. The Mount Talbot PWS source is situated 5.8km northwest of the Northern Cluster, however the boundary of the Zone of Contribution (ZoC) is situated 2.8km north of the Northern Cluster, so it is included here for completeness. A map illustrating the source protection areas of both of these PWSs relative to the Wind Farm site is included in Figure 9-15.

The Killeglan PWS exists in the townland of Rockland, where several springs are mapped by the GSI and on historic 6" mapping. The Zone of Contribution (ZoC) to this spring has been mapped (Appendix 9-4), which encompasses a small area of the Proposed Development Site, near the southern edge of Cam Hill, near the proposed turbine T17. Turbine T18 is not mapped within the ZoC, however, the available water level data cannot discount the potential for some groundwater flow from the T18 area occurring in a southerly direction towards Feacle Turlough.

Site investigation data has been gathered, through the completion of geological logs during borehole drilling by Roadstone Ltd. (private Roadstone quarry at Cam, near the Southern Cluster of the Proposed Development) and HES, for the Southern Cluster, near the northern edge of the Killeglan Spring ZOC boundary. The data gathered by Roadstone Ltd. during the course of their quarry works has been made available to HES. These data are summarised in Table 9-17. Borehole ST2 is near the northern extent of the Killeglan Spring ZoC and so is included in the table below. Boreholes ST4 and ST8 are further north and distal to the northern boundary of the ZOC, so are not included below, although it should be noted that no karst features were encountered these boreholes either.

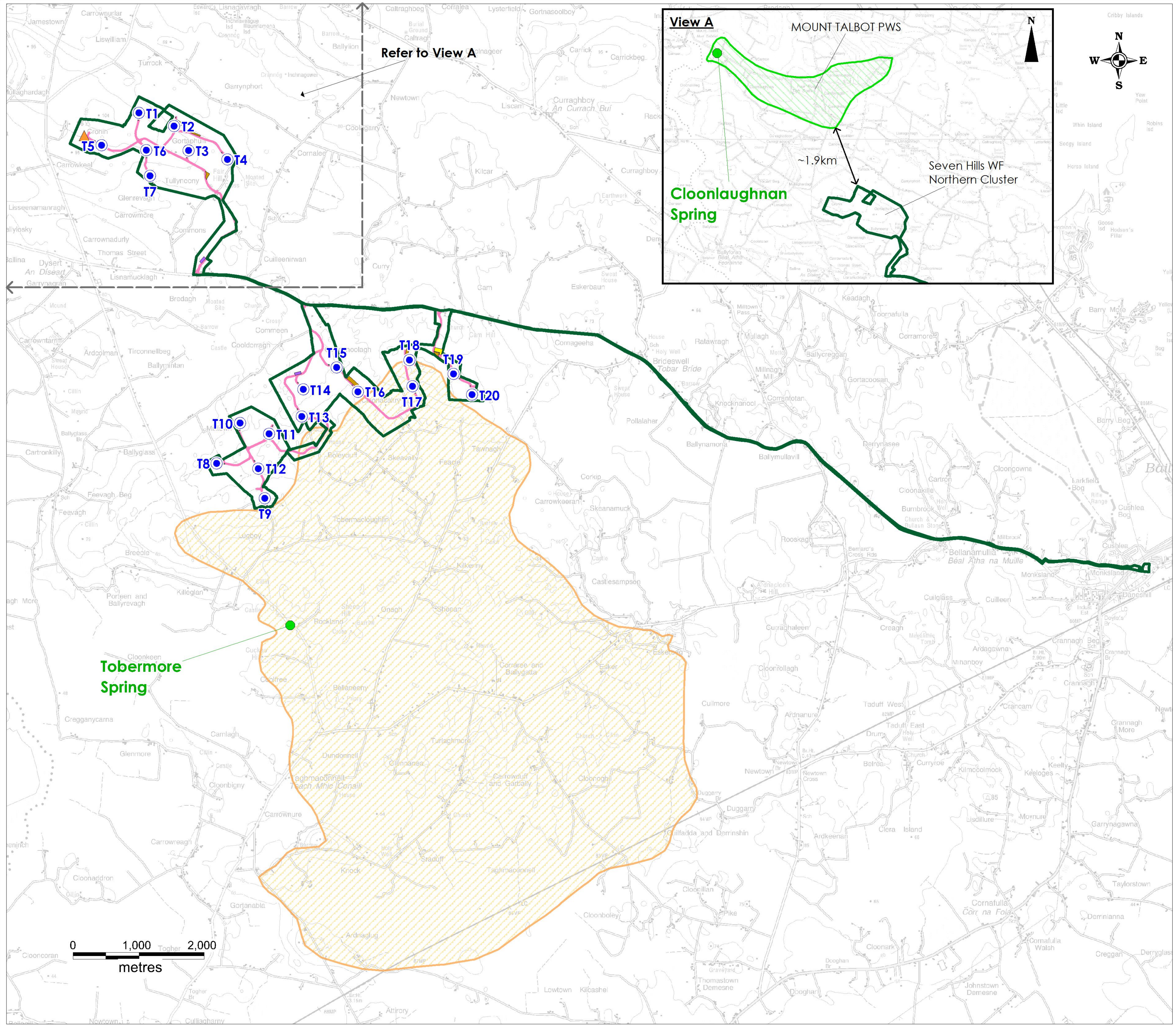
Table 9-17: Summary of available geological/hydrogeological data near Cam Hill, Co. Roscommon

Borehole/SI Location	Easting	Northing	Distance to ZoC	Lithology/Geology	Karst Features observed
Roadstone BH1	190,455	244,044	In ZoC	No log available	
Roadstone BH5	190,652	244,196	In ZoC	No log available	
Roadstone BH6	190,210	244,402	In ZoC	No log available	
Roadstone BH7 (MW1)	190,050	244,338	0.1km	0-7.5m: Limestone boulders, cobbles and gravel 7.5-10.5m: Light grey slightly weathered Limestone 10.5-11.0m: Clay infilled Cavity 11-38m: Light grey slightly weathered Limestone	Possible karst features with cavities, however no large water strikes observed. Drilling dusty rock to 35m, ~0.5 l/s water reduced dust after this.

Borehole/SI Location	Easting	Northing	Distance to ZoC	Lithology/Geology	Karst Features observed
				38-39m: Clay infilled cavity	
Roadstone MW2	190427	245328	0.73	0-4.2m: Light brown/grey fine to coarse angular to subangular Limestone gravel w/ some sandy silt 4.2-39m: Light grey slightly weathered LIMESTONE with some infilled clay fractures	Possible, noted as fractured from 4.2-7.0m but again no water strikes. This is a poor well which is often dry (from HES site visits)
Roadstone BH8	190,049	244,337	0.3	No log available	
ST2	188,286	242,877	0.5	0-0.9 Dense, dry brownish grey slightly gravelly SAND 0.9-2 Dense, dry brownish grey slightly gravelly SAND, with frequent limestone cobbles and boulders 2-6.2 Moderately strong, dry, competent, light grey LIMESTONE with occasional weathering 6.2-13 Moderately strong dry grey LIMESTONE 13-22 Weak to strong, light grey LIMESTONE Clay infill between 16.1-17.8 Fracture from 20.4-20.6 22-40 Strong grey LIMESTONE	No, no karst voids or conduits. No water inflow.

The site investigation data from boreholes near the northern extent of the Killeglan Spring ZoC do not indicate the presence of any water bearing karst/conduit sections. The logs indicated overburden ranging between 2-7.5m thick, consisting of a mixture of silt, sand and gravels derived from Limestone. The bedrock geology is described as Light grey Limestone, which is weathered in places. Clay infilled fractures are also logged, however, there are no water strikes recorded on the borehole logs except for a small flow (~0.5 l/s) in BH7 at a depth of 35m. The Source Protection Zone for the Killeglan PWS is mapped by the GSI with a total area of 4218.5 Ha, which spans a distance of >9km. The total site footprint within the catchment is calculated to be approximately 2.7 Ha.

The Mount Talbot PWS is situated 5.8km northwest of the Northern Cluster and is ~ 0.6km from the River Suck. The source is fed by springs and supplies ~3,540 m^3/day. The Source protection Zone has been mapped for this supply and the southern boundary of this zone is 2.8km north of the Northern Cluster.



Legend

- EIAR Site Boundary
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- Mount Talbot PWS (Cloonlaughnan Spring)

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: ZoC's of local PWS schemes relative to the Proposed Development	
Figure No: 9-15	
Drawing No: P1500-0-0422-A3-915-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:55,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.8 Groundwater Wells – Domestic/Public/Quarry

9.3.7.8.1 *HES Site Data – Domestic, Public (Disused) & Quarry Wells*

Groundwater monitoring of domestic wells was undertaken by HES between 2020-2021. The lack of consistent water level data during the historic, refused Wind Farm project was seen by HES as a considerable gap in hydrogeological data. For this reason, an updated well survey was carried out, with long term monitoring of water levels conducted in wells which were made accessible to HES. The historic, 2010 survey data (Section 9.3.7.8.2) are used as supplementary information regarding well locations, depths and well performance.

There are a number of domestic wells in the area, public wells (hand dug and bored) as well as groundwater wells at the nearby Roadstone Cam quarry (which were made accessible to HES). 20 no. wells have been directly monitored by HES across a 50 km^2 area between 2020-2021, while data from 1 no. EPA monitoring well was also accessed. The wells which were monitored are summarised in Table 9-18. The locations of these wells are shown on Figure 9-16. Please note that it was not possible to monitor all domestic wells in the study area, but we have collected data from a significant number, and these data allow us to make hydrogeological interpretations as described in this chapter.

Table 9-18 Local monitored domestic, public and quarry wells

Well Location	Easting	Northing	Distance to closest Turbine (km)	Max W/L (m OD)	Min W/L (m OD)
W1	187,559	247,069	0.6km across-gradient to T4	66.8	52.6
W2	187739	247367	0.26km across-gradient to T4	62.2	55.01
W3	186611	249268	1.9km downgradient to T7	46.9	30.4
W4	185003	246251	0.95km downgradient to T1	65.5	54.9
W5	188942	247927	1.2km across-gradient to T4	70.8	63.1
W6	188254	246379	1.35km across-gradient to T4	66	60.7
W7	186902	246240	1.15km downgradient to T7	61.9	55.1
W8	185096	247504	0.8km downgradient to T5	62.68	49.75
W9	190474	245303	0.7km upgradient to T18	71.95	<63
W10	190652	244196	0.01km across-gradient to T17	-	-
W11	190050	244338	0.4km across-gradient to T16	69.4	53.7
W12	188667	244811	0.75km across-gradient to T15	64.2	56.2
W13	188140	244256	0.75km across-gradient to T10	60.46	43.4
W14	188503	241713	0.75km downgradient to T9	50.74	46.7
W15	190962	241660	2.5km downgradient to T17	56.8	50.8
W16	191245	242829	1.5km downgradient to T17	48.5	42.5

Well Location	Easting	Northing	Distance to closest Turbine (km)	Max W/L (m OD)	Min W/L (m OD)
W17	191636	242578	1.5km downgradient to T20	59.9	53.5
W18	192342	243877	0.9km downgradient to T20	58.8	54.7
W19	192459	242969	1.45km across-gradient to T20	56.9	53.0
W20	185614	246682	1. 5km downgradient to T7	-	-
W21	186261	249472	1.1km downgradient to T1	61.6	49.1

Maximum groundwater levels in wells across the Northern Cluster range between 46.9 – 70.8 m OD. The wells surrounding the Northern Cluster are W1-W8 and W20-W21. Maximum groundwater levels generally decrease from northeast to southwest. Well W5, a hand dug well near Cornalee turlough has the highest maximum winter water level of 70.8m OD, while the lowest winter water level exists at W3, a domestic well just west of Thomas Street turlough (46.9m OD). Summer water levels generally follow the same trend, with the highest summer level at W5 and the lowest at W3.

Wells W9-W19 cover the area around the Southern Cluster. Maximum groundwater well levels surrounding the Southern Cluster range between 48.5 – 71.95 m OD. The highest water level is recorded at well W9 (71.95 m OD), which is situated near Cam Hill and within the Roadstone Cam quarry, while the lowest groundwater level is recorded at well W16, located just south of Feacle Turlough.

9.3.7.8.2 Historic Data – Domestic Wells

The closest mapped well by the GSI available through their public map viewer[6] is situated ~0.75km from the nearest turbine location. Borehole 1723NEW021 is situated adjacent to the northern edge of Feacle Turlough within a farmyard/domestic property. The County Council Borehole monitored by HES during the groundwater monitoring period is also mapped by the GSI as well 1723NEW085. There are no other groundwater wells mapped by the GSI within the 50m accuracy threshold.

During the hydrogeological field investigations undertaken as part of the historical, refused Wind Farm project in the area around Dysart, Co. Roscommon, a local well survey was conducted by Waterwise Environmental Ltd. This survey data provides further useful information on the number of active wells in the area, the well type and some nominal information on bedrock type and groundwater strikes.

Previous well surveys near the Northern and Southern Clusters were also conducted by Waterwise Environmental in June 2010. The majority of houses were noted to be supplied by mains water while some properties still had older wells.

A further 61 dwellings were visited near the Southern Cluster, with 9 no. groundwater wells (or evidence of wells) observed. Of these 9 no. wells, only 4 are known to be actively used or used as a standby source. The locations and details of well installations are shown below in Table 9-19 and in Figure 9-16.

Table 9-19: Local wells identified in 2010 survey

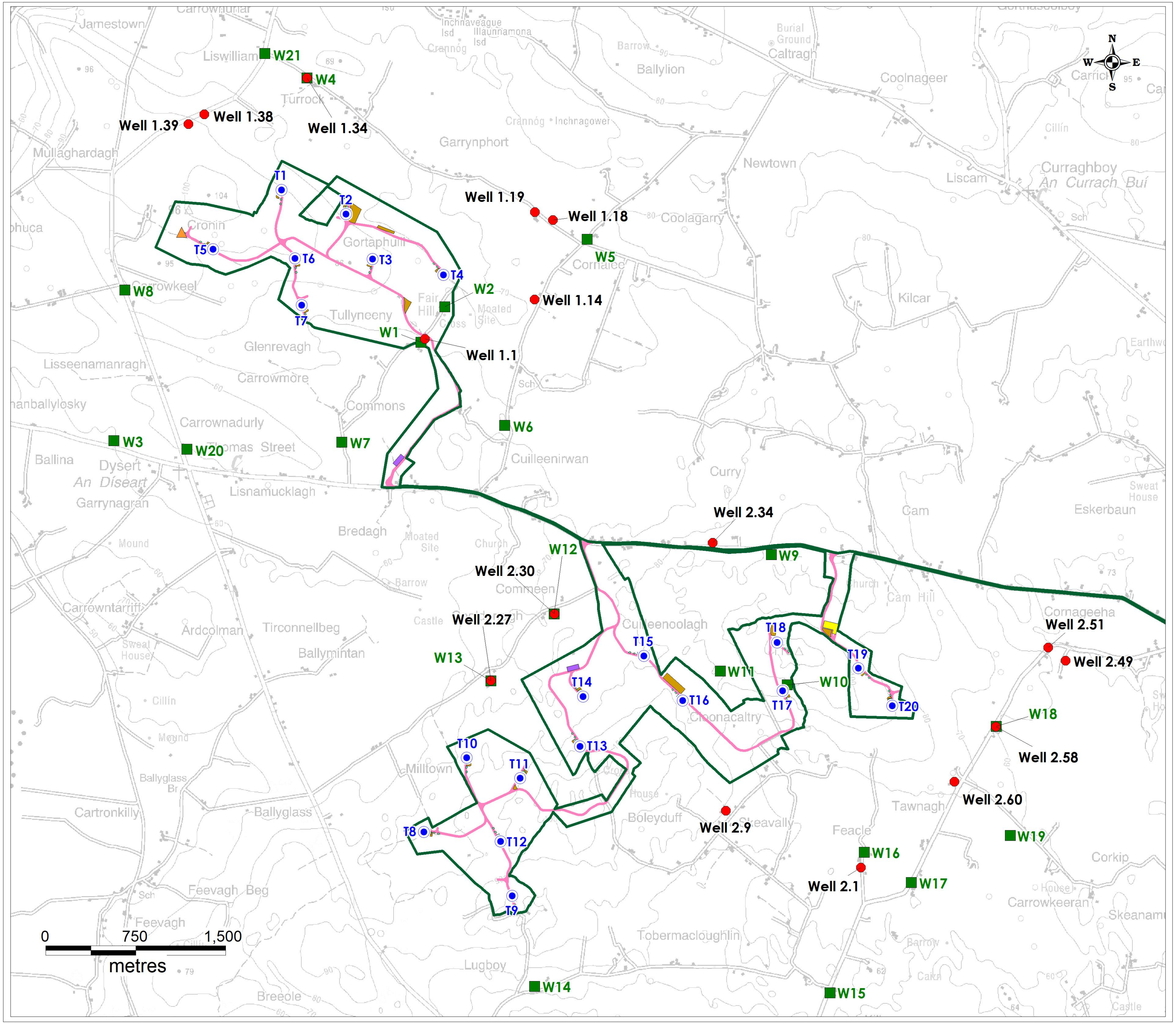
Well Number	Easting	Northing	Distance to the nearest turbine	Description
Well 1.1*	187593	247098	0.6km to T4 (upgradient)	1 no. well (208ft deep) supplying house and farm. Older well at property (80ft deep) had poor yield
Well 1.14	188505	247427	0.8km to T4	4 no. wells at property. 1 no well supplies house and farm. 6” diameter
Well 1.18	188658	248086	0.9km to T4	1 no. well, 250ft deep, 40-50 years old
Well 1.19	188508	248152	0.9km to T4	Pump house in garden
Well 1.34*	186611	249268	0.95km to T1	On mains water but old well at property
Well 1.38	185759	248966	0.9km to T1	Pump house observed
Well 1.39	185626	248885	0.9km to T1	On mains water but old well at property
Well 2.1*	191218	242703	1.5km to T17	On mains water. Sealed well at property

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

Well Number	Easting	Northing	Distance to the nearest turbine	Description
Well 2.9	190094	243176	1.0km to T16	Unsuccessful well drilled to 100m 10-20 years. No yield.
Well 2.27*	188142	244259	0.7km to T10	Well used to supply farm stock. Drilled 1981.
Well 2.30*	188671	244813	0.75km to T15	5.5m of overburden above bedrock. 20mm steel casing to bedrock, open hole to base of the well. Water Level measured at 11.13m below ground level during 2010 well survey. Pump intake at 61m. Electrical Conductivity (2010): 614µS/cm, Temperature: 11.8°C, Total Dissolved Solids: 308ppm, pH: 7.1 Well used in conjunction with mains to supply house and farm. Yield and quality good.
Well 2.34	189987	245404	1.0 km to T18	On mains water, well no longer in use. 96m deep well with ~5m overburden (steel casing) into open hole.
Well 2.49	192921	244422	1.5km to T20	40m borehole. W/L measured at 0.36 mbgl during 2010 survey. 10.6m of overburden with competent rock from 12.2m. Area prone to flooding in winter.
Well 2.51	192776	244533	1.4km to T20	Dug well over 100 years old observed from road. W/L 2.7m below concrete.
Well 2.58*	192341	243875	0.9km to T20	2 no. house development supplied by mains. Standby borehole at property. W/L 3.24mbTOC during 2010 survey.
Well 2.60	191996	243418	0.85km to T20	1 no. borehole (55m deep). Used in conjunction with mains to supply house and farm. W/L 11.1mbTOC during 2010 survey.

**Denotes well is not being used*

In total, 16 no. groundwater wells were identified by the well survey. Of these 16, ~7 wells are known to be actively used or used as a backup source. This is a relatively low number of active domestic wells given the large geographical spread over the Northern and Southern Clusters area and considering the mapping of the groundwater aquifer as a regionally important karstified aquifer (Rkc -Karstified (conduit)).



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Me Mast
- Proposed Substation
- Proposed Temporary Construction Compounds
- Proposed Spoil Storage Areas
- Proposed Access Roads
- Proposed Hardstand
- Local wells identified in 2010 survey
- Local monitored domestic wells 2020/21

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Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Title: Local Groundwater wells relative to the proposed Wind Farm

Figure No: 9-16

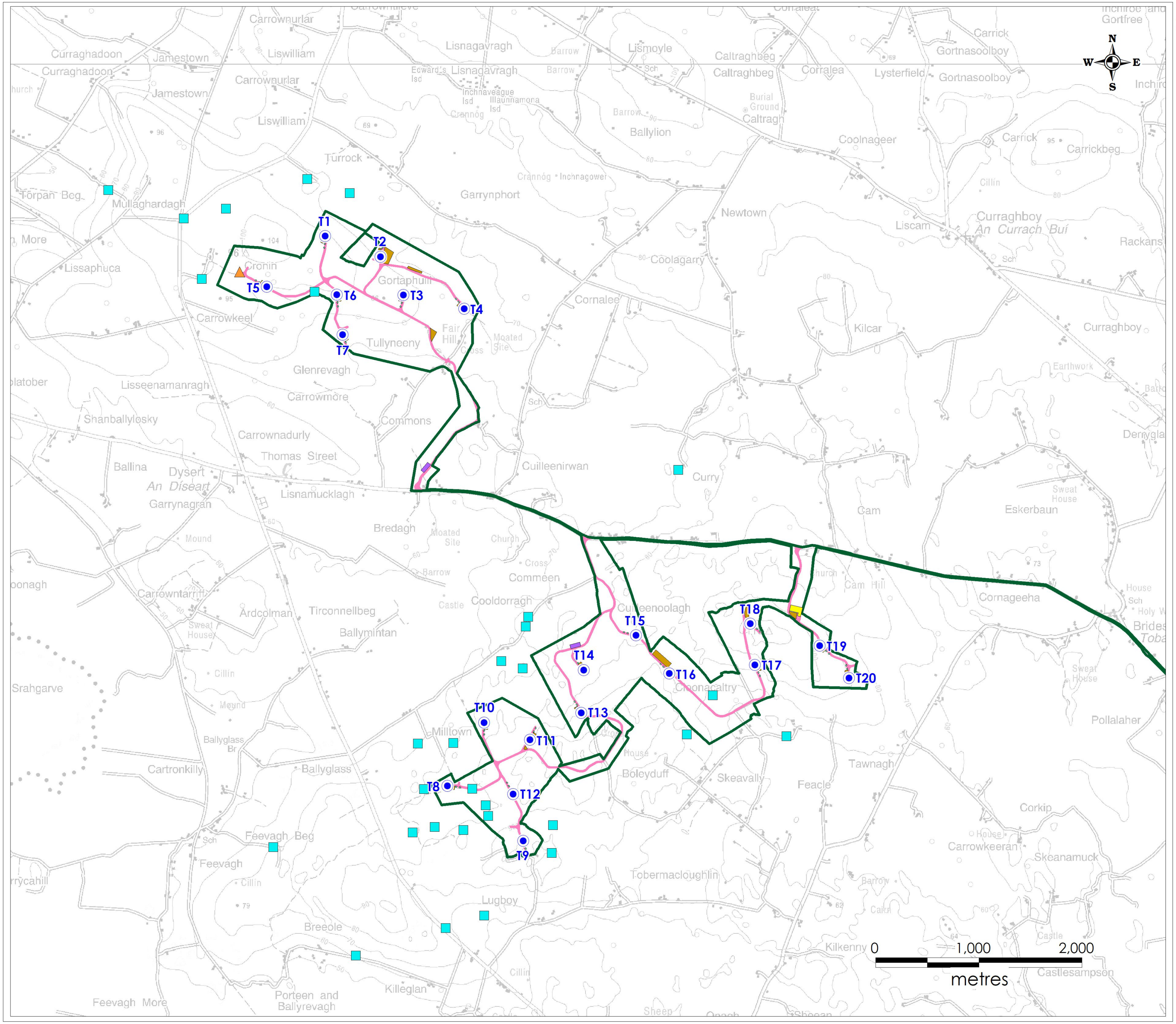
Drawing No: P1500-0-0422-A3-916-0A

Sheet Size: A3	Project No: P1500-0
Scale: 1:30,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.9 Agricultural Water Collection/Supply

During fieldwork conducted by HES in 2019, 2020 and 2021, it was noted while driving along the local/rural roads and while walking across farmland, that there was a significant amount of rainwater harvesting infrastructure dotted along the hills and shallow slopes near the proposed Wind Farm site. The rainwater collectors are typically a mass concrete construction which funnel water falling along the concrete surface into a trough downslope. They are generally ~5m (l) x 3m(w) x 1m(h) in dimensions (refer to Site Photograph 16 in Appendix 8-1). Given the geological mapping of a karstified aquifer underlying the Wind Farm site area, which would suggest that groundwater may be a preferential, cost-effective source rather than having to construct large concrete harvesters, HES undertook a GIS mapping exercise to define the extent and number of these rainwater harvesters in the area. A total of 30 no. rainwater collectors were identified. These rainwater harvesters are located between 0.05 and 1.8km radially from the nearest turbine location, primarily on higher grounds (>80 m OD), and on gradual to steep slopes. The locations of these rainwater harvesters are shown in Figure 9-17.

The presence of a large number of rainwater collectors along the elevated agricultural grounds (broadly between ~70-85 m OD) suggests that groundwater is not as abundant as the geological and aquifer type mapping would indicate. Generally, in areas where groundwater wells are known to be productive, there would be a far greater number of agricultural wells for livestock and agricultural practices. In these areas, farmers will often praise their water supplies, which can be held in equal esteem to the quality of the surrounding grassland. The presence of rainwater collectors on the agricultural lands near the Wind Farm site tends to indicate that it is difficult to find water and that infrastructure, which reduces the space for grazing, must be constructed to maintain livestock. It is likely that bored wells were attempted and abandoned, due to lack of yield, as was found by on-site drilling of monitoring boreholes (refer to Appendix 8-2 of Chapter 8) which presented essentially no water strikes and very slow recovery.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Me Mast
- Proposed Substation
- Proposed Temporary Construction Compounds
- Proposed Spoil Storage Areas
- Proposed Access Roads
- Proposed Hardstand
- Rainwater collectors within 1.8km of Seven Hills Wind Farm Site

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Job: Seven Hills WF, Co. Roscommon	
Title: Rainwater Harvester Locations	
Figure No: 9-17	
Drawing No: P1500-0-0422-A3-917-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:35,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.10 Groundwater Levels and Flow Directions

Groundwater level data has been collected from turloughs (as outlined in Section 9.3.7.6), from Site Investigation Boreholes (Section 9.3.7.3) and from domestic/publicly accessibly water wells (Section 9.3.7.8). In total HES have continuously monitored water levels using Diver water level loggers or attained continuous water level data from external sources, at the following locations:

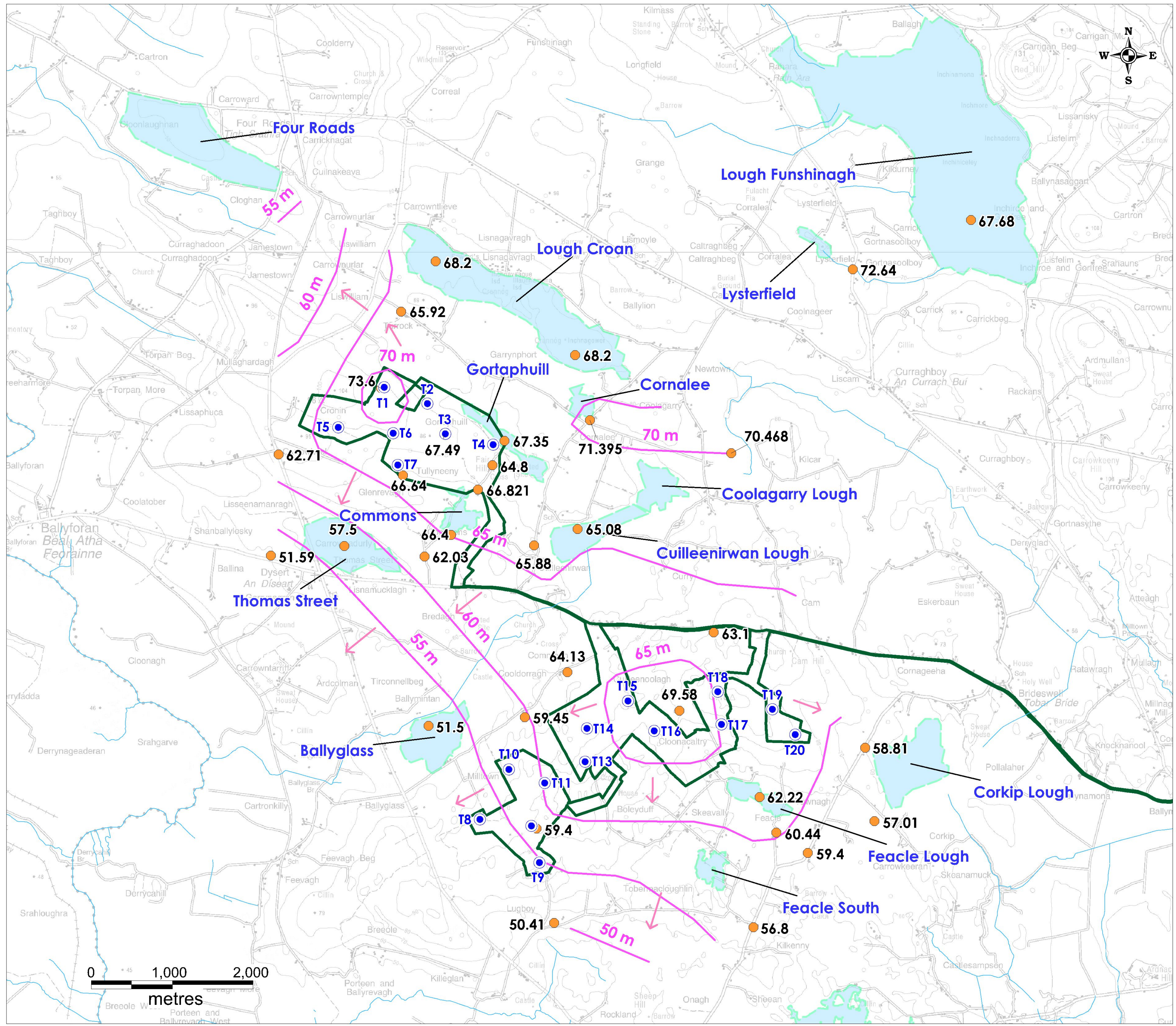
- 6 no. Site Investigation boreholes (NT1, NT3 and NT7 and ST2, ST4 and ST8) – 1,614 no. total days of data;
- 15 no. Domestic wells – 5,043 no. total days of data;
- 3 no. Roadstone quarry wells – 819 no. total days of data;
- 2 no. Hand dug wells – 973. total days of data;
- 1 no. County Council well– 430 no. total days of data;
- 8 no. Turloughs – 1,154 no. total days of data;
- 1 no EPA monitoring well (Turrock) - 4,906 no. total days of data.

These data have been compiled and analysed to form a conceptual model of groundwater gradients and groundwater flow directions across the Northern and Southern Clusters. As the primary focus of the groundwater investigation is on the turloughs (as some of these are designated as SAC's/SPA's/NHA's, detailed in Section 9.3.12) and the turloughs only exist during the winter high water table, the main attention is given to the winter water levels rather than the summer groundwater levels.

In Summary, winter groundwater levels in wells within the Northern Cluster range between 46.9 – 70.5m OD, with the highest water levels in the west/northwest and the lowest towards the southeast (closer to the River Suck). Water levels in the turloughs near the Northern Cluster (Lough Croan, Gortaphuill, Cuileenirwan, Commons, Dooloughan, Thomas Street, Lough Funshinagh and Four Roads) range between 57.5 – 70.5 m OD. Winter water levels in the turloughs are generally higher towards the northeast and lower towards the southwest, similar to groundwater levels in the monitored wells.

Using the acquired groundwater level data from turloughs, site investigation boreholes, local domestic wells, quarry wells and publicly accessible wells, groundwater contour maps have been created. The Winter and Summer groundwater levels from each monitoring point have been mapped separately on Summer and Winter maps. Groundwater contours can then be drawn between points of equal groundwater levels (m OD). Groundwater flow will be at right angles to these contour lines. The Summer and Winter groundwater gradient maps are shown below as Figure 9-18 and Figure 9-19.

Winter groundwater levels in wells within the Southern Cluster range between 48.5 – 71.95 m OD, with the highest water levels near the highest elevated ground (Cam Hill). The lowest groundwater level recorded in a groundwater well was near Feacle Turlough. Water levels in the turloughs range between 51.5 – 62.2 m OD. Water levels in the Ballyglass turlough, towards the northwest of the Southern Cluster, are lowest (51.5 m OD), while water levels in Feacle Turlough to the southeast and on the far side of the Southern Cluster high ground are highest (62.2 m OD).



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Water level_Winter (mOD)
- GW Contours_Winter (mOD)
- GW Contours Flow Direction (Winter)
- Watercourses
- Turloughs

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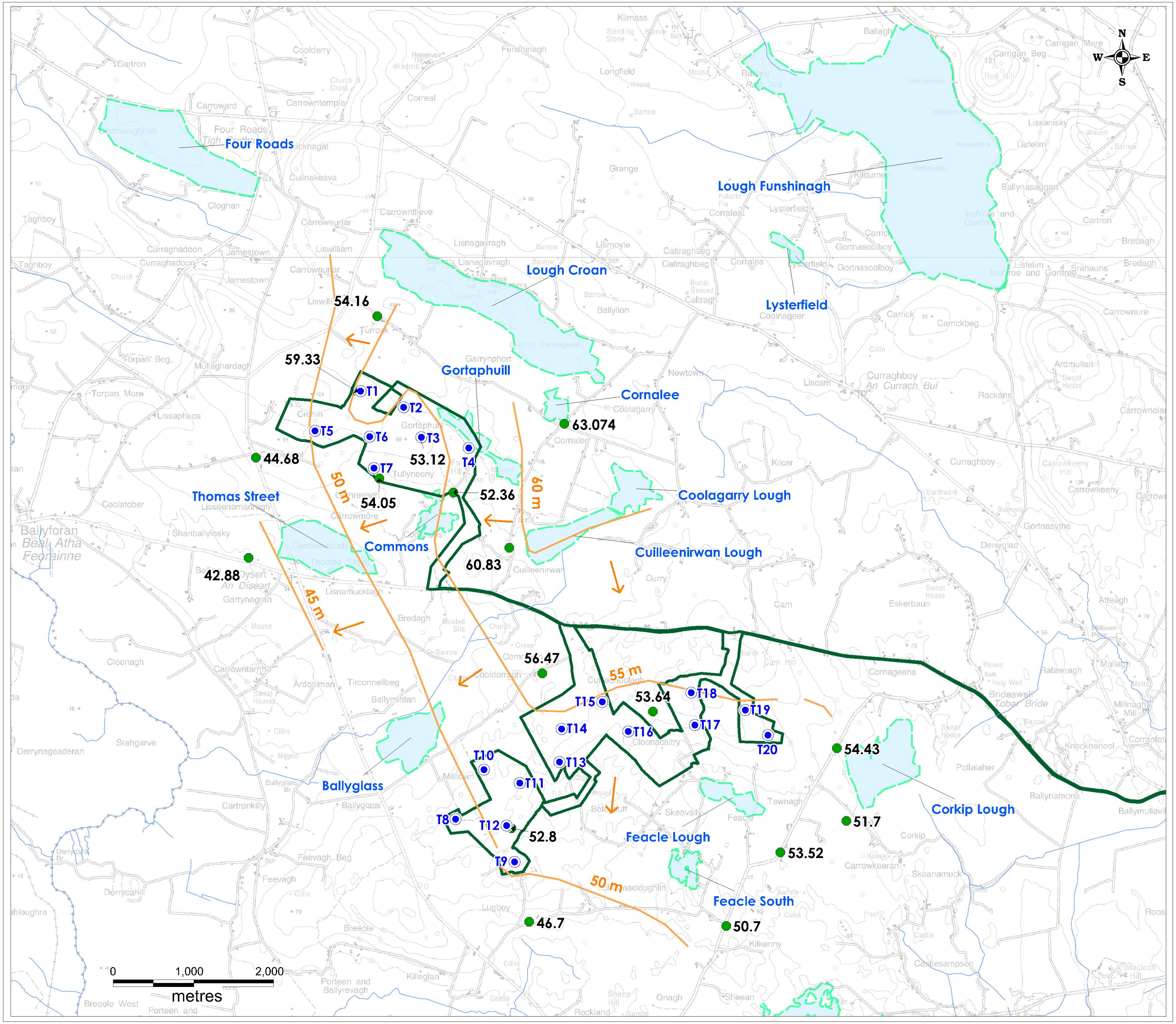
Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Groundwater Contour Map (Winter)	
Figure No: 9-18	
Drawing No: P1500-0-0422-A3-918-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:45,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Water level_Summer (mOD)
- GW Contours_Summer (mOD)
- GW Contours Flow Direction (Summer)
- Watercourses
- Turloughs

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Job: Seven Hills WF, Co. Roscommon	
Title: Groundwater Contour Map (Summer)	
Figure No: 9-19	
Drawing No: P1500-0-0422-A3-919-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:45,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.7.11 Conceptual Hydrogeological Model

A conceptual site model of groundwater movement has been created based on available desk study data and all the available site data collected through the intrusive site investigations (2010-2021) and the hydrogeological fieldwork and water level monitoring (2020-2021). The conceptual site model for the Wind Farm site incorporates the following datasets:

- 285.7m of borehole drilling in the Northern Cluster to determine bedrock geology (2010-2021);
- 394.6m of borehole drilling in the Southern Cluster to determine the bedrock geology(2010-2021);
- 5862 no. total days of water level monitoring data in the 21 no. domestic/public/quarry boreholes across a 50 km2 area (2020-2021);
- 1614 no. total days of water level monitoring data in the 6 no. HES Site Investigation boreholes (2020-2021);
- 1154 no. days of water level monitoring in the 8 no. turloughs (2020-2021);
- 37 no. trial pits in the Northern Cluster to determine depth and nature of subsoils (2010-2021);
- 34 no. trial pits in the Southern Cluster to determine depth and nature of subsoils (2010-2021);
- ~3.6km of geophysical profiles across the turbine locations (2 no. 90m sections at 20 no. locations - 2020-2021);
- Available water level data from the River Suck, Lough Funshinagh and Four Roads and Lisduff Turloughs (2016-2021);
- Mapped karst features and tracing studies (GSI mapping) on the low-lying lands surrounding the site; and,
- Groundwater Body Characterisation Reports (Suck South (GSI, 2003 (a) and Funshinagh GWB (GSI, 2003 (b)).

The conceptual site models of the Northern and Southern Clusters of the proposed Wind Farm site, as well as the local surrounding area, differ from the broad scale conceptual model in the Suck South GWB. There is a small area of the Southern Cluster which is mapped within the Funshinagh GWB, but this is a negligible amount and the characterisation of the Funshinagh GWB is similar to that of the Suck South GWB, which covers an area of 1,099km^2. The site data collected by HES has been focused on an area of ~50 km^2 and includes a significant amount of geological and hydrogeological data. While analysing these data HES have noted many differences between the generic information contained with the broad scale groundwater body characterisation (from the Suck South and Funshinagh GWB characterisation reports) and the actual data collected at the site. In the interest of clarity, we have highlighted some of these differences below in Table 9-20.

Table 9-20: Comparison of GWB broad scale characteristics and site specific hydrogeological conceptual model

GWB Reports/General Perception of groundwater system	Based on Site Investigation	Primary Difference
Karstification is widespread in this Suck South GWB	No significant evidence of karst during site investigation drilling (minor Limestone weathering was noted) and no visual evidence of karst features along the high ground where the majority of drilling took place. Karst features were visible on the low-lying lands, especially obvious within the enclosed	Karst features are spatially variable and seem linked to topography. They are less frequent on the higher ground upon which the Wind Farm site clusters are proposed. Karst features exist and are mapped by the GSI within the

GWB Reports/General Perception of groundwater system	Based on Site Investigation	Primary Difference
	depressions at turloughs such as Thomas Street.	GWBs, however, the collected data indicates infrequent karst occurrences, rather than the ubiquity that is implied in the GWB reports.
Highly vulnerable aquifer – the aquifer is mapped with a vulnerability rating of High to Extreme.	The site specific data on subsoil cover, which is the primary control on groundwater vulnerability shows average subsoil depths within the Northern and Southern Clusters of 7.41 and 7.32m respectively, indicative of moderate groundwater vulnerability (as per GSI guidelines).	Groundwater vulnerability is considerably less than the mapped vulnerability, primarily due to the site-specific information on the significant depths of overburden across the site. The assumption within the broad scale GSI mapping is that vulnerability is high across karst areas as rock is near surface and higher vulnerability is likely on elevated ground. This has been shown to not be the case. While limestone boulders are strewn across the landscape, they previously have been interpreted as indicating shallow depths to bedrock, but this is not the case as considerable depths of overburden have been proven through site investigation across the Northern and Southern Clusters.
Highly transmissive karstic aquifer system across the region	The site-specific data shows no significant water strikes across all site investigation boreholes. In a typical karst aquifer, highly transmissive weathered zones would be expected to be encountered where large water strikes would be met while drilling.	The typical conceptualisation of the karst system is that there is an abundance of groundwater flowing beneath the land surface, however, the site-specific drilling data shows that this is not the case across the Northern and Southern Clusters. While tracer tests have shown karst connections and transmissive groundwater conduits within the lowlands, these are localised and cannot be assumed to represent the overall groundwater flow regime.

GWB Reports/General Perception of groundwater system	Based on Site Investigation	Primary Difference
		There may be a deeper karst groundwater system across the lowlands, but there also is a less productive limestone on higher ground, especially noted at the northern cluster. The abundance of rainwater collection systems, and to a certain extent the lack of groundwater wells locally indicates a difficulty with obtaining significant groundwater yields from groundwater wells in the area.

A conceptual model of rainfall infiltration, percolation, groundwater flow and groundwater discharge to surface water features is presented graphically in Appendix 9-5. The water level data collected within the Northern and Southern Clusters, from private/public wells, site investigation boreholes and from turloughs has been used to derive the local groundwater flow directions and gradients. On a regional scale, the conceptual model broadly shows groundwater flowing west/southwest towards the River Suck and lesser tributaries such as the Ballyglass and Killeglan River.

Northern Cluster

Rainfall falling across the Northern Cluster predominantly percolates to ground. There is an absence of surface water drainage channels across the Northern Cluster. Permeability of the soil and subsoil is variable due to localised deposition of glacial deposits at the end of the last glacial maximum. Subsoils consisting mainly of silty, gravelly sand or sandy gravelly clay have been logged, which vary in thickness from 1.3 – 16.3m. The Particle Size Distribution data from samples taken by IGSL are included within Appendix 6 of Appendix 4-3 (Chapter 4) and show that generally, the subsoils contain less than 20% silt/clay. Rainfall will percolate through the subsoil and recharge the underlying bedrock aquifer.

The topography northwest of the Northern Cluster is elevated in parts and Winter groundwater levels in these areas are generally above 70 m OD, as is the case at NT-1, NT-3 and NT-7 which are on high ground. The groundwater levels in monitored wells of the Northern Cluster range between 46.9 – 70.8 m OD, while the groundwater levels in the turloughs range between 57.5 – 70.5m OD. The groundwater levels within the area of the Northern Cluster are typically elevated above the level of the Limestone bedrock and occur in the overlying subsoil (refer to Appendix 9-5).

The primary groundwater flow direction is in a southwest direction towards the River Suck. This is the predominant groundwater flow direction at the scale of the overall Northern Cluster, however localised gradients may vary slightly. Local variations may inlcude:

- Initially, it was considered that there was a potential groundwater flow pathway in a northwesterly direction from the high ground near T1 and T2 towards Lough Croan, however the land to the northwest of Lough Croan, near the townlands of Ballylion and Lismoyle is elevated at ~100 m OD, and this forms a shallow basin in which Lough Croan is situated. There are also lower recorded water levels at W3 and the

EPA well at Turrock. The combination of these data indicates that any groundwater flow from the site will travel to the north away from Lough Croan, thus preventing any potential groundwater flow from the Northern Cluster feeding towards Lough Croan. The data therefore indicates the lack of a groundwater pathway towards the SAC, thus the lack of a pathway in respect of potential impacts on the Annex II species at the Lough Croan SAC (refer to Chapter 6).

- The available groundwater levels for Lough Funshinagh show the turlough was hydraulically upgradient of the most north/northwestern turlough (Lough Croan) for ~60% of the monitoring period, notably when water levels were at their highest. These data, coupled with the elevated topography to the northwest of the Northern Cluster show the prevailing hydraulic gradient is in a southwest direction towards the River Suck and Ballyglass river and not towards Lough Funshinagh.
- Groundwater gradients near turbines T1 and T5 indicate that groundwater flows northwards (towards well W21). The Four Roads Turlough is situated ~3km north/northwest of T1, therefore groundwater flow towards this area cannot be discounted, although there is a significant separation distance between the Proposed Development at T1/T5 and Four Roads turlough, and there are some intervening surface water streams.

<u>Southern Cluster</u>

Rainfall falling across the Southern Cluster of the Wind Farm site predominantly percolates to ground. There is an absence of surface water drainage network. Permeability of the soil and subsoil is variable due to localised deposition of glacial deposits at the end of the last glacial maximum. Subsoils consisting mainly of silty, gravelly sand or sandy gravelly clay have been logged, which vary in thickness from 1.5 – 16m. The Particle Size Distribution data from samples taken by IGSL within the Southern Cluster are included within Appendix 6 of Appendix 4-3 and show that generally, the subsoils contain less than 20% silt/clay. Rainfall which percolates into the subsoil will recharge to the underlying bedrock aquifer.

The collected water level data indicates that the highest groundwater levels are found towards the north/northwest of the Southern Cluster, near the Roadstone quarry at Cam Hill (~69.6m OD) and flow in a west/southwest direction towards the Killeglan River and River Suck (~40-42 m OD). The lowest groundwater levels are found towards the southwest of the Southern Cluster. This is the generalised groundwater flow direction for the Southern Cluster, however, as in the Northern Cluster, there will be local variations due to the nature of the topographic slopes. Local variations may include:

- While the lowest groundwater levels are found towards the southwest of the Southern Cluster and indicate a groundwater flow in this direction, the groundwater levels and the contour data shows the potential for localised groundwater flow between the the locations of turbine T19/T20 in a southeast direction towards Corkip Lough. Local Winter groundwater levels are measured at 57-58.8 m OD on the western side of Corkip Lough.
- There is potential for groundwater flow in a northerly direction from near T18. The topographic high of Cam Hill and the highest Winter water level coincides approximately with the most northern turbine T18. Winter groundwater levels north of this are measured at 63.1 m OD at a Roadstone borehole just south of the R363. Groundwater levels north and northwest of this (63.1m OD) level are higher (65-70.46 m OD) which creates a limit on the northern groundwater flow from the T18 area. Most likely, groundwater near T18 follows the topography down the hill, before sweeping west and flowing out towards the River Suck.

<u>CSM Summary</u>

The turloughs surrounding the Proposed Development are situated at ~55-65 m OD and are approximately 3-4km from the River Suck, which has a typical water level of 40-42 m OD, which creates a reasonably high hydraulic gradient over a short distance. In a fast flowing, transmissive groundwater environment, one would expect to observe a short residence time for any water collecting upgradient, as the hydraulic head would drive the groundwater through the fracture network. Instead, what is observed is a gradual build up of groundwater from ~November to January (>70m OD in the Northern Cluster and >68 m OD within the Southern Cluster near Cam Hill), a maintenance of that high groundwater level from January to April, then a generally slow recession of groundwater levels until the turloughs dry up in early Summer (depending on winter/spring rainfall amounts).

The most reasonable model of groundwater storage and flow within the area surrounding the Proposed Development is that rainfall falling on the land surface is recharging through the relatively thick soils and subsoils. The ability for the soils and subsoils to accept rainfall is evident from the lack of surface water courses such as minor streams and drainage channels, as well as the lithology of the subsoils defined through the extensive site investigation. Broadly speaking, once the rainfall has infiltrated the subsoil layer it will recharge to the Medium hard to hard Limestone which has been shown to be competent and not fractured or significantly karstified through the site investigations (again this likely differs on the lower lying areas outside of the Wind Farm site). Groundwater levels will build up within the bedrock aquifer during the Winter months.

Although there is a significant driving groundwater gradient with high groundwater levels of >70 m OD just 3-4km from surface waters at ~40-42 m OD, the groundwater within the system does not readily discharge to these surface waters (there is no free-flowing underlying karst drainage network). Instead, the groundwater levels build up (over winter) and groundwater floods the land surface at known turloughs and loughs. While there are some mapped tracer connections (known groundwater flowpaths) within the underlying bedrock system (i.e. Feacle to Killeglan Spring), there has to be bulk resistance to flow, otherwise observed groundwater gradients and indeed Winter water levels would be much lower/flatter. In other words, a system with a large amount of groundwater conduits would drain groundwater from the recharge area (higher elevations) to the discharge area (rivers/lakes) in a shorter time period, therefore there would be low gradient differential (flatter groundwater table). In the system near the Proposed Development site, this is not seen, instead there is a high groundwater gradient as groundwater flow to the discharge areas (i.e. the River Suck) is slow. As a means of explaining this, in South Galway Lough Coole and Caherglassaun Lough (two very large turloughs located northwest of Gort) are several kilometres from the sea, but only have water level ranges of between 2-12m OD at distances of between 5.5-8km from Kinvarra (*i.e* sea level). For these turloughs at peak flood level the groundwater gradient towards Kinvarra is ~9m over 5,500m (using 5.5km as the shortest example), i.e. a gradient of 0.0016. At the Proposed Development site, there is an equivalent gradient of 30m over 3,000m, i.e. a gradient of 0.01 (an almost 10-fold higher gradient).

9.3.8 Groundwater Vulnerability

The mapped vulnerability rating of the aquifer within the Proposed Development site ranges between High to Extreme based on regionally assumed depths of subsoil. In areas where subsoil is shallow or absent and where bedrock is outcropping an Extreme vulnerability rating is mapped. The more elevated areas towards the north of the Northern Cluster are rated “High to Extreme” while the Southern Cluster area is generally mapped as High. The lower lying regions surrounding the Northern and Southern Clusters are mapped as Low to Moderate vulnerability. The mapped groundwater vulnerability of the Wind Farm site, Grid Connection Route and surrounding area is shown on Figure 9-20.

The Groundwater vulnerability ratings are based on typical overburden thicknesses which protect the underlying groundwater aquifer and are outlined in detail in DELG/EPA/GSI (1999)[7]. Within this guideline document, recommendations on assessing groundwater vulnerability are given and in terms of Regionally Important Karstic aquifers, the groundwater vulnerability can be made where the hydraulic gradient is upwards, in groundwater discharge areas, where site investigations do not find zones of significant permeability, or where the waste types are restricted.

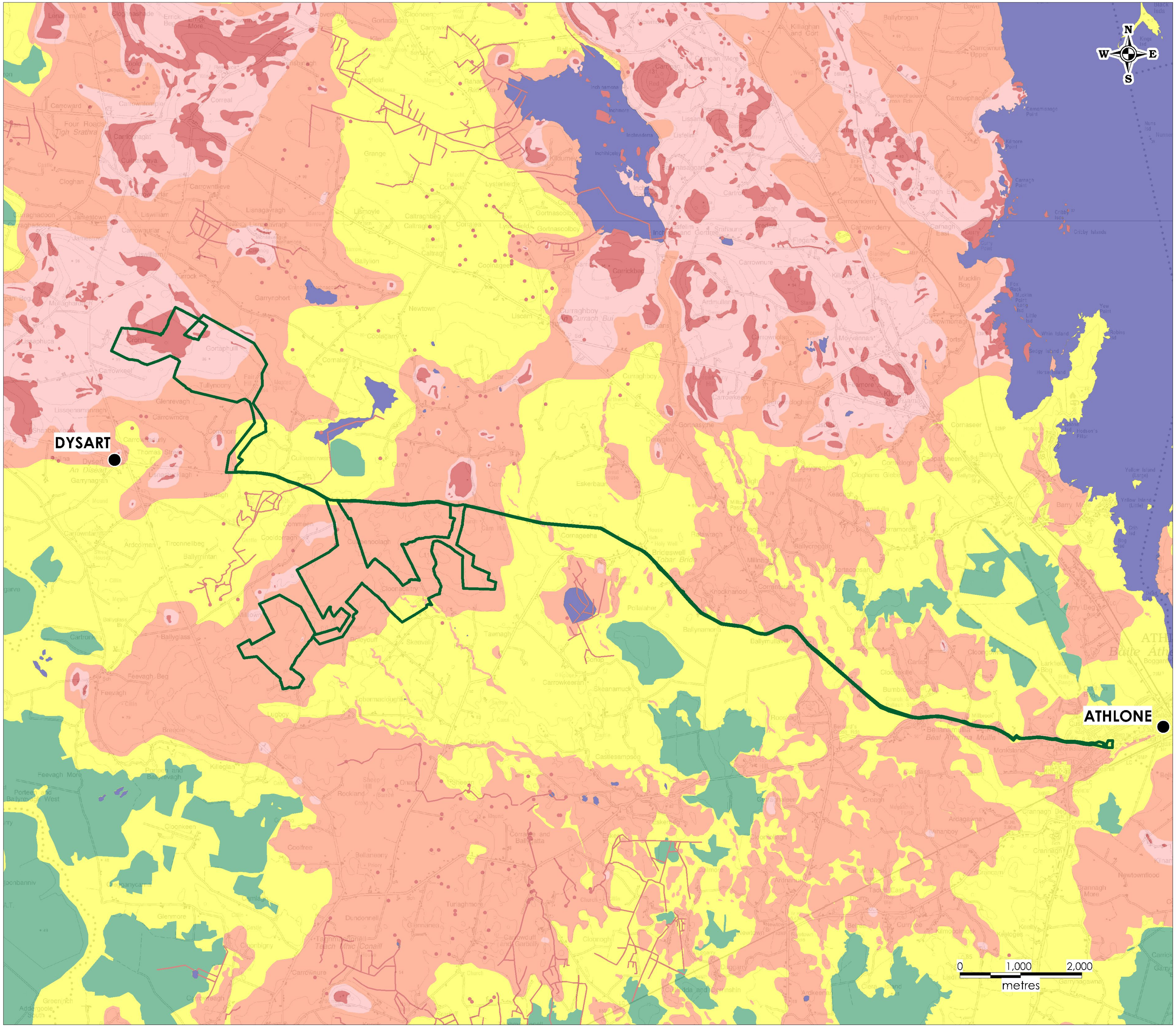
[7] *Groundwater Protection Schemes, DELG, EPA, GSI,. 1999*

The site investigation data indicates an average of 7.41m of subsoil cover within the Northern Cluster area and 7.32m of subsoil cover within the Southern Cluster area. These are average values and the subsoil thickness will vary spatially as outlined in Section 8.3.3 of Chapter 8 of this EIAR. Based on the site investigation data, the groundwater vulnerability can be said to be Moderate to High (5-10m of clayey sandy subsoil).

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

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

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



Legend

EIAR Site Boundary

GW Vulnerability

- Extreme
- High
- Low
- Moderate
- Water
- Rock at or near Surface or Karst

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Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Groundwater Vulnerability Map (Wind Farm & Grid Connection Route)	
Figure No: 9-20	
Drawing No: P1500-0-0422-A3-920-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:60,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

9.3.9 Groundwater Hydrochemistry

Based on data from GSI publication the hydrochemistry of the carbonate rocks, especially pure limestones, is dominated by calcium and bicarbonate ions. Hardness can vary from slightly hard to very hard (typically ranging between 380–450 mg/l). Like hardness and alkalinity, electrical conductivities (EC) can vary greatly. Typical limestone groundwater conductivities are of the order 500–700 µS/cm. Lower values for EC suggest that the residence times of some of the sources are very short. The hydrochemical analyses at the Killeglan Public Water Supply, situated ~1.5km south of the proposed Southern Cluster, suggest that the spring water has a very hard (>350 mg/l $CaCO_3$) calcium-bicarbonate hydrochemical signature, with conductivity ranging between 390 – 590 µS/cm (averaging 575 µS/cm).

Previous sampling from the Killeglan Spring source results found that total and faecal coliforms are consistently present in the raw water samples. In 50% of the raw water samples, there are greater than 10 faecal coliforms per 100 ml.

Groundwater sampling of 4 no. nearby private water wells (W1, W3, W12 and W15, refer to Figure 9-16 for well locations) and 2 no. turloughs (Commons and Thomas Street) was completed on 26th March 2021. The field chemistry data, taken with a calibrated YSI ProDSS, are given below in Table 9-21. The field hydrochemistry indicates a largely similar chemical signature of the 4 no. samples from the private wells. Dissolved oxygen ranges between 6.95 - 10.22 mg/L, electrical conductivity ranges between 405 - 550 µS/cm and pH ranges between 6.87 - 7.14. The water in the turloughs is slightly different, with a higher dissolved oxygen concentration ranging between 13.37 - 14.25 mg/L, with electrical conductivity values ranging between 212.9 - 266.3 µS/cm, considerably less than the water in the private water wells. pH is also higher in the turloughs, ranging between 8.5 - 8.63.

Table 9-21: Summary of field chemistry from private wells and turloughs (26/03/2021)

Location	Temp (°C)	DO (mg/L)	EC (µS/cm)	pH [H^+]	ORP (mV)
W1	9.7	6.95	550	6.87	336.5
W2	9.7	9.03	499.1	7.06	324
W12	8.6	10.22	427.7	7.14	346.7
W15	9.1	7.95	405	7.12	346.2
Commons Turlough	10.4	13.37	212.9	8.63	300
Thomas Street Turlough	10.4	14.25	266.3	8.5	288.3

The laboratory data of the 6 no. samples indicates that the water is of an acceptable chemical quality relative to the Groundwater Regulations (S.I 9 of 2010). Ammonia ranges between <0.005 to 0.015, while Nitrite is below the limit of detection in all samples at <0.005 mg/L. Nitrate ranges between 0.16 to 4.5 mg/L, below the threshold value for groundwaters of 37.5mg/L. Chloride ranges between 13-22 mg/L, below the EQS threshold of 24 mg/L. Hardness within the 4 no. water well samples ranged between 290-410 mg/L as $CaCO_3$, while the 2 no. samples from the turloughs had less hardness at 190 mg/L as $CaCO_3$ respectively. The lower hardness and electrical conductivity in the 2 no. turlough samples may indicate more contribution from rainwater than from deep sourced groundwater.

Table 9-22: Summary of groundwater quality data from laboratory analysis (26/03/2021)

Parameter	EQS	Sample ID					
		PW1	PW4	PW7	PW10	Commons Turlough	Thomas Street Turlough
Ammonia (mg/L)		<0.005	0.015	0.008	<0.005	<0.005	<0.005
Nitrite – N (mg/L)	0.375	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ortho-Phosphate – P (mg/L)	0.035	0.007	0.008	0.009	0.006	0.007	0.007
Nitrate - NO_3 (mg/L)	37.5	1.8	1.7	4.5	2.1	0.16	0.16
Chloride (mg/L)	24	16	22	13	17	13	15
Hardness (mg/L $CaCO_3$)		410	350	310	290	190	190

(*) S.I. No. 9 of 2010 - European Communities Environmental Objectives (Groundwater) Regulations 2010.

9.3.10 Groundwater Body Status

The Northern and Southern Clusters of the Proposed Development are primarily located in the Suck South Groundwater body. A small area of the Southern Cluster is located within the Funshinagh Groundwater Body. Local Groundwater Body (GWB) status information is available (www.catchments.ie) are summarised in Table 9-23.

The proposed Grid Connection route is primarily located within the Funshinagh GWB, with a small section near the Wind Farm site located within the Suck South GWB. A small section in the east of the Grid Connection route is located within the Athlone West GWB.

The Suck South GWB (GWB: IE_SH_G_225) is assigned 'Good Status' under the 2013-2018 WFD cycle, which is defined based on the quantitative status and chemical status of the GWB.

The Funshinagh GWB (IE_SH_G_091) is assigned 'Good Status' under the 2013-2018 WFD cycle, which is defined based on the quantitative status and chemical status of the GWB.

The Athlone West GWB (IE_SH_G_014) is assigned 'Good Status' under the 2013-2018 WFD cycle, which is defined based on the quantitative status and chemical status of the GWB.

Table 9-23: Summary of groundwater body status.

European Code	GWB Name	Chemical status	Overall Status	Quantitative Status	Risk Status	Pressure Category
IE_SH_G_225	Suck South	Good	Good	Good	Under Review	N/A
IE_SH_G_091	Funshinagh	Good	Good	Good	Under Review	N/A
IE_SH_G_014	Athlone West	Good	Good	Good	Not at risk	N/A

9.3.11 Surface Water Body Status

As outlined in Section 9.3.3, the proposed Wind Farm Site is situated within the River Suck catchment, the Cross River catchment. Local Surface water Body status and WFD risk classification are available from (www.catchments.ie) and are summarised in Table 9-24. A Water Framework Directive Assessment has been undertaken as part of this EIAR. Please refer to Appendix 9-6.

The River Suck, west of the Proposed Development, is assigned Good status under the WFD 2013-2018. The Ballyglass River is assigned Good status under the WFD 2013-2018. The northern section of the Cross River (east of the Northern Cluster) is assigned Poor status with the pressures on the river indicated to be peat extraction, while the river is assigned Good status further downstream, directly west of the Southern Cluster. The Cross River also drains the majority of the area of the proposed Grid Connection route. The Killeglan River is assigned Moderate status and is also considered At Risk, with the primary (identified) pressure being peat extraction.

A Water Framework Directive Assessment has been undertaken as part of this EIAR. Please refer to Appendix 9-6.

Table 9-24: Summary of surface water body status.

European Code	GWB Name	Ecological Status	Overall Status	Risk Status	Pressure Category
IE_SH_26S071200	Suck	Good	Good	Under Review	N/A
IE_SH_26B150840	Ballyglass_010	Good	Good	Under Review	N/A
IE_SH_26K040200	Killeglan	Moderate	Moderate	At Risk	Extractive-Peat
IE_SH_26C100060	Cross_010	Poor	Poor	At Risk	Agriculture
IE_SH_26C100200	Cross_020	Good	Good	Not at Risk	N/A

9.3.12 Designated Sites & Habitats

Designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). The Proposed Development site is not located within any designated conservation-site. Designated sites in proximity to the Proposed Development site are shown in Figure 9-21.

The **Lough Croan Turlough SAC**, SPA and pNHA is situated ~1.4km northeast of the Northern Cluster, at an elevation of ~69 m OD. It is a linear wetland, aligned north-west/south-east, which lies in a relatively flat area of glacial till. It is split into two main parts - the east functions as a typical turlough, with a wet area dominated by Common Reed (Phragmites australis) at the centre; at the west is a fen, with floating vegetation in places, which also floods in winter. In between there is undulating ground. There is little over-ground flow, but both basins retain some water all year round. The SAC is designated due to the qualifying interest of Turlough [3180], and it is a groundwater dependent terrestrial ecosystem (GWTDE). The SPA is designated for the following qualifying interests:

- Shoveler (Anas clypeata) [A056]

- Golden Plover (Pluvialis apricaria) [A140]
- Greenland White-fronted Goose (Anser albifrons flavirostris) [A395]
- Wetland and Waterbirds [A999]

The **Four Roads Turlough SAC**, SPA and pNHA is situated northwest of Lough Croan, and ~2.8km north/northwest of the proposed Wind Farm Site Northern Cluster. It lies below a low scarp of limestone hills and is an open, shallow basin without permanent standing water which seems to flood predictably and dry out early, based on available groundwater data (2016-2019). The SAC is designated due to the qualifying interest of Turlough [3180], and it a is groundwater dependent terrestrial ecosystem. The SPA is designated for the following qualifying interests:

- Golden Plover (Pluvialis apricaria) [A140]
- Greenland White-fronted Goose (Anser albifrons flavirostris) [A395]
- Wetland and Waterbirds [A999]

The **Killeglan Grassland SAC** is located ~0.9 km southwest of the Southern Cluster of the proposed Wind Farm Site. The Killeglan grassland is designated due to the qualifying interest of Orchid rich calcareous grassland [6210], which is not groundwater dependent. The site is undulating and slopes southwest from a height of ~90 m OD to ~55 m OD.

The **Feacle Turlough pNHA** is situated ~0.6 km south of the Southern Cluster of the proposed Wind Farm Site. Feacle Turlough is at an elevation of ~67 m OD, while the proposed turbines local to Feacle Turlough) are mapped at >90 m OD. Feacle turlough lies in an uneven, glacial terrain of kame deposits. The basin runs roughly East-West, but the edge is sinuous because of encroaching mounds. An esker-like feature projects from the southern side of Feacle Turlough. The floor of the basin is similarly uneven with a number of discrete hollows: some at the western end expose possible bedrock.

The **Ballynamona Bog and Corkip Lough SAC** is mapped ~1.0km east of the Southern Cluster area of the proposed Wind Farm Site. The site comprises a relatively small portion of what was once a large bog complex, and includes areas of high bog and cutover bog, and also the turlough, Corkip Lough. The site is mapped at an elevation of ~55-58 m OD. The qualifying interests of the SAC are:

- Turloughs [3180]
- Raised Bog (Active) [7110]
- Degraded raised bogs still capable of natural regeneration [7150]
- Depressions on peat substrates of the Rhynchosporion [7150]
- Bog Woodland [91D0]

The Active Raised Bog is hydraulically isolated from the turlough due to the extent of the drainage works around its perimeter. The site is not listed as a groundwater dependent ecosystem, however the formation of the turloughs is due to the annual rise in local groundwater levels.

Further west, the **River Suck Callows SPA** and NHA exist along the banks of the River Suck. This designated site is mapped along the River Suck, ~2.4km from the western edge of the proposed Wind Farm Site (Northern and Southern Clusters). The site is not listed as being groundwater dependent, although groundwater flow/base flow[8] to the River Suck will occur from the surrounding South Suck GWB. The qualifying interests of the River Suck Callows SPA are:

- Whooper Swan (Cygnus cygnus) [A038]
- Wigeon (Anas penelope) [A050]
- Golden Plover (Pluvialis apricaria) [A140]
- Lapwing (Vanellus vanellus) [A142]

[8] *Base flow is a portion of the stream/river flow that is not runoff; it is water from the ground, flowing into the channel over a long time and with a certain delay.*

- Greenland White-fronted Goose (Anser albifrons flavirostris) [A395]
- Wetland and Waterbirds [A999]

Further east, **Lough Funshinagh SAC** and pNHA exists, at a distance of ~5.9km to the eastern edge of the proposed Wind Farm Site. The lake, which is underlain by Carboniferous limestone, is classified as a turlough because it fluctuates to a significant extent every year and occasionally dries out entirely (approximately two to three times every ten years). In most years, however, an extensive area of water persists. This is filled with vegetation, providing excellent breeding habitat for wildfowl, and the site is designated a Wildfowl Sanctuary. The lake is fed by springs and a small catchment to the west. It is mesotrophic in quality, with some marl (calcium carbonate) deposition, and is surrounded by pastures. The qualifying interests of the Lough Funshinagh SAC are:

- Turloughs [3180]
- Chenopodion rubric p.p and Bidention p.p vegetation [3270]

The **River Shannon Callows SAC** and **Middle Shannon Callows SPA** is located 12km east of the Proposed Development site near the town of Athlone. The Cross River drains in the direction of the River Shannon and eventually discharges to it, while the Ballyglass River drains west towards the River Suck. The site is not noted as being groundwater dependent. The SAC is designated for the following qualifying interests:

- Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) [6410]
- Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis) [6510]
- Alkaline fens [7230]
- Limestone pavements [8240]
- Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) [91E0]
- Lutra lutra (Otter) [1355]

The Middle Shannon Callows SPA is designated for the following qualifying interests:

- Whooper Swan (Cygnus cygnus) [A038]
- Wigeon (Anas penelope) [A050]
- Corncrake (Crex crex) [A122]
- Golden Plover (Pluvialis apricaria) [A140]
- Lapwing (Vanellus vanellus) [A142]
- Black-tailed Godwit (Limosa limosa) [A156]
- Black-headed Gull (Chroicocephalus ridibundus) [A179]
- Wetland and Waterbirds [A999]

The **Castlesampson Esker SAC** is situated 3.9km southeast of the Southern Cluster. The SAC consists of eskers, deposited during the last Glacial Maximum, as well as raised bog and a turlough (Corraree). The site is designated as a SAC based on the following qualifying interests:

- Turloughs [3180]
- Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites) [6210]

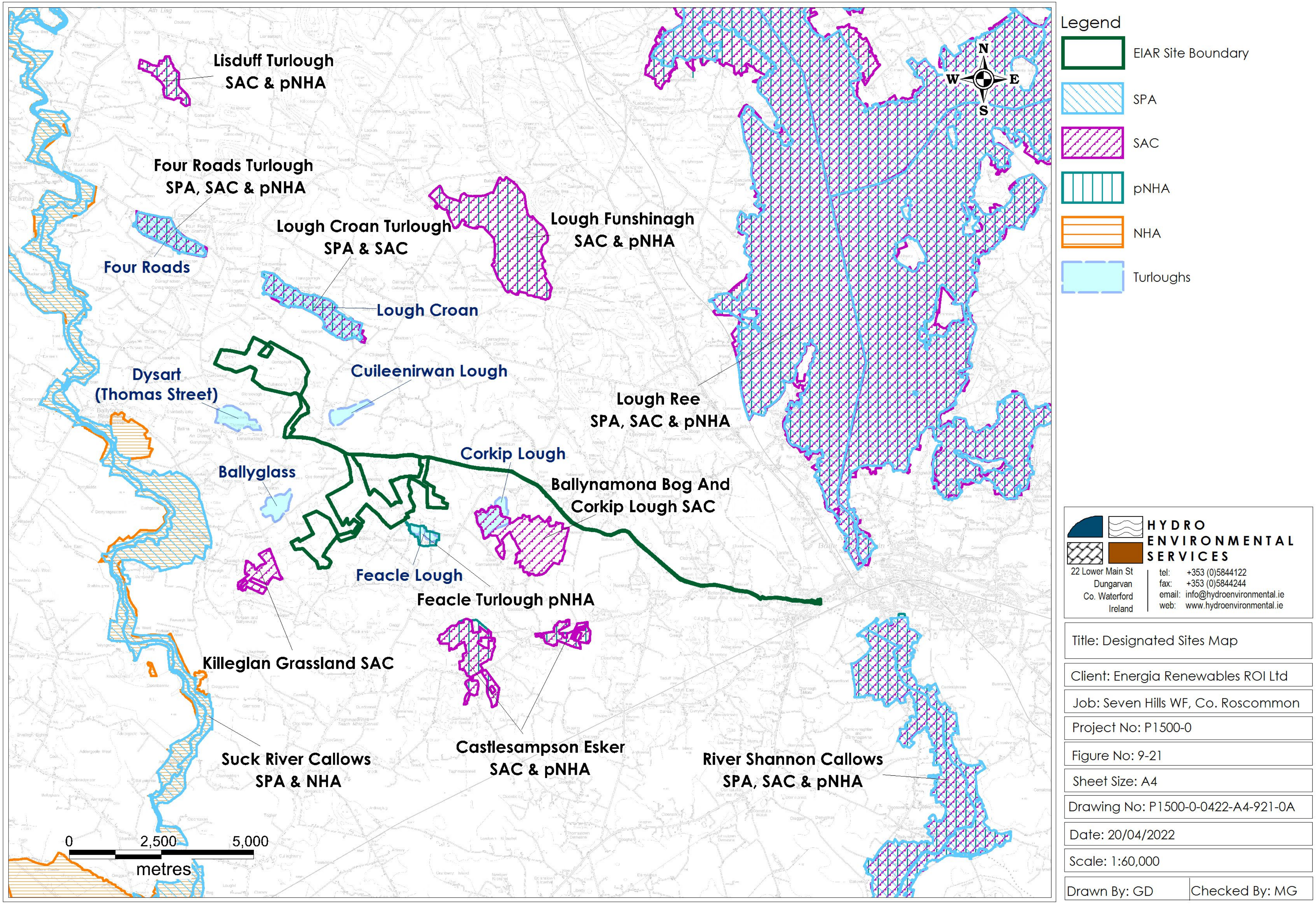
Lisduff Turlough SAC is situated ~7km northeast of the Northern Cluster of the proposed Wind Farm site. It lies in a shallow basin among low hills of glacial drift, with occasional rock outcrops. There is a semi-permanent over-ground inflow from the northwest arm of the turlough and the site is relatively wet. The site is designated based on the following qualifying interests:

- Turloughs [3180]

Lough Ree SAC, **SPA** and pNHA is situated 11km east of the Northern and Southern Clusters. It is the third largest lake in Ireland and is situated in an ice-deepened depression in Carboniferous limestone on the River Shannon system between Lanesborough and Athlone. The site is designated for the following qualifying interests:

- Lough Ree SAC
  - Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation [3150]
  - Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites) [6210]
  - Active raised bogs [7110]
  - Degraded raised bogs still capable of natural regeneration [7120]
  - Alkaline fens [7230]
  - Limestone pavements [8240]
  - Bog woodland [91D0]
  - Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) [91E0]
  - Lutra (Otter) [1355]

- Lough Ree SPA
  - Little Grebe (Tachybaptus ruficollis) [A004]
  - Whooper Swan (Cygnus cygnus) [A038]
  - Wigeon (Anas penelope) [A050]
  - Teal (Anas crecca) [A052]
  - Mallard (Anas platyrhynchos) [A053]
  - Shoveler (Anas clypeata) [A056]
  - Tufted Duck (Aythya fuligula) [A061]
  - Common Scoter (Melanitta nigra) [A065]
  - Goldeneye (Bucephala clangula) [A067]
  - Coot (Fulica atra) [A125]
  - Golden Plover (Pluvialis apricaria) [A140]
  - Lapwing (Vanellus vanellus) [A142]
  - Common Tern (Sterna hirundo) [A193]
  - Wetland and Waterbirds [A999]


Lisduff Turlough SAC & pNHA
Four Roads Turlough SPA, SAC & pNHA
Four Roads
Lough Croan Turlough SPA & SAC
Lough Croan
Lough Funshinagh SAC & pNHA
Dysart (Thomas Street)
Cuileenirwan Lough
Lough Ree SPA, SAC & pNHA
Corkip Lough
Ballyglass
Ballynamona Bog And Corkip Lough SAC
Feacle Lough
Feacle Turlough pNHA
Killeglan Grassland SAC
Suck River Callows SPA & NHA
Castlesampson Esker SAC & pNHA
River Shannon Callows SPA, SAC & pNHA
0
2,500
5,000
metres
Legend
EIAR Site Boundary
SPA
SAC
pNHA
NHA
Turloughs
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web: www.hydroenvironmental.ie
Title: Designated Sites Map
Client: Energia Renewables ROI Ltd
Job: Seven Hills WF, Co. Roscommon
Project No: P1500-0
Figure No: 9-21
Sheet Size: A4
Drawing No: P1500-0-0422-A4-921-0A
Date: 20/04/2022
Scale: 1:60,000
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Checked By: MG

9.3.13 Receptor Sensitivity

Due to the nature of wind farm developments, being primarily near surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. However, given the proximity of the Proposed Development to local groundwater fed turloughs such as Lough Croan, Cuilleenirwan, Thomas Street, Gortaphuill, and Feacle Turlough (not exhaustive, but these are the main receptors) and the mapping of the bedrock aquifer as regionally karstified, the hydrogeology of the area has been extensively monitored and synthesised using site investigation data acquired between 2010-2021, consisting of groundwater level data (2019-2021), monitoring well boreholes logs (2020), rotary core borehole logs (2010-2021), trial pit data (2010-2021), geophysics (2021), PSD data (2019-2021) and other available historical data including the 2010 well survey and EPA groundwater levels (2016-2021). The primary risk to groundwater at the site would be from cementitious materials, hydrocarbon spillage and leakages and the potential for the turbine bases to intercept and interfere with groundwater recharge and flows which are considered to be potentially linked to the downstream turloughs.

Based on criteria set out in Table 9-1, groundwater at the site can be classed as Very Sensitive to pollution as the aquifer is mapped as a Regionally Important Karstified aquifer and groundwater vulnerability is mapped as High to Extreme. This classification is based on generic, assumed conditions inferred from regional mapping of the bedrock geology and aquifer type, without any site-specific data. The site-specific data for the areas of infrastructure indicate the groundwater aquifer is not regionally karstified and that groundwater vulnerability is generally more towards Moderate. Notwithstanding this, and based on the precautionary principle, groundwater is regarded as Very Sensitive.

Surface waters such as the River Suck, Killeglan River, Ballyglass River and Cross River are Sensitive to potential contamination. These rivers and associated lakes are known to be of trout potential and are important locally for fishing (refer to Ecology, Chapter 6 of this EIAR).

None of the sites listed in Section 9.3.12 are directly hydraulically connected by surface water paths to the Proposed Development site. Any potential hydraulic connections are indirect and will be via groundwater flow over a generally long distance (kilometres). The designated sites listed in Section 9.3.12 can be considered Very Sensitive in terms of potential impacts (refer to Chapter 6 of the EIAR and the NIS).

Comprehensive surface water mitigation and controls are outlined below to ensure protection of all downgradient waterbodies (turloughs and rivers). Mitigation measures will ensure that drainage water and recharge from less permeable surfaces within the developed areas of the site (*i.e.* access roads, turbine hardstands) will be of a high quality. Drainage from these areas of the site will percolate to ground based on the underlying site permeability. The mitigation measures outlined to protect surface water during the construction and operational phase will ensure that waters infiltrating to the underlying aquifer will be of a high quality and will therefore not impact on the quality of downstream water bodies. Any introduced drainage works at the site will mimic the existing hydrological regime thereby avoiding any significant changes to recharge patterns.

9.3.14 Characteristics of the Proposed Development

The Proposed Development comprises of the following elements:

- 20 no. wind turbines with an overall ground to blade tip height of 180 metres, a rotor dimeter of 162m and a hub height of 99m, associated foundations, hard-standing areas
- 15 no. spoil storage areas at hardstands of turbines no. 1, 2, 3, 4, 5, 6 and 7 (in the townlands of Turrock, Gortaphuill, Cronin, and Tullyneeny) and turbines no. 8, 10, 11, 13, 14, 17, 19 and 20 (in the townlands of Milltown, Cuilleenoolagh, Cloonacaltry, Feacle and Tawnagh)

- Provision of 1 no. permanent meteorological mast with a maximum height of 100 metres for a period of 30 years from the date of commissioning of the entire wind farm
- Provision of 1 no. 110kV onsite substation in the townland of Cam, along with associated control buildings, MV switchgear building, associated electrical plant, associated security fencing, and equipment and wastewater holding tank
- All underground electrical and communication cabling connecting the proposed wind turbines to the proposed onsite substation and associated control buildings and plant
- All works associated with the connection of the proposed wind farm to the national electricity grid via underground 110kV cabling from the site to the existing Athlone 110kV substation located in the townland of Monksland. Cabling will be placed within the public road corridor of the R362, R363 and L2047, or on private land
- Upgrade works to the existing 110kV Athlone substation consisting of the construction of an additional dedicated bay to facilitate connection of the cable
- Provision of 2 no. new site accesses north and south from the R363 and upgrade of 1 no. junction south of the R363
- Provision of new access tracks/roads and upgrade of existing access tracks/roads
- 7 no. overburden storage areas
- 2 no. temporary construction compounds
- Site drainage works
- Operational stage site signage
- All associated site development works, apparatus and signage

9.3.14.1 Proposed Drainage Management

Local works area runoff control and drainage management are key elements in terms of mitigation against impacts on the underlying groundwater aquifer. Two distinct methods will be employed to manage drainage water within the Proposed Development. The first method involves 'keeping clean water clean' by avoiding disturbance to natural drainage and recharge patterns. 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 settlement ponds prior to controlled diffuse release over vegetated surfaces and subsequent infiltration through the subsoil. As per the prevailing baseline conditions at the site, there will be no direct discharges to surface waters (as there are none local to the Wind Farm site). During the construction phase all drainage water from works areas (i.e., potential dirty water) will be attenuated and treated to a high quality prior to being allowed to slowly percolate to ground. Where turloughs are present close to the proposed infrastructure, 3 no. lines of Terrastop silt fence will be erected to provide a physical separation, which will trap suspended sediment entrained in water flowing downhill from the works area.

Further means of drainage management include:

- Drainage controls at the Wind Farm site will be installed where significant cut and fill works are required. Elsewhere the natural drainage/recharge regime will continue as that will cause the least disturbance and potential impacts to groundwater (this is how existing farm tracks within the Wind Farm site are drained currently).
- No surface water will leave the Proposed Development site. All drainage measures will incorporate water infiltrating back to ground within the EIAR Site Boundary;
- Where pumping water from turbine foundation excavations is necessary, the pumping rate will be limited to 5.8 l/s to prevent overuse of the settlement ponds;
- Excavations will be limited as much as possible in order to minimise the volume of spoil generated;
- Sand blinding, DPM and concrete blinding will be provided at formation level to create a vertical cut-off barrier and to mitigate the risk of concrete leakage into the ground below; and,

- Hardstands will be lined with Terram geotextile to limit direct discharge to the subsoil/bedrock.

A detailed drainage plan showing the layout of the proposed drainage design elements for the development is included in Appendix 4-2. A Drainage Management Plan (MWP, 2021) is also included in Appendix 4-8).

Drainage management along the Grid Connection route will include the following methods:

- Use of small working areas;
- Site specific controls at watercourse crossing;
- No direct discharges to watercourses.
- Use of temporary silt fencing, check dams, and temporary blocking of drainage pathways; and,
- Reinstatement and works areas, house-keeping, including road sweeping.

9.4 Likely and Significant Effects and Mitigation Measures

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

9.4.1 Do Nothing Scenario

An alternative land-use option to the development of a renewable energy project at the Proposed Development site would be to leave the site as it is, with no changes made to existing land-use practices. Agriculture would continue at the site. In implementing the 'Do-Nothing' alternative, however, the opportunity to capture a significant part of the country's renewable energy resource would be lost, as would the opportunity to contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate local employment, development contributions, rates and investment in the local area would also be lost. On the basis of the positive environmental effects arising from the Proposed Development, the do–nothing scenario was not the chosen option. The existing agricultural operations can and will continue in conjunction with the operation of the Proposed Development.

9.4.2 Construction Phase – Likely Significant Effects

The likely significant impacts of the Proposed Development and mitigation measures that will be put in place to eliminate or reduce them for the Water Environment are shown below. These are defined and assessed as per the explanation provided at Section 9.2.3 above.

Please note that the Grid Connection route works are assessed in each impact section below along with the Proposed Development other than for watercourse crossings along the Grid Connection route, which are assessed at Section 9.4.2.12. The Turbine Delivery Route is assessed separate from the Proposed Development at Section 9.4.2.13.

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

Construction phase activities that will require earthworks resulting in the removal of vegetation cover and excavation of mineral subsoil (where present), and bedrock in certain areas, are detailed in the Proposed Development Description Chapter (Chapter 4). Excess soil/subsoil will be stored at the 6 no. proposed overburden storage areas. Excess material along the Grid Connection route will be removed to an offsite licenced facility.

Potential sources of sediment laden water include:

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

These activities can result in the generation of suspended solids in drainage water, and as there are no drainage outlets (other than recharge to ground) across the site, there is a risk that sediment laden recharge water can enter the underlying aquifer. To reiterate, there are no recorded surface water features of concern directly occurring within the Wind Farm site, neither in the Northern Cluster, nor the across the Southern Cluster.

Surface watercourses are absent within the Wind Farm site, however potential impacts in relation to potential overland flow towards surface water bodies such as turloughs will nonetheless be mitigated against, as well as local water runoff that will occur near lower permeability site infrastructure that will need to be recharged locally into subsoils. This recharge water will occur close to source and can migrate vertically to groundwater below the Wind Farm site. The potential impacts on groundwater quality are assessed separately below at 9.4.2.5, 9.4.2.6 and 9.4.2.8.

Pathways: Natural drainage channels and surface water discharge routes – these are absent across the Wind Farm (Northern and Southern Clusters).

Surface drainage system occur along the Grid Connection Route, and these drain towards the Cross River.

Receptors: Underlying groundwater systems and down gradient turloughs and down-gradient rivers and dependant ecosystems near the Northern Cluster as listed below:

- Turloughs – Gortaphuill, Lough Croan, Thomas Street, and Commons
- Rivers – River Suck, Ballyglass River

Underlying groundwater systems and down gradient turloughs and down-gradient rivers and dependant ecosystems near the Southern Cluster as listed below:

- Turloughs – Corkip turlough, Feacle Turlough, Ballyglass
- Rivers – River Suck, Cross River, Killeglan River, Ballyglass River

Down gradient rivers and dependant ecosystems along the Grid Connection Route:

- Rivers – Cross River

Pre-Mitigation Potential Impact:

Indirect, negative, slight, temporary, unlikely impact within the Northern Cluster (receptors listed above) due to the distance to these receptors, the grassland/vegetation acting as a silt filter/trap for suspended sediment and the absence of surface water pathways.

Indirect, negative, slight, temporary, unlikely impact within the Southern Cluster (receptors listed above) due to the distance to these receptors, the grassland/vegetation acting as a silt filter/trap for suspended sediment and the absence of surface water pathways.

Indirect, negative, slight, temporary, unlikely impact along the Grid Connection route (receptors listed above) due to the scale of works (1.2m trench), the temporary nature of any open excavation and the roadside vegetation acting as a natural silt filter/trap.

Mitigation by Avoidance:

The key mitigation measure adopted during the design phase is the avoidance of infrastructure close to turloughs, and surface water features across the Wind Farm site. From Figure 9-5 it can be seen that all of the key areas of the Wind Farm site are sited significantly away from the self-imposed surface water buffer zones (50m). The closest turbine to a surface water feature is Turbine T4, within the Northern Cluster which is situated adjacent to Gortaphuill turlough. Gortaphuill is a temporary surface water body present throughout certain months of the year, and as with all turloughs near the site, does not exist between ~May – November, thus construction proposed between May - November will not impact on the turlough.

The Grid Connection route, along the R363 and R362, crosses over 5 no. watercourses. The turbine delivery route will see turbines being delivered along the R363 and R362 via the M6 as detailed in Section 4.4 of Chapter 4. Additional control measures, which are outlined further on in this section, will be undertaken at these locations.

The large setback distances between sensitive hydrological features and any element of the development within the Northern and Southern Clusters (as outlined in Table 9-15) means that adequate room is maintained for the proposed drainage mitigation measures (discussed below) to be properly installed and operate effectively. The proposed buffer zone will:

- Avoid physical damage to turloughs and watercourses, and associated release of sediment;
- Avoid excavations within close proximity to turloughs and surface watercourses (again, absent at this site);
- Avoid the entry of suspended sediment from earthworks into turloughs and 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 via infiltration areas.

Mitigation by Design:

- Source controls:
  - Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.
  - Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.
- In-Line controls:
  - Interceptor drains, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriate systems.
  - Where a proposed turbine location is near an existing turlough (as is the case at T4), 3 no. lines of Terrastop silt fence will be erected to provide a physical separation, which will trap any suspended sediment entrained in water flowing downhill from the works area Seasonal working constraints will also be applied at T4, whereby no earthworks will occur on the access track to T4 or at T4 when there is water in Gortaphuill turlough.
- Treatment systems:
  - Swales and settlement ponds.

Silt Fences

3 no. lines of silt fencing will be emplaced downgradient of T4, to prevent any silt reaching Gortaphuill turlough. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to any active turloughs, of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in drainage water runoff. Inspection and maintenance of these structures during construction phase is critical to their functioning to stated purpose. Inspection of the silt fencing will be carried out weekly or daily during periods of heavy rainfall (>15mm in 24 hours). This monitoring will be a requirement of the contract for the contractor carrying out the works on site. The silt fences will remain in place throughout the entire construction phase.

Pre-emptive Site Drainage Management

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

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

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

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

Works 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; and,
- Provide temporary or emergency drainage to prevent back-up/local ponding of water.

Management of Drainage from Spoil Storage Areas

Excavated subsoil will be used for landscaping throughout the site and any excess will be stored at 6 no. overburden storage areas.

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

Timing of Site Construction Works

Construction of the site drainage system will only be carried out during periods of low rainfall. This will minimise the risk of entrainment of suspended sediment in drainage water. Construction of the drainage system during this period will also ensure that attenuation features associated with the drainage system will be in place and operational for all subsequent construction works.

Monitoring

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

Any excess build-up of silt levels at check dams, the settlement ponds, or any other drainage features that may decrease the effectiveness of the drainage feature, will be removed.

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (as per the CEMP provided at Appendix 4-9).

Residual Effect: Following the implementation of the mitigation by avoidance measures, which has involved an iterative process of optimising the design and layout of the Proposed Development site to minimise the potential for effects due to earthworks, as well as the mitigation by design measures which involves the detailed and site-specific drainage management plan (refer to Appendix 4-2), the residual impact is considered to be - Negative, indirect, imperceptible, short term, unlikely impact on:

Underlying groundwater systems and down gradient turloughs and down-gradient rivers and dependant ecosystems near the Northern Cluster which include:

- Turloughs – Gortaphuill, Lough Croan, Gortaphuill
- Rivers – River Suck, Ballyglass River

Underlying groundwater systems and down gradient turloughs and down-gradient rivers and dependant ecosystems near the Southern Cluster which include:

- Turloughs – Corkip turlough, Feacle Turlough, Ballyglass
- Rivers – River Suck, Cross River, Killeglan River, Ballyglass River

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

- Rivers –Cross River

Significance of Effects: For the reasons outlined above, and with the implementation of the above outlined mitigations measures, no significant effects on the aforementioned receptors will occur due to the suite of drainage mitigation measures which will be put in place.

9.4.2.2 Potential Effects on Groundwater Flows and Levels due to alteration of recharge

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

A comprehensive site investigation dataset has been accrued between 2010-2021 within the area of the Proposed Development, and this dataset is supported by existing monitoring data from the GSI and EPA. The collated site investigation dataset for the Wind Farm Site has not identified any significant karst features within the underlying bedrock, following 285.7m of drilling at the Northern Cluster and 394.6m of drilling at the Southern Cluster, along with a mass of data from trial pitting in these areas.

Groundwater levels have been monitored extensively. Groundwater levels within the Southern Cluster are significantly below the subsoil level, and hence below the formation levels for the proposed turbine bases. Similarly, within the Northern Cluster, groundwater levels are below the level of emplacement of the turbine bases, although they are higher and do rest within the subsoil layer in places (refer to Appendix 9-3). The data from the rotary core drilling shows that the bedrock is generally medium hard to hard Limestone. The inflow of groundwater into these wells was very slow, taking weeks to reach an equilibrium level. Similarly, only 2 of the 42 no. rotary core boreholes drilled by IGSL were logged with water strikes, both described as “slow”. The bedrock below the Wind Farm site does not contain an abundance of karst flow systems.

Groundwater levels may be affected by any change in recharge within a groundwater catchment. A reduction in recharge, which would be accompanied by an increase in surface water drainage, would clearly reduce the volume of water infiltrating to the bedrock aquifers and therefore lead to a reduction in groundwater levels. The drainage management design of the Proposed Development has been optimised to ensure the volume of rainfall infiltrating through the subsoils to the groundwater aquifer will not change.

Grid Connection Route works will be completed in the dry, i.e. above the groundwater table.

Pathways:

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

Groundwater levels – Rainfall Infiltration (recharge)

Receptors: Downgradient groundwater (flows and levels with the underlying South Suck and Funshinagh GWBs) and downstream connected GWTDEs (Thomas Street turlough, Gortaphuill turlough, Four Roads turlough, Feacle Turlough, Corkip Lough).

No impacts on groundwater levels or groundwater flow will occur along the grid connection route, as all excavations will be above the groundwater table (i.e. excavation depth of 1.22mbgl).

No impacts on groundwater levels or groundwater flow will occur along the TDR, as no excavations are proposed.

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

Mitigation by Avoidance - Groundwater Flows:

The construction activities associated with the Proposed Development have the potential to impact groundwater flows within the Northern and Southern Clusters, if a particular pathway *e.g.* karst conduit, existed near the development, however based on all the available site investigation data no pathways or evidence of potential pathways have been identified. The identification and avoidance of any potential karst features has been a key aim of the intrusive and extrusive site investigations and is considered to be the most rational method of mitigating against effecting flow paths, by avoiding any potential karst areas.

The site data outlined within Section 9.3.7.3 and outlined in more detail within Chapter 8 provides sufficient scientific data to say, with a high degree of certainty, that the construction activities associated with the Proposed Development, will not interact with or alter the existing groundwater recharge, and underlying groundwater flow, regimes.

All proposed Wind Farm infrastructure will be installed above recorded groundwater levels, therefore there is no potential for Wind Farm infrastructure to block or alter underlying groundwater flow regimes.

Mitigation by Design - Groundwater Levels:

As mentioned above, the critical driver of groundwater levels and the potential to affect them is through groundwater recharge. The drainage design of the Proposed Development has been designed to mimic the existing hydrological regime within the site, whereby surface water pathways are generally short and rainfall readily percolates to ground. The drainage design incorporates check dams to reduce velocities, two chamber settlement ponds with baffle plates and over topping weirs and outflow from the drains being dispersed over a wide area of vegetation.

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

Residual Effects: The siting of the proposed site infrastructure was guided by the knowledge accrued through the various phases of site investigations and the iterative design process, as well as the design measures incorporated within the drainage management plan, – therefore there will be no residual effects on groundwater flows or groundwater levels.

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

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

Temporary dewatering of turbine bases during construction has the potential to impact on local groundwater levels. The local groundwater levels have been monitored over an 18 month period resulting in a full understanding of local prevailing hydrogeological conditions. Groundwater level impacts are not anticipated to be significant due the known local hydrogeological regime, and due to the proposed excavation method as outlined below. Groundwater levels across the proposed Wind Farm Site (Northern and Southern Clusters) are well defined through monitoring of numerous groundwater wells, site investigation boreholes and turloughs.

The known groundwater levels within the Northern and Southern Clusters are summarised in Section 9.3.7.10. Briefly, they range between 46.9 – 70.5 m OD in the Northern Cluster and 48.5-71.95 m OD in the Southern Cluster. Ground elevations and typical Winter groundwater levels are included in the Conceptual Site Model - Appendix 9-5). Known winter groundwater levels are significantly below the proposed formation levels of all turbines, and as such there will be no groundwater dewatering requirements during turbine base construction.

No groundwater level impacts will occur from the construction of the Grid Connection underground cabling trench due to the shallow nature of the excavation (i.e. ~1.22m), the excavation of the trench within the road carriageway and the unsaturated nature of the road material/subsoil to be excavated.

HES have identified and monitored (during 2020 and 2021) 20 no. wells (domestic, public and quarry) in proximity to the Northern and Southern Clusters.

Pathway: Groundwater recharge and groundwater flowpaths.

Receptor: Groundwater levels in the underlying bedrock aquifer (South Suck GWB, and Funshinagh GWB) surrounding the Proposed Development site and the associated groundwater levels in mapped and unmapped wells near the Northern and Southern Cluster which source groundwater from the aquifer. Groundwater levels along the proposed Grid Connection route.

Pre-Mitigation Potential Effects: Indirect, slight, short term, unlikely impact on groundwater levels and local groundwater well supplies near the Proposed Development site (Northern and Southern Clusters).

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

Impact Assessment – Wind Farm site

Based on the engineering design, bedrock will be exposed at proposed turbines T1, T5, T6, and weathered bedrock and potentially solid bedrock at T7, T10 and T11. Elsewhere, the proposed turbine base excavations will be within the subsoil strata and do not involve excavation into bedrock. The bedrock has been classified as a Regionally Important aquifer by the GSI, however the site data from HES boreholes and IGSL boreholes indicates that where groundwater has been met in site investigation wells, groundwater inflows are slow, *i.e.* relatively low permeability in the bedrock. As outlined above, no groundwater dewatering will be required during the construction phase in any element of the Wind Farm site as all potential excavations occur significantly above the known groundwater levels across the Northern and Southern Clusters.

The topographical and hydrogeological setting of turbine locations means no groundwater dewatering will be required. Moreover, direct rainfall and surface water runoff will be the main inflows that will require water volume and water quality management. For the avoidance of doubt, we would generally define dewatering as a requirement to permanently drawdown the local groundwater table by means of over pumping, e.g. as would be required for the operation of a bedrock quarry in a valley floor. It is considered that this example (the quarry example) is very different in scale and operation from the proposed operation of a temporary shallow excavations above the groundwater table on the side of a hill for the following reasons:

- The turbines are located on the side of a series of hills where the ground elevations are between ~75 and 100m OD;
- The elevations of the turbine bases are significantly above the elevations of groundwater levels recorded in monitoring wells and local domestic/farm wells, and therefore of the known groundwater levels within the Northern and Southern Cluster areas;
- The local bedrock comprises generally medium hard to hard Limestone and has been shown to be generally unfractured and unproductive during site investigations. This means that groundwater flows at depth, beneath the turbine bases, will be relatively minor;
- No regional groundwater flow regime, i.e. large volumes of groundwater flow, will be encountered at these elevations (as proven by the site investigation drilling);
- Shallow groundwater inflows will largely be fed by recent rainfall, and possibly by limited seepage from localised permeable subsoils;
- Any shallow groundwater seepage (within the subsoils) will be small in comparison to the expected surface water flows following any heavy rainfall events; and,
- The management of surface water will form the largest proportion of water to be managed and treated, although where permeable subsoils are encountered, rainfall may infiltrate to ground rather than ponding at any excavation.

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

In terms of the local well supplies included in Section 9.3.7.8.1 and Section 9.3.7.8.2, as well as any potentially unmapped wells the implementation of the drainage design measures, ensures that recharge to the aquifer will not be altered, thus downgradient water levels will not be altered. As such, there are no well supplies down-gradient of the Northern or Southern Clusters that can be affected by temporary dewatering during turbine base construction.

Impact Assessment – Grid Connection Route

The Grid Connection route cable trench depth will only be approximately 1.22 m in depth, the excavation will be temporary and transient, and the cable trench will be backfilled with excavated material and/or hardcore material (Cl.804 or CBGM), depending on site conditions. Therefore, there will be no net loss of permeability across the 1.22m depth. As a result, and given the shallow depth, there will be very limited potential for groundwater level impacts to occur.

Residual Effect:

Wind Farm site:

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

Grid Connection route:

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

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

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

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

However, as noted above, no direct surface water pathways exist between the Northern and Southern Clusters and downgradient watercourses, therefore, there is no surface water runoff which leaves the site, and all pathways are via groundwater recharge and groundwater flow.

Pathway: Surface recharge, and groundwater flow

Receptor: Downgradient surface waterbodies such as the River Suck, Ballyglass River, Cross River and Killeglan River

Pre-Mitigation Potential Effects: As no direct surface water pathways exist between the Northern and Southern Clusters and these watercourses - Indirect, slight, short term, unlikely impact.

Mitigation by Avoidance:

The primary mitigating factor in relation to downgradient surface water bodies is the distinct lack of surface water courses which drain the Proposed Development site and the surrounding area. The rainfall falling on the site recharges to the underlying groundwater aquifer. There are no small streams (10-50 l/s) which would typically be seen on upland slopes. Instead, the only surface water bodies which exist in proximity to the site are the small-medium rivers (Ballyglass River, Killeglan River, Cross River). All these rivers are fed by groundwater, either through drainage of a groundwater body (Cuilleenirwan and Ballyglass River) or through the emergence of groundwater springs as occurs at Killeglan.

Mitigation by Design:

To ensure the continuation of the existing hydrological regime, whereby rainfall percolates to ground and does not discharge as surface water runoff, the drainage design has incorporated natural attenuation of flows and allows for collected rainwater to be recharged back into the underlying aquifer rather than leaving the site through man-made drains. The drainage design also includes mitigation measures to ensure that any collected surface water is treated prior to discharge/recharge back into the ground, and therefore will not contain suspended sediment. The Proposed Development drainage design is included in Appendix 4-2 and summarised in Appendix 4-8 and Section 9.3.14.

Residual Effect:

Due to the lack of surface water drainage from the site, as well as the proposed drainage management plan which ensures the continuation of the existing hydrological/hydrogeological regime (groundwater recharge, with no runoff), along with the in-line treatment such as check dams, settlement ponds and Terrastop silt fencing (such as at T4) - the residual effect is considered to be: No impact on downgradient surface waterbodies.

Significance of Effects: No significant effects.

9.4.2.5 Potential Release of Hydrocarbons during Construction and Storage

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

At the Wind Farm site, the pathways for the rapid transport of any potential spilt chemicals are limited, due to the absence of any surface water drainage routes (rivers, streams *etc*), however surface water drainage pathways occur along the Grid Connection route. At the Wind Farm site, the primary flow pathway is through infiltration into the subsoil and bedrock and eventually reaching the underlying groundwater aquifer.

The potential release of hydrocarbons can occur during the works within the Wind Farm site (Northern and Southern Cluster) and during works along the proposed Grid Connection route. As stated previously, the Wind Farm site does not directly interact with any surface watercourses. There are 5 no. surface watercourse crossings along the Grid Connection route.

Pathway: Groundwater flowpaths and site drainage network within the Wind Farm site (Northern and Southern Clusters). Groundwater flowpaths and surface water drainage network along the Grid Connection route.

Receptor: *Wind Farm site:* Groundwater within the Suck South and the Funshinagh GWBs.

Grid Connection route: Surface watercourses downgradient of the Grid Connection route (Cross River) and the underlying groundwater aquifer.

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

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

Proposed Mitigation Measures:

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

- No refuelling or maintenance of construction vehicles or plant will take place on site outside of the dedicated bunded refuelling area. Any off-site refuelling will occur at a controlled fuelling station;
- Each vehicle will carry fuel absorbent material and pads in the event of any accidental spillages;

- Onsite refuelling will be carried out by trained personnel only;
- Fuels stored on site will be minimised. Fuel storage areas if required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- Drainage water from temporary construction compounds will be collected and drained via silt traps and hydrocarbon interceptors prior to recharge to ground;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages is contained within Construction and Environmental Management Plan (Appendix 4-9). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

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

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

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

9.4.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from wastewater treatment systems has the potential to impact on groundwater and surface waters if site conditions are not suitable for an on-site percolation unit. There are 2 no. temporary construction compounds proposed (1 no. within the Northern Cluster and 1 no. within the Southern Cluster) as detailed in Chapter 4. The construction compound for the Southern Cluster is situated ~1.0km south of the R363, roughly between Cam quarry and the Ballyglass River.

The construction compounds may also be used as a base during the Grid Connection route works.

No wastewater facilities are proposed along the TDR, therefore this impact cannot occur within that element of the Proposed Development.

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

Grid Connection route: Groundwater flowpaths and drainage network.

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

Pre-Mitigation Potential Impact:

- Indirect, negative, significant, temporary, unlikely impact to surface water quality.
- Indirect, negative, moderate, temporary, unlikely impact to local groundwater.

Proposed Mitigation by Avoidance:

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

Residual Effect: Based on the fact that there will be no discharge of wastewater to either the Proposed Development (including the Wind Farm site (Northern or Southern Clusters) or along the Grid Connection route) and that wastewater will be managed by an appropriately licensed waste contractor, there will be no residual effect.

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

9.4.2.7 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative 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 between 6-9 is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of ±0.5 of a pH unit. Entry of cement-based products into surface watercourses represent a risk to freshwater ecology along the Grid Connection route.

At the Proposed Development site, this pathway (to surface waters) is not present, however, the release of cement-based products to the site drainage system will percolate to ground. Batching of wet concrete on site and washing out of transport and placement machinery are the activities most likely to generate a risk of cement-based pollution to the underlying groundwater system and downstream groundwater dependent GWDTEs. Mitigation measures will be put in place to protect groundwaters, although the risk of cement-based products reaching the aquifer/groundwater level through the thickness of the site subsoils is minimal.

Pathway: *Wind Farm site:* Recharge to groundwater.

Grid Connection route: Local watercourses and Cross River

Receptor: *Wind Farm site:* Groundwater within the underlying Suck South and Funshinagh GWBs.

Grid Connection route: Downgradient surface water bodies – Cross River and underlying Funshinagh GWB. (Note, no watercourse crossings occur over the South Suck GWB or the Athlone West GWB).

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

Grid Connection route: Indirect, negative, moderate, short term, likely impact to surface water along/near the Grid Connection route (i.e., the Cross River and its tributaries). No impact on underlying South Suck GWB, Funshinagh GWB, and Athlone West GWB.

Proposed Mitigation by Avoidance:

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

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

Proposed Mitigation by Design:

The following mitigation measures are proposed:

- No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Any guidance/mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed watercourse 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 surface water flows (note within the Wind Farm site there are no watercourses, and all exceeded rainwater will percolate to ground). This will minimise the risk of entrainment of suspended sediment in drainage water, and transport via this pathway to surface watercourses (any deviation from this will be completed in consultation with the IFI);
- During the near stream construction work (along the Grid Connection route) 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,
- No new stream crossings or culverts will be required. No Section 50 Applications are required for this Proposed Development.

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

Based on the lack of in stream works at watercourse crossing (using existing bridges) and the mitigation measures to prevent the release of concrete water, the residual impact along the Grid Connection route is considered to be - negative, indirect, imperceptible, short term, likely impact to surface water along/near the Grid Connection route (i.e., the Cross River and its tributaries). Note that the impacts of potential Directional Drilling works at proposed watercourse crossings along he Grid Connection route is presented in Section 9.4.2.12.

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

9.4.2.8 Potential Effects on Turloughs

Nearby turloughs, their respective measured water level ranges and their respective distance to the proposed turbines (i.e. distance to turbine foundations) are outlined in Section 9.3.7.6. The designation of some of these turloughs as European Sites (SACs/SPAs) are included within Section 9.3.12. The closest turlough is Gortaphuill, located ~0.1km east of Turbine T4. Turbine T4 will be constructed on higher ground to the west of Gortaphuill turlough.

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

- Turbines 1 and 2 – potential GW catchment to Four Roads turlough (assessed below in Section 9.4.3.4);
- Turbine T4 which is considered to be upgradient of Gortaphuill;
- Turbines 3, 4, 5, 6 and 7 are in the area where groundwater drains towards Thomas Street Turlough;
- Turbines T16, T17, and T18 which are in the catchment to Feacle Turlough; and,
- Turbines T19 & T20 which are considered to be upgradient of Corkip Lough (assessed below in Section 9.4.3.4).

285.7m of borehole drilling has been completed within the Northern Cluster and 394.6m of borehole drilling has been completed within the Southern Cluster, with no identified near surface karst features present across this drilling.

The relatively thick subsoils identified during the borehole drilling, trial pitting and correlated with the geophysics provides confidence in the level of subsoil protection to the underlying groundwater aquifer across the Northern and Southern Clusters.

The potential source pathway receptor model for effects on the turloughs could be considered to be:

Source: Excavation of roads and turbine bases and emplacement of roads/concrete, and hardstanding areas at the 20 no. locations across the Northern and Southern Clusters, and drainage associated with these works.

Pathway(s):

- Alteration of groundwater volumes through alterations of recharge patterns;
- Alteration of groundwater flowpaths which feed the turloughs through excavation / emplacement works;
- Alteration of groundwater quality due to cementitious material/hydrocarbons etc; and,
- Potential surface water/overland flows where infrastructure is proximal to turloughs (Gortaphuill and T4).

Receptor: Turlough water levels (volume), water quality and dependent ecosystems (ecosystems assessed in detail in Section 9.4.2.10).

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

Impact Assessment:

As outlined by the data derived from the Hydrogeological Conceptual model, the site investigation data (2010-2021) and the water level data accrued over the 18-month study period has been used to create groundwater hydrographs, groundwater contour maps, groundwater flow directions and a broader model of how rainfall falling within the Northern and Southern Cluster is reaching the groundwater system, reaching the turloughs and eventually discharging from the turloughs. Using the available data and the CSM we have assessed potential impacts on non-designated turloughs below.

Gortaphuill Turlough & T4: The site investigation data from T4-RC01 (rotary core borehole at Turbine T4) shows 9.6m of sandy gravelly CLAY over Strong to very Strong, dark grey LIMESTONE. Borehole T4-RC02 terminated at 10m after drilling through 10m of gravelly/cobbly CLAY. The intrusive site data indicates a thick subsoil cover and does not indicate the presence of any karst features. The primary risk to Gortaphuill turlough is from local drainage water from T4 during periods of heavy rainfall reaching the turlough. If unmitigated, the surface water may contain suspended sediment which could deposit in the turlough. This turlough is not a designated site. Retention of any local drainage water from T4 within the immediate area around T4 will protect the Gortaphuill turlough.

Thomas Street Turlough - Turbines T3, T4, T5, T6, and T7 : Groundwater from below Turbines T3, T4, T5, T6 and T7 can flow towards Thomas Street turlough. Turbine T7 is situated ~1.0km upgradient of Thomas Street turlough. Foundation works at T7 will be gravity bearing onto existing underlying sandy CLAY, sandy GRAVEL and SAND. Turbine T7 is situated at 70.12 m OD, with a Summer Water Level of ~54 m OD and a winter water level of 66.6 m OD. The emplacement of gravity bearing concrete foundation at T7 will not impact on groundwater flow or groundwater quality. Controls for management of concrete during foundation pours are outlined in Section 9.4.2.7.

Drainage measures will also direct rainfall away from the Wind Farm infrastructure (access roads, hardstands, turbine bases, including T7) to recharge downgradient of the works areas, and therefore there will be no significant alteration of recharge patterns (*see* Section 9.4.2.2) or groundwater quality (*see* Section 9.4.2.1).

There are no mapped turloughs, or designated turlough sites downstream or in close proximity to the proposed Grid Connection route. Therefore, proposed works along the Grid Connection route will not impact on turloughs or designated turlough sites.

Proposed Mitigation Measures:

The following mitigation measures are proposed:

- Construction stage activities on the access road to T4 and at T4 will only be completed during the Summer Months (May – October) when the turlough is drained and empty;
- Site drainage management will be put in place (as outlined in Section 9.4.2.1) in order to prevent any poor quality drainage water reaching the turloughs during the construction phase. This includes 3 no. layers of silt fencing downgradient of Turbine T4, as well as the general separation of clean and dirty water, while maintaining the overall hydrological regime of rainfall recharge to ground; and,
- Mitigation measures relating to hydrocarbons, cementitious materials and wastewater disposal, as outlined in Sections 9.4.2.5, 9.4.2.6 and 9.4.2.7 will provide adequate protection to groundwater and surface water quality and ensure that groundwater quality will not be impacted, thus protecting the groundwater quality of any hydraulically downgradient turloughs.

Residual Effect: Due to the expansive data on subsoils and bedrock within the Northern and Southern Cluster areas, the data on groundwater levels and flow which have been informed the groundwater contour maps and conceptual models, coupled with the mitigation measures associated with drainage management and the protection of water quality, the residual effect is considered to be - Indirect, negative, imperceptible, short term, unlikely impact to groundwater fed turloughs.

Significance of the Effect: No significant effects will occur on downgradient non-designated turloughs (Thomas Street and Gortaphuill turloughs).

9.4.2.9 Potential Effects on Surface and Groundwater WFD Status

The EU Water Framework Directive (2000/60/EC) requires that all member states protect and improve water quality in all waters, with the aim of achieving good status by 2027 at the latest. Any new development must ensure that this fundamental requirement of the Directive is not compromised.

The status of the groundwater and surface water bodies in the vicinity and downstream of the Proposed Development site are described in Section 9.3.10 and 9.3.11 respectively.

In terms of surface waterbodies, the River Suck, located to the west of the Proposed Development, achieved “Good” status under the WFD 2nd Cycle (2013-2018). The Ballyglass River achieved “Good” status while the northern section of the Cross River, located east of the Northern Cluster, achieved “Poor” status. The Killeglan River is assigned Moderate status under the latest WFD cycle (2013-2018). The majority of the Grid Connection route is drained by the Cross River. The WFD status of the Cross River ranges from “Moderate” to “Good” status under the latest WFD cycle (2013-2018).

In terms of groundwater bodies, the majority (18 of 20 no. turbines and >90% of area) of the Proposed Development site is underlain by the Suck South groundwater body which achieved “Good” status in the latest WFD cycle. A small area in the west of the Wind Farm site and much of the Grid Connection route is underlain by the Funshinagh groundwater body which also achieved “Good” status. A small area in the eats of the Grid Connection route overlies the Athlone West GWB.

Potential effects on groundwater and surface water quality and quantity as a result of the Proposed Development has the potential to negatively affect the WFD status of ground and surface water bodies in the vicinity and downstream of the Proposed Development. The potential change in WFD status for waterbodies resulting from the Proposed Development, and in the absence of any mitigation measures, is summarised in Table 9-25 below and outlined in further detail in the WFD Compliance Assessment attached as Appendix 9-6.

Our understanding of the WFD objectives is that water bodies, regardless of whether they have ‘Poor’ “Moderate” or ‘High’ status, should be treated the same in terms of the level of protection and mitigation measures employed in order to ensure there is no deterioration in the status of a waterbody.

Table 9-25: Summary of WFD Status Change in an Unmitigated Scenario (Construction Phase)

WFD Element	WFD Code	Current Status 2013-2018	Assessed Status – Unmitigated Scenario
Ballyglass_010	IE_SH_26B150840	Good	Moderate
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Moderate
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Poor
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor
Suck South GWB	IE_SH_G_225	Good	Moderate
Funshinagh GWB	IE_SH_G_091	Good	Moderate
Athlone West	IE_SH_G_014	Good	Moderate

Pathway(s): Groundwater recharge and groundwater flow (downstream discharge of groundwater to surface waterbodies).

Receptor: The following surface waterbodies have been deemed to have the potential to be affected by the Proposed Development due to their location downstream of the Wind Farm site and/or Grid Connection route: Ballyglass_010, Suck_130, _140, _150 and _160, the Cross(Roscommon)_020, _030, _040 and the Shannon(Upper)_110. The following ground waterbodies have the potential to be affected by the Proposed Development due to their location underlying the Wind Farm site and/or Grid Connection route: Suck South GWB and the Funshinagh GWB. Please refer to the WFD Compliance Assessment attached as Appendix 9-6 for a detailed description of the screening process.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, likely effect on the WFD status of underlying groundwater bodies. Indirect, negative, imperceptible, short term, unlikely effect on the WFD status of downstream surface waterbodies.

Impact Assessment/Mitigation Measures: Due to the hydrogeological regime at the Wind Farm site, the groundwater bodies underlying the site i.e. Suck South GWB and Funshinagh GWB are the most sensitive receptors. Surface watercourses downstream of the Wind Farm site will be less susceptible to effects from the Proposed Development due to the lack surface water pathways between the site and downstream surface water receptors. However, a total of 5 no. watercourse crossings are proposed along the Grid Connection route and these surface waterbodies are more at risk due to their proximal location to the Proposed Development works.

Strict mitigation measures in relation to the protection of surface and groundwaters are outlined above in Section 9.4.2.1 to 9.4.2.8. The implementation of these mitigation measures during the construction phase of the development will ensure the qualitative and quantitative status of the receiving groundwaters waters will not be altered by the Proposed Development.

There will be no change in GWB or SWB status in the underlying GWBs or downstream SWBs resulting from the Proposed Development (refer to Table 9-26). There will be no change in quantitative (volume) or qualitative (chemical) status, and the underlying GWBs are protected from any potential deterioration from chemical pollution.

As such, the Proposed Development is compliant with the requirements of the Water Framework Directive (2000/60/EC).

Table 9-26: Summary WFD Status with the implementation of Mitigation Measures (Construction Phase)

WFD Element	WFD Code	Current Status 2013-2018	Assessed Status – Unmitigated Scenario
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor
Suck South GWB	IE_SH_G_225	Good	Good
Funshinagh GWB	IE_SH_G_091	Good	Good
Athlone West GWB	IE_SH_G_014	Good	Good

Residual Effect: Due to the local hydrogeological regime at the proposed Wind Farm site (no surface water drainage), coupled with the implementation of the proposed mitigation measures for the protection of groundwater recharge and water quality, and additionally, given the extensive knowledge of the local hydrogeological regime at the Wind Farm site we consider that there will be no residual effect on the WFD status of the underlying groundwater bodies (South Suck GWB, Funshinagh GWB and Athlone West GWB). We also consider that there will be no residual effect on the WFD status of surface waterbodies downstream of the Proposed Development.

Significance of the Effect: With the implementation of the mitigation measures outlined above there will be no change in the GWB or SWB status in the underlying GWBs or downstream SWBs resulting from the Proposed Development. The Proposed Development will not result in the deterioration in the WFD status of any surface or groundwater body nor will it jeopardise the attainment of good status in the future.

9.4.2.10 Potential Effects on Designated Sites

9.4.2.10.1 *Groundwater dependent SAC's, SPA's and pNHA's*

Primarily groundwater dependent designated sites near the Northern and Southern Clusters of the Wind Farm site are:

- Lough Croan Turlough SAC/SPA/pNHA
- Four Roads Turlough SAC/SPA/pNHA
- Ballynamona Bog and Corkip Lough SAC
- Lough Funshinagh SAC/pNHA
- Lisduff Turlough SAC
- Castlesampson Esker SAC (turlough)

As outlined in Section 9.4.2.8, groundwater levels and contours have been derived for the Northern and Southern Clusters and groundwater flow directions towards turloughs have been identified where the data suggests so. The groundwater dependent SAC's include turloughs considered proximal to the Northern and Southern Clusters (Lough Croan and Corkip Lough) as well as more distal turloughs such as Four Roads Turlough, Lisduff turlough and Lough Funshinagh.

Source(s): Excavation of roads and turbine bases, Emplacement of roads/concrete hardstandings at the 20 no. locations across the Northern and Southern Clusters.

Pathway (s):

- Alteration of groundwater volumes through alterations of recharge patterns;
- Alteration of groundwater flowpaths which feed the turloughs through excavation/emplacement of turbine infrastructure; and,
- Alteration of groundwater quality due to silt, cementitious material/hydrocarbons entering the groundwater system below the Wind Farm Site.

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

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

Impact Assessment – Lough Croan Turlough SAC/SPA/pNHA

Groundwater flows towards Lough Croan SAC from the Northern Cluster will not occur. The collated groundwater data indicate that the high water level in Lough Croan is higher than that recorded in Gortaphuill turlough (adjacent to T4), and that data, combined with the local topography and other recorded water level data (EPA well at Turrock and well W3) demonstrates that Lough Croan is not hydraulically connected to groundwater flows below the proposed Norther Cluster of the Wind Farm site. Therefore, none of the impact pathways (listed above) can occur at Lough Croan Turlough SAC/SPA/pNHA in respect of the Proposed Development.

Impact Assessment – Four Roads Turlough SAC/SPA/pNHA

Groundwater levels at Four Roads Turlough SAC range between 47.8 -48.6 m OD from the historical data, with maximum water level estimated at ~51m OD (GSI GWFlood Data). Groundwater flow from near turbines T1 and T2 are >76 m OD, with water levels recorded between Four Roads and the Northern Cluster of 61.6-65.5 m OD. There are 2 no. watercourses which emerge between Four Roads turlough and the Northern Cluster and any groundwater which may flow north/northwest from the site is more likely to emerge as baseflow in these, however the possibility of groundwater reaching Four Roads Turlough cannot be discounted. Proposed drainage mitigation is outlined below in respect of the potential impact pathways listed above.

Impact Assessment – Ballynamona Bog and Corkip Lough SAC

As outlined in Section 9.4.2.8 above, Corkip Lough is situated ~1km southeast of T20 and ~1.4km southeast of T19. The site investigation data near T19 and T20 indicates that there is >10m of subsoil overburden at these turbine locations, providing a considerable thickness of protection to the underlying groundwater aquifer. The local subsoil (at T19 and T20) is logged as sandy gravelly CLAY, sandy GRAVEL and clayey sandy COBBLES. Maximum groundwater levels near Corkip Lough range between 57.01 – 58.8 m OD in Winter. There is a very shallow valley on the eastern side of Cam Hill which slopes in a south-easterly direction. T19 and T20 are situated just inside the boundaries of this valley. The shallow valley broadly trends in the direction of Corkip Lough, therefore groundwater from near T19/T20 will likely drain towards Corkip Lough. The Ballynamona bog is artificially drained around its perimeter which likely partially isolates it hydraulically from the surround regional groundwater flow systems. These bogs are also normally hydraulically isolated from the surrounding groundwater regime by an impermeable clay/marl layer which underlies the bog. For these reasons, and combined with the considerable thickness of subsoil present below the proposed turbine locations, the bog section of this SAC is not considered further as a potential receptor. Proposed drainage mitigation is outlined below in respect of the potential impact pathways listed above relative to the open water elements of Ballynamona Bog and Corkip Lough SAC.

Impact Assessment – Lough Funshinagh SAC/pNHA

Lough Funshinagh SAC/pNHA is situated 6.2km northeast of the Northern Cluster, with a maximum Winter water level of 67.35 m OD. The Lough Funshinagh SAC/pNHA is situated within a separate mapped groundwater body to the majority of the proposed development site. As outlined in Section 9.3.7.11, Lough Funshinagh, the available groundwater levels for Lough Funshinagh show Funshinagh is hydraulically upgradient of the most north/northwestern turlough to the Northern Cluster (Lough Croan) for ~60% of the monitoring period, notably when water levels were at their highest. These data, coupled with the elevated topography to the northwest of the Northern Cluster show the prevailing hydraulic gradient within the site is west/southwest towards the River Suck, 3-4km west at ~42m OD, not northeast towards Lough Funshinagh. There is also elevated ground (northwest-southeast ridge line) between Lough Funshinagh and Lough Croan and also the Northern Cluster of proposed turbines. Surface water emerges from the eastern flank of this ridge to form the Lysterfield stream, and this stream flow into Lough Funshinagh to the east. The Lysterfield stream water levels are ~72m OD, and are significantly higher than any water levels recorded at Lough Croan or below the wind farm footprint. Given the high recorded water levels in the Lysterfield stream (between Lough Croan and Lough Funshinagh) there is catchment divide located between those water bodies, and based on this observation, there can be no hydraulic connection between the Wind Farm Site and Lough Funshinagh. As such, none of the impact pathways (listed above) can occur at Lough Funshinagh SAC/pNHA in respect of the Proposed Development.

Impact Assessment – Lisduff Turlough SAC

Lisduff Turlough SAC is situated 7km north of the Northern Cluster. The historical data gathered from Lisduff turlough (2016-2018) shows a maximum winter water level of ~49 m OD. An area of high ground exists between the Wind Farm site and the Lisduff Turlough SAC at Correal (133 m OD) and Glenfin (150m OD). This area of high ground wraps southern and eastern flanks of the Lisduff turlough SAC catchment and will act as a hydraulic boundary separating this distal SAC from the Northern or Southern Clusters. As such, none of the impact pathways (listed above) can occur at Lisduff Turlough SAC in respect of the Proposed Development.

Impact Assessment – Castlesampson Esker SAC (turlough)

The Castlesampson Esker is included, as a turlough is noted within its qualifying interests, however the turlough makes up a very small area of the SAC and is situated within an enclosed area of esker deposits. The SAC is situated ~4km south of the Southern Cluster. The catchment of the turlough is most likely defined by the surrounding sand and gravel deposits. The regional groundwater flow from the Proposed Development site is not in the direction of the Castlesampson Esker SAC. As such, none of the impact pathways (listed above) can occur at Castlesampson Esker SAC (turlough) in respect of the Proposed Development.

There are no mapped turloughs, or designated turlough sites downstream or in close proximity to the proposed Grid Connection route. Therefore, proposed works along the Grid Connection route will not impact on turloughs or designated turlough sites.

Impact Assessment – Feacle Turlough pNHA & T16, T17 and T18*:* The site investigation data form Turbines T16, T17 and T18 indicates there is between ~2.2-4.5m of overburden (sandy GRAVEL and COBBLES) at these locations. The data from the rotary core boreholes does not record any groundwater strikes or fractures within the bedrock. T16 is located on elevated ground ~1.1km to the northwest of Feacle Turlough. The topography around from T17 to T18 slopes to the south in the direction of Feacle Turlough. Due to this sloping topography from these turbines towards Feacle Turlough, groundwater flow towards Feacle Turlough cannot be discounted. The depth of subsoils and lack of any groundwater strikes at T16, T17 or T18 indicate that any potential subsurface connection will be minor.

Proposed Mitigation Measures:

Mitigation measures have been outlined within Sections 9.4.2.2, 9.4.2.3, 9.4.2.5, 9.4.2.6, 9.4.2.7 and 9.4.2.8 which these will ensure the protection of groundwater quality and quantity leaving the proposed development site. These mitigation measures include:

- Iterative design phases to optimise turbine layout and avoid any potentially poor ground;
- Site specific drainage design ensuring all water recharges to ground and mimics the existing hydrological regime;
- Protection of groundwater from cement-based materials - sand blinding, DPM and concrete blinding are to be provided at formation level to create a vertical cut-off barrier and to mitigate the risk of concrete leakage into the ground below; and,
- Protection of groundwater from the potential release of silt and hydrocarbons.

Residual Effect: Due to the lack of hydraulic connectivity as outlined above, there will be no residual effects on Lough Croan Turlough SAC/SPA/pNHA, Lough Funshinagh SAC/pNHA, Lisduff Turlough SAC and Castlesampson Ester SAC (turlough).

Due to the separation distances involved, the site specific knowledge of the ground conditions (subsoil and bedrock competency) groundwater levels, gradients and flow directions as well as the mitigation measures provided to ensure the protection of water quality and water quantity (recharge), there will be no residual impacts on Four Roads Turlough SAC/SPA/pNHA and Feacle Turlough pNHA.

Based on the site conditions at T19 and T20 including the known ground conditions, as well as the mitigation measures including site specific drainage and protection of groundwater from cement based materials, silt and hydrocarbons, there will be no residual impact on Ballynamona Bog and Corkip Lough SAC.

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

9.4.2.10.2 Surface Water Dependent SAC's, SPA's and pNHA's

Primarily Surface water dependent designated sites near the Northern and Southern Clusters of the Wind Farm site and the Grid Connection route are:

- Lough Ree SAC/SPA/pNHA
- River Shannon Callows SAC/SPA
- River Suck Callows SPA/NHA

The Lough Ree SAC is principally fed by the River Shannon, likely with a moderate amount of groundwater inflow around its margins. Water levels in Lough Ree are generally at ~35 m OD. The catchment to Lough Ree (Upper Shannon Catchment) measures ~1,500 km^2. The available groundwater data (c.f. Section 9.3.7) does not indicate any potential groundwater flow towards Lough Ree, it is east of Lough Funshinagh which has already been shown to be upgradient of the Northern and Southern Cluster turloughs in Winter. There are no surface waterbodies which drain from the Proposed Development site, and no surface water bodies which proximal to the Proposed Development site which drain towards Lough Ree.

The River Shannon Callows is situated 12km east of the Proposed Development site. The only potential pathway to the River Shannon Callows SAC is through groundwater base flow to a nearby watercourse proximal to the Proposed Development site (Cross, Killeglan, Ballyglass and Suck rivers) which then discharge to the River Shannon. There will be no surface water drainage from the site, all proposed drainage is via recharge and groundwater flowpaths.

The River Suck Callows SPA is mapped 2.4km west of the Proposed Development site. Again, there is no surface water drainage from the site which could impact on surface water quality to the SPA. The site is designated for the presence of bird species (Whooper Swan, Golden Plover, Wigeon, Lapwing, Greenland White-fronted Goose) as well as for wetlands.

Mitigation by Design:

There will be no net change in runoff/recharge from the site due to the drainage design. All water will recharge to ground. Any "dirty" surface water generated on site will be collected within an interceptor drain, be attenuated and flow to a settlement pond at each "dirty" water outfall, before being allowed to infiltrate over the vegetated surface.

Residual Effect: Due to the separation distances involved, the knowledge of the ground conditions (subsoil and bedrock competency) groundwater levels, gradients and flow directions as well as the mitigation measures provided to ensure the protection of water quality and water quantity (recharge), there will be no residual effects on surface water ecosystems at Lough Ree SAC/SPA/pNHA, River Shannon Callows SAC/SPA, and River Suck Callows SPA/NHA.

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

9.4.2.10.3 Non hydrologically dependent SAC's, SPA's and pNHA's

The Killeglan Grassland SAC is the only non-water dependent designated site near the Northern and Southern Clusters of the Wind Farm site and the proposed Grid Connection route.

Groundwater flow from the Southern Cluster will drain in the direction of the Killeglan Grassland SAC but will be significantly below ground level at the SAC. There are no surface water channels which could hydraulically connect the Proposed Development Site and the Killeglan Grassland SAC. The qualifying interest of the SAC, Orchid rich grassland, are not reliant on surface water or groundwater.

Pathways: There are no identified pathways between the Proposed Development site and the Killeglan Grassland SAC.

Receptors: The qualifying interest of the Killeglan Grassland SAC, Orchid rich calcareous.

Pre-Mitigation Potential Effect: No Potential Effect

Mitigation Measures: No mitigation is required

Residual Effect: As there is no pathway for potential effects on this designated site, from a hydrological or hydrogeological perspective (groundwater below the grassland will not interact with the surface vegetation), there are no residual effects.

Significance of effects: None.

9.4.2.11 Potential Effects on Public Water Supplies

The public water supplies near the Proposed Development site are outlined in Section 9.3.7.7 and include the Killeglan PWS located 1.9km south of the Southern Cluster and the more distal Mount Talbot PWS, the source of which is situated 5.8km northwest of the Northern Cluster. The quality and quantity of water being abstracted from these locations is critically important to these schemes. There is a risk of poor quality or contaminated water entering the groundwater system below the Proposed Development site and flowing towards the existing water sources (Killeglan PWS and Mount Talbot PWS).

The ZoC to the Killeglan Spring PWS has been mapped by the GSI which encompasses a small area of the Proposed Development site (i.e., 2.7 Ha), near the southern edge of Cam Hill, where the proposed turbine T17 and T18 are situated. T18 is located close to the extent of the ZoC, but is located on the northern side of the topographic high of Cam Hill and as such is hydraulically separated from the groundwater catchment to the south. All other areas of the Proposed Development site are excluded from the Zone of contribution to the Killeglan Spring ZoC.

The ZoC to the Mount Talbot PWS has been mapped also. The southern boundary of the ZoC is located 2.8km north of the Proposed Development site.

Receptor: Groundwater quantity and/or quality at the PWS sources.

Pathway: Groundwater Flowpaths from the Southern Cluster towards the Killeglan Spring PWS or from the Northern Cluster towards Mount Talbot PWS.

Pre-Mitigation potential Impact: Indirect, negative, moderate, long term, unlikely impact on groundwater quality and quantity in the ZoCs to Killeglan PWS and Mount Talbot PWS.

Impact Assessment & Proposed Mitigation Measures:

The Zone of Contributions (ZoC) to both of these nearby sources have been mapped. The ZoC assessment excludes any area of the Proposed Development from the catchment to the Mount Talbot PWS. The ZoC assessment of the Killeglan Spring PWS does include a small section of the Proposed Development site near T17 and T18, and short sections of proposed access tracks.

Winter groundwater levels near T17 measure ~69.5 m OD, while the ground elevation measures ~90 m OD. There is ~4.5 - 4.8m of overburden (COBBLES and GRAVEL) at T17 overlying Strong to very Strong fine to medium grained Limestone with no water strikes recorded during the drilling of the site investigation boreholes. This provides a good depth of subsoil protection over an unproductive aquifer zone, where maximum water levels are at least 20m below ground during Winter.

Winter groundwater levels near T18 were dipped by IGSL at ~83 m OD following the initial drilling of rotary core boreholes (this only an indicative water level as water level dipping straight after drilling can be slightly erroneous). The subsoils at T18 are logged as 4.1 - 4.5m of sandy gravelly COBBLES and sandy GRAVEL. The underlying bedrock is logged as Limestone with no fractures noted or groundwater strikes recorded.

The area of Proposed Development site which is located within the mapped Zone of Contribution is negligible (1.53 Ha) within the scale of the overall catchment (4218.5 Ha) to the Spring. (0.36 %).

Furthermore, the mitigation measures (including drainage design measures) outlined in Sections 9.4.2.1 - 9.4.2.7, which will protect groundwater water quality and quantities, will mean that there will be no net effect on any groundwater from the T17 area and other areas identified which may flow towards the Killeglan PWS.

No part of the proposed Grid Connection is proposed within the ZoC to either of the PWSs (Killeglan PWS and Mount Talbot PWS), and therefore there can be impact on water quality or water quality at either of the PWSs arising from the construction of the proposed Grid Connection.

Residual Impact: Based on the separation distance, the relative area of the Proposed Development site within the Killeglan Spring ZoC and the mitigation measures outlined in Sections 9.4.2.1 - 9.4.2.7, the residual impact on the Killeglan Spring PWS is considered to be – Indirect, negative, imperceptible, long term, unlikely impact on groundwater quality and quantity in the ZoCs to Killeglan PWS and Mount Talbot PWS.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigations measures, no significant effects on the Killeglan PWS will occur.

9.4.2.12 Potential Effects along the Grid Connection Route from HDD Works

Surface water quality impacts could occur at local watercourses and the Cross River during drilling and groundworks associated with the 5 no. proposed watercourse crossings along the Grid Connection route.

Watercourse crossing will be completed using one of the following methods:

- Crossing Using Standard Trefoil Formation
- Flatbed Formation over Bridges/Culverts
- Horizontal Directional Drilling (HDD)

Instream works are not required at any watercourse crossing along the proposed IPP cable route or Grid Connection route.

Trefoil and Flatbed methods will require local transient drainage controls to protect water quality in the stream being crossed.

If HDD is used this will prevent direct impacts on the watercourse. However, there is a risk of indirect impacts from sediment laden runoff during the launch pit and reception pit excavation works. There is also the unlikely risk of fracture blow out and contamination of the watercourse with drilling fluid.

Pathway: Surface water and groundwater flows

Receptor: Local watercourses and the downstream Cross River. All watercourse crossings occur over the Funshinagh GWB.

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

No impact on underlying Funshinagh GWB.

Mitigation Measures

- Although no in-stream works are proposed, the directional drilling works will only be done over a dry period between July and September (as required by IFI for in-stream works) to avoid the salmon spawning season and to have more favourable (dryer) ground conditions;
- The crossing works area will be clearly marked out with fencing or flagging tape to avoid unnecessary disturbance;
- There will be no storage of material / equipment or overnight parking of machinery inside the 15m buffer zone to the watercourse;
- Before any ground works are undertaken, double silt fencing will be placed upslope of the watercourse channel along the 15m buffer zone boundary;
- Additional silt fencing or straw bales (pinned down firmly with stakes) will be placed across any natural surface depressions / channels that slope towards the watercourse;
- Silt fencing will be embedded into the local soils to ensure all site water is captured and filtered;
- For HDD method, the area around the bentonite batching, pumping and recycling plant will be bunded using terram (as it will clog) and sandbags in order to contain any spillages;
- Drilling fluid returns will be contained within a sealed tank / sump to prevent migration from the works area;
- Spills of drilling fluid will be clean up immediately and stored in an adequately sized skip before been taken off-site;
- If rainfall events occur during the works, there will be a requirement to collect and treat small volumes of surface water from areas of disturbed ground (i.e. soil and subsoil exposures created during site preparation works);
- This will be completed using a shallow swale and sump down slope of the disturbed ground; and water will be pumped to a proposed percolation area at least 50m from the watercourse, or into a tanker for off site disposal;
- The discharge of water onto vegetated ground at the percolation area will be via a silt bag which will filter any remaining sediment from the pumped water. The entire percolation area will be enclosed by a perimeter of double silt fencing;
- Any sediment laden water from the works area will not be discharged directly to a watercourse or drain;
- Works shall not take place during periods of heavy rainfall and will be scaled back or suspended if heavy rain is forecasted;
- Daily monitoring of the compound works area, the water treatment and pumping system and the percolation area will be completed by a suitably qualified person during the construction phase. All necessary preventative measures will be implemented to ensure no entrained sediment, or deleterious matter is discharged to the watercourse;
- If high levels of silt or other contamination is noted in the pumped water or the treatment systems, all construction works will be stopped. No works will recommence until the issue is resolved and the cause of the elevated source is remedied;
- On completion of the works, the ground surface disturbed during the site preparation works and at the entry and exit pits will be carefully reinstated and re-seeded at the soonest opportunity to prevent soil erosion;

- The silt fencing upslope of the watercourse/river will be left in place and maintained until the disturbed ground has re-vegetated;
- There will be no batching or storage of cement allowed within 50m of any of the watercourse crossing;
- There will be no refuelling allowed within 100m of the watercourse crossing; and,
- All plant will be checked for purpose of use prior to mobilisation to the watercourse crossing locations.

Horizontal Directional Drilling 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: Due to the avoidance of instream works, the works being mainly carried out in the corridor of a public road along with the proposed mitigation measures the effect at Grid Connection route watercourse crossing, which may include direction drilling, will be negative, imperceptible, indirect, temporary, likely effect on surface water in local streams and the Cross River. There will be no impact on the underlying Funshinagh GWB.

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

9.4.2.13 Potential Effects of the Proposed Turbine Delivery Route

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

9.4.3 Operational Phase – Likely Significant Effects

9.4.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the downstream surface water drainage network, *if* the drainage design included surface water runoff leaving the site. However, at this site, the drainage design has been optimised to allow for all rainfall which may fall on impermeable surfaces (such as at turbine hardstands) to recharge to ground as would normally occur at the site. The footprint comprises turbine hardstandings, new and upgraded access roads, and the substation. The majority of the proposed Grid Connection will be installed within the existing road network, an established impermeable surface. Therefore, there will no potential impact associated with the Grid Connection during the operational phase.

Pathway: Site drainage network and recharge to underlying groundwater in the South Suck GWB.

Receptor: Groundwater recharge, surface waters (Gortaphuill turlough) and downgradient GWDTEs.

Pre-Mitigation Potential Impact: Indirect, negative, slight, permanent, unlikely impact on groundwater quality and quantity within the South Suck GWB.

Impact Assessment/Mitigation Measures

As summarised in Section 9.3.14 and outlined in detail in Appendix 4-2, the drainage design for the Wind Farm site includes for the release of any surface water captured within the interceptor drains to recharge back to ground, with a very nominal spatial diversion of the water (10's of metres). In doing so, all rainfall which falls on the site will still infiltrate to ground. There will be no net increase in runoff from the Wind Farm site.

Proposed Mitigation by Design:

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

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean local drainage water, in order to minimise the amount of rainfall reaching areas where suspended sediment could become entrained. Collected drainage water will then be directed to areas where it can be slowly re-distributed over the ground surface and infiltrate through the soil and subsoils;
- Swales/road side drains will be used to collect drainage 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; and,
- Check dams will be used along sections of access road drains to attenuate flows and intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock.

Residual Impact: Due to the retention of groundwater recharge regime, with no surface water drainage from the Wind Farm site, as well as the relative short displacement of any rain water before it infiltrates and the mitigation measures to ensure the quality of the drainage discharge water, the residual effect is considered to be - indirect, negative, imperceptible, permanent, unlikely impact on groundwater quality and quantity within the South Suck GWB.

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

9.4.3.2 Potential Hydrological and Hydrogeological Effects on Turloughs

Nearby turloughs, their respective measured water level ranges and their respective distance to the Proposed Turbines (i.e. the turbine foundations) are outlined in Section 9.3.7.6. The closest turlough is Gortaphuill, located ~0.1km east of Turbine T4. Winter groundwater levels have been plotted across the site and groundwater level contours have been derived from these levels. Groundwater flow is considered to be perpendicular to groundwater contours, however, some local variation will likely occur across the site based on topography and on the wide spread of groundwater levels. Based on these groundwater contours/flow-paths, turloughs which are considered to be downgradient of proposed turbines are;

Turbine T4 which is considered to be upgradient of Gortaphuill, Turbines T19 & T20 which are considered to be upgradient of Corkip Lough.

The potential impacts and effects on the turloughs during the construction phase has been considered and outlined in Section 9.4.2.8. During the operational phase, the potential for effects are more limited that 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.

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

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

Receptor: Turlough water quantity, quality and flow pathways

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

Impact Assessment:

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

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

Any hydrocarbons (oil) stored within the substation will be enclosed within a bund with 110% capacity.

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

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

9.4.3.3 Potential Effects on Surface and Groundwater WFD Status

The potential effects on groundwater and surface water during the operational phase of the Proposed Development are much reduced in comparison to the construction phase described above in Section 9.4.2. Therefore, the potential for the operational phase of the Proposed Development to affect the WFD status of waterbodies in the vicinity and downstream of the site is reduced compared to the construction phase (Section 9.4.2.9).

During the operational phase of the Proposed Development, all major earthworks will have been completed and all permanent drainage controls will be in place which will significantly reduce the potential for sediment laden drainage water. During the operational phase some maintenance works may be completed at the Wind Farm site, however these would be of a very minor scale and would be very infrequent.

No maintenance works will occur along the Grid Connection route as the underground cabling will already be in place in the carriageway of the existing public road network.

With the absence of surface water pathways, combined with the minor and infrequent nature of the maintenance works, the operational phase of the Proposed Development will have very limited potential to alter the WFD status of downstream surface waterbodies. During the operational phase groundwater quality will still be at risk from the infrequent maintenance works (hydrocarbon spillages, wastewater disposal etc) which has the potential to affect the status of the underlying groundwater bodies. As discussed in Section 9.4.3.1, the Proposed Development does not have the potential to affect the quantitative status of the underlying ground waterbodies.
The potential change in WFD status for waterbodies resulting from the operational phase Proposed Development, and in the absence of any mitigation measures, is summarised in

Table 9-27 below and outlined in further detail in the WFD Compliance Assessment attached as Appendix 9-6.

Table 9-27: Summary of WFD Status Change in an Unmitigated Scenario (Operational Phase)

WFD Element	WFD Code	Current Status 2013-2018	Assessed Status – Unmitigated Scenario
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor
Suck South GWB	IE_SH_G_225	Good	Moderate
Funshinagh GWB	IE_SH_G_091	Good	Moderate
Athlone West GWB	IE_SH_G_014	Good	Good

Pathway(s): Groundwater recharge and groundwater flow (downstream discharge of groundwater to surface waterbodies).

Receptor: The following surface waterbodies have been deemed to have the potential to be affected by the Proposed Development due to their location downstream of the Wind Farm site and/or Grid Connection route: Ballyglass_010, Suck_130, _140, _150 and _160, the Cross(Roscommon)_020, _030, _040 and the Shannon(Upper)_110. The following ground waterbodies have the potential to be affected by the Proposed Development due to their location underlying the Wind Farm site and/or Grid Connection route: Suck South GWB and the Funshinagh GWB. Please refer to the WFD Compliance Assessment attached as Appendix 9-6 for a detailed description of the screening process.

Pre-Mitigation Potential Impact: Indirect, negative, moderate, short term, likely effect on the WFD status of underlying groundwater bodies. No potential effect on the WFD status of downstream surface waterbodies.

Impact Assessment/Mitigation Measures:

As outlined above, the potential for effects during the operational phase of the Proposed Development is reduced in comparison to the construction phase.

During the operational phase of the Proposed Development, the only plant which will be required on site will be maintenance/inspection vehicles (jeeps/vans/quads). These will be refuelled within a bunded refuelling area. Mitigation measures outlined for the protection of surface and groundwaters from hydrocarbon spillage, wastewater disposal and the use of cement based products during the construction phase (Section 9.4.2.5, 9.4.2.6 and 9.4.2.7) will also be implemented during the operational phase. The implementation of these mitigation measures during the operational phase of the development will ensure the qualitative status of the receiving groundwaters waters will not be altered by the proposed development.

There will be no change in GWB or SWB status in the underlying GWBs or downstream SWBs resulting from the Proposed Development (refer to Table 9-28). There will be no change in quantitative (volume) or qualitative (chemical) status, and the underlying GWBs are protected from any potential deterioration from chemical pollution.

As such, the Proposed Development is compliant with the requirements of the Water Framework Directive (2000/60/EC).

Table 9-28: Summary WFD Status with the implementation of Mitigation Measures (Operational Phase)

WFD Element	WFD Code	Current Status 2013-2018	Assessed Status – Unmitigated Scenario
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor
Suck South GWB	IE_SH_G_225	Good	Good
Funshinagh GWB	IE_SH_G_091	Good	Good
Athlone West	IE_SH_G_014	Good	Good

Residual Effect: Due to the local hydrogeological regime at the Proposed Development site, the minor and infrequent nature of works during the operational phase, coupled with the implementation of the proposed mitigation measures for the protection of groundwater recharge and water quality, and additionally, given the extensive knowledge of the local hydrogeological regime at the Wind Farm site we consider that there will be no residual effect on the WFD status of the underlying groundwater bodies (South Suck GWB, Funshinagh GWB and Athlone West GWB). Furthermore, during the operational phase there will be limited works (if any, only minor repairs if needed) along the Grid Connection route, the minor and infrequent nature of the works during the operational phase, coupled with the proposed mitigation measures we consider that there will be no residual effect on the WFD status of the underlying groundwater bodies.

Significance of the Effect: With the implementation of the mitigation measures outlined above there will be no change in the GWB or SWB status in the underlying GWBs or downstream SWBs resulting from the Proposed Development. The Proposed Development will not result in the deterioration in the WFD status of any surface or groundwater body nor will it jeopardise the attainment of good status in the future.

9.4.3.4 Potential Hydrological and Hydrogeological Effects on Designated Sites

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

During the operational phase of the Proposed Development, these potential sources of potential impact no longer exist. Any potential impacts then on designated sites are related to the operational maintenance of the Wind Farm site infrastructure.

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

Receptor(s): Groundwater and surface water dependent SAC's (as listed in Section 9.4.2.10.1 and 9.4.2.10.2).

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

Mitigation Measures:

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

- Regular maintenance of the on-site drainage system;
- The use of fuel storage bunds for any hydrocarbons (fuel/oils) and the ongoing maintenance of the bund structures; and,
- Any maintenance works which may involve soil movement (such as the removal of sediment from the settlement ponds) will take place during the dry months of the year (May - September).

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

Significance of Effects: For the reasons outlined above, there will be no significant effects.

9.4.4 Decommissioning Phase – Likely Significant Effects

Wind Farm site

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

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

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

The potential removal of this infrastructure (hardstanding areas, foundations *etc.*) would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increase in erosion, sedimentation, dust, noise, traffic and an increased possibility of contamination of the local water table. However, if removal is deemed to be required all infrastructure will be removed with mitigation measures similar to those in place during the construction phase being employed. These measures will ensure the protection of water reaching the underlying aquifer, through the implementation mitigation measures related to suspended sediment, hydrocarbons, cement-based materials.

It is proposed that underground cables will be cut back and left in place. The onsite electrical substation will remain in place as it will be under the ownership of the ESB. There are no impacts associated with this.

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

In terms of the WFD status of waterbodies, with the implementation of the proposed mitigation measures, the Proposed Development will not have the potential to result in a deterioration in the WFD status of any surface or groundwater body nor will it jeopardise the attainment of good status in the future.

Grid Connection Route

The cabling along the Grid Connection route will also remain in place and as such there will be no impacts associated with this. An outline Decommissioning Plan is contained in Appendix 4-10 of this EIAR for the decommissioning of the Proposed Development, the detail of which will be agreed with the local authority prior to any decommissioning. The potential for effects during the decommissioning phase of the proposed Grid Connection route is considered to be - No residual effect.

In terms of the WFD status of waterbodies, there is no potential for the Proposed Development to result in the deterioration in the WFD status of any surface or groundwater body along the grid route nor will it jeopardise the attainment of good status in the future.

Decommissioned turbine removal route

It is envisaged that the turbines, when decommissioned will be removed off site via the same route as the Turbine Delivery Route. The lifetime of the turbines is ~30 years. It is assumed that the road network will be as accessible as currently or likely that the road carriageways will have been upgraded. Therefore, no road widening or upgrade works are envisaged and there are no associated potential effects. In terms of flooding, under High End Future Scenario Flood Model (Floodinfo.ie/floodmaps), there is a small section of roadway which is mapped within the potential flood zone, just before the R362 and R363 merge. In the event of a flood in this area, the decommissioning will be postponed until flood water have subsided.

In terms of the WFD status of waterbodies, there is no potential for the Proposed Development to result in the deterioration in the WFD status of any surface or groundwater body along the turbine removal route nor will those works jeopardise the attainment of good status in the future.

9.4.5 Cumulative Assessment

9.4.5.1 Wind Farm Site

Both the proposed Wind Farm site and the Grid Connection route are located in the River Shannon catchment. However, in terms of hydrological cumulative impacts arising from the proposed Wind Farm site infrastructure and the Grid Connection route, none are anticipated as the proposed Grid Connection route is along the carriageway of public roads. There is no proposed surface water discharge from the proposed Wind Farm site, with all rainfall percolating to ground and following the general regional groundwater flow direction (southwest). The Grid Connection is, located primarily east of the proposed Wind Farm site, topographically downgradient of the proposed Wind Farm site and generally within the subcatchment of the Cross River. As such there will be no interaction between the hydrology of the Wind Farm site and the Grid Connection route. In addition, all proposed works along turbine delivery route are local and minor in nature (removal and replacement of street furniture, and no major earthworks) and have no potential to contribute to cumulative impacts in the water environment.

A hydrological cumulative impact assessment regarding other wind farm and non-wind farm developments within the River Shannon catchment within a 20km radius of the proposed Wind Farm site was also undertaken. There is 1 no. existing, 1 no. permitted, and 1 no. proposed wind farms located to the north of the Proposed Development as described in in Table 9-29 below.

Table 9-29: Wind Farm Developments in the River Shannon catchment (within 20km of the Proposed Development)

Catchment Area	Wind Energy Development	No. of Turbines	Proposed/Existing	Distance to Wind Farm Site
Upper Shannon (26G)	Skrine WF	2	Existing	8.9km – North of Site (T1)
Upper Shannon (26E)	Derrane WF	2	Permitted	19.8km – North of Site (T1)
Upper Shannon (26E)	Kilcash WF	1	Proposed	10.3km – North of Site (T1 and T2)

Therefore, the total number of turbines that could potentially be operating inside a 20km radius of the Proposed Development site within the River Shannon catchment (including the proposed 20 no. turbines) is 25.

The catchment area of the River Shannon within a 20km radius of the site (and lying between the Suck and Lough Ree) is ~750km^2 and therefore this equates to one turbine for approximately every ~30km^2 which is considered imperceptible in terms for potential cumulative hydrological impacts.

In relation to non-wind farm developments, the majority of local developments relate to the provision and/or alteration of one-off housing and agricultural developments. Applications which are not of an individual domestic or agricultural nature in the vicinity of the EIAR Site Boundary are referenced in Chapter 2 Appendix 2-1 and 2-2.

All the local non-wind developments in the vicinity of the Proposed Development (including the Roadstone Quarry at Cam, and local drainage works in the Suck Drainage District) area are small scale and localised in nature and impacts on water quality or flows (surface water or groundwater) are not expected. Therefore, hydrological cumulative impacts with respect to the Proposed Development will not occur.

Regardless, implementation of the proposed drainage mitigation will ensure there will be no cumulative significant negative impacts on the water environment during construction from the Proposed Development site, and other wind farm developments and non-wind farm developments within the River Shannon catchment.

During the operational phase of the Proposed Development all excavation and construction related work will have ceased and therefore there is no potential for water quality impacts from these sources. Also, the proposed Wind Farm site drainage measures will ensure there is no runoff from the Proposed Development site and that all rainfall percolates back to ground, as is the natural hydrological regime of the area. No cumulative negative effects on the water environment due to the Proposed Development will occur during the operational phase.

No significant cumulative impacts on the hydrology and hydrogeology environment will occur during the decommissioning stage.

9.4.5.2 Grid Connection Route

The hydrological impact assessment undertaken above in this chapter outlines that significant effects are very unlikely due to the localized nature of the construction works along the Grid Connection route. Impacts on the water environment will not extend beyond the immediate vicinity of the Grid Connection route excavations.

Therefore, no cumulative impacts on the water environment, between the Grid Connection route, the Wind Farm site and any other wind or non-wind energy development will occur.

9.4.6 Assessment Summary

The assessment is summarised as follows:

- HES were given the scope and latitude to complete a comprehensive set of field investigations and to collect an unparalleled hydrogeological dataset (water level data);
- The impact assessment is underpinned by site specific geological and hydrogeological dataset, and desk study information is backed up by comprehensive site data;
- Site investigations completed at the site were iterative and multi-phased;
- Multi-phased site investigation works were specified from a hydrogeological (impact) assessment perspective, and from an engineering geology/design and site drainage perspective;
- Seasonal water level monitoring in local turloughs and groundwater wells has been completed and parallel rainfall monitoring has also been undertaken. All recorded water levels are relative to Ordnance Datum (m OD);
- Subsoils permeability and variability across both Wind Farm site clusters has been investigated and is understood;
- No proposed WTG is located over known or suspected karst anomaly. The iterative approach to design has ensured that turbine locations were moved or reconfigured to avoid potential subsurface anomalies identified from drilling and geophysical investigations;
- A clearly defined design (turbine locations, foundation levels and types, access road alignment etc) has been developed for the wind farm and has been subject to detailed and robust hydrological and hydrogeological environmental assessment;

- The drainage proposals for the Wind Farm site layout are bespoke and complementary to the prevailing geological, hydrological and hydrogeological environment;
- Detailed geological investigations and assessment has also been completed for the Grid Connection route; and,
- The findings of the Water Section are unambiguous and are underpinned by a significant geological and hydrogeological dataset that comprises best-in-class scientific information and knowledge.

APPENDIX 9-1

FLOOD RISK ASSESSMENT

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PROPOSED SEVEN HILLS WINDFARM, CO. ROSCOMMON

SITE-SPECIFIC FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:
Energia Renewables ROI Ltd.

Prepared by:
Hydro-Environmental Services

DOCUMENT INFORMATION

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Author(s):	**Michael Gill Conor McGettigan Adam Keegan**
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Disclaimer:
This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client, and others in respect of any matters outside the scope of the above. The flood risk assessment undertaken as part of this study is site-specific, and the report findings cannot be applied to other sites outside of the survey area which is defined by the site boundary. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested to undertake a site-specific Flood Risk Assessment (FRA) for the proposed Seven Hills Wind Farm development (the Proposed Development), Co. Roscommon. A site location map is shown below as **Figure A.**

This FRA is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009).

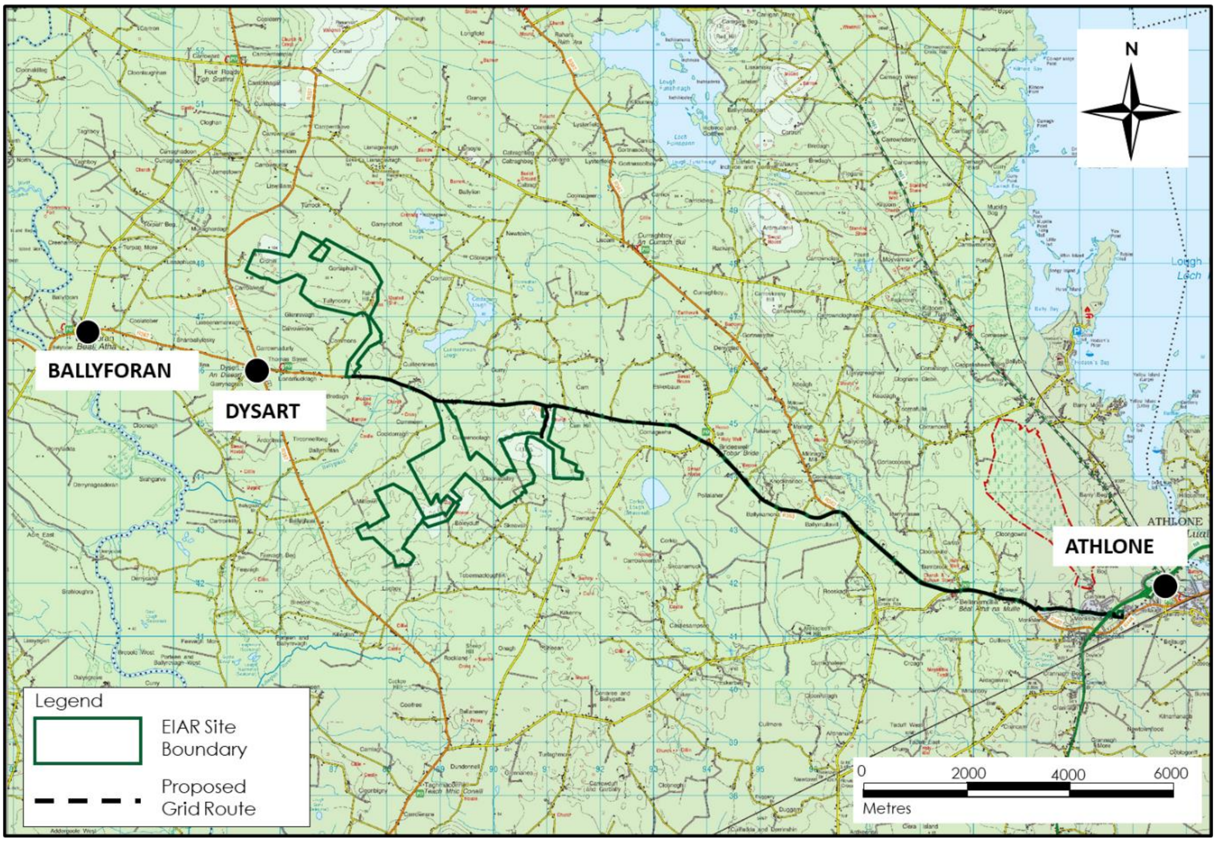

Figure A: Site Location Map

1.2 STATEMENT OF EXPERIENCE

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

Our core area of expertise and experience is hydrology and hydrogeology, including flooding assessment and surface water modelling. We routinely work on surface water monitoring and modelling, and prepare flood risk assessment reports.

Michael Gill PGeo (BA, BAI, MSc, Dip Geol, MIEI) is an Environmental Engineer with 18 years environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. Michael has significant experience in surface water drainage issues, SUDs design, and flood risk assessment.

Adam Keegan (BSc, MSc) is a hydrogeologist with three years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects and associated Flood Risk Assessments, including Derrinlough WF, Lyrenacarriga WF (SID), Cleanrath WF and Carrownagowan WF (SID).

Conor McGettigan (BSc, MSc) is an environmental scientist with one years experiences in the environmental sector in Ireland. In recent times Conor has assisted in the preparation of several Flood Risk Assessments (FRAs) for a range of developments including several wind farms.

1.3 REPORT LAYOUT & METHODOLOGY

This FRA report has the following format:

- Section 2 describes the proposed site setting and details of the proposed development;
- Section 3 outlines the hydrological and geological characteristics of the local surface water catchment in the vicinity of the proposed development site;
- Section 4 deals with a site-specific flood risk assessment (FRA) undertaken for the proposed development which was carried out in accordance with the above-mentioned guidelines. The section determines whether a Justification Test for the development would be required and then options going forward with regard flood risk management are presented;
- Section 5 reviews the flood impact and risks associated with the proposed development; and,
- Section 6 presents the FRA report conclusions.

As stated above this FRA is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009). The assessment methodology involves researching and collating flood related information from the following data sources:

- Local Base maps – Ordnance Survey of Ireland;
- Flood Hazard Maps and flooding information for Ireland (www.floodmaps.ie);
- Office of Public Works (OPW);
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA hydrology maps (www.catchments.ie);
- GSI Groundwater Flood Maps (www.gsi.ie)
- CFRAM Mapping; and,
- Site Walkovers, drainage mapping, intrusive geological investigations (trial pits, boreholes, dynamic probes) and seasonal groundwater level monitoring.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting of the proposed site along with a description of the proposed development.

2.2 SITE LOCATION AND TOPOGRAPHY

The proposed development comprises of a proposed 20 no. turbine wind farm, grid connection and all associated siteworks. The Wind Farm site comprises of a Northern Cluster and a Southern Cluster as detailed in Chapter 4 of this EIAR.

The Northern Cluster includes 7 no. turbines and is located ~2.8km northwest of the village of Ballyforan and 1.5km northeast of Dysart village, Co. Roscommon. The Northern Cluster lies within a ~2km^2 area between the townlands of Cronin, Gortaphuill and Cornalee. Elevation ranges between 70-105 mOD, with the proposed turbine locations situated along a northwest-southeast trending ridge. The land is generally agricultural, primarily used for grazing and appears well drained.

The Southern Cluster of the proposed development includes a further 13 no. turbines and is located ~3km southeast of Dysart, Co. Roscommon and 12km west of Athlone, Co. Westmeath. The area consists of 13 no. proposed turbine locations over a ~5km^2 area, from the townland of Lugboy towards Cuilleenoolagh and Cam Hill. Elevation ranges between 70-110 mOD, along a northwest-southeast range of small hills. The land is generally rough agricultural and scrub and appears generally well drained with some forestry on the higher ground near the old Dysart cemetery.

A site location map is shown as **Figure B** above.

2.3 PROPOSED DEVELOPMENT DETAILS

There are 20 no. turbines (7 no. turbines in the Northern Cluster and 13 no. turbines in the Southern Cluster) and associated hardstands included in the proposed development. The proposed development also includes 2 no. construction compounds (1 in the north and 1 in the south), 3 no. spoil storage areas (1 in the north and 2 in the south), 1 no. proposed substation, site access roads and all associated infrastructure. The proposed substation is located within the northeast of the Southern Cluster in the townland of Cam.

The proposed development includes a grid connection route joining the Northern Custer and the Southern Cluster along the R363. The grid route will then continue from the proposed on-site substation within the Southern Cluster of the Wind Farm site to the Athlone 110kV substation, located ~10km southeast of the Southern Cluster. The proposed underground grid connection will be in the carriageway of the existing public road network, travelling along R363 and the R362 as far as the Athlone substation.

Please note, for the purpose of this report, where:

- The Wind Farm site is referred to, this relates to all infrastructure located in both the Northern and Southern Clusters. In some instances, the Northern and Southern Clusters are differentiated.
- The Grid Route is referred to, this relates to all grid infrastructure outside of the Wind Farm site.
- The Proposed Development is referred to, this relates to the all project components, including the Wind Farm site and the grid connection.
- The Site is referred to relates to the primary study area for the development, as delineated by the EIAR site boundary.

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the proposed development.

3.2 BASELINE HYDROLOGY

3.2.1 Regional and Local Hydrology

On a regional scale, the Proposed Development is located in the Upper Shannon (26D) catchment, with a small section to the southeast of the Site within the Upper Shannon (26G) catchment, all within Hydrometric Area 26 (Upper Shannon) of the Irish River Basin District.

On a more local scale the Wind Farm site (Northern and Southern Cluster) is broadly contained within the River Suck sub-catchment (Suck_SC_090), with a small section in the east of the Southern Cluster contained within the Cross River sub-catchment (Shannon[Upper]_SC_100).

The River Suck is located ~3.5km west of the Southern Cluster, and ~3.9km west of the Northern Cluster. The River Suck flows south through the village of Ballyforan, west of Dysart, continuing south through the town of Ballinasloe before turning southeast and discharging to the River Shannon at Shannonbridge, ~20km south of the Southern Cluster.

The Cross River is situated ~3.2km east of the nearest Southern Cluster turbines and drains the broader area east of Lough Croan and Cuilleenirwan Lough. The headwaters of the Cross River is on the western slope of a small hill (~80mOD) in the townland of Kilcar and is mapped as a series of smaller turloughs near Dooloughan Lough. The most southeastern turbines of the Southern Cluster area drain towards this river, although Corkip turlough is situated downslope of these 2 no. turbines before the small tributaries of the Cross River.

The Wind Farm site and the general regional area between Roscommon town and south of Dysart is distinctively void of mapped river channels. This implies that the majority of effective rainfall is infiltrating to the groundwater system, rather than creating runoff which would lead to a larger number of streams/rivers. However, several locations in this area are known to flood temporarily during wet winters creating a turlough type feature (groundwater fed water feature).

The main surface water drainage in the vicinity of the Wind Farm site is provided by the Ballyglass and Cross rivers. The Ballyglass River, which flows southwest from Cuilleenirwan Lough ~ 1.6km southeast of the Northern Cluster and ~ 1.3km north of the Southern Cluster and reaches a confluence with the River Suck in the townland of Srahgarve. There are no other tributaries, aside from very short minor drains, mapped for the Ballyglass River, so it is likely that the majority of the flow is derived from Cuilleenirwan Lough. Cuilleenirwan lough itself is seasonal, and tends to "disappear" during the summer months, therefore flows within the Ballyglass River will vary considerably throughout the year. The Killeglan River is mapped ~1.5 km southwest of the Southern Cluster and ~2-3km south of the Ballyglass River. This river originates at Killeglan Spring and flows west/southwest towards the River Suck.

The Grid Route is situated along an existing road and is generally distant from any hydrological features. There are, however, 5 no. river crossings along the Grid Connection route at existing bridges and culverts. Along the Ballyglass River in the townland of Cuilleenirwan, 2 no. tributaries of the Cross River in the townlands of Brideswell and Ballymullavill and the Cross River in the townland of Bellanamullia. There is also an additional culvert crossing in the townland of Cloonakille.

A local hydrology map is shown as **Figure B**.

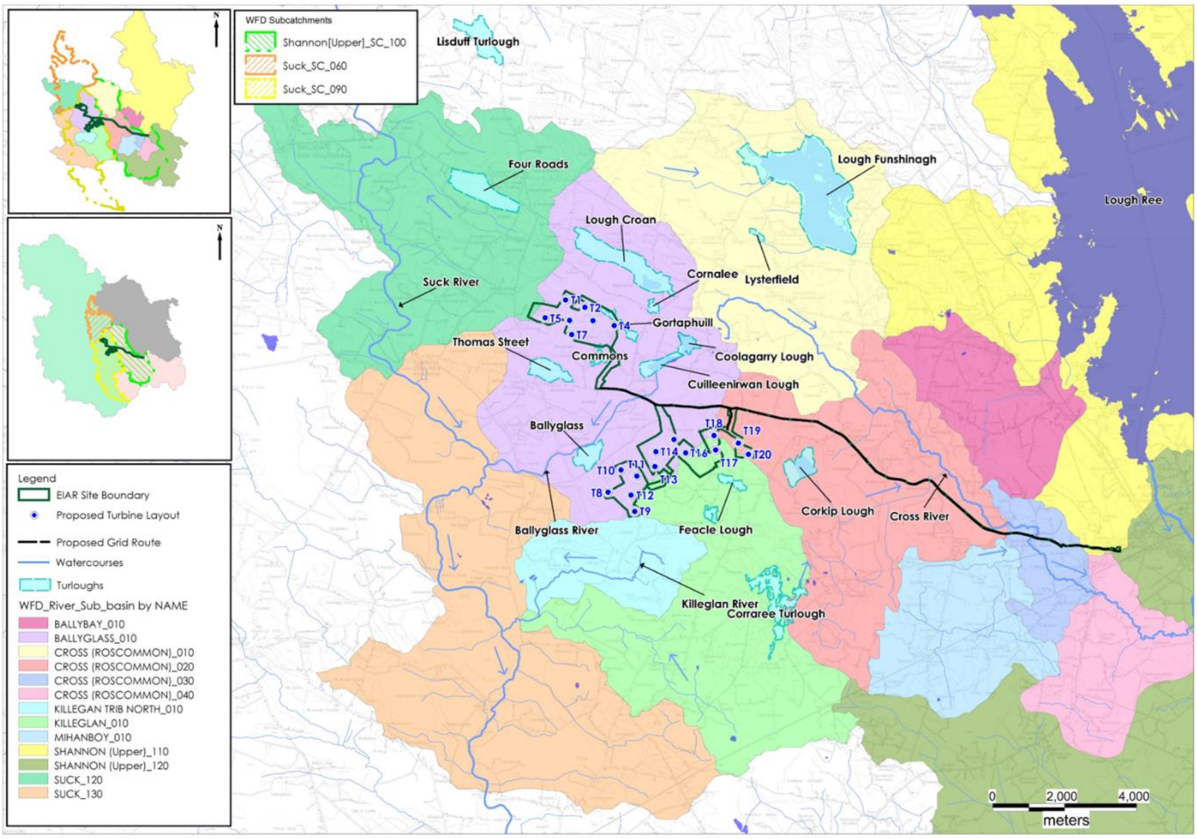

Figure B: Local Hydrology Map

3.3 RAINFALL AND EVAPORATION

The Standard Average Annual Rainfall (SAAR) recorded at Ballyforan, ~4km southeast of the Site, is 9584mm (www.met.ie). The average potential evapotranspiration (PE) at Mullingar, ~60km east of the Wind Farm site, is 446mm/year (www.met.ie). The actual evapotranspiration ("AE") is calculated to be 423mm (95% PE). Using the above figures the effective rainfall ("ER")[1] for the area is calculated to be (ER = SAAR – AE) 562mm.

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 60% recharge is taken for the Site as an overall average. This value is for "moderate permeability subsoil overlain by well drained soils". However, in reality, the recharge potential for the site is likely between 80-100%. The distinct lack of surface water features (streams/rivers) near the Site would indicate that all water is infiltrating to ground (i.e. 100% recharge). Site investigations have revealed a variance in the thickness and clay/silt content of subsoils across the site. The depth of subsoil introduces variance in permeability and it is likely that rainfall infiltrates through the sandy/silty/gravelly subsoil, seeps by gravity following the local undulating topography, before recharging to the bedrock aquifer in areas of shallow subsoil downslope. A regional permeability value of 100% is assumed, based on the lack of surface water features, however this will vary locally.

Therefore, annual recharge and runoff rates for the Site (Northern and Southern Cluster) are estimated to be 500-562 mm/yr and 0-62mm/yr respectively.

Table A below presents return period rainfall depths for the area of the Site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide

[1] *ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.*

rainfall depths for various storm durations and sample return periods (1-year, 5-year, 30-year, 100-year).

Table A: Rainfall return period depths for the Seven Hills Wind Farm site

	Return Period (Years)				
Duration	**1-year**	**5-years**	**10-years**	**50-years**	**100-years**
15 mins	5.7	9.4	11.6	17.9	21.5
1 hour	9.7	14.9	17.9	26.3	30.8
6 hours	19.1	27.2	31.6	43.1	49.0
12 hours	24.9	34.4	39.3	52.2	58.6
24 hours	32.5	43.4	49.0	63.2	70.2
2 days	40.4	52.4	58.5	73.6	81.0

3.4 GEOLOGY

The general area of the Wind Farm site is mapped by the GSI as being overlain by Limestone Tills, with smaller areas of Fen peat mapped west of Dysart (which do not coincide with the Site) and isolated ribbons of Esker deposits which are broadly oriented in a northwest-southeast direction.

According to EPA mapping (www.epa.ie), soils in the Northern Cluster comprise predominantly of deep well drained basic mineral soils (BminDW) with smaller pockets of shallow well drained mineral soil (BminSW) mapped near the townlands of Cronin and Turrock. A small area of fen peat is mapped near the townland of Garrynaphort, close to Lough Croan. The GSI subsoils map (www.gsi.ie) shows the Northern Cluster is underlain by Tills derived from limestone (TLs) with some areas of karstified bedrock outcrop or subcrop (KaRck) mapped on higher ground, particularly near Cronin. The underlying bedrock in the Northern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). There are no mapped faults in the area.

Within the Northern Cluster a total of 22 no. boreholes have been drilled along with the excavation of 48 no. trial pits, the completion of geophysical surveys and PSD and permeability analysis of subsoils. The subsoils consist of sandy CLAY, gravelly SAND and sandy GRAVEL, with a depth of overburden between 1.3 – 16.3m where the full profile was described (i.e. at boreholes). Average depth to bedrock was 7.41mbgl (metres below ground level). Bedrock was described as typically strong, dark grey bioclastic limestone with discrete weathered zones and intermittent clay infilled fractures. No significant karst features were logged during the drilling of the 22 no. boreholes.

According to EPA mapping (www.epa.ie), soils in the Southern Cluster comprise predominantly of deep well drained basic mineral soils (BminDW) with some basic poorly drained mineral soils (BminPD) mapped on higher ground. The GSI subsoils map (www.gsi.ie) shows the Southern Cluster is underlain by Tills derived from limestone (TLs) with some eskers comprised of gravels of basic reaction (BasEsk) mapped east and southeast of the site near the townlands of Boleyduff and Cloonacaltry. The underlying bedrock in the Southern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). There are no mapped faults or bedrock outcrop in this area.

Within the Southern Cluster a total of 32 no. boreholes haven been drilled along with the excavation of 61 no. trial pits, the completion of geophysical surveys and PSD and permeability analysis of the subsoils. The subsoils consist of sandy CLAY, clayey gravelly SAND and sandy clayey GRAVEL, with a depth of overburden between 1.3m – 30m where the full profile was described (*i.e* at boreholes). Average depth to bedrock was 7.32mbgl (metres below ground level). Bedrock was described as strong to very strong, dark blueish grey, fine to medium grained Limestone. The bedrock geology in the area was found to be largely competent and does not appear to be characteristic of a karst system.

Soils along the Grid Route are mapped as deep well drained basic mineral soils (BminDW) between Dysart and Brideswell. The soils mapped between Brideswell and the Monksland substation vary between shallow well drained basic mineral soil (BminSW), cutover Peat (Cut), basic shallow, lithosolic or podzolic type soils potentially with peaty topsoil (BminSRPT). A small section of Alluvium occurs along near the Cross River and with made ground between the R362 and R446. Subsoils along the Grid Connection are mapped as Tills derived from Limestone (TLs) between Dysart and the townland of Cornageeha. A small area of Esker is mapped between the townlands of Cam and Cornageeha. Limestone gravels (GLs) are mapped just southeast of the Esker deposit between Cornageeha and Brideswell. Cutover raised Peat is mapped between Brideswell and Ballymulavil. The subsoils between Ballymulavil and the Monkland (Athlone) substation are a mixture of Limestone gravels, Limestone Tills and cutover Peat, with some Alluvium mapped along the Cross River. The bedrock geology mapped along the Grid Route consists of Undifferentiated Visean Limestones between Dysert and Bellanamullia, with Waulsortian Limestone mapped between Bellanamullia and the Monksland substation. There is 1 no. fault mapped within the Waulsortian Limestone near Monksland which trends northwest-southeast.

The soils and subsoils were investigated along the Grid Route by means of Slit trenching, rotary core borehole drilling and down hole hammer borehole drilling. The soils and subsoils were found to consist primarily of GRAVEL/Silty GRAVEL/SAND. No bedrock met within any boreholes which ranged in depth from 4.2m – 16m.

3.5 HYDROGEOLOGY

The Dinantian Pure Bedded Limestones of the Visean Formation are classified by the GSI as a Regionally Important Karstified Aquifer with conduit groundwater flow characteristics. The majority of the proposed Wind Farm site is located within the Suck South GWB (GSI, 2014) with a small area inn he west of the Southern Cluster located within the Funshinagh GWB.

Pure bedded limestones are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are often enlarged by karstification which significantly enhances the permeability of the rock. Karstification can also be accentuated along structural features such as fold axes and faults (GSI, 2014).

The GSI bedrock mapping is completed at a broad regional scale and should be considered to be indicative of the bedrock type. However, it is superseded by the collection of site investigation data which is site-specific and completed at a much finer scale, for the purposes of the Proposed Development. The bedrock geology encountered during the site investigations comprised of hard to medium hard, medium grey bioclastic Limestone and does not record any significant karst features.

The hydrology of the area between Roscommon town and just south of Dysart is dominated by groundwater hydrology, with a lack of surface water drainage features, but there is a strong connection between surface waters (rivers, streams and lakes) and groundwater flow by means of springs, swallow holes and gaining/losing streams.

Groundwater hydrology is dominant particularly in summer, spring and autumn. However, during winter when groundwater level rise, due to rainfall recharge, the sub-surface groundwater hydrology overflow/spills onto the land surface resulting in increased spring discharge, gaining streams and a karst phenomenon known as turloughs. Turloughs are temporary lakes caused by lowlands flooding with groundwater.

Based on the GSI karst database, there are several karst features, including turloughs, enclosed depressions and springs in the lands surrounding the Site (**Figure C**). Several of these mapped turloughs correspond to the loughs mapped in the local hydrology map above (**Figure B)**.

Extensive groundwater level monitoring has been completed in the area of the Proposed Development and is discussed in detail in Chapter 9 of the EIAR.

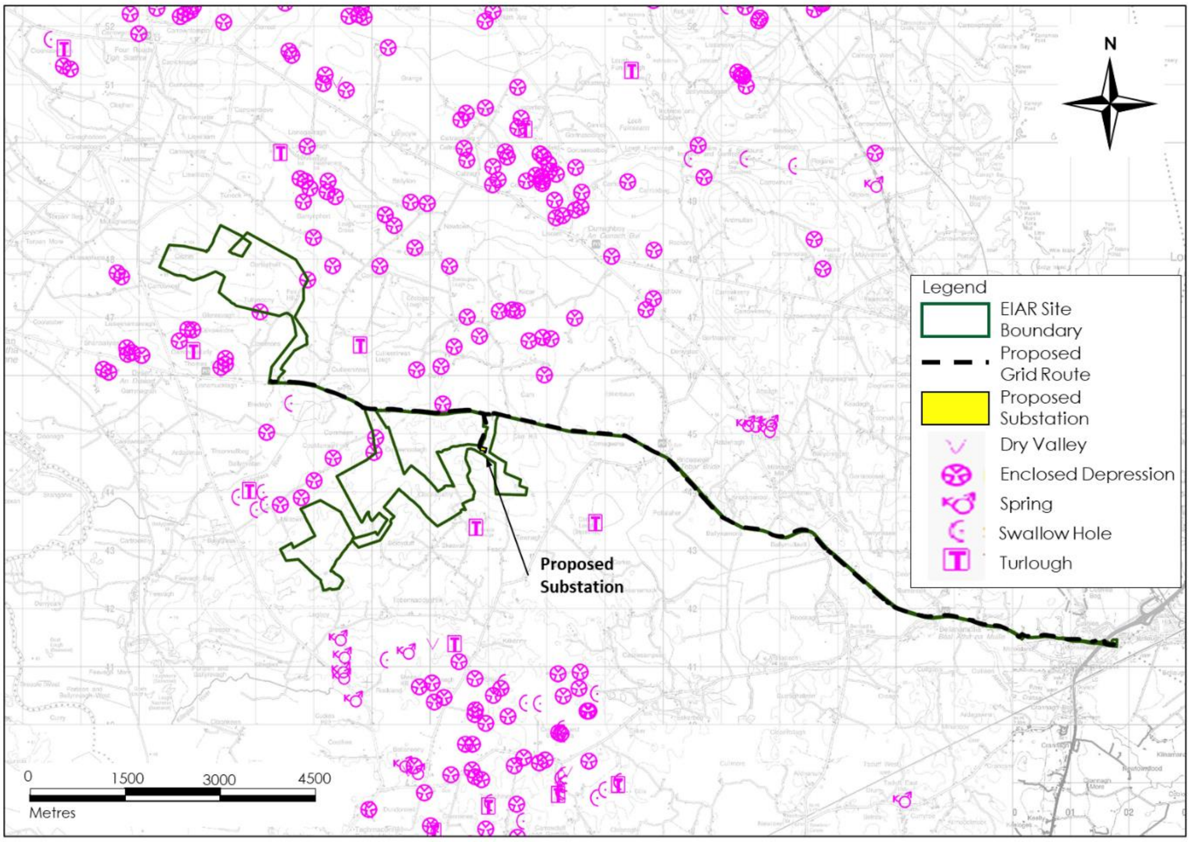

Figure C: GSI Karst Mapping

3.6 DESIGNATED SITES & HABITATS

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), proposed National Heritage Areas (pNHAs), candidate Special Areas of Conservation (cSAC), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). No designated sites are mapped within the proposed site boundaries.

The nearest designated site to the Northern Cluster is the Lough Croan Turlough SAC, SPA and pNHA (Site Code: 000610), located ~1.4km to the northeast, at an elevation of ~69 mOD. This is a linear wetland, aligned north-west/south-east, which lies in a relatively flat area of glacial till. It is split into two main parts - the east functions as a typical turlough, with a wet area dominated by Common Reed (Phragmites australis) at the centre; at the west is a fen, with floating vegetation in places, which also floods in winter. In between there is undulating ground. There is little over-ground flow, but both basins retain some water all year round. The SAC is designated under the qualifying interest of Turlough (3180).

The Four Roads Turlough SAC, SPA and pNHA (Site Code: 001637) is situated northwest of Lough Croan, and ~2.8km north/northwest of the Northern Cluster. It lies below a low scarp of limestone hills and is an open, shallow basin without permanent standing water which seems to flood predictably and dry out early. The SAC is designated under the qualifying interest of Turlough (3180).

The nearest designated site to the Southern Cluster is the Killeglan Grassland SAC (Site Code: 002214)[2]. The Killeglan grassland is designated under the qualifying interest of Orchid rich calcareous grassland. The site is undulating and slopes southwest from a height of ~90mOD to ~55 mOD.

The Feacle Turlough pNHA is situated ~0.6km south of the Southern Cluster of the proposed Wind Farm site. Feacle Lough is at an elevation of ~ 67 mOD, while the proposed turbines are mapped at >90 mOD. Feacle turlough lies in an uneven, glacial terrain of kame deposits. The basin runs roughly East- West but the edge is sinuous because of encroaching mounds. An esker-like feature projects from the southern side. The floor of the basin is similarly uneven with a number of discrete hollows: some at the western end show bedrock.

The Ballynamona Bog and Corkip Lough SAC is mapped ~1.0km east of the Southern Cluster area of the proposed Wind Farm site. The site comprises a relatively small portion of what was once a large bog complex, and includes areas of high bog and cutover bog, and also the turlough, Corkip Lough. The site is mapped at an elevation of ~55-58 mOD.

Further west, the River Suck Callows SPA and NHA exist along the banks of the River Suck. This designated site is mapped ~ 2.4km from the western edge of the proposed Site. Further east, Lough Funshinagh SAC and pNHA exists, at a distance of ~5.8km to the eastern edge of the proposed Site. The lake, which is underlain by Carboniferous limestone, is classified as a turlough because it fluctuates to a significant extent every year and occasionally dries out entirely (approximately two to three times every ten years). In most years, however, an extensive area of water persists. This is filled with vegetation, providing excellent breeding habitat for wildfowl, and the site is designated a Wildfowl Sanctuary. The lake is fed by springs and a small catchment to the west. It is mesotrophic in quality, with some marl (calcium carbonate) deposition, and is surrounded by pastures.

[2] https://www.npws.ie/protected-sites/sac/002214

4. SITE SPECIFIC FLOOD RISK ASSESSMENT

4.1 INTRODUCTION

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009). The basic objectives of these guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and,
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

A stage 1 assessment of flood risk requires an understanding of where the water comes from (*i.e.* the source), how and where it flows (*i.e.* the pathways) and the people and assets affected by it (*i.e*. the receptors). It is necessary to identify whether there may be any flooding or surface water management issues related to the proposed site that may warrant further detailed investigation.

As per the guidance (DOEHLG, 2009), the stages of a flood risk assessment are:

- *Flood risk identification* – identify whether there are surface water flooding issues at a site; and,
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development.

Further to this, a stage 2 assessment involves the confirmation of sources of flooding, appraising the adequacy of existing information and determining what surveys and modelling approach may be required for further assessment.

4.2 FLOOD ZONE MAPPING

Flood zones are geographical areas within which the likelihood of flooding is in a particular range. There are three types or levels of flood zones defined according to OPW guidelines:

- Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding); and,
- Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

4.3 FLOOD RISK IDENTIFICATION

4.3.1 Soils Maps – Fluvial Maps

A review of the soil types in the vicinity of the Proposed Development was undertaken as soils can be a good indicator of past flooding in an area. Due to past flooding of rivers deposits of transported silts/clays referred to as alluvium build up within the floodplain and hence the presence of these soils is a good indicator of potentially flood-prone areas.

Based on the EPA/GSI soil map for the area no regions of river alluvium are mapped within the Wind Farm site (Northern and Southern Clusters). The closest mapped area of river alluvium (fluvial deposits) deposits to the Northern Cluster are found ~3km to the northeast along the Cross River and ~2.7km to the west on the Suck River. The closest mapped area of river alluvium (fluvial deposits) deposits to the Southern Cluster are found ~3km to the west along the Suck River and ~2km to the southeast on a local 1st order stream.

The EPA soils map (www.epa.ie) records an area of lake marl in the southeast of the Southern Cluster in the townland of Feacle and extending westwards into Cloonacaltry. This area corresponds to a known turlough, referred to as Lough Feacle, which does not correspond to the location of any wind farm infrastructure. Lough Feacle is located ~1.8km south of the proposed substation location.

Therefore, there is no significant alluvium deposition that would be associated with a flood plain or a large geographical area prone to flooding.

Along the Grid Route alluvium deposits are mapped on the Cross River in the townland of Bellanamullia. Significant areas of alluvium deposition occur downstream of the grid route along the Cross River.

4.3.2 Historical Mapping

There is no text on local available historical 6" or 25" mapping for the proposed Wind Farm site (Northern and Southern Cluster) or along the proposed grid route that identifies areas that are "*prone to flooding*".

4.3.3 OPW National Flood Hazard Mapping

The OPW National Flood Hazard Maps have no records of recurring flood incidences within the Wind Farm site (www.floodinfo.ie). However, there are several recurring flood incidents locally, which related to the turloughs in the surrounding lands.

A recurring flood event (Flood ID-177) is recorded to the southwest of the Northern Cluster and to the northeast of Dysart village. The Roscommon area engineer's report states that a "*large area floods every 2-3 years. The R357 is liable to flooding approximately every 10 years. The flooding is caused mainly by groundwater and runoff*". This recurring flood event corresponds to the location of the Carrownadurly Turlough.

Additional recurring flood events are reported to the east of the Northern Cluster, in the townlands of Cuilleenirwan (Flood ID: 806) and Ballinteleva (Flood ID: 183). The flooding at Cuilleenirwan is related to Cuilleenirwan Lough/Turlough while at Ballinteleva low-lying areas are reported to be susceptible to flooding every winter. This recurring flood event corresponds to the location of Coolagarry Lough. Further north, a turlough related recurring flood event (Flood ID-802) is mapped at Lough Croan in the townland of Turrock. No recurring or historic flood instances are recorded at Gortaphuill Turlough, located immediately to the north of T4.

Further south, a recurring flood event (Flood ID: 19) is mapped ~500m northwest of the Southern Cluster along the Ballyglass River. Here the Ballyglass River is noted to overflow its banks and flood a large area. A recurring flood event (Flood ID: 807) is also mapped to the southeast of the Southern Cluster, in the townland of Feacle. This flood event coincides with the location of Lough Feacle. No recurring or historic flood events are located at the proposed substation location. The closest mapped flood incident to the substation location is at Lough Feacle, ~1.2km south of the substation location, with a second flood incident ~2km to the east at Lough Corkip (Flood ID: 808).

No recurring flood incidents are reported along the proposed Grid Route. A map of the locations of recurring and historic flood incidents is included as **Figure D** below.

The OPW (www.floodinfo.ie) do not record the presence of any Arterial Drainage Schemes or Benefited Lands within the proposed Wind Farm site, along the Grid Route or in the surrounding lands. The closest mapped benefited lands are along the Suck River to the west of the Site. This suggests that there has been no requirement to improve these lands for agriculture and/or to mitigate flooding within the Wind Farm site or along the Grid Route.

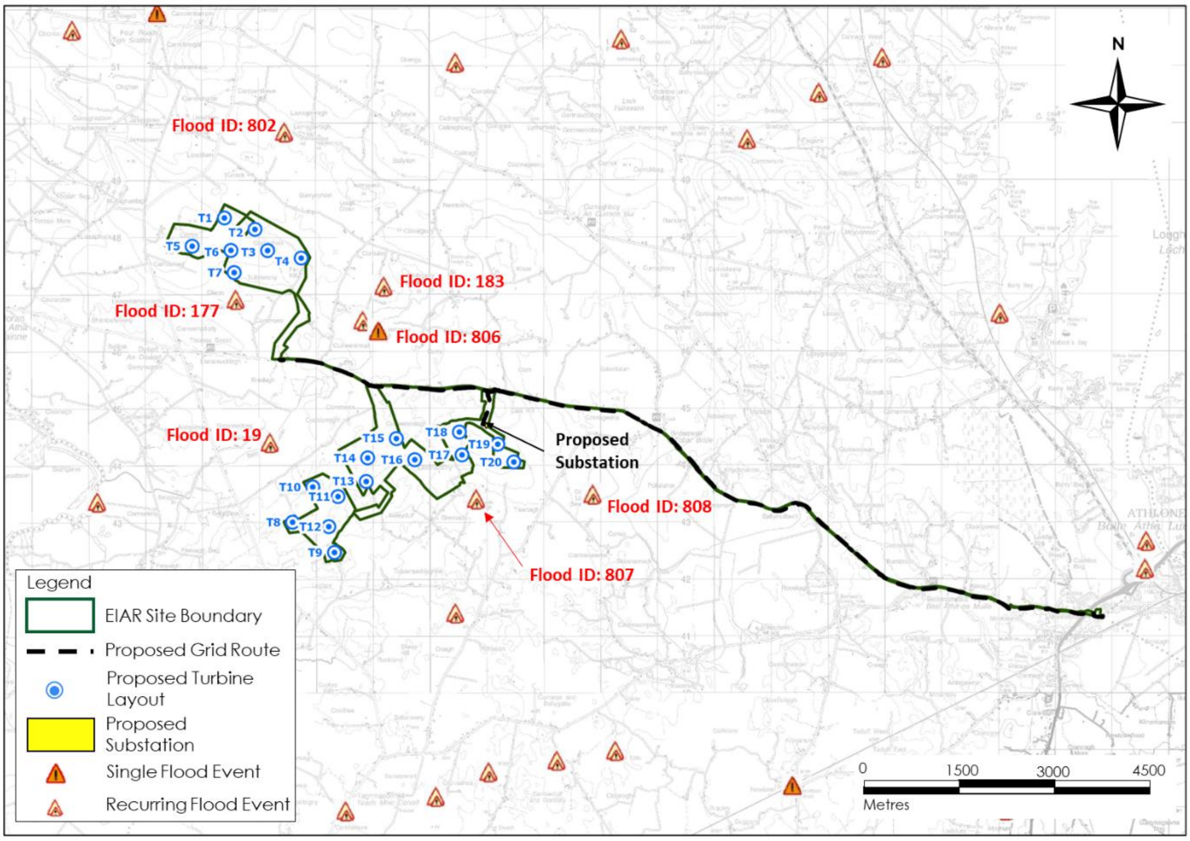

Figure D: OPW Flood Hazard Mapping (www.floods.ie)

4.3.4 OPW Flood Risk Assessment – Fluvial and Pluvial Flooding

Where complete the Catchment Flood Risk Assessment and Management (CFRAM)[3] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the Preliminary Flood Risk Assessment Maps (PFRA) maps. However, CFRAM mapping is not currently available for the area of the proposed Wind Farm site and therefore the PFRA maps were reviewed.

Flood maps were queried via the Roscommon Council website and via the OPW Flood Mapping (www.floodmaps) for potential areas prone to flooding (**Figure E**). The maps show that the Wind Farm site (Northern and Southern Clusters) is located outside the 1 in 100-year and the extreme (1 in 1,000-year) fluvial flood event zones (Flood Zones A and B respectively). The Northern and Southern Clusters, including the proposed substation location are therefore located in fluvial Flood Zone C (Low Risk).

The closest mapped fluvial flood zone to the Wind Farm site is located along the Suck River. At the closest point the mapped extreme fluvial flood zone is located more than 1.5km west of the Southern Cluster.

Along the Grid Route, fluvial flood zones are mapped on the Cross River to the west of Athlone town. CFRAM mapping has also been completed in this area. However a road crossing currently exists above the Cross River and the road itself is not mapped within any fluvial flood zones. Therefore the entire grid connection route lies within fluvial Flood Zone C (Low Risk).

There is no OPW pluvial flood mapping available for the Wind Farm site, however due to the hydrogeological regime present at the Wind Farm site characterised by very high groundwater recharge rates, no surface water and/or pluvial flooding is likely after heavy or persistent rainfall.

The GSI Historical 2015/2016 surface water flood map[4] shows fluvial and pluvial flooding, during the winter 2015/2016 flood event, which was the largest flood on record in many areas. This map does not show any surface water flooding within the Wind Farm site (Northern and Southern Clusters). The closest mapped surface water flood zones to the proposed on-site substation are located ~2.3km to the northeast and ~2.7km to the northwest. In terms of the T4 in the northern cluster, the closest mapped flood zone is ~1.1km to the northeast, corresponding to the location of Cornalee Turlough. In terms of the Grid Route, no surface water flooding was recorded along the route during the 2015/2016 flood event. Extensive areas of flooding are recorded ~1.2km southeast of Monkstown substation, associated with flooding of the River Shannon south of Athlone town.

[3] CFRAM is Catchment Flood Risk Assessment and Management. The national CFRAM programme commenced in Ireland in 2011, and is managed by the OPW. The CFRAM Programme is central to the medium to long-term strategy for the reduction and management of flood risk in Ireland.

[4] GSI Historical flood mapping principally developed using Sentinel-1 Satellite Imagery from the European Space Agency Copernicus Programme as well as any available historic records (from winter 2015/2016 or otherwise).

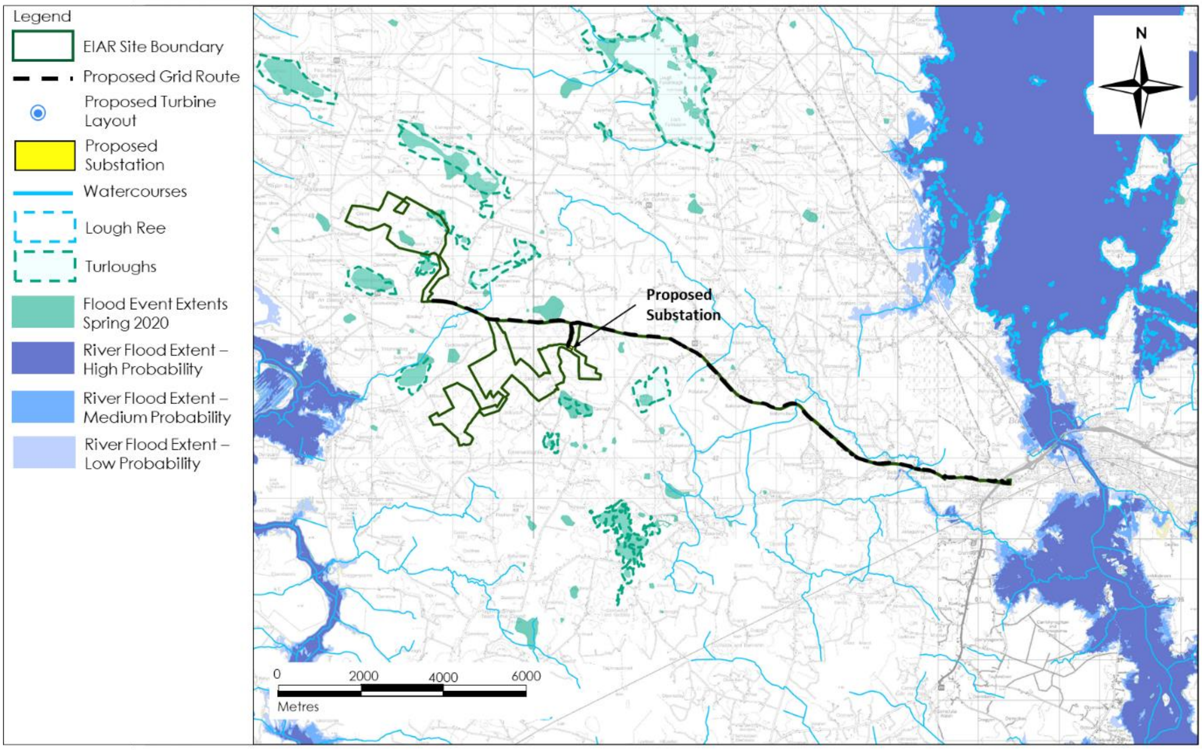

Figure E: Roscommon County Council Flood Mapping (www.rosco.maps.arcgis.com)

4.3.5 Historic Groundwater Flooding

The GSI Historical 2015/2016 groundwater flood map (**Figure F**) shows the observed peak flood extents caused by groundwater flooding in Ireland.

A large area of historic groundwater flooding is recorded in the southeast of the Northern Cluster in the townlands of Glenrevagh and Tulluyneeny. These groundwater flood zones are located ~700m southeast of T7 and ~700m southwest of T4. This area coincides with the Commons Turlough. Historic groundwater flooding is also recorded ~100m to the north of T4, associated with the Gortaphuill Turlough. Additional extensive groundwater flood zones are located to the southeast and northwest of the Northern Cluster, corresponding to the Carrownadurly Turlough and Lough Croan respectively.

A large area of groundwater flooding is mapped to the northwest of the Southern Cluster. This corresponds to the location of the Ballyglass turlough and is ~600m northwest of T10. Some areas of groundwater flooding are also recorded in the vicinity of T16, ~80m north of the proposed turbine location and within the proposed soil storage area. This groundwater flood zone is mapped ~1km southwest of the proposed substation location. Further extensive historic groundwater flood zones are mapped in the southeast of the Southern Cluster, corresponding to the location of Lough Feacle. This flood mapped flood zone is ~500m south of T17.

Some historic groundwater flooding is also mapped along the Grid Route in the townlands of Cam and Cornageeha, ~1.4km northeast of the proposed substation. As stated above, the proposed substation location itself is located ~1km from the closest historic groundwater flood zone.

Historic flood maps queried from Roscommon County Council show groundwater flooding in the Spring of 2020 (**Figure E** above). These flood zones largely coincide with the historic groundwater flood zones mapped by the GSI for the Winter 15/16 flood event and the location of known turloughs.

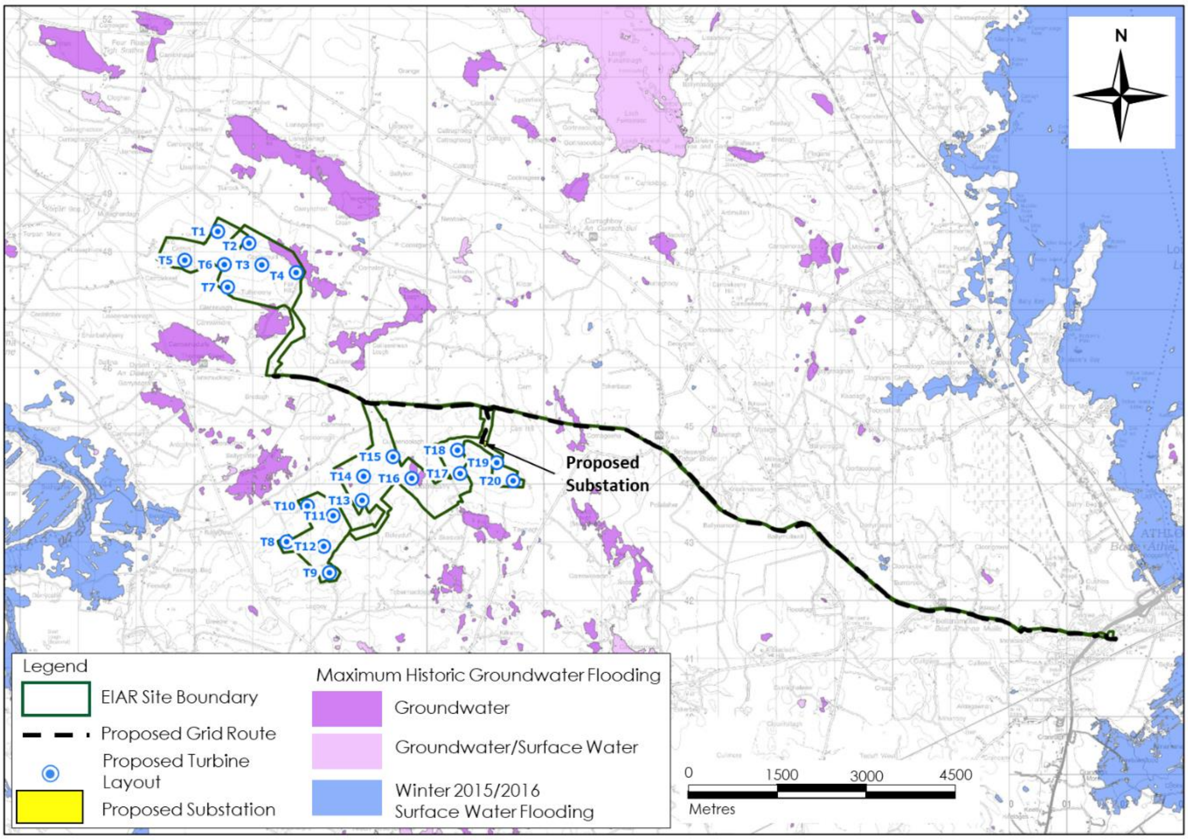

Figure F: GSI Historical Groundwater Flood Zones

4.3.6 Predictive Groundwater Flooding

In addition, the GSI predictive groundwater flood map records groundwater flood zones [high (1 in 10-year,) medium (1 in 100-years) or low (1 in 1,000-years) probability flood zone] in the southeast of the Northern Cluster in the townlands of Glenrevagh and Tulluyneeny. No wind farm infrastructure is proposed in this area of the Wind Farm site. In the northeast of the Northern Cluster, the high probability flood zone associated with the Gortaphuill Turlough is located ~100m northeast of T4, with the low probability flood zone located ~60m from the proposed turbine location. The low probability flood extents associated with the Carrownadurly Turlough to the southwest and Lough Croan to the northeast do not encroach upon the Wind Farm site.

Similarly, within the Southern Cluster no key wind farm infrastructure is located within the high, medium or low probability groundwater flood zones. A small area in the southeast of the Wind Farm site, located ~700m southeast of T18 and ~1km south of the proposed substation location, in the townlands of Feacle and Cloonacaltry, is mapped within these predicted groundwater flood zones. This corresponds to the location of Lough Feacle and is the closest mapped predictive groundwater flood zone to the proposed substation. No other predictive groundwater flood zones are mapped within the Southern Cluster. The area mapped as a historic groundwater flood zone to the north of T16 is not mapped by the GSI as a predicted flood zone. Finally, the Modelled flood zones associated with the Ballyglass Turlough to the northwest of the Southern Cluster do not encroach upon the Wind Farm site.

No areas along the proposed Grid Route are mapped within the GSI predictive groundwater flood zones.

While the local area is dominated by groundwater hydrology and turlough associated groundwater flooding, no proposed Site infrastructure (turbines, hardstands, access roads and/or the proposed substation) is located in a modelled groundwater flood zone.

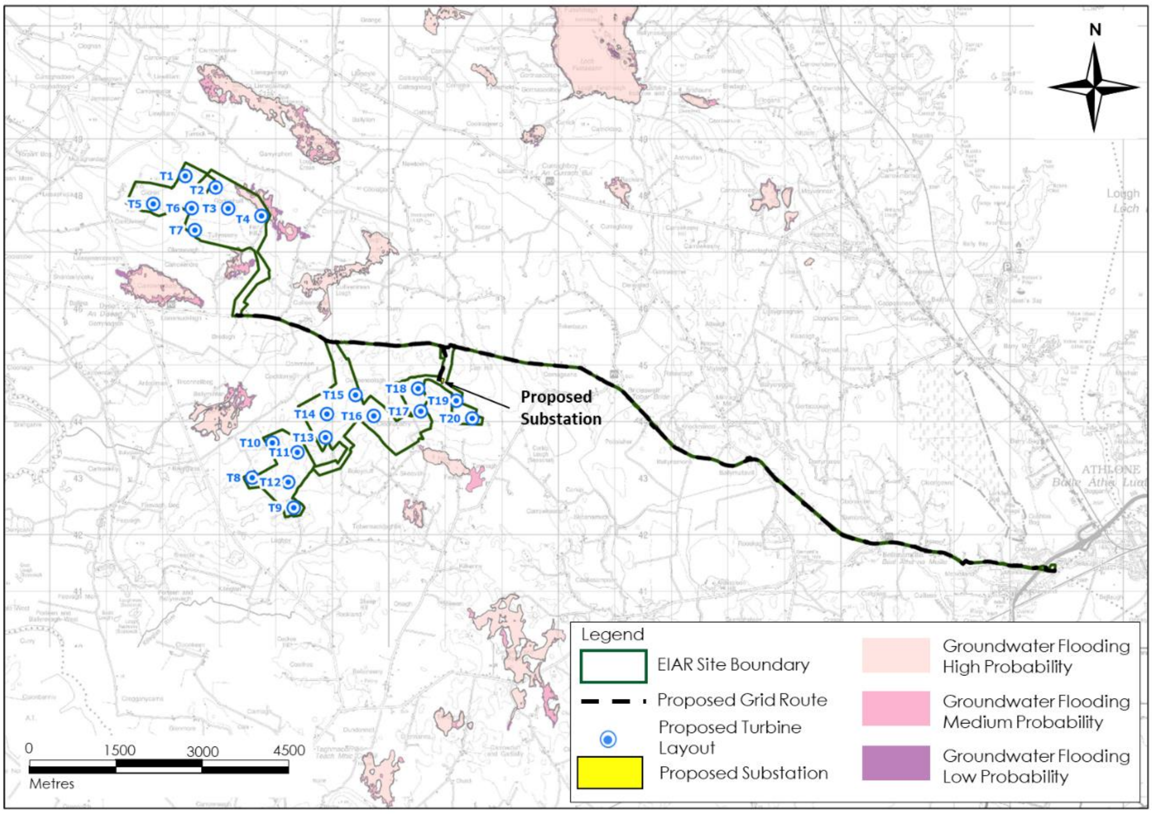

Figure G: GSI Predictive Groundwater Flood Zones

4.3.7 Summary – Flood Risk Identification

Based on the information gained through the flood identification process, it would appear that the Wind Farm site is not susceptible to fluvial or pluvial flooding. While sections of the Wind Farm site are susceptible to groundwater flooding these areas do not include any of the proposed key infrastructure locations. The Wind Farm site, including the proposed substation location and all 20. no turbine locations are therefore mapped as Flood Zone C *i.e.* low risk of flooding with small areas located in Flood Zone A.

In addition, the Grid Route is located in Flood Zone C.

4.4 INITIAL FLOOD RISK ASSESSMENT

4.4.1 Site Survey and Drainage

Detailed walkover surveys of the Site, the proposed Grid Route and the surrounding areas was undertaken by HES on several dates between 2019 and 2021.

The Northern Cluster lies generally on agricultural land, with grass pastures used primarily for sheep grazing. Some areas of scrub were noted to the north of the Northern Cluster. Land use in the Southern Cluster is also largely grassland used for sheep grazing, with some areas of rough scrub which is strewn with boulders. Both the Northern Cluster and the Southern Cluster are easily accessible with access roads situated within the grasslands.

The Wind Farm site (Northern and Southern Clusters) is characterized by a lack of surface water drainage features. The low drainage density of this area implies that the majority of effective rainfall is infiltrating to the groundwater system, rather than surface water runoff which would lead to a larger number of streams and rivers in the area.

The area is characterised by the occurrence of several karst features. A clear relationship exists between the local topography and the mapped karst hydrology with the majority of mapped karst features located on low-lying lands. The hills in the area, which generally stand at 70-100mOD are generally devoid of any karst features. Several turloughs are located in the lands surrounding the Wind Farm site. These are karst wetland ecosystems which flood annually in autumn through springs and fissures in the underlying karst limestone bedrock and drain in the springtime through the same fissures or swallow holes. HES completed groundwater monitoring in several of these turloughs between January 2020 and May 2021, the results of which are discussed in terms of flood risk in **Section 4.4.2** below.

4.4.2 Groundwater Level Monitoring

To further assess the risk of groundwater flooding at the Wind Farm site water level monitoring has been completed at a number of local turloughs over a period of 13 no. months between January 2020 - May 2021. The maximum recorded water level in each turlough is listed in **Table B** along with the distance to the nearest proposed turbine and the turbine elevation.

The turloughs are located between 0.1 – >5km from the nearest proposed turbine. The recorded maximum winter water levels within the turloughs range between 51.5 – 70.5 mOD, with elevation differences between each turlough and its nearest proposed turbine ranging between 4.6 - ~33m. The water levels in these turloughs generally increased from February to March before levelling out and gradually subsiding over the following months.

Table B: Turloughs near the proposed Wind Farm site

Turlough	Distance to nearest turbine (m)	Elevation of Max. Winter Water Level (mOD)	Turbine Elevation (mOD)	Elevation difference (m)
Ballyglass	0.9 km to T8	51.5	~71 mOD	19.4m
Thomas Street/Carrownadurly	1.1km to T7	57.5	~72 mOD	14.4m
Coolagarry/Cuilleenirwan)	1.3km to T4	65.1	~72 mOD	6.9m
Corkip Lough	1.0km to T20	~57	~95 mOD	~38m
Commons	0.9km to T7	66.44	~72 mOD	5.6m
Dooloughan	2.9km to T4	70.5	~72 mOD	1.5m
Feacle Lough	0.7km to T18	62.2	~90 mOD	27.8
Four Roads	2.75km to T1	48.6	~93 mOD	~41m
Gortaphuill	0.1km to T4	67.4	~72 mOD	4.6m
Lough Croan	1.3km to T2	68.2	~76 mOD	7.8m
Lough Funshinagh	>5km	69.04	N/A	N/A

As stated in **Table B** and in **Section 4.2**, T4 is located in close proximity (~100m) to Gortaphuill Turlough. The current ground elevation at the proposed turbine location is 72mOD and the turbine formation level is ~69mOD. The formation level is ~1.6m above the elevation of the maximum winter water level (67.4mOD) recorded during the 13 month monitoring period at Gortaphuill turlough. However as seen in below, the proposed turbine location is located on a local topographic high to the southwest of the turlough and some ground excavations will be required in this area. The topography to the northeast of Gortaphuill turlough is lower-lying with topography less than 68.1mOD. In the event of an extreme groundwater flood event, Gortaphuill turlough will preferentially flood theses areas of lower elevation to the northeast. As the water level in the turlough increases so does the plan area of the turlough. Therefore, greater volumes of groundwater are required to cause an increase in water level across the turlough. Consequently, significant volumes of water would be required for the proposed T4 location to experience flooding. Groundwater flooding at T4 is therefore highly unlikely.

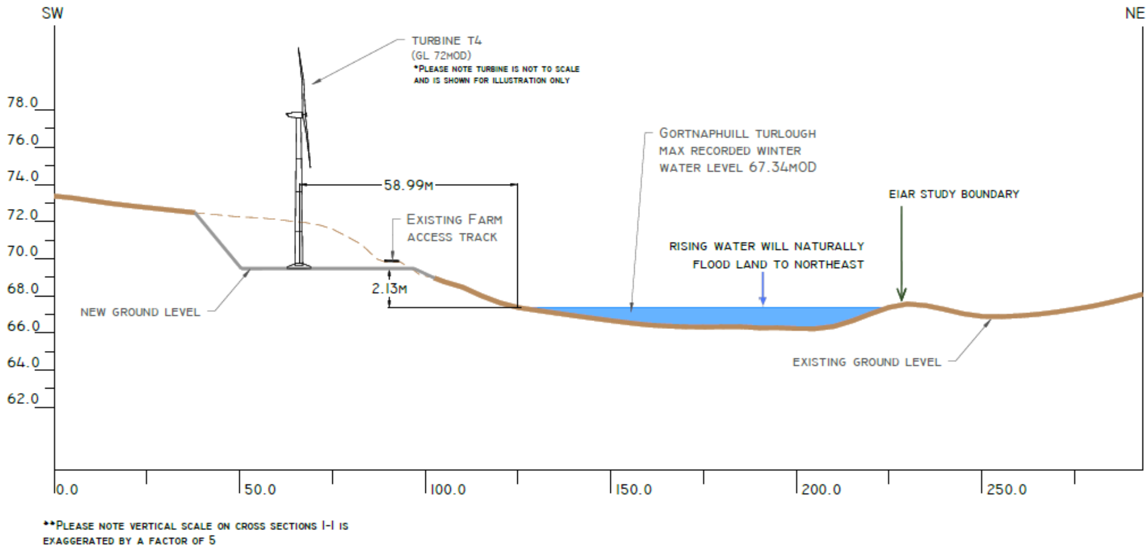

Figure H: Cross-Section of T4 and Gortaphuill Turlough

4.4.3 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the proposed site can be described using the Source – Pathway – Receptor Model ("S-P-R"). The primary potential source of flooding in this area, and the one with most consequence for the proposed site, is groundwater flooding.

The primary potential pathways, in the most likely order of significance, would be groundwater flooding during extremely wet winters. The potential receptors in the area are infrastructure and land as outlined below.

4.4.4 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process it would appear that flooding is unlikely to be problematic at the site or downstream of the site. The potential sources of flood risk for the proposed site are outlined and assessed in **Table C**.

Table C: S-P-R Assessment of Flood Sources for the proposed site

Source	Pathway	Receptor	Comment
Tidal	Not applicable	Land and infrastructure.	The proposed site is >55km from the coast and there is no risk of coastal flooding.
Fluvial	No streams/rivers mapped within the Wind Farm site. Overbank flooding along the Ratawragh stream, Barr's Drain and the Cross River along the grid route.	Land and infrastructure.	The area of the Site has a low drainage density with few watercourses. No fluvial flood zones are mapped in the area of the Wind Farm site and no historic flood events have been recorded, with the exception of one event along the Ballyglass River. The Wind Farm site including all key development infrastructures and the proposed substation location is located in Fluvial Flood Zone C (Low Risk). The Grid Route is located in Flood Zone C with no fluvial flood zones encroaching upon the route.
Pluvial	Ponding of rainwater on site	Land and infrastructure.	The Wind Farm site including all key development infrastructures and the proposed substation location is elevated with sloping topography, well drained and permeable soils and subsoils. Therefore, the Wind Farm site is not at risk of pluvial flooding.
Surface water	Surface ponding/ Overflow	Land and infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels	Land and infrastructure.	GSI mapping records the occurrence of groundwater flood zones in the lands surrounding the Wind Farm site, some of which encroach upon the site but do not coincide with the location of key infrastructures (turbines or the proposed substation). No flood zones are mapped along the grid connection route. Gortaphuill turlough is located ~100m from T4. Local topography will ensure that lands to the northeast of the turlough will preferentially flood during extreme flood events. Groundwater flooding at T4 is extremely unlikely due to its location on a topographic high. The proposed T4 turbine and hardstand are therefore not susceptible to groundwater flooding, and the proposed construction of these wind farm elements will not impact on flood levels elsewhere.

4.5 REQUIREMENT FOR A JUSTIFICATION TEST

The matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test[5] is shown in **Table D** below.

It may be considered that the Proposed Development can be categorised as "Highly Vulnerable Development". However, as stated above, all key development infrastructures including turbines, the proposed substation and access roads are located in Flood Zone C. The Grid Route is also mapped as Flood Zone C with all river crossings already in existence and not mapped within flood zones. Consequently, the proposed development is not at risk of flooding and is deemed appropriate (refer to **Table D** below).

Table D: Matrix of Vulnerability versus Flood Zone

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly vulnerable development (including essential infrastructure)	Justification test	Justification test	**Appropriate**
Less vulnerable development	Justification test	Appropriate	Appropriate
Water Compatible development	Appropriate	Appropriate	Appropriate

Note: Taken from Table 3.2 (DoEHLG, 2009)
Bold: *Applies to this project*

[5] *A 'Justification Test' is an assessment process designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk, (DoEHLG, 2009).*

5. FLOOD RISK ASSOCIATED WITH THE PROPOSED DEVELOPMENT

5.1 INTRODUCTION

This section assesses the flood risk of the proposed development with regard to Section 5.28 of the Flood Risk Management Guidelines. The assessment is made based on the Groundwater flood zone mapping as this is currently the only available published flood mapping for the development site.

5.2 FLOODING IMPACT ASSESSMENT OF PROPOSED INFRASTRUCTURE

This section outlines the potential for flooding to arise elsewhere as a result of the proposed development.

As no proposed wind farm infrastructure is located within mapped low probability groundwater flood zones, no water will be displaced by the proposed development during times of extreme flooding (1 in 1,000-year flood events). Therefore, the proposed development will not increase the flood risk elsewhere in the wider area.

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. However, the proposed Site is located within a large rural catchment with a low drainage density and in an area of high groundwater recharge rates. The footprint of the impermeable areas (hardstands, turbine bases and access roads) and the associated increase in runoff rate is very small in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. Notwithstanding the low increase in flood risk due to the Proposed Development, the drainage system has been designed to prevent any increase in discharge rates above that which already exist in the undeveloped site. Therefore, runoff from impermeable surface will be directed laterally to soakaways/infiltration trenches where it will recharge to the groundwater system within metres of where it would have naturally done so.

The proposed Grid Connection route does not pose any risk to downstream flooding as the cable trench will be excavated in the carriageway of the existing public road network.

5.3 FLOODING IMPACT ASSESSMENT OF FUTURE CLIMATE CHANGE SCENARIOS

Current climate models project increased winter rainfall in the coming decades, particularly in western Ireland. Lowland karst systems will be particularly vulnerable to these changing climate conditions due to extremely fast recharge. Climate change is therefore predicted to increase the frequency of extreme groundwater flooding events, indicating that more significant flooding events, such as the winter of 2015/2016 flood event, are likely to become more common.

In extreme future groundwater flood events, as highlighted by the medium and low probability flood events, an increasing proportion of the Wind Farm site will be located within groundwater flood zones. However, these flood zones do not coincide with the location of any proposed infrastructure locations (turbines, hardstands, substation). Therefore, the proposed development will not result in the displacement of floodwaters as extreme events become more common in the coming decades.

6. FRA REPORT CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the proposed Seven Hills Wind Farm development in Co. Roscommon. From this study:
    - No instances of historical flooding were identified in historic OS maps within the Site;
    - No instances of recurring flooding were identified on OPW maps within the Site;
    - The Site was not identified as being within the CFRAM Flood Zones; and,
    - The Site is not mapped within any PFRA fluvial flood zones, with all key wind farm infrastructures located at least 50m away from mapped surface watercourses.
- The Site is therefore not susceptible to fluvial flooding;
- Due to the high permeability of the soils and subsoils at the Site there is a limited surface water drainage network. As a result all available rainfall recharges to groundwater;
- Several recurring flood instances have been reported in the lands surrounding the Wind Farm site, which relate to locally mapped turloughs;
- The GSI Historic and Predictive Groundwater Flood Maps shows the extent of local groundwater flood zones which generally coincide with the known mapped turloughs in the area. All key wind farm infrastructures and also the proposed substation site are located outside of the GSI predictive and historic groundwater flood zones;
- Groundwater level monitoring in local turloughs revealed that the proposed turbine locations remained 1.5 – 33m above the maximum winter water level of the nearest turlough;
- T4 is located ~100m from Gortaphuill Turlough and is not mapped within any historic or predictive groundwater flood zone. Local topography ensures that groundwater flooding at Gortaphuill will occur preferentially to the northeast and away from the Wind Farm site, increasing the plan area of the turlough. Flooding at T4 in not likely as significant volumes of groundwater would be required to flood to this elevation;
- The proposed substation location is not mapped within a high, medium or low probability fluvial or groundwater flood zone and is therefore located in Flood Zone C;
- A small section of the Grid Route is mapped in the GSI Historic Groundwater Flood Zone in the townlands of Cam and Cornageeha. However, the public road network already currently exists in this location;
- The Justification Test concluded that the proposed Site, all key infrastructure including turbines and the proposed on-site substation and grid route are located within a low-risk area (Flood Zone C), and as such is appropriate from a flood risk perspective; and,
- Flood risks associated with potential flooding downstream of the Site can be managed by way of avoidance during flooding, standard SuDs drainage measures, scour protection measures and the implementation of surface water attenuation systems.

* *

7. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
DOEHLG	2009	The Planning System and Flood Risk Management.
GSI	2014	GWB Characterisation Report - Suck South GWB
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.

APPENDIX 9-2

LAB REPORTS

ENVIRONMENTAL LABORATORY SERVICES
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email:info@elsltd.com

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.111T

Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/001
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Brian Fallon Well	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A							
Ammonia as N		EW175	0.005		<0.005	mg/l N	INAB
Ammonium as NH4 (calc)		EW175	0.006		<0.006	mg/l NH4	INAB
Nitrate as N		EW175	0.15		1.8	mg/l N	INAB
Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
Phosphate (Ortho/MRP) as P		EW175	0.005		0.007	mg/l P	INAB
Chloride mg/L		EW175	1.0		16	mg/L	INAB
Sulphate mg/L		EW175	1.0		5.5	mg/L	INAB
Metals-Dissolved							
Hardness-Dissolved		EW188	3.0		410	mg/L CaCO3	
Iron-Dissolved		EW188	20		<1.0	ug/L	YES
Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
Aluminium-Dissolved		EW188	5.0		<2.0	ug/L	YES
Arsenic-Dissolved		EW188	0.2		0.7	ug/L	YES
Calcium-Dissolved		EW188	1.0		160	mg/L	
Magnesium-Dissolved		EW188	0.3		6.2	mg/L	YES
Subcontracted							
Potassium-Dissolved		EW188	0.2		3.0	mg/L	YES
Sodium-Dissolved		EW188	0.5		7.7	mg/L	YES
Titralab							
pH		EW153	0.0		7.1	pH Units	INAB
Conductivity @20 DegC		EW153	25		744	uscm-1@20	INAB
Alkalinity Total (R2 pH4.5)		EW153	10		416	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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5."*" Indicates sub-contract test
6.Where the date of sampling has not been provided,sample stability times cannot be assessed. It is therefore possible that the results provided may be compromised

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Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/002
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Noel Fallon Well	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		0.015	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		0.020	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		1.7	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.008	mg/l P	INAB
	Chloride mg/L		EW175	1.0		22	mg/L	INAB
	Sulphate mg/L		EW175	1.0		5.0	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		350	mg/L CaCO3	
	Iron-Dissolved		EW188	20		7.6	ug/L	YES
	Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
	Aluminium-Dissolved		EW188	5.0		<2.0	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.5	ug/L	YES
	Calcium-Dissolved		EW188	1.0		130	mg/L	
	Magnesium-Dissolved		EW188	0.3		3.9	mg/L	YES
	Potassium-Dissolved		EW188	0.2		4.6	mg/L	YES
	Sodium-Dissolved		EW188	0.5		10.5	mg/L	YES
Titralab								
	pH		EW153	0.0		7.3	pH Units	INAB
	Conductivity @20 DegC		EW153	25		670	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		362	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.111T

Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/003
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Commons Turlough	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A							
Ammonia as N		EW175	0.005		<0.005	mg/l N	INAB
Ammonium as NH4 (calc)		EW175	0.006		<0.006	mg/l NH4	INAB
Nitrate as N		EW175	0.15		0.16	mg/l N	INAB
Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
Phosphate (Ortho/MRP) as P		EW175	0.005		0.007	mg/l P	INAB
Chloride mg/L		EW175	1.0		13	mg/L	INAB
Sulphate mg/L		EW175	1.0		1.2	mg/L	INAB
Metals-Dissolved							
Hardness-Dissolved		EW188	3.0		190	mg/L CaCO3	YES
Iron-Dissolved		EW188	20		6.41	ug/L	YES
Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
Aluminium-Dissolved		EW188	5.0		8.7	ug/L	YES
Arsenic-Dissolved		EW188	0.2		0.5	ug/L	YES
Subcontracted							
Calcium-Dissolved		EW188	1.0		69	mg/L	YES
Magnesium-Dissolved		EW188	0.3		3.4	mg/L	YES
Potassium-Dissolved		EW188	0.2		2.1	mg/L	YES
Sodium-Dissolved		EW188	0.5		6.2	mg/L	YES
Titralab							
pH		EW153	0.0		8.5	pH Units	INAB
Conductivity @20 DegC		EW153	25		291	uscm-1@20	INAB
Alkalinity Total (R2 pH4.5)		EW153	10		148	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/004
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Thomas Street Turlough	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		<0.005	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		<0.006	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		0.16	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.007	mg/l P	INAB
	Chloride mg/L		EW175	1.0		15	mg/L	INAB
	Sulphate mg/L		EW175	1.0		2.3	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		190	mg/L CaCO3	YES
	Iron-Dissolved		EW188	20		26	ug/L	YES
	Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
	Aluminium-Dissolved		EW188	5.0		8.2	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.7	ug/L	YES
	Subcontracted							
	Calcium-Dissolved		EW188	1.0		69	mg/L	YES
	Magnesium-Dissolved		EW188	0.3		3.5	mg/L	YES
	Potassium-Dissolved		EW188	0.2		3.6	mg/L	YES
	Sodium-Dissolved		EW188	0.5		6.9	mg/L	YES
Titralab								
	pH		EW153	0.0		8.5	pH Units	INAB
	Conductivity @20 DegC		EW153	25		375	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		192	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/005
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Ballyglass River	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		0.006	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		0.007	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		1.0	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.007	mg/l P	INAB
	Chloride mg/L		EW175	1.0		17	mg/L	INAB
	Sulphate mg/L		EW175	1.0		4.5	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		310	mg/L CaCO3	YES
	Iron-Dissolved		EW188	20		39	ug/L	YES
	Manganese-Dissolved		EW188	1.0		1.2	ug/L	YES
	Aluminium-Dissolved		EW188	5.0		89	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.6	ug/L	YES
	Calcium-Dissolved		EW188	1.0		120	mg/L	
	Magnesium-Dissolved		EW188	0.3		3.4	mg/L	YES
	Subcontracted							
	Potassium-Dissolved		EW188	0.2		2.4	mg/L	YES
	Sodium-Dissolved		EW188	0.5		8.2	mg/L	YES
Titralab								
	pH		EW153	0.0		8.1	pH Units	INAB
	Conductivity @20 DegC		EW153	25		589	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		325	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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Contact Name	David Broderick	**Report Number**	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	**Sample Number**	196737/006
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	**Received or Collected**	Hand
Customer PO	Per Batch	**Date of Report**	19/04/2021
Project No.	QN010649	**Sample Type**	Ground Waters
Customer Ref	Kileglan River	**Condition on receipt**	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		<0.005	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		<0.006	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		2.1	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.008	mg/l P	INAB
	Chloride mg/L		EW175	1.0		16	mg/L	INAB
	Sulphate mg/L		EW175	1.0		7.7	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		310	mg/L CaCO3	YES
	Iron-Dissolved		EW188	20		29	ug/L	YES
	Manganese-Dissolved		EW188	1.0		2.4	ug/L	YES
	Aluminium-Dissolved		EW188	5.0		2.0	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.6	ug/L	YES
	Calcium-Dissolved		EW188	1.0		120	mg/L	
	Magnesium-Dissolved		EW188	0.3		11.2	mg/L	YES
	Subcontracted							
	Potassium-Dissolved		EW188	0.2		3.2	mg/L	YES
	Sodium-Dissolved		EW188	0.5		8.1	mg/L	YES
Titralab								
	pH		EW153	0.0		7.5	pH Units	INAB
	Conductivity @20 DegC		EW153	25		643	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		351	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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Contact Name	David Broderick	Report Number	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	Sample Number	196737/007
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	Received or Collected	Hand
Customer PO	Per Batch	Date of Report	19/04/2021
Project No.	QN010649	Sample Type	Ground Waters
Customer Ref	MJ Daly Well	Condition on receipt	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		0.008	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		0.010	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		4.5	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.009	mg/l P	INAB
	Chloride mg/L		EW175	1.0		13	mg/L	INAB
	Sulphate mg/L		EW175	1.0		6.6	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		310	mg/L CaCO3	YES
	Iron-Dissolved		EW188	20		<1.0	ug/L	YES
	Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
	Subcontracted							
	Aluminium-Dissolved		EW188	5.0		2.4	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.5	ug/L	YES
	Calcium-Dissolved		EW188	1.0		120	mg/L	
	Magnesium-Dissolved		EW188	0.3		3.3	mg/L	YES
	Potassium-Dissolved		EW188	0.2		5.8	mg/L	YES
	Sodium-Dissolved		EW188	0.5		8.0	mg/L	YES
Titralab								
	pH		EW153	0.0		7.6	pH Units	INAB
	Conductivity @20 DegC		EW153	25		598	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		315	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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Contact Name	David Broderick	Report Number	**196737 - 1**
Address	Hydro-Environmental Services 22, Lower Main Street, Dungarvan,	Sample Number	196737/008
		Date of Receipt	25/03/2021
		Date Started	25/03/2021
Tel No	058 44122	Received or Collected	Hand
Customer PO	Per Batch	Date of Report	19/04/2021
Project No.	QN010649	Sample Type	Ground Waters
Customer Ref	M Moore Well	Condition on receipt	Satisfactory

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.
Gallery Plus-Suite A								
	Ammonia as N		EW175	0.005		<0.005	mg/l N	INAB
	Ammonium as NH4 (calc)		EW175	0.006		<0.006	mg/l NH4	INAB
	Nitrate as N		EW175	0.15		2.1	mg/l N	INAB
	Nitrite as N		EW175	0.005		<0.005	mg/l N	INAB
	Phosphate (Ortho/MRP) as P		EW175	0.005		0.006	mg/l P	INAB
	Chloride mg/L		EW175	1.0		17	mg/L	INAB
	Sulphate mg/L		EW175	1.0		4.8	mg/L	INAB
Metals-Dissolved								
	Hardness-Dissolved		EW188	3.0		290	mg/L CaCO3	YES
	Iron-Dissolved		EW188	20		3.38	ug/L	YES
	Manganese-Dissolved		EW188	1.0		<1.0	ug/L	YES
	Subcontracted							
	Aluminium-Dissolved		EW188	5.0		<2.0	ug/L	YES
	Arsenic-Dissolved		EW188	0.2		0.4	ug/L	YES
	Calcium-Dissolved		EW188	1.0		110	mg/L	
	Magnesium-Dissolved		EW188	0.3		4.0	mg/L	YES
	Potassium-Dissolved		EW188	0.2		4.7	mg/L	YES
	Sodium-Dissolved		EW188	0.5		7.6	mg/L	YES
Titralab								
	pH		EW153	0.0		7.4	pH Units	INAB
	Conductivity @20 DegC		EW153	25		561	uscm-1@20	INAB
	Alkalinity Total (R2 pH4.5)		EW153	10		295	mg/L CaCO3	INAB

Signed : Máire Bradley 19/04/2021

Máire Bradley-Deputy Technical Manager

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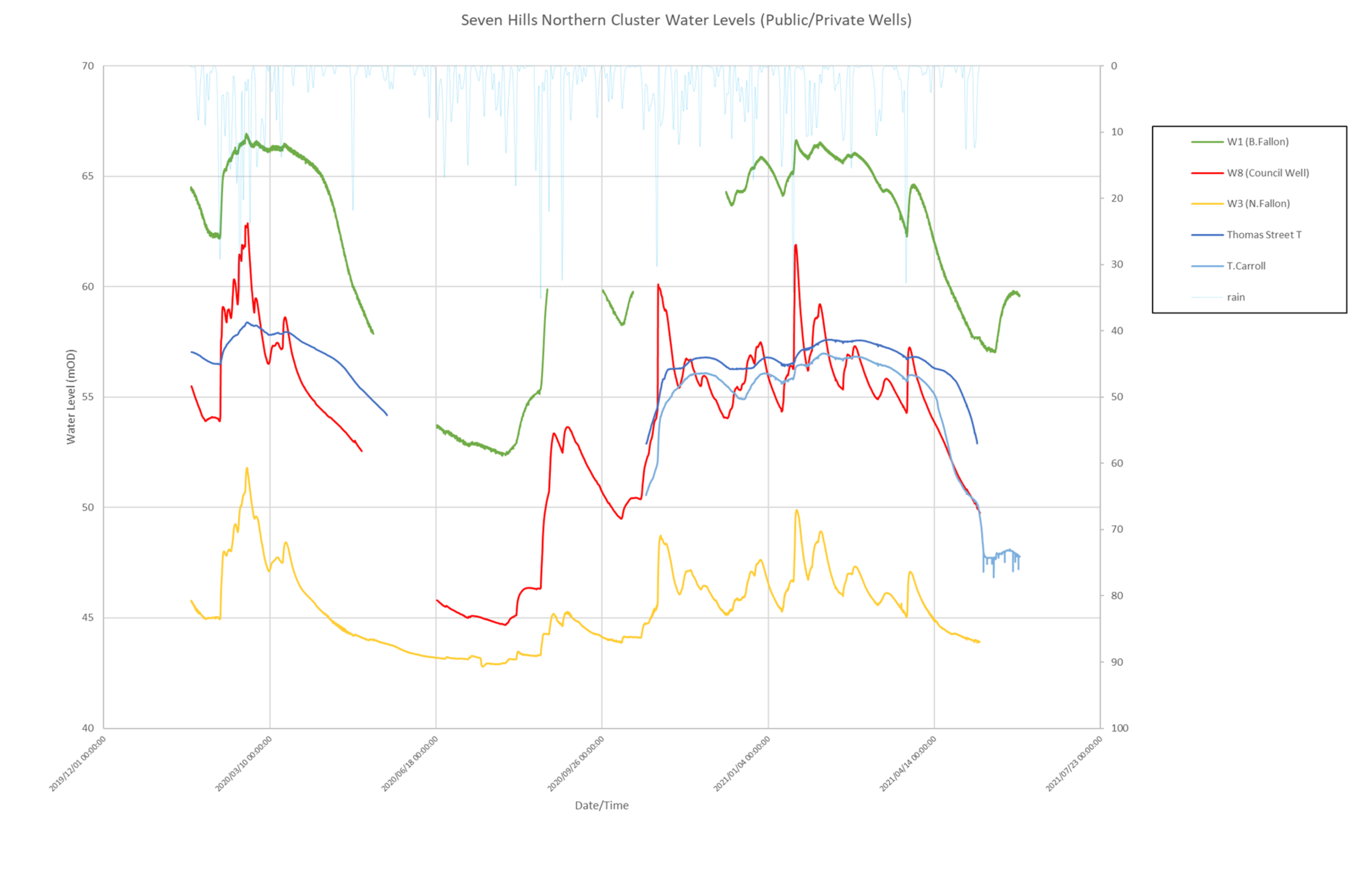
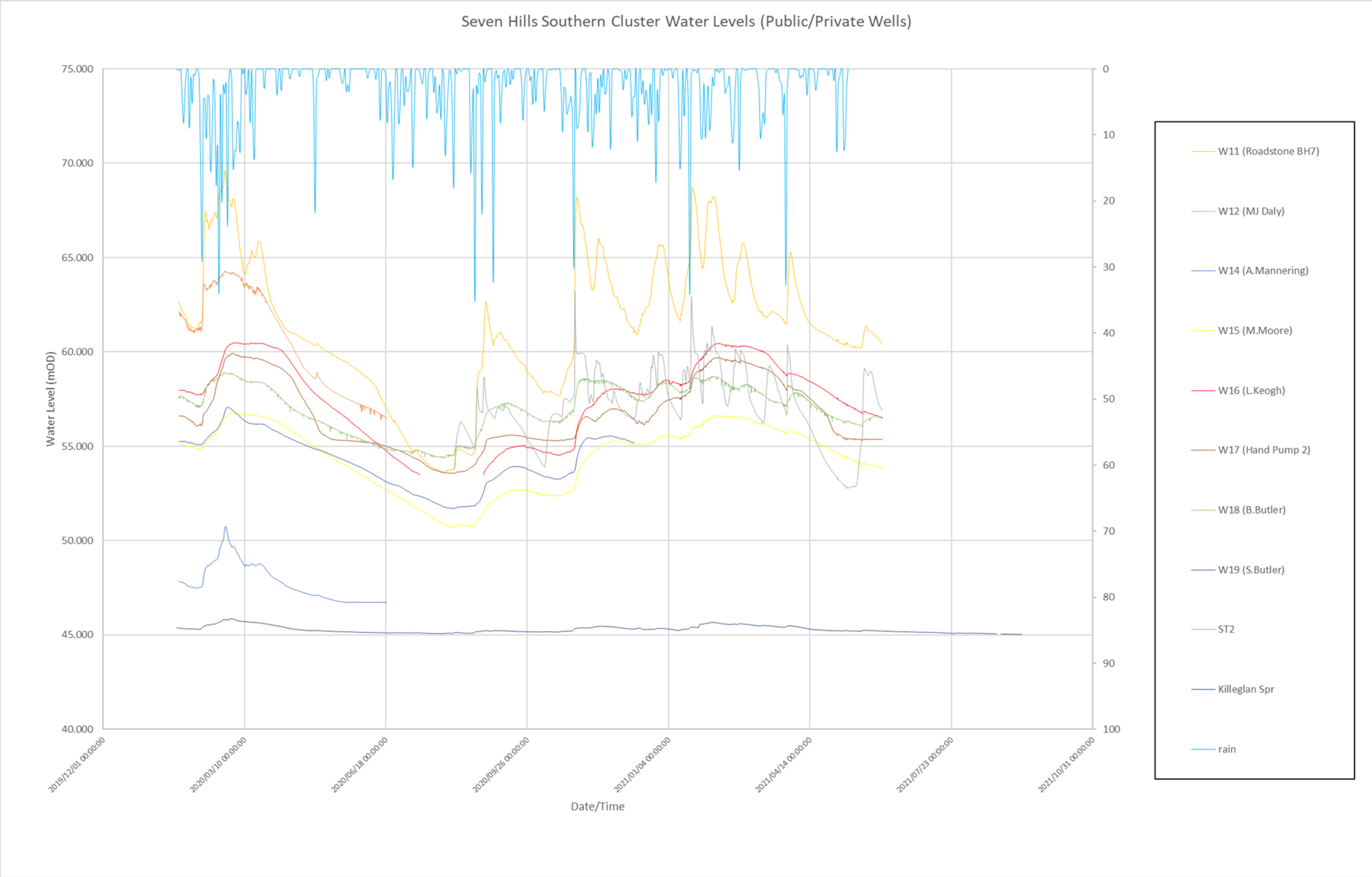
APPENDIX 9-3

WATER LEVEL GRAPHS



Seven Hills Northern Cluster Water Levels (Public/Private Wells)
Water Level (mOD)
70
65
60
55
50
45
40
0
10
20
30
40
50
60
70
80
90
100
2019/12/01 00:00:00
2020/03/10 00:00:00
2020/06/18 00:00:00
2020/09/26 00:00:00
2021/01/04 00:00:00
2021/04/14 00:00:00
2021/07/23 00:00:00
Date/Time
W1 (B.Fallon)
W8 (Council Well)
W3 (N.Fallon)
Thomas Street T
T.Carroll
rain



Seven Hills Southern Cluster Water Levels (Public/Private Wells)
Water Level (mOD)
75.000
70.000
65.000
60.000
55.000
50.000
45.000
40.000
0
10
20
30
40
50
60
70
80
90
100
2019/12/01 00:00:00
2020/03/10 00:00:00
2020/06/18 00:00:00
2020/09/26 00:00:00
2021/01/04 00:00:00
2021/04/14 00:00:00
2021/07/23 00:00:00
2021/10/31 00:00:00
Date/Time
W11 (Roadstone BH7)
W12 (MJ Daly)
W14 (A.Mannering)
W15 (M.Moore)
W16 (L.Keogh)
W17 (Hand Pump 2)
W18 (B.Butler)
W19 (S.Butler)
ST2
Killeglan Spr
rain

APPENDIX 9-4

GWS ZOC AND SPA REPORTS

Killeglan Water Supply Scheme

Tobermore Spring

Groundwater Source Protection Zones

(April 2003)

Prepared by:
Monica Lee and Coran Kelly
Geological Survey of Ireland

In collaboration with:
Roscommon County Council

Table of Contents

1 Introduction

Tobermore Spring supplies the Killeglan Water Supply Scheme.

The objectives of the report are:

- To delineate source protection zones for the Tobermore Spring and any other springs that emerge in the vicinity of the Tobermore Spring.
- To outline the principle hydrogeological characteristics of the Killeglan area.
- To assist Roscommon County Council in protecting the water supply from contamination.

2 Location, Site Description and Well Head Protection

The Tobermore Spring is located 10 km north of Ballinasloe.

It supplies water to over 5300 houses. The demand on the spring is mostly agricultural activities, which makes up over 50% of the demand.

The Tobermore Spring comprises a large circular sump, which collects water that emerges from bedrock at the bottom of the sump.

The site area is closed off by a gate and fence. The sump is covered with concrete. Overflow occurs through an opening at the bottom of the sump. The rest of the site is grassed over.

3 Summary of Spring Details

GSI no.	:	1723NEW084
Grid ref. (1:50,000)	:	18874 24044
Townland	:	Rockland
Well type	:	Spring
Owner	:	Roscommon County Council
Elevation (ground level)	:	c. 50 m OD.
Depth to rock	:	< 3 m
Static water level	:	Ground level.
Normal Abstraction	:	6000 – 9000 m^3/d
Estimated Total Discharge	:	6000 – 30000 m^3/d

It is noted that the current requirement of the Killelgan WSS is not being met during drier periods, possibly due to an increased demand on the supply.

4 Methodology

4.1 Desk Study

Details about the spring such as elevation and abstraction figures were obtained from GSI records and County Council personnel; geological and hydrogeological information was provided by the GSI.

4.2 Site visits and fieldwork

This included depth to rock drilling, subsoil sampling, flow gauging and water quality sampling. Field walkovers were also carried out to investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

4.3 Assessment

The analysis utilised field studies, previously collected data and hydrogeological mapping in order to delineate protection zones around the springs.

5 Topography and Land Use

Tobermore Spring emerges at the base of a hilly area (c.50 m OD), which rises to a maximum of 119 m OD east of the spring.

Agricultural activity dominates the area with most of the land used for grassland.

A number of houses and farms are present near the spring, some of which are within 500 metres of the source.

6 Surface Hydrology

The surface water regime is closely interconnected with the groundwater regime. There are several springs, swallow holes and numerous collapse features that are linked to the main surface water bodies in the area.

There are four main stream networks in the vicinity of Tobermore Spring. These are as follows:

1. Just north of Taghmaconnell, a stream rises in the townland of Bellaneeny. This stream flows west for approximately 4 km, to join the Killeglan River, which then discharges in the River Suck.
2. A stream network exists to the south of Taghmaconnell, in the townlands of Knock and Sraduff. These streams flow to a turlough in the townland of Glennanea. This turlough appears to take all the flow from the stream network. Another section of stream rises east of this network and then disappears after flowing approximately 1 km to the north-east.
3. An intermittent, seasonal stream is located to the east of the Tobermore Spring. This stream rises in the townland of Carrowduff and Garbally, and travels first north and then east. During wet weather the upper parts of the stream are flowing. Groundwater from the Tobermore Spring and discharge area joins this channel to form the head of the Killeglan River (Figure 1).
4. A small stream network is located in the townland of Esker. This stream network is recorded as having permanent flow, but has no apparent surface water outlet. It is therefore likely that this area of surface water feeds into the groundwater system.

The majority of the outflow from this area is via the Killeglan River, which includes the Tobermore Spring discharge. A second smaller outflow is through the stream at Bellaneeny, south of the springs.

7 Geology

An understanding of the geological material underlying the Killeglan area provides a framework for the assessment of groundwater flow and source protection zones, as discussed in Sections 8 and 9.

7.1 Bedrock Geology

Bedrock information (Figure 2) was taken from the Bedrock Geology 1:100,000 scale GSI map series, Sheets 12 (Geraghty et al, 1996) and from other unpublished work (Bedrock Section, GSI).

The majority of the area is underlain by Undifferentiated Visean Limestone. In the southern part of the county, this limestone is equivalent to Burren Limestone. To the south of the Visean Limestone is a thin band of Waulsortian Limestone.

The Visean Limestone is generally described as pale grey, clean, medium to coarse-grained, bedded limestone. The Waulsortian Limestones is a clean, pale grey massive limestone.

A number of small outcrops are noted along the path of the intermittent, seasonal stream, within the Visean Limestone.

7.1.1 Karst Features

A brief karst mapping programme was undertaken in the Killeglan area during the summer of 2001. As shown in Figure 1, the mapping identified a large number of features. These included enclosed depressions (dolines), swallow holes, springs and turloughs. The mapping highlights the high density of dolines and swallow holes along the path of the intermittent seasonal stream.

7.2 Subsoils

Subsoil mapping was undertaken by Dr. R. Meehan (Teagasc) to produce the Forest Inventory and Planning System – Integrated Forestry Information System (FIPS-IFS) Soils Parent Material Map (Figure 2). This information forms the basis of subsequent subsoil permeability assessments for the county (Lee and Daly, 2002). Further data was gathered from GSI drilling programmes (1988, 1999 and 2001).

The subsoil comprises a mixture of coarse and fine-grained materials, namely peat, alluvium, sand/gravels, and tills. The characteristics of each category are described briefly below.

Peat is located in the low-lying boggy regions of the area, mostly in the southern part.

Alluvium is generally found in the low-lying eastern part of the area and in two of the larger turloughs that are shown in Figure 2.

Till is the dominant subsoil type in the area and is an unsorted mixture of coarse and fine materials laid down by ice. The gravel-sized fragments ranging up to 10 cm in size are angular to sub-rounded and are composed of limestone. The matrix is primarily silty SAND (BS 5930) with frequent gravels and clay. There are four particle size distributions (PSD) available for the tills in this area. Three of the PSD have less than 30% fines (silt+clay) and of these two have over 50% of either sand or gravel.

Extensive fluvioglacial ***sand/gravel*** are present east and north-east of the springs. A large proportion of the sand/gravel forms a characteristically random, hummocky topography however long, sinuous, braided ridges of sand/gravel (eskers) have also been deposited (Figure 2). They are described as silty GRAVEL (BS 5930).

7.2.1 Depth to Bedrock

Broad variations in depth to bedrock have been interpreted across the area by using information from the GSI databases, field mapping and air photo interpretation.

Data from the drilling programmes indicate that the depth to rock ranges from 2 m to 33 m. In general, the low-lying areas around the spring and towards the central part of the catchment are closer to bedrock. Higher parts of the catchment have greater depths to bedrock.

7.2.2 Groundwater Vulnerability

The concept of vulnerability is discussed in the Roscommon Groundwater Protection Scheme Main Report (Lee and Daly, 2002).

The till in this region are either described as SAND (BS 5930) with a reasonably high percentage of fines, or clean sand/gravel. The available grain size distributions supporting this description. These materials are categorised as having either a ‘moderate’ or ‘high’ permeability respectively. Where subsoil thickness is greater than 3 m, the vulnerability classification ranges from ‘high’ to ‘moderate’[1], depending on the combination of permeability and specific subsoil thickness (Figure 3).

At subsoil thickness of less than 3 m, as indicated by the outcrop, subcrop and drilling data, bulk permeability becomes less relevant in mapping vulnerability across wide areas (as opposed to specific sites). This is because infiltration is more likely to occur through ‘bypass flow’ mechanisms such as cracks in the subsoil. Based on the general depth to bedrock, a vulnerability classification of ‘extreme’ has been assigned in areas of shallower subsoil.

Several types of karst feature (e.g. dolines, swallow holes) provide locations of point recharge i.e. surface water can infiltrate directly to the bedrock, by-passing any attenuation capacity of the subsoil. These locations are classified as ‘extremely’ vulnerable, which includes an arbitrary buffer of 30 m.

8 Hydrogeology

8.1 Introduction

This section presents the current understanding of groundwater flow near the Killeglan Water Supply Scheme. The interpretations and conceptualisations of flow are used to delineate source protection zones around the Tobermore Spring. Hydrogeological and hydrochemical information for the study was obtained from the following sources:

- GSI databases.
- Roscommon County Council dye tracer testing.
- Roscommon County Council hydrochemistry data.
- STRIDE Report (1994).
- The Vulnerability to Pollution and Hydrochemical Variation of Eleven Springs (Catchments) in the Karst Lowlands of the West of Ireland. M Sc. Thesis, Sligo RTC (Doak, 1995).
- A Sediment Permeability Report for the Killeglan Catchment (Quinn, 1988).
- Field work (flow gauging, drilling, subsoil sampling, water quality sampling).

8.2 Meteorology and Recharge

The term ‘recharge’ refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and assumed to consist of input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation, as it will be used to estimate the size of the zone of contribution (i.e. the outer source protection area). The calculations are summarised in

Table 1 below.

[1] The permeability estimations and depth to rock interpretations are based on regional-scale evaluations. The mapping is intended only as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems.

Table 1. Estimate of Recharge.

Parameter	Amount (mm/yr)	Data Source
Annual rainfall	1039	Contoured rainfall map based on Met Éireann data.
Annual evapotranspiration	342	Potential evapotranspiration (PE) is estimated as 360 mm/yr (Met Éireann data). Actual evapotranspiration (AE) is estimated as 95% of PE.
Potential recharge	697	Rainfall minus AE.
Runoff losses	140	Assumed as 20% of potential recharge, based on thin and/or permeable subsoil.
Estimated Recharge	557	

8.3 Groundwater Levels, Flow Directions and Gradients

The water level at Tobermore Spring is at ground level and the entire flat, low lying area around the spring is saturated and marshy. Tobermore Spring is located in a discharge area that comprises at least one other spring. Other springs also occur along the intermittent, seasonal stream, near the Tobermore Spring. The occurrence of springs and saturated ground in low-lying areas generally indicate a shallow water table.

Roscommon County Council surveyed groundwater levels in 1987. The survey indicates the general features of the water table, such as the level, direction, and gradient. The contours are widely spaced which suggests high permeability. The flow directions interpreted from the map indicate that groundwater flows toward the springs from the south-east, east, north-east and north.

Roscommon County Council also undertook tracer testing at two swallow holes south east of the Tobermore Spring in 1991 and 1994. The first swallow hole is in the townland of Glennanea (2.6 km SSE of the source), and the second is in the townland of Carrowduff (3.9 km SE of the source). For both, dye was detected at the spring 1.5 days later indicating minimum groundwater velocities of 70 m/hr and 110 m/hr respectively. For the Glennanea trace, the dye was detected first in a stream in Dundonnell townland, and then at a spring in Bellaneeny townland, before it appeared at the main Tobermore Spring (Doak, 1995).

The connection between the Glennanea swallow hole and the Tobermore Spring suggest that the groundwater flow directions are complicated, especially within this locality. This is due to the karstic nature of the bedrock, whereby the fissures/conduits locally dictate the flow directions.

The groundwater gradient calculated from the water table map is 0.0015.

8.4 Aquifer Characteristics

The Undifferentiated Visean Limestone provides the groundwater to the Tobermore Spring. It is a high yielding spring located in a discharge area that comprises at least one other spring (Doak, 1995).

A large fracture network probably underlies the source and causes the water to concentrate in the spring and discharge area. Bedrock is close to the surface near the springs.

Karstification is an important process in Irish hydrogeology. It involves the enlargement of rock fissures when groundwater dissolves the fissure walls as it flows through them. The process can result in significantly enhanced permeability and groundwater flow rates. It generally occurs in 'cleaner' limestones. Many swallow holes and collapse features provide evidence for karstification in the Killeglan area. The tracer tests that were carried out also indicate significant karstification.

The proximity of the springs to each other and the discharge from the area indicates high permeability. The widely spaced groundwater contours also suggest high permeability. The tracer tests indicate minimum groundwater velocities of between 70 and 110 m/hr. These flow rates depend on several factors including topography, rainfall and groundwater levels. However, such high velocities are characteristic of flow in karstified limestone aquifers.

The bedrock in the Killeglan area is likely to be characterised by:

- groundwater flow in solutionally-enlarged bedding plane partings, joints, faults and conduits;
- high groundwater velocities, several orders of magnitude greater than in sand/gravel aquifers;
- concentration of groundwater flow in zones of high permeability;
- a combination of diffuse and point (through swallow holes, sinking streams) means of recharge;
- irregular or poorly connected water table;
- often extreme vulnerability to contamination due to point recharge by-passing the potential attenuation capability of the subsoil;
- minimal attenuation of contaminants, except by dilution;
- high turbidity, suspended solids and colour after heavy rain, particularly in the autumn;
- short response times when pollution incidents occur.

8.5 Aquifer Category

The Undifferentiated Visean Limestone, which underlies the majority of the area, is classified as a Regionally Important Karstic Aquifer, which is characterised by conduit flow (**Rk**^{c}).

Development potential of the clean Waulsortian Limestone is considered to be limited by its massive nature, and is therefore categorised as a Locally Important Aquifer, which is moderately productive in local zones (**Ll**).

The derivation of these classifications is presented in the County Roscommon Groundwater Protection Scheme Main Report (Lee and Daly, 2002).

8.6 Hydrochemistry and Water Quality

The available water quality data are from Roscommon County Council drinking water returns for 1999 to 2001. These samples were collected as part of the Rural Water Quality Monitoring Programme. The EPA biannual data (1997 – 2001) was also included in this assessment as were two sampling rounds undertaken by the GSI (February and September 2001).

The hydrochemical analyses suggest that the spring water has a very hard (>350 mg/l $CaCO_3$) calcium-bicarbonate hydrochemical signature, with conductivity ranging between 390 – 590 µS/cm (averaging 575 µS/cm).

The results highlight that total and faecal coliforms are consistently present in the raw water samples and are one of the few parameters to exceed the EU Drinking Water Directive maximum admissible concentrations (MAC). In 50% of the raw water samples, there are greater than 10 faecal coliforms per 100 ml, which is considered to be gross contamination (Keegan *et al*., 2002). It is important to note that these results are for untreated water.

There are three instances where the level of manganese slightly exceeds the MAC (0.05 mg/l), one of which is coincident with an elevated iron level (0.9 mg/l).

Nitrate levels range from 12-29 mg/l, with two occasions in the summer of 1999 where levels exceeded GSI threshold (25 mg/l). There does not appear to be any obvious seasonal variability in the data, and there is no apparent upward trend in the dataset.

Elevated phosphate levels are a cause of eutrophication in surface water. Three samples taken in 1999 exhibited concentrations in excess of the EPA guide level (0.02 mg/l).

Turbidity has not exceeded the MAC during the monitoring however, discoloration of the water has frequently been noticed by individuals who use the supply.

8.7 Discharge Estimates

Flows have been measured by the GSI and by the County Council at several locations to estimate the amount of water leaving the catchment. These locations are shown in Figure 1 and described below:

Tobermore Spring. Assumed abstraction plus measured overflow at the sump.

Discharge Area. Flow measured at exit of marshy discharge area, east of the road. This also includes the overflow from the Tobermore Spring.

Second Stream. Flow measured on the lower section of the intermittent seasonal channel, prior to its confluence with flow from the 'discharge area'. This section of the channel has permanent flow with two springs contributing to its flow.

The discharge in the vicinity of the source is thought to comprise the flow from the 'discharge area' (which includes the Tobermore Spring overflow) and the flow from the 'second stream', as well as the water which is abstracted from the Tobermore Spring. Estimates of these values are given in Table 2 below.

Table 2. Estimates of Flows in the vicinity of the Tobermore Spring.

	Tobermore Spring [1] (m^3/d)	Discharge Area (m^3/d)	Second Stream (m^3/d)	Head of Killeglan River (m^3/d)
01-Jul-99	9960	5586	10764	26310
01-Jan-00	30975	37315	48825	96100
28-Jun-00	9960	4689	19721	34370
04-Jul-00	9960	7545	21249	38753
17-Jul-00	9960	2588	21249	33797
10-Aug-00	9960	841	3733	14533
22-Aug-00	9960	0	2540	12500
06-Sep-00	9960	0	444	10404
11-Oct-00	9960	3535	8242	21737
12-Jan-02	17630	28638	24627	63225

[1] Estimated abstraction – assumed to be 9960 m^3/d – plus measured overflow.

Flow from the Bellaneeny townland stream has not been measured accurately but is estimated to be less than half the winter overflow from Tobermore Spring (February 2000).

8.8 Conceptual Model

- Groundwater discharges to three zones in the area:
  1) Tobermore Springs and one other spring in the 'discharge area'.
  2) At least two springs located along the banks of the seasonal stream, close to the confluence with the flow from the discharge area.
  3) An unnamed stream and spring in the townland of Bellaneeny.
- Surface water and groundwater are interconnected. Many swallow holes occur along the course of the seasonal stream that runs through most of the catchment. During times of heavy rainfall, this surface channel takes the excess flow.

- The clean limestone aquifer provides water to the springs. The Visean Limestone in the region has undergone significant karstification, shown by the numerous swallow holes, turloughs and collapse features. Tracer test results also infer that the karst is well developed.
- Groundwater is likely to flow through interconnected, probably solutionally enlarged fracture zones and along fractures and joints outside the main fracture systems. The tracer tests results possibly highlight some of the larger conduits. However, the precise pathways are not known.
- Minimum groundwater velocities are high (70 m/hr; 110 m/hr). The widely spaced groundwater contours also infer that there is high permeability in the limestone.
- There are few surface streams in the catchment. These are the stream at Bellaneeny, the seasonal stream that flows through the centre of the catchment, the stream network that flow into the swallow hole at Glennanea, and the stream network to the south of Esker, which also appear to flow into a swallow hole. This also gives an indication of the clean nature of the underlying bedrock.
- Both diffuse and point types of recharge are occurring. Swallow holes and collapse features provide the means for point recharge. The subsoil is free draining and hence allows a relatively high proportion of recharge to occur through it.

9 Delineation Of Source Protection Areas

9.1 Introduction

This section delineates the areas around the spring that are believed to contribute groundwater, and that therefore require protection. The delineated areas are based on the conceptualisation of the groundwater flow pattern, as described in Section 8.8 and are presented in Figure 1.

Two source protection areas are delineated:

- ♦ Inner Protection Area (SI), designed to give protection from microbial pollution.
- ♦ Outer Protection Area (SO), encompassing the zone of contribution (ZOC) of the source.

9.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), and is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by a) the total discharge, b) the groundwater flow direction and gradient, c) the rock permeability and d) the recharge in the area.

Although relatively good hydrogeological data exists for the Killeglan area, the underlying aquifer is karstified. Groundwater flow through karst areas is extremely complex and difficult to predict. Flow velocities are relatively fast and variable, both spatially and temporally. Catchment areas are often difficult to define and they may change seasonally. Consequently, some uncertainty generally exists when delineating boundaries in karst areas.

The ZOC has been defined for Tobermore Spring, the springs in discharge area, and the springs along the seasonal stream. The reason for this is that the same catchment is providing groundwater to all of the springs. Given the available data, it is impossible to define the precise zone for each individual spring as they occur in a karst environment.

The shape and boundaries of the ZOC were determined using hydrogeological mapping and the conceptual model. The boundaries of the ZOC catchment boundaries and the uncertainties associated with them are as follows:

1. The **Northern Boundary** is defined by a topographical ridge that runs from the townland of Lugboy through Cam Hill as far as the townland of Tawnagh.

2. The **Eastern Boundary** is defined by topographic ridges in the townland of Castlesampson. There are a series of streams in this area, all of which flow eastwards toward the River Shannon. The eastern boundary include the stream network to the south of Esker as it is likely that this flow is entering the groundwater system via swallow holes and may also contribute to the discharge at, or around, the Tobermore Spring.

3. The **Southern Boundary** is defined in part by the large bog in the townland of Taghmaconnell and by the ridges that occur in the townland of Ardnaglug. Tracing from the swallow hole in the townland of Glennanea indicates that all the catchment to this swallow hole and its associated stream should be included inside the southern boundary.

4. Derivation of the **Western Boundary** is more complicated. The tracer test results show a link from the swallow hole in Glennanea to the Tobermore Spring and to the streams that flow out of the catchment at Bellaneeny and Dundonnell. The boundary takes into account the localised groundwater flow direction that is inferred.

   It is assumed that water down-gradient of either the streams or springs will not flow to the Tobermore Spring. Therefore an arbitrary buffer of 30 m is placed on the down-gradient side of the head of the Dundonnell stream and the Tobermore Spring. This buffer also includes the discharge area, where at least one other spring is located.

These boundaries delineate the physical limits within which the ZOC is likely to occur. The area constrained by the hydrogeological mapping is approximately 40 km^2.

To date, the discharge data (Section 8.7) are not comprehensive enough to undertake a water balance and thus, accurately estimate the catchment area for the discharge at the head of the Killeglan River. However an approximation of the averaged discharge data and recharge data (Section 8.2) indicate that the delineated catchment is area is large enough to meet the discharge from the springs.

9.3 Inner Protection Area

According to the National Groundwater Protection Scheme (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100 day time of travel to the supply.

The tracer tests carried out by Roscommon County Council recorded rapid groundwater velocities in the Undifferentiated Visean Limestone (70 m/hr; 110 m/hr), which cover the majority of the ZOC. Groundwater can therefore reach the spring within 5 days from any point in the ZOC which is underlain by Visean Limestone.

Flow through the Waulsortian Limestone in the south of the ZOC has not been measured, however there are permeability estimates for similar rock types in other counties (Daly, 1994). These range from 0.1 to 10 m/d for locally important fractured aquifers. Although flow through the Waulsortian Limestone is estimated to be slower than through the Visean, there are surface channels across this formation which sink once they reach the karstified Visean Limestone (Glennanea swallow hole).

It is therefore likely that all groundwater within the delineated catchment could reach the source in less than 100 days. This could either occur entirely as groundwater flow, or intermittently via the surface watercourses. These data suggest that the entire ZOC should be incorporated into the Inner Protection Area.

10 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the source protection areas and vulnerability categories – giving a possible total of 8 source protection zones (see Table 3). In practice, this is achieved by superimposing the vulnerability map (Figure 3) on the source protection area map. Each zone is represented by a code, e.g. **SI/H**, which represents an <u>Inner Source Protection area</u> where the groundwater is highly vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present around any given source. Only three groundwater protection zones are present around the Killeglan source (Figure 4), as shown in the matrix below.

Table 3. Matrix of Source Protection Zones.

VULNERABILITY RATING	SOURCE PROTECTION	
	Inner	***Outer***
Extreme (E)	SI/E	na
High (H)	SI/H	na
Moderate (M)	SI/M	na
Low (L)	na	na

11 Potential Pollution Sources

Within the ZOC, there are a number of houses and farmyards. Some of these are located within 500 m of the Tobermore Spring. Agriculture in the main land use in the area, which is dominated by pasture. There are also several small-scale sand and gravel pits in the ZOC.

The hydrochemical data mainly highlights consistently elevated levels of total and faecal coliforms. Given the levels of other indicator parameters, the source of this contamination is likely to be organic wastes.

The main hazards associated within the ZOC are therefore considered to be domestic, such as on site treatment systems (septic tanks), and agricultural (farmyard waste leakage, landspreading). The location of these activities in any part of the ZOC categorised as ‘extremely’ vulnerable presents a potential risk, given rapid travel time through the underlying bedrock. It should be noted that detailed assessments of hazards were not carried out as part of this study.

12 Conclusions and Recommendations

- The source at Killeglan is located in, and predominantly supplied by, the Undifferentiated Visean Limestone.
- It is unlikely that the spring can provide additional long-term water supplies during drier periods. However flow from the ‘discharge area’ and in the ‘second stream’ was recorded after the Tobermore Spring overflow had ceased during the summer months.
- Although there are several springs around the Tobermore Spring, the delineated ZOC encompasses all of them. This approach is necessary due to the complicated nature of groundwater flow in karstified rock and the lack of data.
- Due to the rapid groundwater velocities through the karstified bedrock, it is considered that waters within any part of the ZOC could potentially reach the spring within 100 days. Therefore the entire ZOC has also been classified as the Inner Protection Area.
- The groundwater in the Protection Area is ‘extremely’ to ‘moderately’ vulnerable to contamination. The enclosed concrete sump and well maintained pump house area suggest that there will be limited susceptibility to surface water inundation specifically at the source.
- The protection zones delineated in this chapter are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

- It is recommended that:
  - flow monitoring is continued, both at the head of the Killeglan River and individually from the 'discharge area' and the 'second stream'. If appropriate, these flows may have development potential for augmentation purposes.
  - tracer tests are undertaken in other parts of the ZOC to increase our understanding of the groundwater flows. Such information may aid delineation of more specific areas contributing to the other springs identified, such as those along the seasonal stream.
  - the present chemical and bacteriological analyses of raw water should be continued. The chemical analyses should include all major ions – calcium, magnesium, sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and nitrate.
  - the potential hazards in the ZOC should be located and assessed.
  - the sump and pump house area should continue to be adequately maintained to minimise the risk of inundation by surface water at the source.

13 References

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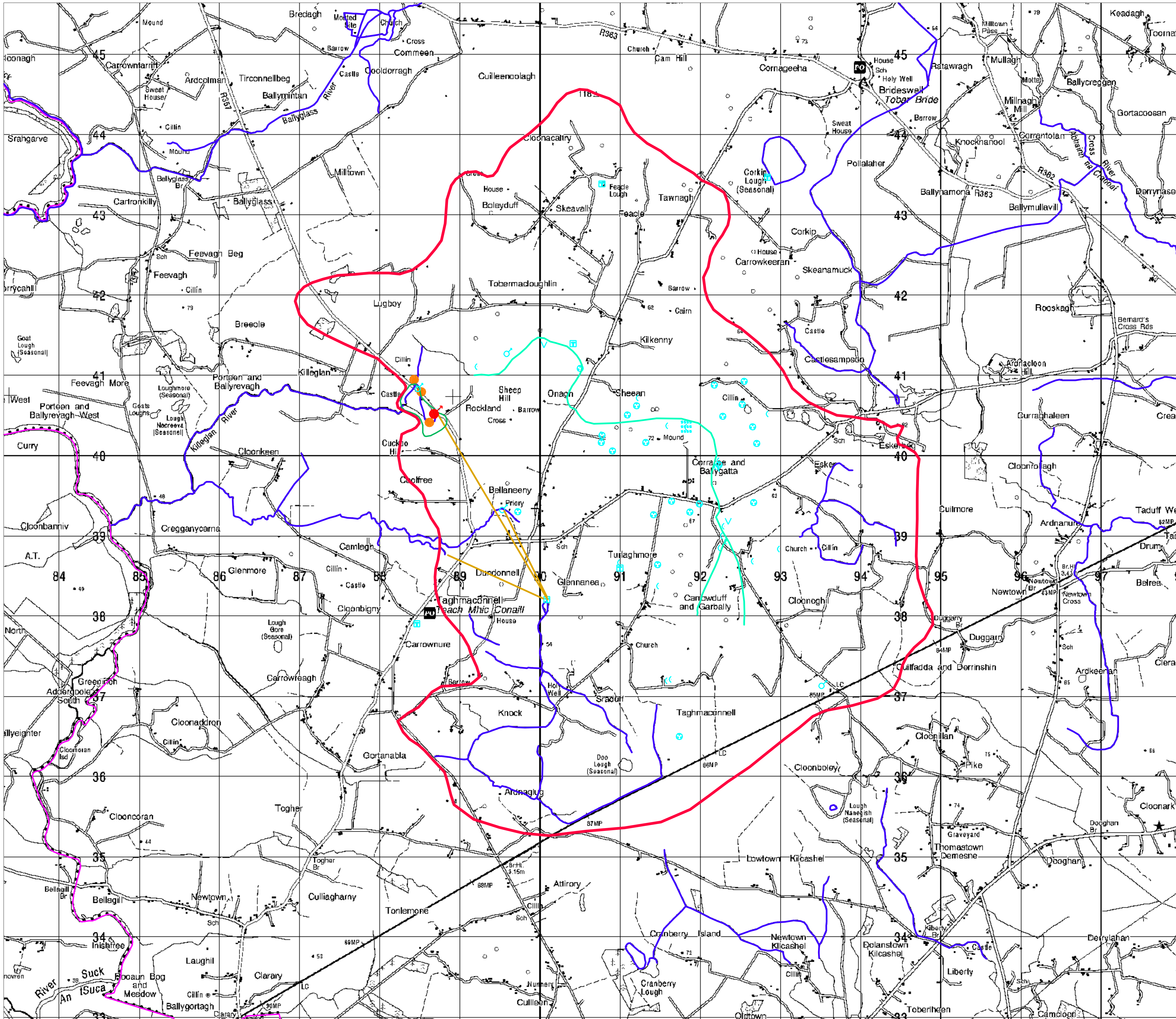
KILLEGLAN WATER SUPPLY SCHEME

Figure 1. Site Location and Feature Map



Karst Features

- Turlough
- Enclosed Depression
- Swallow Hole
- Cave
- Spring

Other Features

- Streams
- Zone of contribution (ZOC)
- Public Supply Spring
- Monitoring points of flow gauging
- Discharge area
- Seasonal Stream
- Established Connections (tracer test lines)

0 1km 2km

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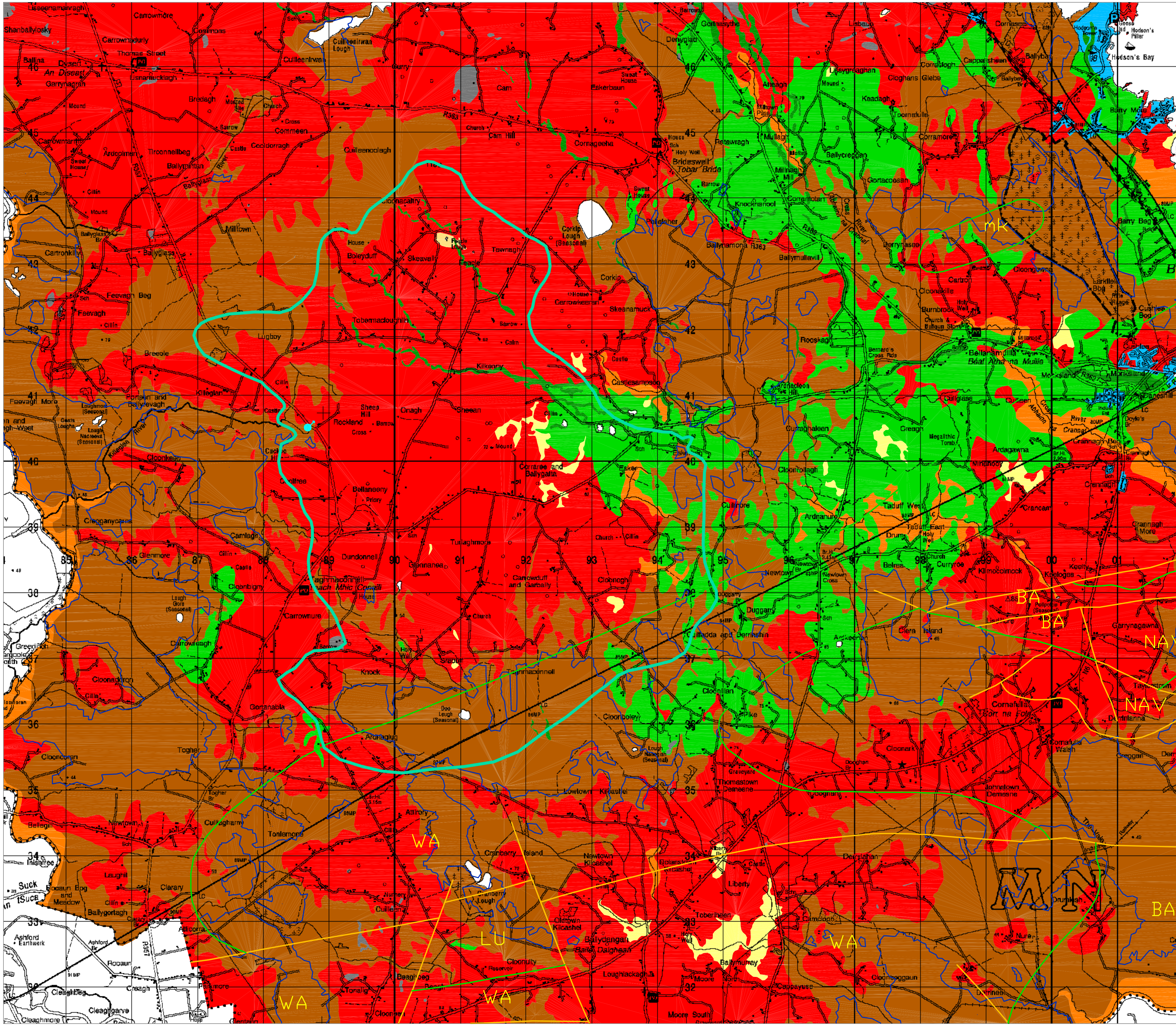
KILLEGLAN WATER SUPPLY SCHEME

Figure 2. Geology and Subsoils Map



- Alluvium undifferentiated
- Cut Peat
- Esker Sands and Gravels
- Sands and Gravels
- Lake Sediments
- Lake
- Rock outcrop or subcrop
- Tills

LU	Lucan Formation	Dark limestone and shale.
WA	Waulsortian Limestones	Lime-mudstone
BA	Ballysteen Formation	Muddy limestones
NAV	Navan Group	Limestone and shale
mk	Mudbank limestones	

- Cut peat boundaries used for Vulnerability map
- Geological Boundaries
- Geological Faults
- Zone of Contribution
- Public Supply Spring

Sources of Information

G.S.I. 1:100,000 Bedrock Series Sheet 12 : compiled by M.Geraghty, C.MacDermot and D.C.Smith.

"FIPS-IFS Soil Parent Material Map" Compiled by R. Meehan (Teagasc).

This **geology and subsoils map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations.

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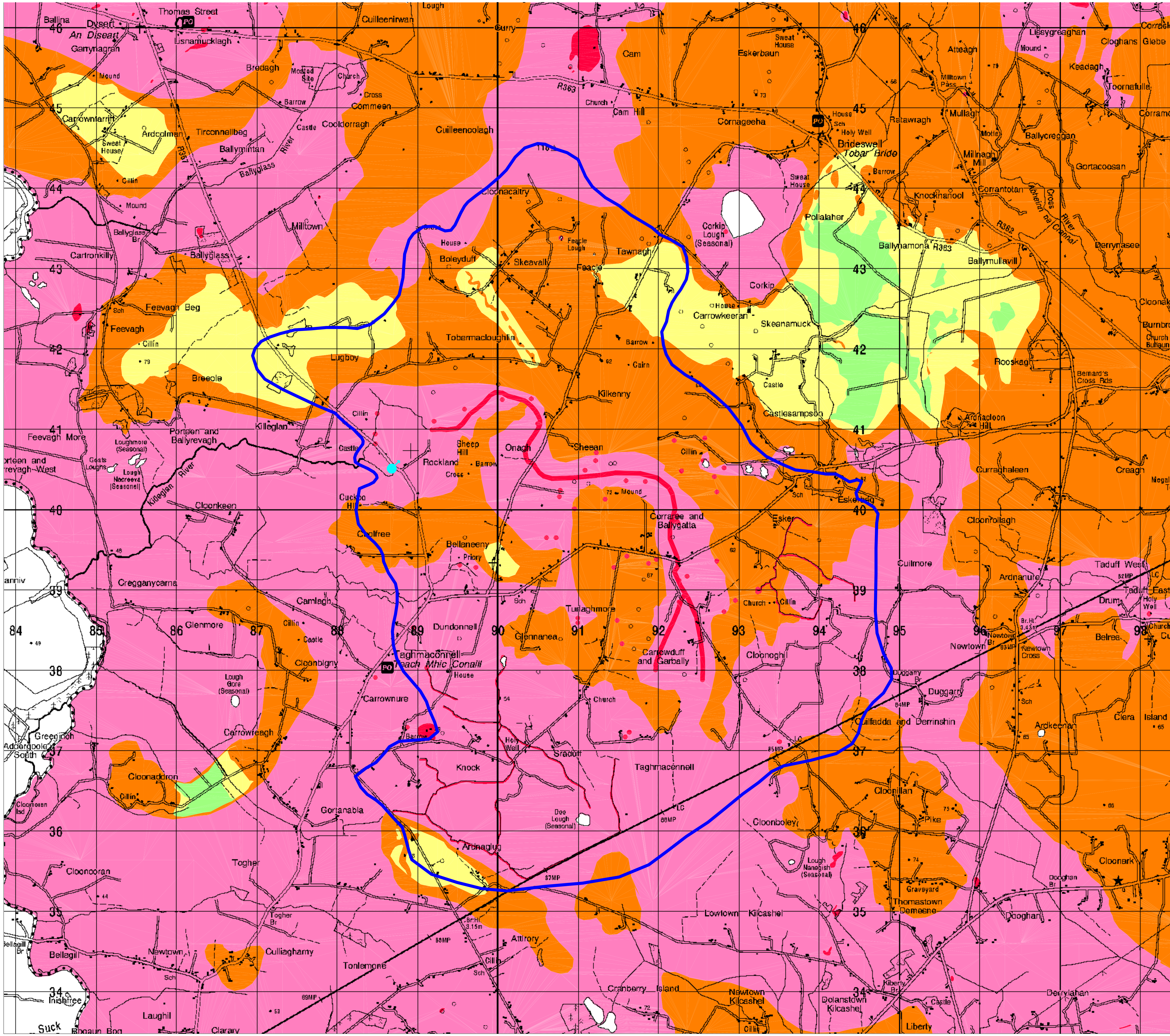

KILLEGLAN WATER SUPPLY SCHEME

Figure 3. Vulnerability Map

- Extreme (E)
- Outcrop/Shallow rock (E)
- High (H)
- Moderate (M)
- Low (L)
- Zone of Contribution to Well
- Public Supply Spring

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the **vulnerability** of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This **vulnerability** map is designed for general information and strategic planning usage.The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments,and will frequently require site investigations to determine the risk to groundwater.

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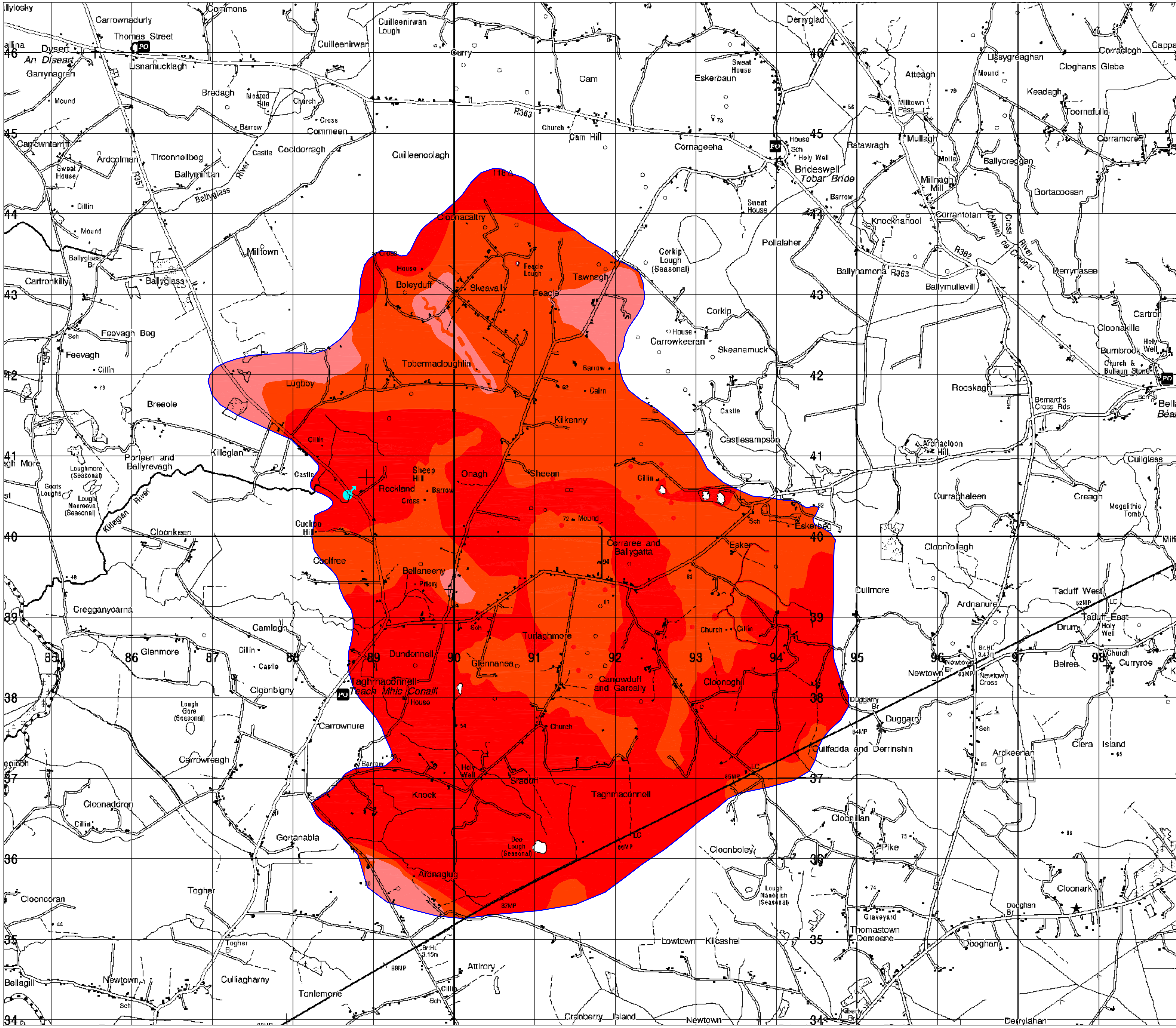

KILLEGLAN WATER SUPPLY SCHEME

Figure 4. Source Protection Zones

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner (SI)	
Extreme (E)		SI/E
High (H)		SI/H
Moderate (M)		SI/M
Low (L)	not present	SI/L

Zone of Contribution to well (SI)

Public Supply Spring

This **Source Protection Zone map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

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0 1km 2km

Mount Talbot Water Supply Scheme

Cloonlaughnan Springs

Groundwater Source Protection Zones

(April 2003)

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Geological Survey of Ireland

In collaboration with:

Roscommon County Council

Table of Contents

1 Introduction

A series of springs in the townland of Cloonlaughnan supply the Mount Talbot Water Supply Scheme.

The objectives of the report are as follows:

- To delineate source protection zones for the Mount Talbot Scheme Springs.
- To outline the principle hydrogeological characteristics of the Mount Talbot area.
- To assist Roscommon County Council in protecting the water supply from contamination.

2 Location, Site Description and Well Head Protection

The source comprises at least two springs in the Cloonlaughnan townland, which is located approximately 5 km south of Athleague.

The springs feed into an artificial channel (c.4 m wide by c.100 m long), which discharges into a stream to the south. This stream flows north-west into the River Suck, approximately 350 m from the springs.

A large covered sump is located adjacent the artificial channel, partially beneath the pump house. The sump collects water from the channel through an intake pipe. There is also an overflow pipe from the sump which discharges into the channel further downstream.

The source area is closed off with a gate and fence. The remainder of the site is grassed over.

3 Summary of Spring Details

GSI no.	:	1725SWW019
Grid ref. (1:50,000)	:	18203 25232
Townland	:	Cloonlaughnan
Well type	:	Springs
Owner	:	Roscommon County Council
Elevation (ground level)	:	c. 47 m OD.
Depth to rock	:	< 2 m
Static water level	:	c. 1 m below ground level.
Sump dimensions	:	7 m diameter by 3.5 m deep
Average abstraction	:	3,540 m^3/d
Estimated total discharge	:	6,000 – 17,000 m^3/d

4 Methodology

4.1 Desk Study

Details about the springs such as elevation and abstraction figures were obtained from GSI records and County Council personnel; geological and hydrogeological information was provided by the GSI.

4.2 Site visits and fieldwork

This included depth to rock drilling, subsoil sampling, flow gauging and water quality sampling. Field walkovers were also carried out to investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

4.3 Assessment

The analysis utilised field studies, previously collected data and hydrogeological mapping in order to delineate protection zones around the springs.

5 Topography, Surface Hydrology and Land Use

The springs emerge at approximately 47 m OD, within a flat, low-lying, area. A limestone ridge trending north-east to south-west is situated approximately 4.5 km east of the source. The ridge rises sharply from 60 m to 133 m and forms part of a regional surface water divide between the River Suck catchment and the Lough Funshinagh/Lough Ree catchment. A smaller hill (rising to 69 m OD) is located in the generally flat land between the ridge and the springs.

The artificial channel flows south to discharge into a stream flowing north-westwards into the River Suck. The River Suck flows north to south, approximately 350 m west of the source. Another smaller stream, the Cloonalin River, is located approximately 1.0 km to the north of the source. This stream also flows in a north-western direction to discharge into the River Suck.

The land use in this area is predominantly agricultural, with much of the land used for grazing. There are a number of houses and farmyards present in the vicinity of the springs.

6 Geology

An understanding of the geological material in the Mount Talbot area provides a framework for the assessment of groundwater movement and source protection zones, as discussed in Sections 7 and 8.

6.1 Bedrock Geology

Bedrock information was taken from the Bedrock Geology 1:100,000 scale GSI map series, Sheets 12 (Geraghty et al, 1996) and from unpublished work undertaken by the Bedrock Section, GSI.

The entire region is underlain by Undifferentiated Visean Limestone. In the southern part of the county, this limestone is equivalent to Burren Limestone, which is generally described as pale grey, clean, medium to coarse-grained, bedded limestone.

6.1.1 Karst Features

Specific karst mapping has not been undertaken in the Mount Talbot area. However a small number of karst features have been identified in this region comprising turloughs, a swallow hole and a cave.

6.2 Subsoils

Subsoils mapping was undertaken by Dr. R. Meehan (Teagasc) to produce the Forest Inventory and Planning System – Integrated Forestry Information System (FIPS-IFS) Soils Parent Material Map (Figure 2). This information forms the basis of subsequent subsoil permeability assessments for the county (Lee and Daly, 2002). Further data was gathered from GSI drilling programmes (1999 and 2001). Additional information specific to the area of interest includes:

- Nicholas O'Dwyer and Partners, (1982). Mount Talbot Regional Water Supply Scheme. Site

Investigation.

- Doak, M., (1995) The Vulnerability to Pollution and Hydrochemical Variation of Eleven Springs (Catchments) in the Karst Lowlands of the West of Ireland. M Sc. Thesis, Sligo RTC.

The subsoil comprises a mixture of coarse and fine-grained materials, namely: peat, alluvium and tills. The characteristics of each category are described briefly below.

Peat is situated in the low-lying areas. The regions are specifically located along the streams to the north and south of the springs. A small area of peat is also recorded to the east of the springs, which coincides with a turlough. A thin layer of peat (0.2 m – 2.0 m) was also recorded in the immediate vicinity of the springs.

Alluvium is located to the west of the springs, along the River Suck.

Tills are the dominant subsoil type in the area and are described as an unsorted mixture of coarse and fine materials laid down by ice. There are seven till samples taken within a 4 km radius of the springs. All seven are described as SILT (BS 5930). Four of the samples have particle size distribution data (PSD) which all have between 30% and 40% fines (silt+clay). Three of these samples have been analysed for their clay percentage, which ranges from 6% to 11%.

6.2.1 Depth to Bedrock

Broad variations in depth to bedrock have been interpreted across the area by using information from the GSI databases, field mapping and air photo interpretation.

Areas of outcrop and subcrop are recorded in the ridge to the east of the springs (Figure 2).

Data from the drilling programmes indicate that the depth to rock ranges from less than 2.0 m in the immediate vicinity of the springs, to just over 6 m to the east of the springs. In general, the flatter area to the east of the springs have slightly greater depths to bedrock, which become increasingly shallower on the higher ridge area.

It is also noted that the depth to bedrock increases to greater than 10 m towards the River Suck.

6.2.2 Groundwater Vulnerability

The concept of vulnerability is discussed in the Roscommon Groundwater Protection Scheme Main Report (Lee and Daly, 2002).

The till in this region is generally described as SILT (BS 5930), with the available particle size distributions supporting this description. This material is categorised as having a 'moderate' permeability. Therefore where subsoil thickness are estimated to be between 3 m and 10 m, the vulnerability is classified as 'high'[1].

At subsoil thickness of less than 3 m, as indicated by the outcrop, subcrop and drilling data, bulk permeability becomes less relevant in mapping vulnerability across wide areas (as opposed to specific sites). This is because infiltration is more likely to occur through 'bypass flow' mechanisms such as cracks in the subsoil. Based on the general depth to bedrock, a vulnerability classification of 'extreme' has been assigned along the ridge area, as shown in Figure 3.

[1] The permeability estimations and depth to rock interpretations are based on regional-scale evaluations. The mapping is intended only as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems.

7 Hydrogeology

This section presents the current understanding of groundwater flow near the Mount Talbot Water Supply Scheme. The interpretations and conceptualisations of flow are used to delineate source protection zones around the springs.

Hydrogeological and hydrochemical information for the study was obtained from the following sources:

- GSI databases.
- Roscommon County Council hydrochemistry data.
- Nicholas O'Dwyer and Partners, (1982). Mount Talbot Regional Water Supply Scheme. Site Investigation.
- Doak, M., (1995) The Vulnerability to Pollution and Hydrochemical Variation of Eleven Springs (Catchments) in the Karst Lowlands of the West of Ireland. M Sc. Thesis, Sligo RTC.
- Field work (flow gauging, drilling, subsoil sampling, water quality sampling).

7.1 Meteorology and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation as it is used to estimate the size of the zone of contribution (i.e. the outer source protection area). The calculations are summarised in Table 1 below.

Table 1. Estimate of Recharge.

Parameter	Amount (mm/yr)	Data Source
Annual rainfall	1026	Average annual rainfall 1961 – 1990 (Met Éireann, 1996).
Annual evapotranspiration	388	Potential evapotranspiration (PE) is estimated as 408 mm/yr (Met Éireann data). Actual evapotranspiration (AE) is estimated as 95% of PE.
Potential recharge	638	Rainfall minus AE. Estimation of the excess soil moisture available for either vertical downward flow to groundwater, or lateral soil quickflow and overland flow direct to surface water.
Runoff losses	64	Assumed as 10% of potential recharge. Based on: • Negligible runoff over half the area due to the high proportion of outcrop/subcrop, also shown by the lack of surface streams; • 20% runoff losses over half the area due to thicker subsoils.
Estimated Recharge	574	

7.2 Hydrogeological Features

- The water level at the Mount Talbot Springs is approximately 1 m below ground level. The flat, low lying area west of the spring is quite wet and requires artificial drainage in order to utilise the land. The presence of springs and saturated ground indicate a shallow water table.
- The discharge area of the springs constitutes an artificial channel and comprises at least two

springs.

- A turlough is located to the east of the spring. The turlough has not been investigated to determine whether it has a swallow hole, and whether there is a possible connection between it and the springs.
- Specific karst mapping has not been undertaken in this general area however, a number of karst features are recorded within a 5 km radius of the springs. These features include turloughs, a swallow hole and a cave.
- In the absence of further data, the watertable is generally thought to reflect the topography. It is assumed therefore that groundwater will move in a north-west direction towards the springs and in the general direction of the River Suck. The dominant driving head for the water emerging at the spring is likely to be the higher limestone ridge situated to the east of the springs.

7.3 Aquifer Characteristics

The Undifferentiated Visean Limestone provides the groundwater to the Mount Talbot Springs. These springs consistently give a high yield.

Given the nature of the underlying bedrock, a fracture network possibly underlies the source and causes the water to concentrate in the discharge area at the springs. Bedrock is close to the surface near the springs.

Karstification is an important process in Irish hydrogeology. It involves the enlargement of rock fissures when groundwater dissolves the fissure walls as it flows through them. The process can result in significantly enhanced permeability and groundwater flow rates. It generally occurs in 'cleaner' limestones. Although karst mapping has not been undertaken in this specific area, there are a significant number of karst features recorded in the Visean Limestone.

Tracer tests in the Visean Limestones have been undertaken within 20 km of the source. These suggest that the limestone is characterised by rapid groundwater velocities, as are outlined in Table 2 below.

Table 2. Tracer Test in the Visean Limestones in South Roscommon

Location	**Velocity (m/hr)**	**Data Source**
Fuerty to Ballinagard Springs *(10 km north of source)*	c. 24	Roscommon County Council, 1991
Lough Funshinagh to Milltown Pass *(12.5 km east of source)*	70	Drew *et al.*, 1996
Killeglan Water Supply Scheme *(15 km south of source)*	70; 110	Roscommon County Council, 1991 and 1994

The lack of surface drainage in the Mount Talbot area suggests that infiltration occurs readily.

Based on the general characteristics of the Visean Limestone in this region, the bedrock in the Mount Talbot area is likely to be characterised by:

- groundwater flow in solutionally enlarged bedding plane partings, joints, faults and conduits;
- high groundwater velocities; possibly orders of magnitude greater than in sand/gravel aquifers;
- concentration of groundwater flow into zones of high permeability;
- a combination of diffuse and point (through swallow holes, sinking streams) means of recharge;
- irregular or poorly connected water table;
- often extreme vulnerability to contamination due to point recharge by-passing the potential

attenuation capability of the subsoil;

- minimal attenuation of contaminants, except by dilution;
- high turbidity, suspended solids and colour after heavy rain, particularly in the autumn;
- short response times when pollution incidents occur.

7.4 Aquifer Category

The Undifferentiated Visean Limestone underlies the entire area and is classified as a Regionally Important Karstic Aquifer, which is characterised by conduit flow (**Rk**^{c}).

The derivation of this classification is presented in the County Roscommon Groundwater Protection Scheme Main Report (Lee and Daly, 2002).

7.5 Hydrochemistry and Water Quality

The available water quality data are from Roscommon County Council drinking water returns for 1999 to 2001. These samples were collected as part of the Rural Water Quality Monitoring Programme. The EPA biannual data (1997 – 2001) were also included in this assessment as were two GSI sampling rounds (February and September 2001). Further data includes that from Doak (1995).

- The hydrochemical analyses suggest that the spring water has a very hard (>350 mg/l $CaCO_3$) calcium-bicarbonate hydrochemical signature, with conductivity ranging between 394 – 790 µS/cm (averaging 640 µS/cm). A 9% coefficient of variation of conductivity was calculated, suggesting a karstified bedrock which is sensitive to pollution (Doak, 1995).
- The results highlight that total and faecal coliforms are consistently present in the raw water samples, exceeding the EU Drinking Water Directive maximum admissible concentrations (MAC). In 62% of the 21 raw water samples, there are greater than 10 faecal coliforms per 100 ml, which is considered to be gross contamination (Keegan *et al*., 2002).
- Sodium:Potassium ratios (Na:K) range from 0.23 – 0.38 in 7 samples (averaging 0.31). Two samples exceeded the GSI threshold (0.35). Elevated Na:K ratios suggest that farmyard waste, rather than septic tanks, are the source of organic wastes.
- Nitrate levels are low, ranging from 2 – 19 mg/l. There does not appear to be any obvious seasonal variability in the data, and there is no apparent upward trend in the dataset.

The dataset shows that the spring water is very hard and is regularly contaminated with bacteria, some of which is likely to have an agricultural (farmyard waste) source.

7.6 Discharge Estimates

The total discharge from the springs is thought to comprise the abstraction plus the overflow. The spring overflow has been measured by the GSI and by the County Council. The overflow was measured prior to the water entering the stream to the south of the artificial channel. This location would include the flow by-passing the sump intake as well as sump overflow, which is not abstracted. Estimates of these values are given in Table 3 below.

Table 3. Discharge Estimates from the Cloonlaughnan Springs.

	Spring Abstraction [1] (m^3/d)	Overflow (m^3/d)	Total Discharge (m^3/d)
July 1999	3504	3071	6575
January 2000	3593	12148	15741
April 2000	3545	8111	11656
September 2000	3547	6221	9768
October 2000	3547	6165	9712
January 2001	3547	13365	16912

[1] Abstraction for September 2000, October 2000 and January 2001 estimated as average of measured abstractions given in the Table.

Flow was also measured in the Cloonalin River to the north and the stream to the south in April 2000. The gauged flows were:

Cloonalin River: 4680 m^3/d

Stream to the south of the springs: 11020 m^3/d

7.7 Conceptual Model

- There are very few surface streams in the catchment. This lack of surface drainage suggests that potential recharge readily infiltrates into the groundwater system.
- Recharge is likely to comprise both diffuse and point types. Furthermore, the subsoils are reasonably free draining allowing a relatively high proportion of recharge to occur through them.
- The clean Visean Limestone aquifer provides water to the springs.
- The Visean Limestone in the region has undergone significant karstification, shown by the numerous swallow holes, turloughs, and collapse features throughout south Roscommon. Tracer test results from the general region also infer that the karst is well developed.
- Groundwater is likely to flow through interconnected, probably solutionally enlarged fracture zones and along fractures and joints outside the main fracture systems. These precise pathways are not known.
- The groundwater is likely to move from the higher ridge to the east of the springs, through the Visean Limestone in a west to north-west direction, to the lowest point of the catchment. At this point some of the groundwater emerges at the surface as the Mount Talbot Springs.
- The variation of electrical conductivity (9%) suggests that the springs respond rapidly to recharge.
- The groundwater regime in the area is complex and the available hydrogeological information does not allow a definitive understanding of the hydrogeology.

8 Delineation Of Source Protection Areas

8.1 Introduction

This section delineates the areas around the springs that are believed to contribute groundwater and that therefore require protection. The delineated areas are based on the conceptualisation of the groundwater flow pattern, as described in Section 7.7 and are presented in Figure 1.

Two source protection areas are delineated:

- ♦ Inner Protection Area (SI), designed to give protection from microbial pollution.
- ♦ Outer Protection Area (SO), encompassing the zone of contribution (ZOC) of the source.

8.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), and is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by a) the total discharge, b) the groundwater flow direction and gradient, c) the rock permeability and d) the recharge in the area.

The shape and boundaries of the ZOC are essentially based on topography. The boundaries of the ZOC and the uncertainties associated with them are as follows:

1. The **Eastern boundary** comprises the north-east to south-west trending limestone ridge in the townlands of Correal and Cuilnakeava. This ridge represents the highest point in the ZOC and forms part of a regional surface water divide as suggested by the limited surface drainage patterns in the area.
2. The **Northern Boundary** is slightly more complicated than the eastern boundary. It is based on a smaller topographic ridge, generally trending east to west, in the townlands of Cartron and Carroward. This boundary differentiates the ZOC for the springs from the Cloonalin River catchment, to the north.
3. Similarly, the **Southern Boundary** is defined by a small topographic ridge, which passes through the townland of Cloghan. This is the also the catchment boundary of the stream to the south.
4. The **Western Boundary** is defined by topography along its north-western portion. This slightly elevated ridge is a continuation of the northern boundary ridge. The springs are located in the south-west of the ZOC. It is assumed that water down-gradient of the springs will not flow back to them, but will continue flowing to the River Suck. Therefore an arbitrary buffer of 30 m is placed on the down-gradient side of the springs.

These boundaries delineate the physical limits within which the ZOC is likely to occur. It is possible that groundwater may be reaching the springs from beyond the delineated ZOC however, this cannot be determine from the limited data. The area constrained by the mapping is approximately 6 km^2.

To date, the discharge data (Section 7.6) are not comprehensive enough to undertake a water balance and thus, accurately estimate the catchment area for the Mount Talbot Springs. However, an approximation of the averaged discharge data and recharge data (Section 7.1) indicate that the delineated catchment area is large enough to meet the discharge from the springs.

Similar water balance estimates for the Cloonalin River and the stream to the south suggest that their topographic catchment areas are realistic. This infers that the shared catchment boundaries, i.e. the northern and southern ZOC boundaries, are also reasonable.

Although the area delineated by hydrogeological mapping approximates to that required by the discharge, the underlying rock is karstified. Groundwater flow through karst areas is extremely complex and difficult to predict. Flow velocities are relatively fast and variable, both spatially and temporally. Catchment areas are often difficult to define and they may change seasonally. Consequently, some uncertainty generally exists when delineating boundaries in karst areas.

8.3 Inner Protection Area

According to the National Groundwater Protection Scheme (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100 day time of travel to the supply.

Flow through the Visean Limestones in the ZOC has not been measured. However, there are permeability data for these limestones in south Roscommon; tracer tests recorded velocities of at least 24 m/hr (Section 7.3). Assuming that these flow rates are applicable to the Mount Talbot area, it is possible that groundwater could reach the source from the furthest point on the eastern boundary within 11 days.

It is therefore likely that all groundwater within the delineated catchment could reach the source in less than 100 days. Given the lack of surface drainage in the ZOC, it is likely that flow to the spring occurs mainly as groundwater. These data suggest that the entire ZOC should be incorporated into the Inner Protection Area.

9 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the source protection areas and vulnerability categories – giving a possible total of 8 source protection zones (see Table 4). In practice, this is achieved by superimposing the vulnerability map (Figure 3) on the source protection area map. Each zone is represented by a code, e.g. **SI/H**, which represents an Inner Source Protection area where the groundwater is highly vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present around any given source. Only two groundwater protection zones are present around the Mount Talbot source (Figure 4), as shown in the matrix below.

Table 4. Matrix of Source Protection Zones.

VULNERABILITY RATING	SOURCE PROTECTION	
	Inner	***Outer***
Extreme (E)	SI/E	na
High (H)	SI/H	na
Moderate (M)	Na	na
Low (L)	Na	na

10 Potential Pollution Sources

Within the ZOC, there are a number of houses and farmyards. Some of these are located within 500 m of the Mount Talbot Springs. Agriculture in the main land use in the area, which is dominated by pasture.

The hydrochemical data mainly highlights consistently elevated levels of total and faecal coliforms in raw water samples. Given the levels of other indicator parameters, the source of this contamination is likely to be organic wastes, especially from farmyard wastes.

The main hazards associated within the ZOC are therefore considered to be domestic, such as on site treatment systems (septic tanks), and agricultural (farmyard waste leakage, landspreading). The location of these activities in any part of the ZOC categorised as 'extremely' vulnerable presents a potential risk, given the potentially rapid travel time through the underlying bedrock. It should be noted that detailed assessments of hazards were not carried out as part of this study.

11 Conclusions and Recommendations

- The source at Mount Talbot is located in, and supplied by, the Undifferentiated Visean Limestone.

- The available data suggest that there is permanent overflow.
- There are few available data relating specifically to the groundwater in this general area. Therefore the ZOC boundaries are predominantly delineated by topography.
- Due to the rapid groundwater velocities through the karstified bedrock, it is considered that waters within any part of the ZOC could potentially reach the spring within 100 days. Therefore the entire ZOC has also been classified as the Inner Protection Area.
- The groundwater in the Protection Area is 'extremely' and 'highly' vulnerable to contamination.
- The enclosed concrete sump and standard of maintenance suggests that there will be limited susceptibility to surface contamination specifically at the source.
- The protection zones delineated in this chapter are based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

- It is recommended that:
  - flow monitoring is continued. Monitoring over a longer duration would enable accurate water balances to be undertaken and it would confirm whether the overflow continues during drier periods. A continuous flow through drier periods would suggest that a greater quantity may be abstracted if required.
  - karst mapping be undertaken in this area. This would highlight the possibility of further tracer testing work.
  - a drilling and groundwater monitoring programme be considered to determine groundwater levels, flow directions and gradients.
  - the present chemical and bacteriological analyses of raw water be continued. The chemical analyses should include all major ions – calcium, magnesium, sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and nitrate.
  - the potential hazards in the ZOC should be located and assessed.
  - the sump and pump house area continue to be adequately maintained to minimise the risk of inundation by surface water at the source.

12 References

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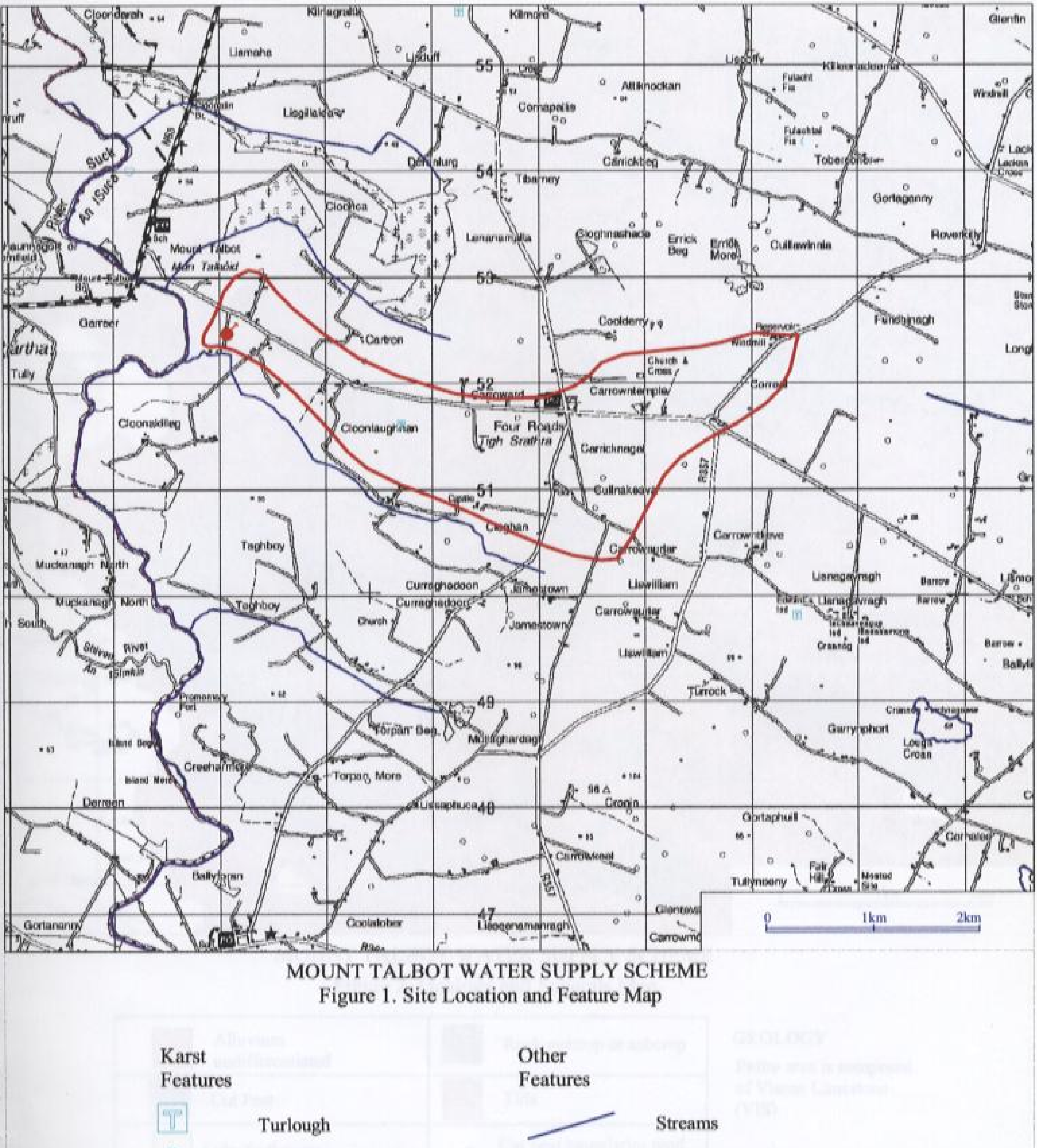
Figure 1. Site Location and Feature Map.

Figure 2. Geology and Subsoils Map.

Figure 3. Vulnerability Map.

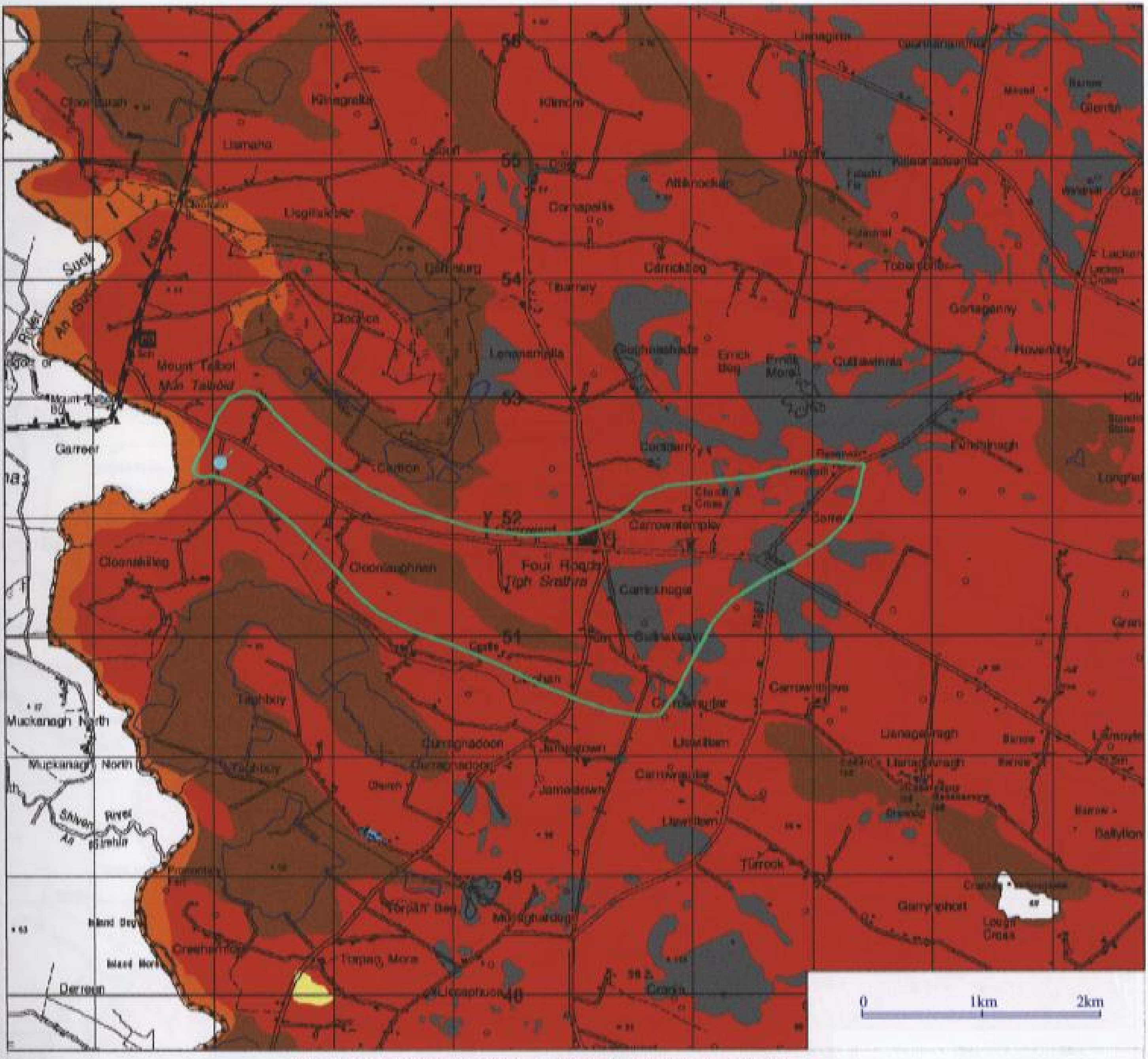
Figure 4. Source Protection Zones.



MOUNT TALBOT WATER SUPPLY SCHEME
Figure 1. Site Location and Feature Map

Karst Features		Other Features	
	Turlough		Streams
	Enclosed Depression		Zone of contribution (ZOC)
	Swallow Hole		Public Supply Spring
	Cave		
	Spring		

The topographic base is reproduced with the permission of the Ordnance Survey of Ireland



MOUNT TALBOT WATER SUPPLY SCHEME

Figure 2. Geology and Subsoils Map

Alluvium undifferentiated	Rock outcrop or subcrop
Cut Peat	Tills
Lake Sediments	Cut peat boundaries used for Vulnerability map
Lake	

GEOLOGY

Entire area is composed of Visean Limestone (VIS)

Zone of Contribution

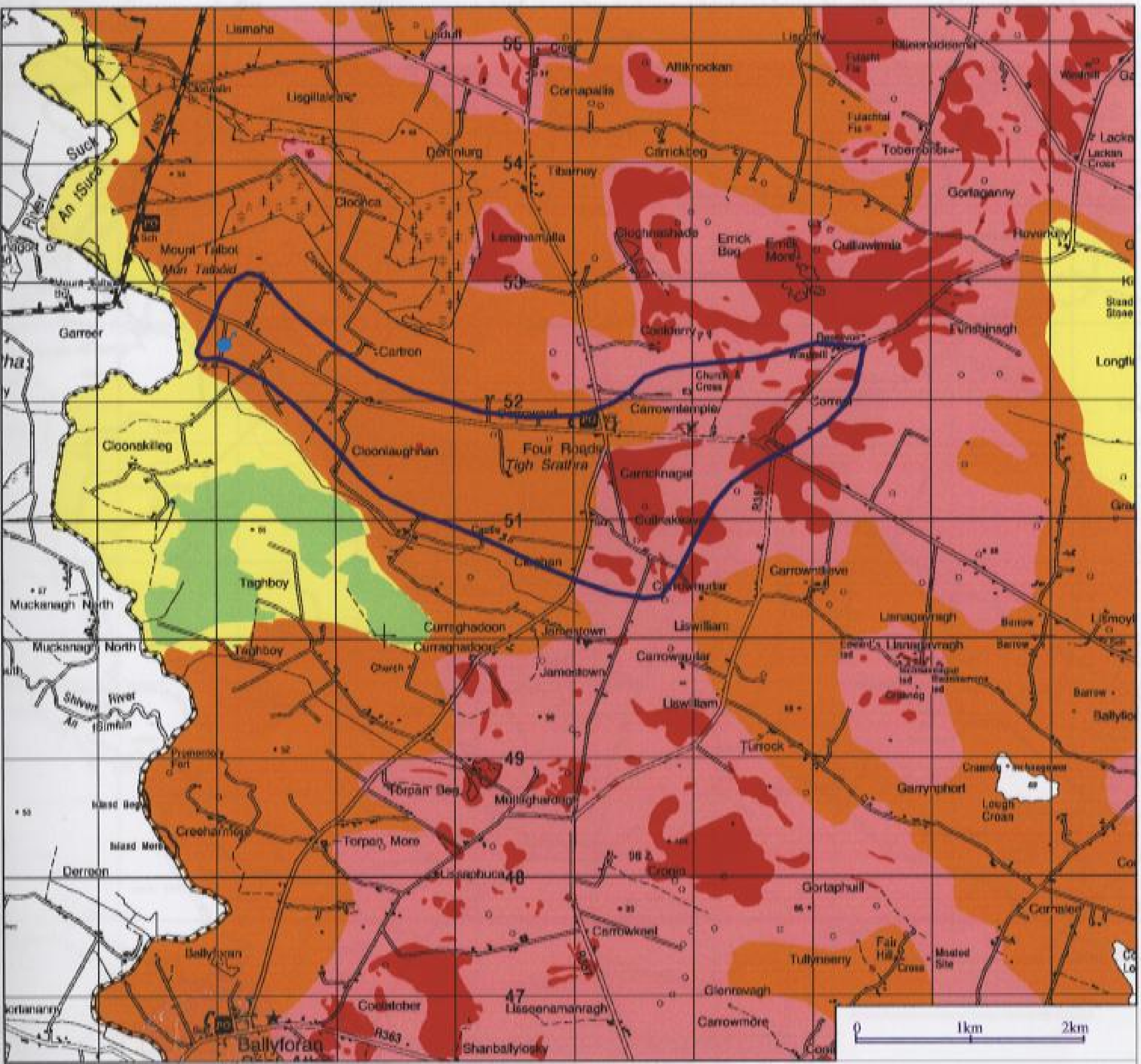
Public Supply Spring

Sources of Information

G.S.I. 1:100,000 Bedrock Series Sheet 12 : compiled by M.Geraghty, C.MacDermot and D.C.Smith.

"FIPS-IFS Soil Parent Material Map" Compiled by R. Meehan (Teagasc).

This **bedrock map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale.
Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations.



MOUNT TALBOT WATER SUPPLY SCHEME

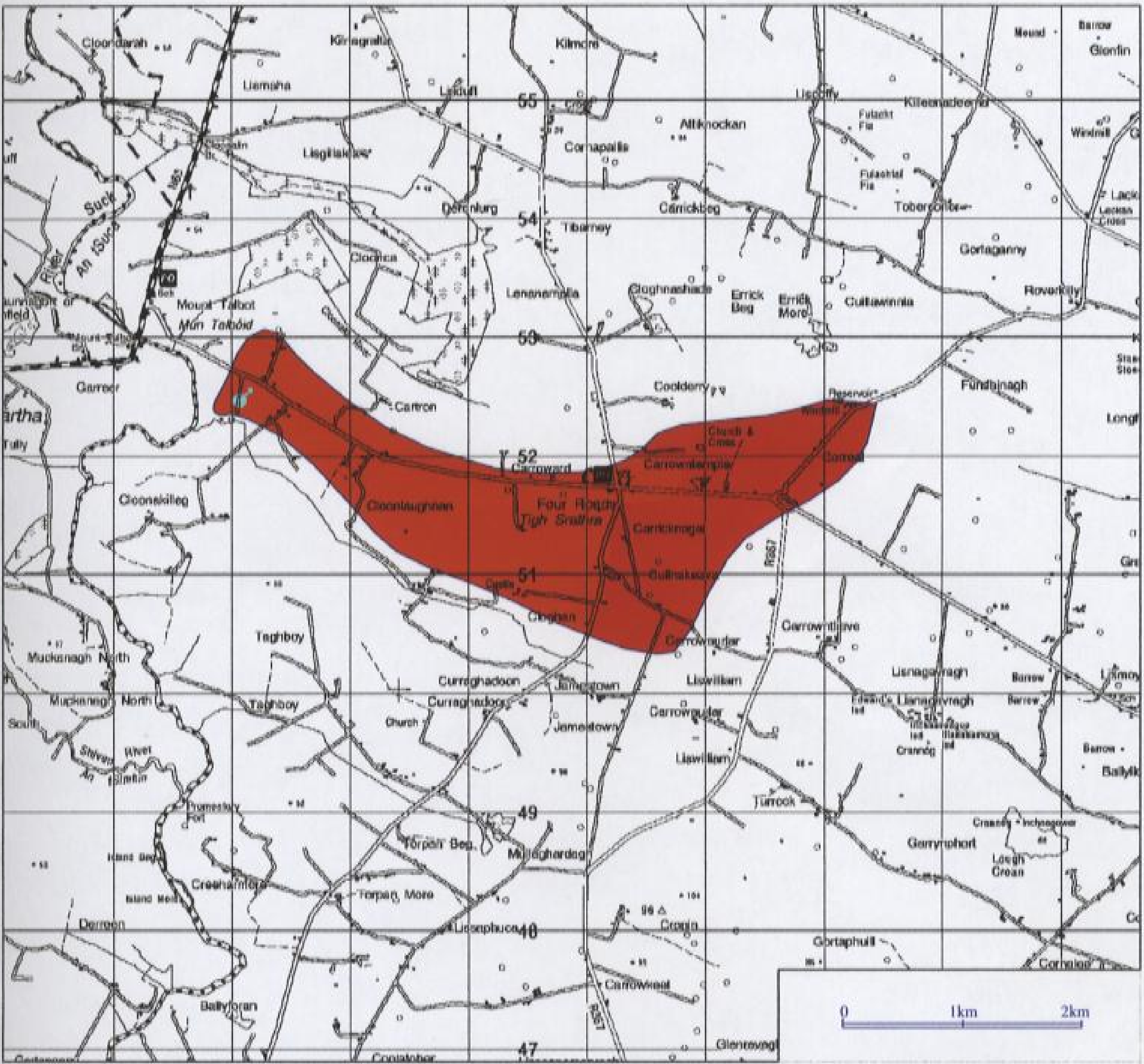
Figure 3.Vulnerability Map

- Extreme (E)
- Outcrop/Shallow rock (E)
- High (H)
- Moderate (M)
- Low (L)
- Zone of Contribution to Well
- Public Supply Spring

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the **vulnerability** of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This **vulnerability** map is designed for general information and strategic planning usage.The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments,and will frequently require site investigations to determine the risk to groundwater.



MOUNT TALBOT WATER SUPPLY SCHEME
Figure 4. Source Protection Zones

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner (SI)	
Extreme (E)		SI/E
High (H)		SI/H
Moderate (M)	not present	SI/M
Low (L)	not present	SI/L

Zone of Contribution to well (SI)

Public Supply Spring

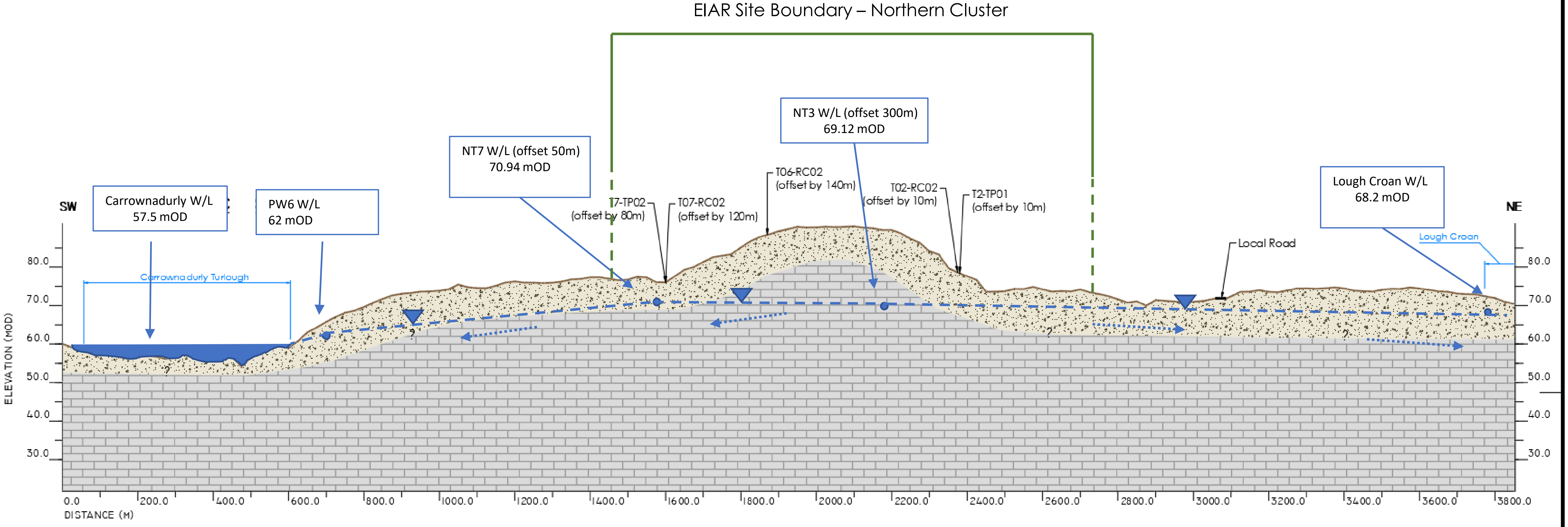
This **Source Protection Zone map** is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

APPENDIX 9-5

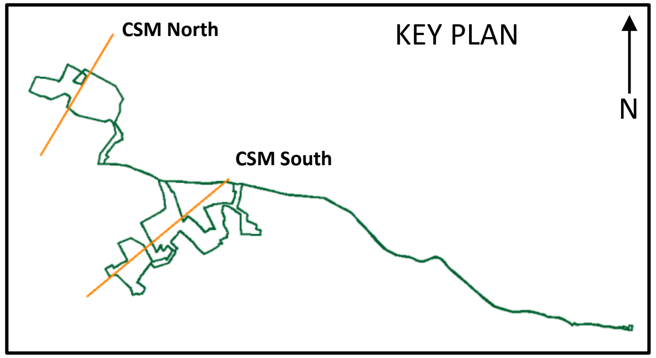
CONCEPTUAL SITE MODELS (NORTHERN AND SOUTHERN CLUSTERS)

CSM - North



LEGEND:

- Existing ground level
- Glacial till overburden
- Strong hard limestone bedrock with occasional weathered intervals



CSM Notes:

- CSM = Conceptual Site Model. This is standard terminology used in hydrogeological assessments. The CSM is defined to demonstrate an understanding of the groundwater flow characteristics below each wind turbine cluster (Northern and Southern Clusters).
- The CSMs are orientated as illustrated on the Key Plan. Their orientation is intended to be perpendicular to groundwater flow and also orientated in the direction of upstream/downstream sensitive receptors, such as turloughs and water supply sources.
- The CSMs (including the geological cross-section upon which the CSM is annotated) are based on site-specific data obtained from iterative and extensive on-site geological investigations and hydrogeological monitoring.
- Datapoints (with offset distances shown on the cross-sections) used in the drawing of these CSMs have been identified along with other important features including public roads and local turloughs.
- Note, due to the large scale of the proposed wind farm site (including the northern and southern clusters), the CSMs only illustrate a generalized geological profile. Refer to Appendix 8-5 and Chapter 8 for a detailed characterisation of the Wind Farm site geology.

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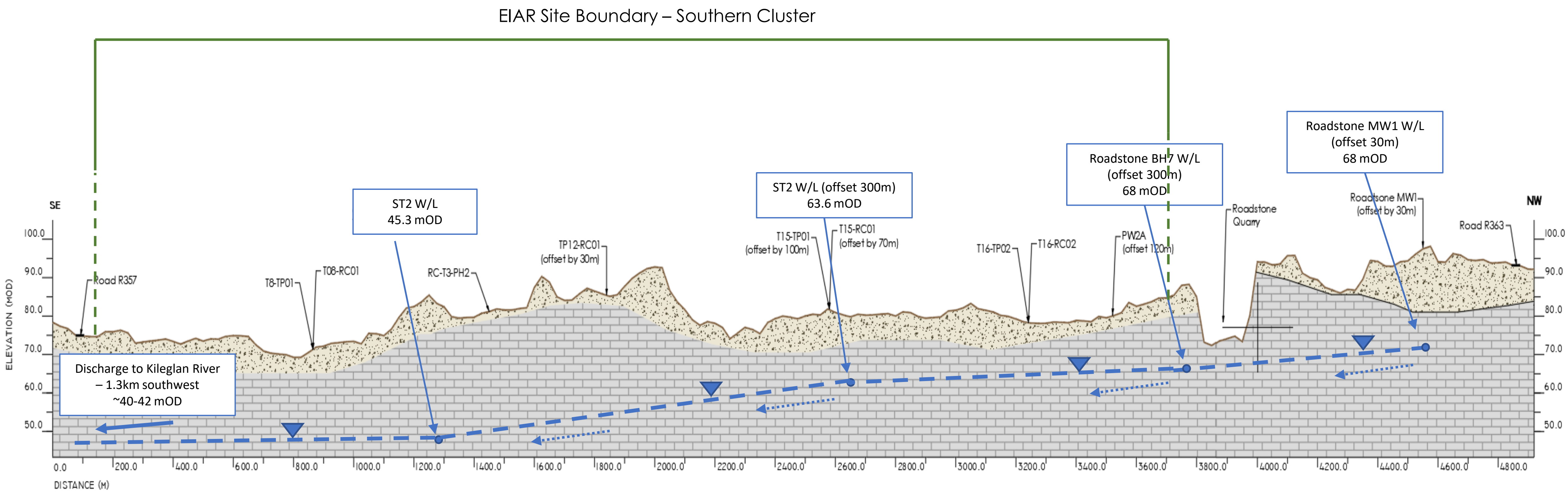
Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Title: Appendix 9-5 - Conceptual Site Models

CSM - South

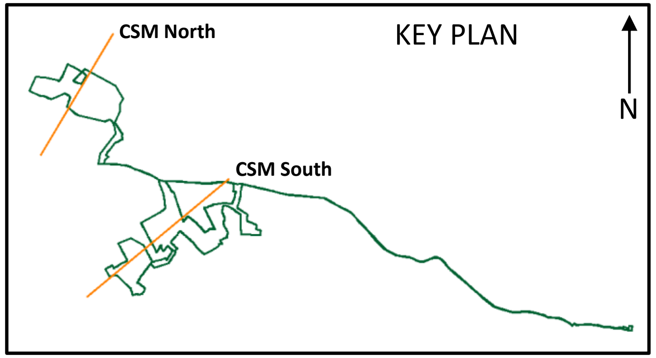


LEGEND:

Existing ground level

Glacial till overburden

Strong hard limestone bedrock with occasional weathered intervals



CSM Notes:

- CSM = Conceptual Site Model. This is standard terminology used in hydrogeological assessments. The CSM is defined to demonstrate an understanding of the groundwater flow characteristics below each wind turbine cluster (Northern and Southern Clusters).
- The CSMs are orientated as illustrated on the Key Plan. Their orientation is intended to be perpendicular to groundwater flow and also orientated in the direction of upstream/downstream sensitive receptors, such as turloughs and water supply sources.
- The CSMs (including the geological cross-section upon which the CSM is annotated) are based on site-specific data obtained from iterative and extensive on-site geological investigations and hydrogeological monitoring.
- Datapoints (with offset distances shown on the cross-sections) used in the drawing of these CSMs have been identified along with other important features including public roads and local turloughs.
- Note, due to the large scale of the proposed wind farm site (including the northern and southern clusters), the CSMs only illustrate a generalized geological profile. Refer to Appendix 8-5 and Chapter 8 for a detailed characterisation of the Wind Farm site geology.

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APPENDIX 9-6

WATER FRAMEWORK DIRECTIVE ASSESSMENT

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WATER FRAMEWORK DIRECTIVE ASSESSMENT
PROPOSED SEVEN HILLS WIND FARM, CO. ROSCOMMON

FINAL REPORT

Prepared for:

ENERGIA RENEWABLES ROI LTD.

Prepared by:

HYDRO-ENVIRONMENTAL SERVICES

DOCUMENT INFORMATION

Document Title:	**WATER FRAMEWORK DIRECTIVE ASSESSMENT PROPOSED SEVEN HILLS WIND FARM, CO. ROSCOMMON**
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current revision no:	**P1500-0_0085_FINAL_REV F0**
Author:	**MICHAEL GILL CONOR MCGETTIGAN**
Signed:	 **Michael Gill B.A., B.A.I., M.Sc., MIEI Managing Director – Hydro-Environmental Services**

Disclaimer:
This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO, on behalf of the Applicant, to complete a Water Framework Directive (WFD) Compliance Assessment for a planning application for the proposed Seven Hills Wind Farm, Co. Roscommon.

The Proposed Development comprises a 20 no. turbine wind farm, an on-site electrical substation, meteorological mast, 2 no. temporary construction compounds, underground cabling, the provision of new access roads together with the upgrade of existing access roads and all associated development works. The Proposed Development includes an underground grid connection from the proposed on-site electrical substation to the Athlone 110kV substation at Monksland, Athlone. The Seven Hills Wind Farm can be divided into two areas, the Northern Cluster and the Southern Cluster of wind turbines. The Northern Cluster includes 7 no. turbines and is located ~2.8km northwest of the village of Ballyforan and 1.5km northeast of Dysert village, Co. Roscommon. The Southern Cluster includes a further 13 no. turbines and is located ~3km southeast of Dysert, Co. Roscommon and 12km west of Athlone town, Co. Westmeath.

The purpose of this WFD assessment is to determine whether specific components or activities associated with the Proposed Development (including the proposed Wind Farm and Grid Connection route) will compromise WFD objectives or result in a deterioration or prevent the improvement of the status of any waterbodies in the vicinity or downstream of the Proposed Development site. This assessment will determine the water bodies with the potential to be impacted, describe the proposed mitigation measures and determine if the project is in compliance with the objectives of the WFD.

This WFD Assessment is an Appendix to Chapter 9 of the EIAR submitted as part of the Proposed Development planning application.

1.2 STATEMENT OF AUTHORITY

Hydro-Environmental Services (HES) are a specialist 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. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types including wind farms.

This WFD assessment was prepared by Michael Gill and Conor McGettigan.

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

Conor McGettigan (BSc, MSc) is a junior Environmental Scientist, holding an M.Sc. in Applied Environmental Science (2020) from University College Dublin. Conor has also completed a B.Sc. in Geology (2016) from University College Dublin. In recent times Conor has assisted in the preparation of hydrological and hydrogeological impact assessments for a variety of developments.

1.3 WATER FRAMEWORK DIRECTIVE

The EU Water Framework Directive (2000/60/EC), as amended by Directives 2008/105/EC, 2013/39/EU and 2014/101/EU, was established to ensure the protection of the water environment. The Directive was transposed in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 3002).

The Directive requires that all member states protect and improve water quality in all waters, with the aim of achieving good status by 2027 at the latest. Any new development must ensure that this fundamental requirement of the Directive is not compromised.

The WFD is implemented through the River Basin Management Plans (RBMP) which comprises a six-yearly cycle of planning, action and review. RBMPs include identifying river basin districts, water bodies, protected areas and any pressures or risks, monitoring and setting environmental objectives. In Ireland the first RBMP covered the period from 2010 to 2015 with the second cycle plan covering the period from 2018 to 2021.

The River Basin Management Plan (2018 - 2021) objectives, which have been integrated into the design of the proposed wind farm development, include:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2027;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objectives and (2) addressing more complex issues that will build knowledge for the third cycle.

Our understanding of these objectives is that water bodies, 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.

We note that the River Basin Management Plan 2022-2027 is out for public consultation presently, and that closed in March 2022.

2. WATERBODY IDENTIFICATION CLASSIFICATION

2.1 INTRODUCTION

This section identifies those surface water and groundwater bodies with potential to be affected by the Proposed Development and reviews any available WFD information.

2.2 SURFACE WATERBODY IDENTIFICATION

Regionally the Proposed Development site is located primarily within the Upper Shannon (26D) catchment, with a small section to the southeast of the Wind Farm site within the Upper Shannon (26G) catchment, all within Hydrometric Area 26 (Upper Shannon) of the Irish River Basin District.

On a more local scale, the majority of the Proposed Development site (Northern and Southern Clusters) is broadly contained within the River Suck sub-catchment (Suck_SC_090), with a small section in the east of the Southern Cluster (T19 & T20) contained within the Cross River sub-catchment (Shannon[Upper]_SC_100). The Grid Connection route is mostly located within the Cross River sub-catchment (Shannon[Upper]_SC_100), with a small section close to Athlone, including the Athlone 110kV Monksland substation, located in the Shannon[Upper]_SC_090 sub-catchment.

Within the Suck_090 sub-catchment, the River Suck is located ~3.5km west of the Southern Cluster, and ~3.9km west of the Northern Cluster. The Suck River flows south through the village of Ballyforan, west of Dysert, continuing south through the town of Ballinasloe before turning southeast and discharging to the River Shannon at Shannonbridge, ~20km south of the southern cluster. Within this sub-catchment much of the Proposed Development is located within the Ballyglass_010 river-sub-basin. A small area in the northwest of the Northern Cluster is mapped within the Suck_120 river sub-basin. Further south, the southern section of the Southern Cluster is located within the Killeglan_010 and the Killeglan Tributary North_010 river sub-basins. The Ballyglass and Killeglan rivers discharge into the Suck River to the west of the Wind Farm site.

Within the Cross River sub-catchment, the Cross River is situated ~3.2km east of the nearest Southern Cluster turbines and it drains a catchment that is located east of Lough Croan/Cuilleenirwan Lough and generally south of Lough Funshinagh. The headwaters of the Cross River is on the western slope of a small hill (~80mOD) in the townland of Kilcar and is mapped as a series of smaller water features near Dooloughan Lough. The Cross River flows to the southeast before discharging into the River Shannon (Shannon Upper) to the south of Athlone. Within this sub-catchment the Proposed Development is located within the Cross (Roscommon)_020 river sub-basin.

Following its confluence with the Suck River at Shannonbridge, the River Shannon (Shannon Lower) continues to flow southwards discharging into the Lough Derg lake waterbody to the south of Portumna. The Shannon then flows to the southwest entering the Limerick Dock transitional waterbody in the vicinity of Limerick City. To the west of Limerick, the River Shannon flows through the Upper and Lower Shannon estuaries before entering the Mouth of the Shannon coastal waterbody.

There are 5 no. watercourse crossings along the proposed Grid Connection route. 4 no. crossings are located at existing bridge and culvert crossings over mapped river waterbodies (Ballyglass_010, Cross (Roscommon)_020 (2 no. crossings) and Cross (Roscommon)_030 river waterbodies). An additional crossing is proposed over an unnamed local drain which is not a WFD mapped waterbody. This unmapped drain is located in the Cross(Roscommon)_020 river sub-basin.

Figure A below presents a local hydrology map of the area, highlighting those SWBs downstream of the Wind Farm site and Grid Connection route as far as Lough Derg.

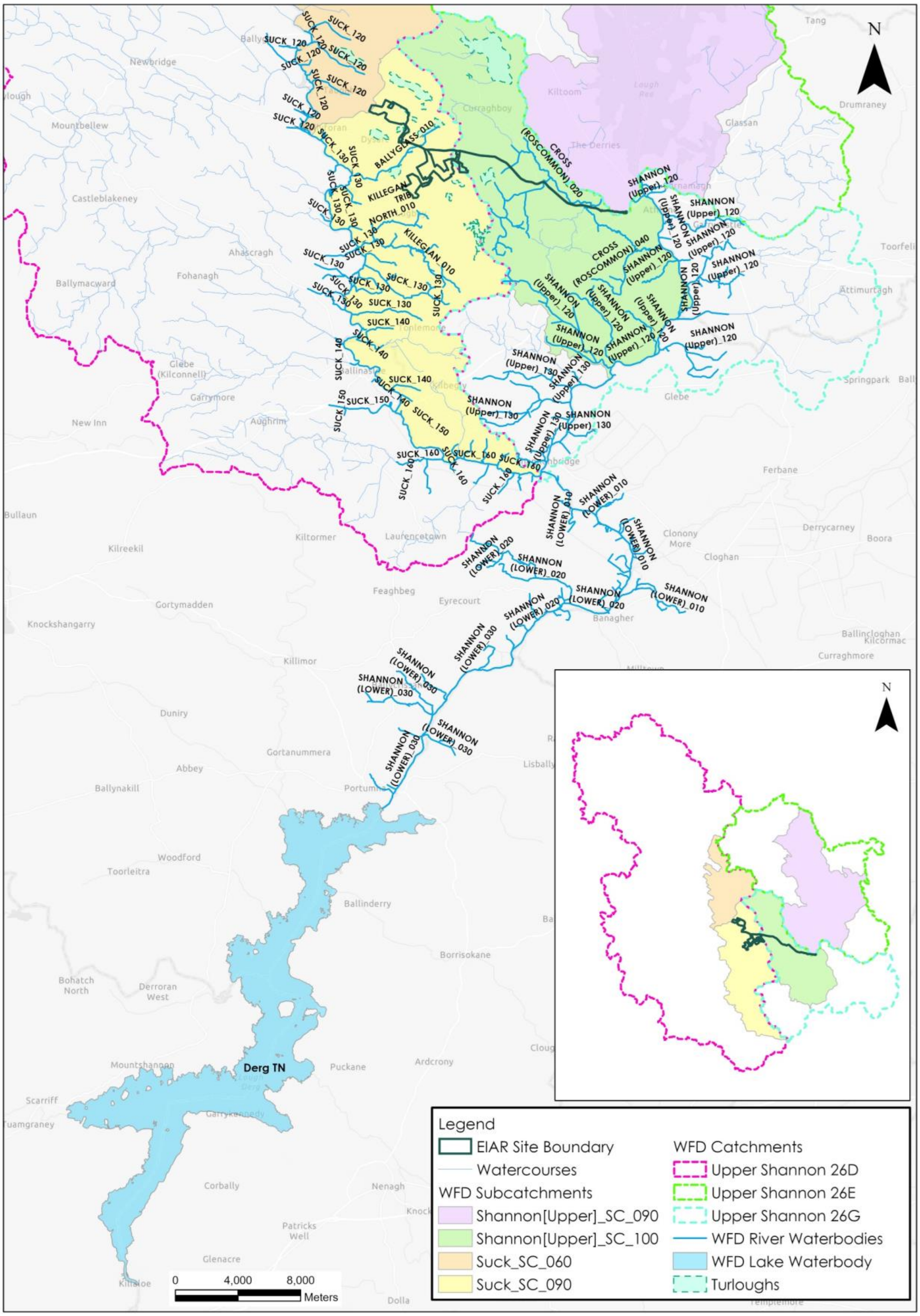

Figure A: Local Hydrology Map

2.3 SURFACE WATER BODY CLASSIFICATION

A summary of the WFD status and risk result for Surface Water Bodies (SWBs) downstream of the Proposed Development are shown in **Table A**.

Local Groundwater Body (GWB) and Surface water Body (SWB) status information is available from (www.catchments.ie).

To the west of the Wind Farm site, the Suck_120 and the Suck_130 river waterbodies achieved "Moderate" and "Good" status respectively in both the 1st (2010-2015) and 2nd (2013-2018) WFD cycles. The Ballyglass_010 (which drains the majority of the wind farm site) achieved "Good" status in the latest WFD cycle while the Killeglan Trib. North_010 river waterbody achieved "Moderate" status. The Killeglan_010 river waterbody has improved from "Poor" status in the 1st WFD cycle to "Moderate" in the 2nd WFD cycle. Further downstream, the Suck_140 and Suck_150 river waterbodies achieved "Moderate" status in both WFD cycles. Upstream of its confluence with the River Shannon, the Suck_160 river waterbody is of "Poor" status.

To the east of the Wind Farm site, the overall status of the Cross (Roscommon) river (Cross(Roscommon)_020, Cross(Roscommon)_030 and Cross(Roscommon)_040) ranges from "Moderate" to "good" status. Downstream of Athlone and its confluence with the Cross river, the River Shannon (Shannon(Upper)_120) achieved "Poor" status in both WFD cycles. Further downstream the Shannon(Upper)_130 waterbody achieved "Poor" status. Downstream of its confluence with the Suck River the Shannon(Lower)_010 river waterbody remains unassigned with regards WFD status. Further downstream the Shannon(Lower)_020 and Shannon(Lower)_030 SWBs achieved "Moderate" status in the latest WFD cycle. Meanwhile, the Lough Derg lake waterbody experienced an improvement in status, from being of "poor" status in the 1st WFD cycle to being of "Moderate" status in the 2nd WFD cycle.

The risk status of the SWBs in the vicinity and downstream of the site are largely "at risk" or "under review" and is presented in **Table A**.

The 3rd Cycle Upper Shannon Catchment (26G) Report states that morphological issues and nutrients remain the most prevalent issues in this catchment. Agriculture is a significant pressure on the Cross(Roscommon)_030 river waterbody. Urban wastewater is also listed as a significant pressure on this SWB due to the Monksland Wastewater treatment agglomeration. Peat drainage and extraction are listed as significant pressures in the Cross(Roscommon)_040 and Shannon(Upper)_120 SWBs. This has resulted in increased sediment loads which has the potential to alter habitats, morphology and hydrology.

The 3rd Cycle Upper Shannon (Suck) Catchment (26D) Report states that excess nutrients and morphological impacts are the most prevalent issues in the Suck Catchment. The main pressures downstream of the Wind Farm site are hydromorphological issues and extractive industry. The Suck_030 has been influenced by land drainage modifications. Meanwhile, peat extraction and drainage has been identified as a significant pressure on the Suck_150 and Killeglan_010 river waterbodies.

The SWB status for the 2013-2018 WFD cycle are shown on **Figure B.**

Table A: Summary WFD Information for River Water Bodies

SWB	Overall Status 2010-2015	Risk Status 2010-2015	Overall Status 2013-2018	Risk Status 2013-2018	Pressures
Suck_120	Moderate	At risk	Moderate	At risk	Hydromorphology
Suck_130	Good	Not at risk	Good	Not at risk	-
Ballyglass_010	Unassigned	Under review	Good	Under review	-
Killeglan Trib North_010	Unassigned	Under review	Moderate	Under review	Extractive industry
Killeglan_010	Poor	At risk	Moderate	At risk	Peat
Suck_140	Moderate	At risk	Moderate	At risk	Hydromorphology
Suck_150	Moderate	At risk	Moderate	At risk	Hydromorphology & Peat
Suck_160	Unassigned	Under review	Poor	Under review	Hydromorphology & extractive industry
Cross(Roscommon)_020	Good	Not at risk	Good	Under review	-
Cross(Roscommon)_030	Good	Not at risk	Moderate	At risk	Agriculture, hydromorphology & urban wastewater
Cross(Roscommon)_040	Moderate	At risk	Moderate	At risk	Hydromorphology & Peat
Shannon(Upper)_110	Unassigned	Under Review	Poor	At risk	Agriculture, atmospheric & hydromorphology
Shannon(Upper)_120	Poor	At risk	Poor	At risk	Hydromorphology & Peat
Shannon(Upper)_130	Unassigned	Under review	Poor	Under review	Industry & urban wastewater
Shannon(Lower)_010	Unassigned	Under review	Unassigned	Under review	Urban wastewater
Shannon(Lower)_020	Good	Not at risk	Moderate	At risk	-
Shannon(Lower)_030	Unassigned	Under Review	Moderate	Under review	Anthropogenic
Derg TN	Poor	At risk	Moderate	At risk	Agriculture, hydromorphology & invasive species

2.4 GROUNDWATER BODY IDENTIFICATION

According to data from the GSI database and bedrock geology series (www.gsi.ie), The Wind Farm site and the majority of the Grid Connection route are underlain by a Regionally Important Aquifer – Karstified (conduit), which consists of Visean Limestones (Undifferentiated). A small area in the east of the route, in the vicinity of Athlone 110kV substation, is underlain by a Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones, which consists of Dinantian Pure Unbedded Limestones.

The majority of the Wind Farm site is located within the Suck South GWB (18 no. turbines, 3 no. soil storage areas and 2 no. temporary construction compounds). A small area in the west of the Southern Cluster is located within the Funshinagh GWB (2 no. turbines and the proposed on-site electrical substation).

The proposed Grid Connection route is primarily located within the Funshinagh GWB, with a small section near the Wind Farm site located within the Suck South GWB. A small section in the east of the route is underlain by the Athlone West GWB.

Due to the local hydrogeological regime, there is a high connectivity between surface and groundwaters in the vicinity of the site. Several turloughs have been identified in the lands surrounding the Wind Farm site.

2.5 GROUNDWATER BODY CLASSIFICATION

Both the Suck South GWB (IE_SH_G_225), Funshinagh GWB (IE_SH_G_091) and Athlone West GWB (IE_SH_G_014) are assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB. The risk status of the Suck South and Funshinagh GWBs is currently under review while the Athlone West GWB has been deemed to be not at risk of failing to meet its WFD objectives. No significant pressures have been identified to be impacting on these GWBs.

The GWB status for the 2013-2018 WFD cycle are shown on **Figure B.**

Table B: Summary WFD Information for Groundwater Bodies

GWB	2010-2015 Status	2010-2015 Risk Status	2013-2018 Status	2013-2018 Risk Status	Pressures
Suck South	Good	Under review	Good	Under review	-
Funshinagh	Good	Under review	Good	Under review	-
Athlone West	Good	Not at risk	Good	Not at risk	-

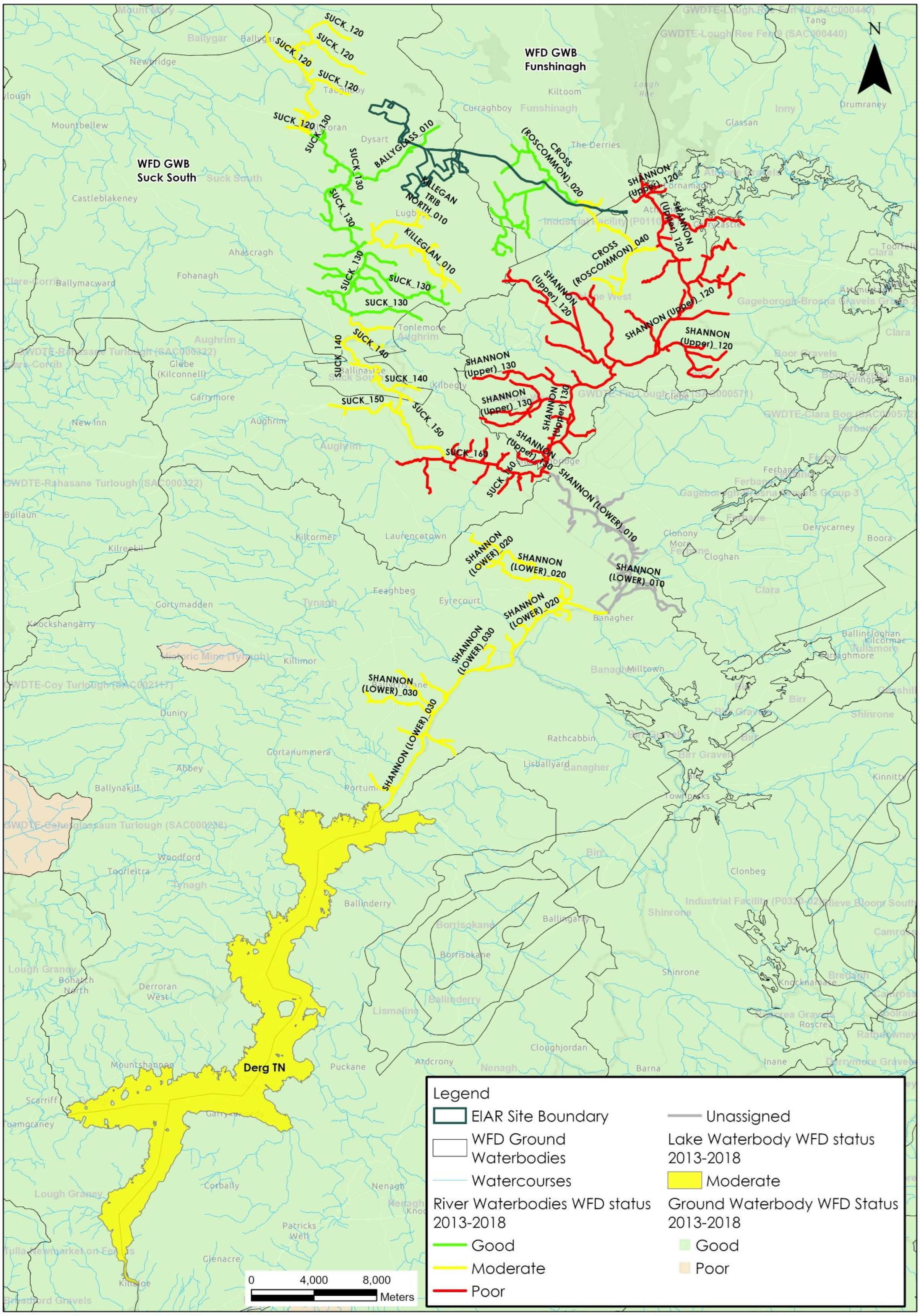

Figure B: WFD Groundwater and Surface Waterbody Status (2013-2018)

3. HYDROLOGICAL & HYDROGEOLOGICAL SITE CONDITIONS

As part of the Environmental Impact Assessment for the proposed Seven Hills Wind Farm an extensive database of geological and hydrogeological information has been accrued through site investigations and a review of available historical site investigation data. Site investigations at the Seven Hills Wind Farm site date from 2010 to 2021 and include 152 no. site investigation points (trial pits and boreholes), 114 laboratory tests (PSD, permeability and density analysis of subsoil samples) accompanied by 80 no. geophysical surveys. In terms of hydrology, 19 no. water level monitoring devices were installed in groundwater wells, with an additional 8 no. monitoring devices installed within turloughs. Local groundwater level monitoring has been completed over a period of 17 months from January 2020 to May 2021.

A conceptual site model has been development from the available site-specific data and is summarised below:

- Rainfall falling within the Wind Farm site will percolate through the relatively thick soils/subsoils and reach the underlying bedrock aquifer.
- The ability for the soils and subsoils to accept rainfall is evident from the lack of surface water courses such as minor streams and drainage channels within the Wind Farm site, as well as the lithology of the subsoils defined through the extensive site investigation.
- Once the rainfall has infiltrated and percolated through the subsoil layer, it will recharge to the underlying limestone which through site investigations has been proven to be medium hard to hard, competent and lacking any significant karst features.
- Groundwater level montoring has revealed a significant hydraulic head between the turloughs surrounding the proposed Wind Farm site and the Suck River. Water level monitoring of the turloughs reveal a gradual buildup of water during the winter months and a slow recession of groundwater levels in the spring. This hydrogeological data does not suggest the presence of fast flowing groundwater movements in enlarged fracture conduits typical of karst systems.
- Instead groundwater moves slowly through the underlying hard competent limestone i.e. there is no free-flowing karst drainage network underlying the proposed Wind Farm site. Karst features are not ubiquitous in the area of the Wind Farm site.
- Groundwater flows in a southwest direction from the highest groundwater areas (>70mOD) to the lowest areas (Ballyglass river and River Suck at ~40-45 mOD) and discharges to these surface water features.
- Where local topography varies (*i.e.* on a northwest sloping hill), the groundwater flow direction may follow this local variance for a short period, however, it will eventually normalise to the regional groundwater gradient and flow southwest.

This understanding of the hydrological and hydrogeological regime of the Proposed Development site aids in the screening of those waterbodies with the potential to be impacted by the Proposed Development and the assessment of the potential impacts on each respective waterbody.

4. WFD SCREENING

As discussed in **Section 2**, there are a total of 18 no. river water bodies located downstream of the Wind Farm site/Grid Connection route and upstream of Lough Derg. In addition, 2 no. groundwater bodies underlie the proposed Wind Farm site.

4.1 SURFACE WATER BODIES

As shown in Figure A above, there are 18 no. river water bodies located in the vicinity or downstream of the Proposed Development site.

With consideration for the construction, operational and decommissioning phases of the Proposed Development, it is considered that all sections of the Ballyglass (Ballyglass_010), Killeglan (Killeglan-010), Suck (Suck_130, _140, _150 and Suck_160) and Cross (Cross(Roscommon)_020, _030 and _040) rivers downstream of the site are carried through into the WFD Impact Assessment. The Proposed Development works within the Wind Farm site must not in any way result in a deterioration in the status of these SWBS and/or prevent them from meeting the biological and chemical characteristics for good status in the future.

The Suck_120 SWB located to the northwest of the Northern Cluster has been screened out due its location upstream of all development infrastructures. Similarly, the Killeglan Trib North_010 SWB has been screened out due to the absence of key development works within the catchment of this river waterbody. The proposed works have no potential to cause a deterioration in the status of these screened out SWBs and/or jeopardise their attainment of good surface water status due to the lack of proposed development works in the upstream catchment to these waterbodies and the local hydrogeological regime described in Section 3 above.

All waterbodies along the proposed Grid Connection route (Ballyglass_010, Cross(Roscommon)_020, _030 and Shannon(Upper)_110) are carried through to the WFD Impact Assessment. The Proposed Development works along the Grid Connection route must not in any way result in a deterioration in the status of these SWBS and/or prevent them from meeting the biological and chemical characteristics for good status in the future.

All remaining sections of the River Shannon (Shannon (Upper)_120, 130, Shannon (Lower)_010, _020 and _030) downstream of the Proposed Development, including Lough Derg, have been screened out due to the large volumes of water within these SWBS and the large catchment area draining to these SWBs. The Proposed Development has no potential to cause a deterioration in the status of these waterbodies and/or jeopardise their attainment of good surface water status in the future because of the prevailing hydrogeological conditions local to the Proposed Development (largely a groundwater dominated environment) any the scale of the downstream catchments and their relative volumetric flows in comparison to those arising from the Proposed Development site (which has to flow through a groundwater system before entering the downstream surface water system).

Note that while the Shannon(Lower)_010 river waterbody is unassigned with regards WFD status, the Proposed Development is remote from this waterbody and comprises a very small percentage of the total catchment area to this surface waterbody. In addition, there are no direct discharges to surface waters at the Wind Farm site, significantly reducing any potential impact on downstream surface waters. Therefore, irrespective of the condition of the Shannon(Lower_110) waterbody if it was categorised, and due to its distant location from the wind farm site, the Proposed Development has no potential to cause a deterioration in the status of the waterbody and/or jeopardise its attainment of good surface water status or good surface water chemical status in the future.

4.2 GROUNDWATER BODIES

With respect to groundwater bodies, Suck South (IE_SH_G_225), Funshinagh (IE_SH_G_091) and Athlone West (IE_SH_G_014) GWBs are carried through into the WFD Impact Assessment due to their location directly underlying the Proposed Development.

4.3 WFD SCREENING SUMMARY

A summary of WFD Screening discussed above is shown in **Table C**.

While several SWBs are screened in due to their proximity to the Wind Farm site it is worth noting that no direct surface water linkages exist between the Wind Farm site, making groundwater the key receptor for the Proposed Development.

Table C: Screening of WFD water bodies located within the study area

Type	WFD Classification	Waterbody Name/ID	Inclusion in Assessment	Justification
Surface Water Body	River	Suck_120	No	While the northwest of the Wind Farm site is mapped within the catchment area to the Suck_120 SWB, no development infrastructure is located within this sub-basin. All development works associated with the proposed Wind Farm are located downstream of the Suck_120 SWB. Therefore, the Suck_120 SWB has been screened out as the Proposed Development has no potential to impact the status of this SWB.
	River	Ballyglass_010	**Yes**	The majority of the Wind Farm site, including 16 no. turbines, is mapped within the catchment area of the Ballyglass_010 SWB. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Suck_130	**Yes**	The Suck_130 SWB is located directly downstream of the Ballyglass_010 and Killeglan_010 SWBs and in close proximity to the site (<1km). An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Killeglan Trib North_010	No	A small area in the southwest of the Southern Cluster is mapped within the catchment area to the Killeglan Trib North_010 SWB. However, no key development infrastructure is located within this sub-basin. Therefore, the Killeglan Trib North_010 SWB has been screened out as the Proposed Development has no potential to impact the status of this SWB.
	River	Killeglan_010	**Yes**	Much of the south of the Southern Cluster, including 2 no. turbines, is located within the catchment area to the Killeglan_010 SWB. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Suck_140	**Yes**	The Suck_140 SWB is located directly downstream of the Suck_130 SWB and in close proximity to the site (~8.5km). An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Suck_150	**Yes**	The Suck_150 SWB is located directly downstream of the Suck_140 SWB. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Suck_160	**Yes**	The Suck_160 SWB is located directly downstream of the Suck_150 SWB. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Cross(Roscommon)_020	**Yes**	The east of the Southern Cluster, including 2 no. turbines, is located within the catchment area to the Cross_020 SWB. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Cross(Roscommon)_030	**Yes**	The Cross_030 SWB is located directly downstream of the Cross_020 SWB and in close proximity to the site (~6.8km). An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Cross(Roscommon)_040	**Yes**	The Cross_040 SWB is located directly downstream of the Cross_030 SWB and <10km from the site. An assessment is required to consider the potential impacts of the

				Proposed Development on this SWB.
	River	Shannon(Upper)_110	**Yes**	The eastern section of the proposed Grid Connection works is located within the Shannon(Upper)_110 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Shannon(Upper)_120	No	The Shannon(Upper)_120 SWB has been screened out due to its distant location from the site (~12.5km) and the large volumes of water within the River Shannon.
	River	Shannon(Upper)_130	No	The Shannon(Upper)_130 SWB has been screened out due to its distant location from the site (~15km), the large volumes of water within the River Shannon and the emergence of new pressures on this SWB (*i.e.* industry & urban wastewater).
	River	Shannon(Lower)_010	No	The Shannon(Lower)_010 SWB has been screened out due to its distant location from the site (~18km), the large volumes of water within the River Shannon and the emergence of new pressures on this SWB (*i.e.* urban wastewater).
	River	Shannon(Lower)_020	No	The Shannon(Lower)_020 SWB has been screened out due to its distant location from the site (~28km), the large volumes of water within the River Shannon and the emergence of new pressures on upstream SWBs.
	River	Shannon(Lower)_030	No	The Shannon(Lower)_030 SWB has been screened out due to its distant location from the site (~29km), the large volumes of water within the River Shannon and the emergence of new pressures on upstream SWBs.
	Lake	Lough Derg TN	No	The Lough Derg SWB has been screened out due to its distant location from the site (~39km) and the large volumes of water within Lough Derg.
Groundwater Body	Groundwater	Suck South	**Yes**	The majority of the Wind Farm site including 18 no. turbines overlies the Suck South GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB.
	Groundwater	Funshinagh	**Yes**	The eastern section of the Southern Cluster, including 2 no. turbines, overlies the Funshinagh GWB. Additionally, the majority of the proposed Grid Connection route overlies this GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB.
	Groundwater	Athlone West	**Yes**	The eastern section of the proposed Grid Connection route overlies the Athlone West GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB.

5. WFD COMPLIANCE ASSESSMENT

5.1 PROPOSALS

The Proposed Development includes 20 no. turbines, underground Grid Connection, 110kv electrical substation, temporary construction compounds (2 no.), overburden storage areas (6 no.), met mast, new and upgraded access roads and all associated site development works including drainage infrastructure and landscaping.

Due to the local hydrological/hydrogeological regime of the site, with a distinct absence of a surface water drainage network and relatively thick glacial soils/subsoils, rainfall falling within the site percolates to ground and into the underlying bedrock aquifer. Therefore, the underlying Suck South and Funshinagh GWBs are particularly susceptible to potential effects associated with the Proposed Development. The primary risks to groundwater at the site will be from cementitious materials and hydrocarbon spillage and leakages.

No direct surface water connections exist between the Wind Farm and downstream surface watercourses *i.e.* Ballyglass, Suck and Cross Rivers. All hydraulic connections are indirect, and via the underlying groundwater flow system. Rainfall (recharging to the ground) from the Wind Farm site will only reach these SWBs via groundwater recharge and groundwater flow. While the proposed Grid Connection route is generally distant from any hydrological features, there are 5 no. river crossings along the proposed route (1 no. crossing on the Ballyglass_010 SWB, 2 no. crossings on the Cross_020 SWB, 1 no. crossing on an unmapped drain within the Cross_020 sub-basin and 1 no. crossing along the Cross_030 SWB). The primary risk to surface waters will be entrained suspended sediments (soil particles) in site runoff during earthworks along with cement-based compounds and hydrocarbons spillage and leakages.

5.2 POTENTIAL EFFECTS

5.2.1 Construction Phase (Unmitigated)

5.2.1.1 Potential Surface Water Quality Effects from Works within Wind Farm Site

Construction phase activities including site levelling/construction and building turbine foundation excavation and the excavation of the Grid Connection trench will require earthworks resulting in removal of vegetation cover and excavation of mineral soil/subsoil (where present) and bedrock in certain areas, The main risk will be from surface water runoff from spoil storage areas and excavation drainage/dewatering during construction works. These activities can result in the entrainment of suspended solids in surface waters. However, no direct pathways exist between the Wind Farm site and downstream surface waterbodies. Therefore, construction phase activities within the Wind Farm site do not have the potential to increase the suspended sediment load or turbidity in downstream surface water receptors.

Hydrocarbons and cement-based compounds will also be used during the construction phase. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to surface waters at all construction. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in the death of aquatic organisms. However, no direct surface water pathways exist between the Wind Farm site and downstream surface waterbodies. Therefore, accidental spillage of hydrocarbons within the wind farm site have limited potential to impact the water quality in downstream surface watercourses.

Release of effluent from wastewater treatment systems also has the potential to impact on groundwater and surface waters if site conditions are not suitable for an on-site percolation unit. There are 2 no. construction compounds proposed (1 no. within the Northern Cluster and 1 no. within the Southern Cluster).

As described above, surface water draining from an active construction site can contain elevated levels of suspended sediment, cementitious runoff and/or hydrocarbons depending on the nature of the construction activity. Additionally, any alteration of the drainage regime within a site can impact on the volume of runoff which leaves the site. These impacts can affect the quantity and quality of downstream surface waterbodies (where a flow path exists between the site and the waterbody).

However, no direct surface water pathways exist between the Wind Farm site and downgradient watercourses, and all pathways are via groundwater recharge and groundwater flow. Therefore, the proposed works within the Wind Farm site have limited potential to alter the status of downstream surface waterbodies. As such, we consider that there will be no change to the WFD status of downstream surface watercourses as a result of the construction activities within the proposed Wind Farm site.

A summary of potential status change to SWBs arising from potential water pollution (suspended solids entrainment, hydrocarbon spillage, release of cement-based products and/or wastewater) during the unmitigated construction phase are outlined in **Table D**.

Table D: Potential Surface Water Quality Effects from Works Within Wind Farm Site during Construction Phase (Unmitigated)

WFD Element	WFD Code	Current Status	Assessed Potential Status Change
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500l	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate

5.2.1.2 Potential Surface Water Quality Effects along Grid Connection Route

Based on the WFD mapping, there will be a requirement for 5 no. watercourse crossings along the proposed Grid Connection route (located at existing bridges and culverts). The proposed Grid Connection route will run along the R363, which bisects the Northern and Southern Clusters, crossing the Ballyglass_010 SWB to the west of the Southern Cluster. The Grid Connection route will continue along the R363 to the east of the Southern Cluster, transitioning to the R362 near the townland of Ballymullavill. The Grid Connection route then crosses 2 no. mapped tributaries of the Cross River and an unmapped local drain within the Cross(Roscommon)_020 river sub-basin. Further to the southeast, the route crosses the Cross

River (_030) in the townland of Bellanamullia before reaching the Athlone 110 kV substation at Monksland, located within the Shannon(Upper)_110 river sub-basin.

No in-stream works are required at any of these watercourse crossings, however due to the close proximity of local waterbodies to the Grid Construction work at the crossing locations, there is a potential for surface water quality impacts during trench excavation work due to runoff from the road surface. This runoff may contain elevated concentrations of suspended sediment, cementitious runoff and/or hydrocarbons.

Construction activities along the Gird Connection route have the potential to adversely impact the status of the Ballyglass_010, Cross(Roscommon)_020 and Cross(Roscommon)_030 SWBs. The status of the Shannon(Upper)_110 will not be impacted due to absence of surface watercourses in the area of the proposed Grid Connection works in this river sub-basin. Note that the closest mapped surface waterbody within the Shannon(Upper)_110 sub-basin is located in excess of 2km from the proposed Grid Connection route.

A summary of potential status change to SWBs arising from works along the proposed Grid Connection route during the unmitigated construction phase are outlined in **Table E**.

Table E: Potential Surface Water Quality Effects along Grid Route during Construction Phase (Unmitigated)

WFD Element	WFD Code	Current Status	Assessed Potential Status Change
Ballyglass_010	IE_SH_26B150840	Good	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Moderate
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Poor
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor

5.2.1.3 Potential Effects on Groundwater Quality/Quantity and Flow Patterns

As described in **Section 5.2.1.1** and **Section 5.2.1.2**, the accidental spillage of hydrocarbons, the release of effluent from wastewater treatment systems and the release of cement-based products have the potential to negatively impact water quality at the Proposed Development (Wind Farm site and Grid Connection route). Due to the absence of a surface water drainage network and the permeable nature of the underlying glacial soils and subsoils, groundwater underlying the Wind Farm site is susceptible to pollution from construction related activities. Groundwater quality along the Grid Connection route will also be vulnerable to pollution during construction activities but to a lesser extent than at the wind farm site due to the scale of the works.

In addition, groundwater quantity and flows underlying the Proposed Development have the potential to be impacted:

The alteration of groundwater recharge rates due to the activation of karst features: A comprehensive site investigation dataset has been accrued between 2010-2021 within the Seven Hills Wind Farm site. The collated site data has not identified any significant karst features within the underlying bedrock, described as generally medium hard to hard Limestone. The bedrock below the proposed Seven Hills Wind Farm Site does not contain an abundance of karst flow systems. In addition, groundwater levels have been found to be below the level of emplacement of the turbine bases in both the Northern and Southern Clusters.

Effects on groundwater levels due to excavation dewatering: Temporary dewatering of turbine bases during construction has the potential to impact on local groundwater levels. Groundwater levels across the proposed Wind Farm site (Northern and Southern Clusters) are well defined through monitoring of numerous groundwater wells, site investigation boreholes and turloughs. Known winter groundwater levels are significantly below the proposed formation levels of all turbines, and as such we can confirm there will be no groundwater dewatering requirements during turbine base construction. No groundwater level impacts are anticipated from the construction of the Grid Connection underground cabling trench due to the shallow nature of the excavation (i.e. ~1.2m), the excavation of the trench within the road carriageway and the unsaturated nature of the subsoil/bedrock to be excavated.

Therefore, the Proposed Development works will not affect the groundwater quantity or flow patterns in the underlying Suck South, Funshinagh or Athlone West GWBs.

However as stated above, unmitigated construction phase activities will potentially result in a deterioration in groundwater quality at the Wind Farm site and along the proposed Grid Connection route.

A summary of potential status change to GWBs arising from construction phase activities during the unmitigated construction phase are outlined in **Table F**.

Table F: Potential Effects on Groundwater Quality/Quantity during Construction Phase (Unmitigated)

WFD Element	WFD Code	Current Status	Assessed Potential Status Change
Suck South GWB	IE_SH_G_225	Good	Moderate
Funshinagh GWB	IE_SH_G_091	Good	Moderate
Athlone West GWB	IE_SH_G_014	Good	Moderate

5.2.2 Operational Phase (Unmitigated)

5.2.2.1 Increased Runoff due to Replacement of Natural Surfaces with Lower Permeability Surfaces

Progressive replacement of the soil, subsoil or vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. This could potentially increase runoff from the site and increase flood risk downstream of the development.

Due to the local hydrological/hydrogeological regime the most sensitive receptor to changes in runoff volumes is the Suck South GWB. However, given the small scale of the development footprint in comparison to the total area of the Suck South and Funshinagh GWBs no significant affect will occur. Runoff from emplaced access tracks and turbine bases will recharge to ground at the edges of the works areas (only short distances from where it would have recharge in the pre-development scenario).

A summary of potential status change to SWBs arising from increased runoff during the operation stage of the Proposed Development in the unmitigated scenario are outlined in **Table G**.

Table G: Potential Effect of Increased Runoff during Operational Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate
Suck South GWB	IE_SH_G_225	Good	Good
Funshinagh GWB	IE_SH_G_091	Good	Good

5.2.2.2 Surface Water Quality Impacts from Site Maintenance

During the operational phase, the potential for silt-laden runoff is much reduced compared to the construction phase.

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

However as described above, no direct surface water pathways exist between the Wind Farm site and downgradient watercourses, and all pathways are via groundwater recharge and groundwater flow. Therefore, any works required during the operational phase of the Proposed Development will have limited potential to alter the status of downstream surface waterbodies.

A summary of potential status change to SWBs arising from surface water quality impacts during the operation stage of the Proposed Development in the unmitigated scenario are outlined in **Table H**.

Table H: Surface Water Quality Impacts from Site Maintenance during Operational Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Ballyglass_010	IE_SH_26B150840	Good	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate
Suck_150	IE_SH_26S071500l	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate

5.2.2.3 Groundwater Quality Impacts from Site Maintenance

The risks to groundwater quality are the same as those described in **Section 5.2.1.3** but of a lesser extent than during the construction phase due to the limited activity at the Wind Farm site with only minor maintenance required during the operational phase. There will be no groundwater quality impacts along the proposed Grid Connection route.

A summary of potential status change to GWBs arising from groundwater quality impacts during the operation stage of the Proposed Development in the unmitigated scenario are outlined in **Table I**.

Table I: Groundwater Quality Impacts During Operational Phase (Unmitigated)

WFD Element	WFD Code	Current Status	Assessed Potential Status Change
Suck South GWB	IE_SH_G_225	Good	Moderate
Funshinagh GWB	IE_SH_G_091	Good	Moderate
Athlone West GWB	IE_SH_014	Good	Good

5.3 MITIGATION MEASURES

In order to mitigate against the potential negative effects on surface and groundwater quality, quantity and flow patterns, mitigation measures will be implemented during the construction and operational phases of the Proposed Development. These are outlined below.

5.3.1 Construction Phase

5.3.1.1 Mitigation Measures for Suspended Solids Entrainment in Drainage Recharge

Surface watercourses are absent within the EIAR Site Boundary, however potential impacts in relation to potential overland flow towards surface water bodies such as turloughs will nonetheless be mitigated against, as well as surface water runoff that will occur at site infrastructure that will need to be recharged locally into subsoils. This recharge water will occur close to source and can migrate vertically to groundwater below the site. No discharge to surface waterbodies will occur within the Wind Farm site.

The proposed drainage management plan has been prepared in order to control the erosion of sediment within the Proposed Development site and prevent the entrainment of suspended solids in local runoff (prior to recharge) during the construction phase. The drainage management plan has been designed with the knowledge of the sites hydrological and hydrogeological conditions.

A suite of drainage controls available for water management are summarised (along with their application) in **Table J** below. These include avoidance controls, source controls, in-line controls, water treatment controls, and outfall controls.

A key mitigation measure adopted during the design phase of the Proposed Development is the avoidance of infrastructure close to turloughs and surface water features. The closest turbine to a surface water feature is T4, located ~60m from Gortaphuill turlough which is a temporary waterbody and as with all turloughs near the site, does not exist between May and November. The buffer zone will avoid physical damage to turloughs, avoid excavation in close proximity to turloughs and avoid the entry of suspended sediment into turlough water bodies.

As stated, surface watercourses are absent within the Wind Farm site, with rainfall falling within the site infiltrating into the soil/subsoils and recharging to groundwater. The proposed drainage management plan will utilise the natural site conditions whereby the existing vegetation and soils will filter and clean runoff from the work areas prior to recharge to ground. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas (i.e., potential dirty water) will be attenuated and treated to a high quality prior to being allowed to slowly percolate to ground. This is how rainfall enters the local groundwater system in the baseline condition.

During the construction phase of the Proposed Development, excavations will be limited to minimise the generation of spoil. For example, site access roads will be constructed on top of the current ground surface where ground conditions are good, hence avoiding unnecessary excavations. The roads will be constructed on a geotextile membrane which will prevent direct discharge to ground. This road construction methodology will:

- Reduce the quantity of soil/subsoil to be excavated and stored at the site;
- Allow clean water to pass from uphill to downhill unimpeded;
- Will treat dirty water at the source of dirty water generation (no requirement for dirty water drains); and,
- Reduce the volume of water requiring treatment at settlement ponds.

Sediment will be generated where excavations are required (turbine and substation foundations) and dirty water from these work areas will be routed via drains to settlement ponds for treatment and removal of suspended solids prior to diffuse discharge over the vegetated land surface. Where pumping water from turbine foundation excavations is required the pumping rate will be limited to 5.8l/s to prevent overuse of the settlement ponds. In addition, hard stands will be lined with Terram geotextile to limit direct discharge to the underlying subsoils and bedrock.

Excess sediment generated during the construction phase will be stored at 7 no. overburden storage areas and 15 side casted areas. The spoil storage areas will be sealed with a digger bucket and vegetated as soon as possible to reduce sediment entrainment in runoff. Once revegetated and stabilised these areas will no longer be a potential source of sediment laden runoff.

Finally, regular inspection and maintenance for the on-site drainage system will be completed regularly during the construction phase. This will be a particular importance following periods of heavy rainfall to check for blockages in any drains and any excess build-up of silt within settlement ponds which will decrease the effectiveness of the drainage system unless removed.

Table J: Summary of Drainage Mitigation & their Application

Management Type	Description of SuDs drainage control method	Applicable Works Area
Avoidance Controls:	• Avoidance of infrastructure close to turloughs and surface water features; • Using small working areas; • Minimising excavations (road construction methodology); • Seasonal works (e.g. at T4); • Working in appropriate weather and suspending certain work activities in advance of forecasted wet weather.	Construction work areas where sediment is being generated.
Source Controls:	• Use of interceptor drains upstream of works areas where excavations are required; • Dirty water drains will collect dirty water from work areas and transfer to settlement ponds for treatment. • Pumping from excavations will be limited to 5.8l/s; • Hardstands will be lined with geotextile;	Construction work areas where sediment is being generated.
	• Using small working areas; • Minimise excavations; • Covering stockpiles; • Weathering off / sealing stockpiles and promoting vegetation growth.	Stockpiles areas
In-Line Controls:	• Drains; • Erosion and velocity control measures including check dams; • Settlement ponds; and, • Where a proposed turbine is located near an existing turlough i.e. T4, 3 no. lines of Terrastop silt fence will be erected to trap all water flowing downhill from the works area.	Interceptor and collection drainage systems
Treatment Systems:	• Settlement ponds.	Surface water treatment locations
Outfalls Controls:	• Discharge to ground over existing vegetated surface.	All water will recharge to ground. No surface water discharge.

5.3.1.2 Mitigation Measures to Protect Groundwater Flows and Levels

The construction of the turbines, met mast, access roads and other ancillary features of the Proposed Development could impact groundwater flows within the Wind Farm site, if a particular pathway e.g. karst conduit, existed near the development, however based on all the available site investigation data no reasonable pathways have been identified. The identification and avoidance of any potential karst features has been a key aim of the intrusive and extrusive site investigations and is considered to be the most rational method of mitigating against effecting flow paths, by avoiding any potential karst areas. The site data outlined within Chapters 8 and 9 of the EIAR provides sufficient scientific data to say, with a high degree of certainty, that the construction of the turbine bases, met mast, site access roads, substation and other relatively near surface constructs, will not interact with or alter the existing groundwater recharge, and underlying groundwater flow, regimes.

As mentioned above, the critical driver of groundwater levels and the potential to affect them is through groundwater recharge. The drainage design of the Seven Hills Wind Farm site has been designed to mimic the existing hydrological regime within the site, whereby surface water pathways are generally short and rainfall readily percolates to ground. The drainage design incorporates check dams to reduce velocities, two chamber settlement ponds with baffle plates and over topping weirs and outflow from the drains being dispersed over a wide area of vegetation. The net effect of the drainage design will be that all rainfall falling within the Seven Hills Wind Farm site will remain on the site and infiltrate to ground and will not exit the site as runoff to surface watercourses.

5.3.1.3 Mitigation Measures to Protect Downgradient Surface Waterbodies

The primary mitigating factor in relation to downgradient surface water bodies is the distinct lack of surface water courses which drain the Seven Hills Wind Farm site and the surrounding area. The rainfall falling on the site recharges to the underlying groundwater aquifer. There are no small streams (10-50 l/s) which would typically be seen on upland slopes. Instead, the only surface water bodies which exist in proximity to the site are the small-medium rivers (Ballyglass River, Killeglan River, Cross River). All these rivers are fed by groundwater, either through drainage of a groundwater body (Cuilleenirwan and Ballyglass River) or through the emergence of groundwater springs as occurs at Killeglan.

To ensure the continuation of the existing hydrological regime, whereby rainfall percolates to ground and does not discharge as surface water runoff, the drainage design has incorporated natural attenuation of flows and allows for collected rainwater to be recharged back into the underlying aquifer rather than leaving the site through man-made drains. The drainage design also includes mitigation measures to ensure that any collected surface water is treated prior to discharge/recharge back into the ground, and therefore will not contain suspended sediment. There will be no discharge to downstream surface waterbodies.

5.3.1.4 Mitigation Measures to Protect Against the Release of Hydrocarbons

Mitigation measures proposed to avoid the release of hydrocarbons at the wind farm site and along the grid connection route include:

- Minimal refuelling or maintenance of vehicles or plant will take place on-site. Off-site refuelling will occur where possible;
- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser;
- The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located.
- The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages.

- The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site.
- Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Onsite refuelling will be carried out by trained personnel only;
- Fuels stored on site will be minimized and will be appropriately bunded;
- Surface water runoff from temporary construction compounds will be collected and drained via silt traps and hydrocarbons interceptors prior to recharge to ground;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages is included within the Construction and Environmental Management Plan;
- Spill kits will be available to deal with any accidental spillage in and outside the re-fuelling area.

5.3.1.5 Mitigation Measures to Prevent Groundwater and Surface Water Contamination from Wastewater Disposal

Mitigation measures proposed to avoid the release of wastewater at the Wind Farm site include:

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

5.3.1.6 Mitigation Measures to Prevent the Release of Cement-Based Products

Best practice methods for cement-based compounds:

- No batching of wet-concrete 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 concrete 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 concrete washout ponds;
- Weather forecasting will be used to plan dry days for pouring concrete; and,
- The pour site will be kept free of standing water and plastic covers will be ready in case of sudden rainfall event.

5.3.1.1 Mitigation Measures to Protect Surface Water Quality along Grid Connection Route

Silt Fences/Roadside Drain Blocking:

Silt fences will be placed down-gradient of the proposed Grid Connection route during construction work. Silt fences are effective at removing larger particle sized 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 structures during the 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 down-gradient of all construction areas inside the hydrological buffer zones (i.e., near stream crossings). Any roadside drains will be temporarily blocked using sandbags in the area where trenching works is taking place.

Surplus Excavated Spoil:

Excavated spoil emanating from the cut for the trenches, where appropriate (i.e. when trenching within private tracks or the public road verge) will be used to backfill the trenches. Any excess will be disposed at an appropriate licenced facility. All excavated material emanating from trenches within the public road will be disposed at an appropriate licenced facility.

Timing of Site Construction Works:

Excavation of the cable trench shall be undertaken during the summer months and during a period of low rainfall. This will minimise the risk of entrainment of suspended sediment in surface water runoff and transport via this pathway to surface watercourses. The Ballyglass_010 SWB is ephemeral and it is recommended to complete works when this SWB has no flow and is dry.

Hydrocarbons:

Mitigation measures relating to hydrocarbon usage are outlined in **Section 5.3.1.4** and include refuelling off-site where possible, the appropriate safe use and handling of hydrocarbons along the Grid Connection route where necessary including fuel bunds.

Cement-Based Products:

Mitigation measures to prevent the release of concrete runoff are outlined in **Section 5.3.1.6.** No instream works are proposed along the Grid Connection route.

5.3.2 Operational Phase

5.3.2.1 Increased Site Runoff and Hydromorphology Effects

The measures for control of runoff and sediment release relate primarily to the construction phase. During the operation phase, there is no particular risk of sediment runoff due to the lack of earthworks. Runoff from roads will continue to be discharges diffusely to over the existing vegetated land which will filter and clean the water. Any drains, check dams and settlement ponds required during the construction phase will continue to operate during the operational phase, ensuring that runoff continues to be attenuated and dispersed across existing vegetation. There will be no increase in runoff from the Wind Farm site.

5.3.2.2 Mitigation Measures to Protect Groundwater and Surface Water Quality

During the operational phase, the only plant which will be required on site will be maintenance/inspection vehicles (jeeps/vans/quads). These will be refuelled off site, thus preventing hydrocarbon spills. There will be no discharge of wastewater during the operational phase.

Mitigation measures relating to hydrocarbons, cementitious materials and wastewater disposal, as outlined in **Sections 5.3.1.4**, **5.3.1.6** and **5.3.1.5** will continue to provide adequate protection to groundwater and surface water quality during the operational phase and ensure that groundwater quality will not be impacted, thus protecting the groundwater quality of any hydraulically downgradient turloughs.

Any hydrocarbons (oil) stored within the substation will be enclosed within a bund with 110% capacity.

Any works that may require soil movement will take place in the summer months. Mitigation measures relating to the entrainment of suspended solids in waters are outlined above in **Section 5.3.1.1**.

5.3.3 Decommissioning Phase

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

During the decommissioning phase there would be increased trafficking and an increased risk of disturbance to underlying soils at the Wind Farm site. Any such potential impacts would be less than during the construction stage as the drainage system would be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site would be bunded.

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

The potential removal of this infrastructure (hardstanding areas, foundations *etc.*) would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increase in erosion, sedimentation, dust, noise, traffic and an increased possibility of contamination of the local water table. However, if removal is deemed to be required all infrastructure will be removed with mitigation measures similar to those in place during the construction phase being employed. These measures will ensure the protection of water reaching the underlying aquifer, through the implementation mitigation measures related to suspended sediment, hydrocarbons, cement-based materials.

t is proposed that underground cables within the Wind Farm site will be cut back and left in place. The onsite electrical substation will remain in place as it will be under the ownership of the ESB. There are no impacts associated with this.

The cabling along the Grid Connection route will also remain in place and as such there will be no impacts associated with this.

With the implementation of the mitigation measures outlined above no significant effects on the hydrological and hydrogeological environment will occur during the decommissioning stage of the Proposed Development.

5.3.4 Potential Effects with the Implementation of Mitigation

In all instances, the mitigation measures described in **Section 5.3** are sufficient to meet the WFD Objectives. The assessment of WFD elements for the WFD waterbodies is summarised in **Table K** below.

Table K: Summary WFD Status of Unmitigated and Mitigated Scenarios

SWB	WFD Code	Current Status	Assessed Status - Unmitigated	Assessed Status – with Mitigation Measures
Ballyglass_010	IE_SH_26B150840	Good	Moderate	Good
Killeglan_010	IE_SH_26K040200	Moderate	Moderate	Moderate
Suck_130	IE_SH_26S071200	Good	Good	Good
Suck_140	IE_SH_26S071400	Moderate	Moderate	Moderate
Suck_150	IE_SH_26S071500I	Moderate	Moderate	Moderate
Suck_160	IE_SH_26S071550	Moderate	Moderate	Moderate
Cross(Roscommon)_020	IE_SH_26C100200	Good	Moderate	Good
Cross(Roscommon)_030	IE_SH_26C100300	Moderate	Poor	Moderate
Cross(Roscommon)_040	IE_SH_26C100400	Moderate	Moderate	Moderate
Shannon(Upper)_110	IE_SH_26S021660	Poor	Poor	Poor
Suck South GWB	IE_SH_G_225	Good	Moderate	Good
Funshinagh GWB	IE_SH_G_091	Good	Moderate	Good
Athlone West GWB	IE_SH_014	Good	Moderate	Good

6. WFD ASSESSMENT CONCLUSION

WFD status for SWBs (Surface Water Bodies) and GWBs (Groundwater Bodies) hydraulically linked to the Proposed Development site are defined in **Section 2** above.

There is no direct discharge from the development site to downstream surface watercourses. The hydrological and hydrogeological regime of the wind farm site is characterized by a distinct absence of surface water features, with rainfall percolating through the glacial subsoils and recharging to the underlying bedrock aquifer. However, there is a high degree of connectivity between surface and groundwaters in this area. All rivers in the vicinity of the site (Ballyglass River, Killeglan River and Cross River) are fed by groundwater, either through drainage of a groundwater body or through the emergence of groundwater springs.

There are 2 no. groundwater bodies underlying the proposed Wind Farm site *i.e.* Suck South GWB and Funshinagh GWB. Due to the local hydrogeological regime these GWBs are the most sensitive receptors to the Proposed Development. Surface watercourses downstream of the wind farm site will not be susceptible to effects from the Proposed Development due to the lack surface water pathways between the site and these downstream receptors. However, a total of 4 no. watercourse crossings are proposed along the Grid Connection route and these surface waterbodies are more at risk due to their proximal location to the Proposed Development works.

Mitigation proposed for the protection of ground and surface waters during the construction, operation and decommissioning phases of the Proposed Development will ensure the qualitative and quantitative status of the receiving groundwaters waters will not be altered by the Proposed Development.

There will be no change in GWB or SWB status in the underlying GWBs or downstream SWBs resulting from the Proposed Development. There will be no change in quantitative (volume) or qualitative (chemical) status, and the underlying GWBs are protected from any potential deterioration from chemical pollution.

As such, the Proposed Development:

- will not cause a deterioration in the status of all surface and groundwater bodies assessed;
- will not jeopardise the objectives to achieve ‘Good’ surface water/groundwater status;
- does not jeopardise the attainment of 'Good’ surface water/groundwater chemical status;
- does not jeopardise the attainment of ‘Good’ surface water/groundwater quantity status;
- does not permanently exclude or compromise the achievement of the objectives of the WFD in other waterbodies within the same river basin district;
- is compliant with the requirements of the Water Framework Directive (2000/60/EC); and,
- is consistent with other Community Environmental Legislation including the EIA Directive (2014/52/EU), the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) (Note that a full list of legislation complied with in relation to hydrology and hydrogeology is included in Section 9.1.4 of EIAR Chapter 9).

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