9. HYDROLOGY AND HYDROGEOLOGY

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 Ballivor wind farm development on the hydrological and hydrogeological environment. The proposed Ballivor wind farm site (the "proposed site" is a large area comprising 4 no. bog basins (Ballivor Bog, Carranstown Bog, Bracklin Bog, and Lisclogher Bog) situated between the towns of Raharney and Delvin, Co. Westmeath and the village of Ballivor, Co. Meath.

The Ballivor wind farm development (the "Proposed Development") includes 26 no. wind turbines, associated access tracks and hardstands, an onsite 110 kV substation, met masts, temporary site compounds, borrow pits, drainage works, and all ancillary site and ground works. A full description of the Proposed Development is provided in Chapter 4: Description of Development.

The objectives of this assessment are:

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

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist 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 upland/wetland hydrology, hydrogeology and windfarm drainage design. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types.

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

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS for Oweninny WF, Cloncreen WF, Derrinlough WF, and Yellow River WF, and over 100 other wind farm-related projects.

Adam Keegan (BSc, MSc) is a hydrogeologist with 5 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), Derrinlough WF (SID), and Fossy WF.

Conor McGettigan (BSc, MSc) is an Environmental Scientist with 3 years experience in the environmental sector in Ireland. Conor holds an MSc in Applied Environmental Science and a BSc in Geology. Conor routinely prepares the hydrology and hydrogeology EIAR chapters and has worked om the EIAR for several wind farm developments on peatlands.

9.1.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Chapter 2 of the EIAR. Consultation responses relating to the water environment were received from the Geological Survey of Ireland, Department of Agriculture, Food and the Marine (response was related to forestry) and the Health Services Executive. Details of these scoping responses and actions taken to address them are in Chapter 2 of this EIAR.

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 following legislation has been complied with:

- S.I. No. 349/1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84/1994, S.I. No. 101/1996, S.I. No. 351/1998, S.I. No. 93/1999, S.I. No. 450/2000 and S.I. No. 538/2001, S.I. No. 134/2013 and the Minerals Development Act 2017), the Planning and Development Act, and S.I. No. 600/2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/337/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- Planning and Development Acts, 2000 (as amended);
- Planning and Development Regulations, 2001 (as amended);
- S.I. No 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of the EIA Directive as amended by the Directive 2014/52/EU into Irish Law;
- S.I. No. 94/1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293/1988: Quality of Salmon Water Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and S.I. No. 722/2003 European Communities (Water Policy) Regulations, as amended, which implement EU Water Framework Directive (2000/60/EC) and provide for the implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council

Directive 2013/64/EU; and Commission Directive 2014/101/EU ("**WFD**"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722/2003);

- S.I. No: 122/2010: European Communities (Assessment and Management of Flood Risks) Regulations, resulting from EU Directive 2007/60/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. 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 Hydrology and Hydrogeology chapter of the EIAR was prepared having regard, where relevant, to guidance contained in the following documents:

- 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 (2003) Advice Notes on Current Practice (in the preparation of Environmental Impact Statements);
- Environmental Protection Agency (2006): Environmental Management in the Extractive Industry;
- Environmental Protection Agency (2002) Guidelines on the Information to be Contained in Environmental Impact Statements;
- DoE/NIEA (2015): Wind farms and groundwater impacts - A guide to EIA and Planning considerations";
- 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;
- Wind Farm Development Guidelines for Planning Authorities (2006);
- OPW (2009): The Planning system and Flood Risk Management;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Watercourses;
- Good Practice During Wind farm Construction (Scottish Natural Heritage, 2010);
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Water Courses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006); and,
- Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2001.

9.2 Methodology

9.2.1 Desk Study

A desk study was completed by HES in late 2021 and early 2022 to collate all relevant hydrological, hydrogeological and meteorological data for the proposed site and the surrounding area. The desk study was completed to supplement site walkover surveys and site investigations. The desk study information has been checked and updated, where necessary, in February 2023.

The desk study involved consultation with the following sources:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Databases (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive "catchments.ie" Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 13 (Geology of Meath);Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Flood Mapping (www.floodmaps.ie); and,
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie).

9.2.2 Baseline Monitoring and Site Investigations

Hydrological walkover surveys, including detailed drainage mapping, was undertaken by HES on 18th May 2020, 15th – 17th September 2020, 05th October 2020, 01st December 2020, 22nd March 2021, 01st April 2021, 20th September 2021, 28th October 2021, 19th January 2022 and 22nd February 2023.

Hydrological monitoring, including flow monitoring, field hydrochemistry and grab sampling was completed by HES on 3 no. occasions during the study period (01st April 2021, 28th October 2021 and 19th January 2022). The monitoring and sampling completed in April 2021 occurred during a dry period with minimal rainfall. The sampling completed in October 2021 was preceded by several wet days while the January 2022 sampling was completed in a relatively dry period.

Reporting and site investigations and monitoring data used to compile the Hydrology and Hydrogeology Chapter of the EIAR included the following:

- Walkover surveys and hydrological mapping of the proposed site and the surrounding areas were undertaken whereby water flow directions and drainage patterns were recorded;
- A flood risk assessment for the proposed site;
- A total of over 457 no. peat probe/investigation points were carried out by HES, MKO and Fehily Timoney (FT) in Ballivor Bog, Carranstown Bog, Bracklin Bog and Lisclogher Bog. These investigations were completed to determine the thickness and geomorphology of the peat at the proposed site, and also to understand the subpeat geology across the proposed site;
- Ground investigations completed by FTC and IDL in the form of 78 no. trial pits, 16 no. boreholes and 5 no. rotary coreholes;
- Completion of 24 no. trial pits excavated by Bord na Móna;
- A geotechnical assessment of peat stability for the proposed site was completed by FT (FT, 2023) (Appendix 8-1);
- A peat and spoil management plan was completed by FT (FT, 2023) (Appendix 4-2);
- A series of groundwater monitoring wells were drilled at the locations of the 4 no. proposed borrow pits to facilitate groundwater monitoring in order to aid the understanding of the local hydrogeological regime at these locations;
- Seasonal groundwater level monitoring has been undertaken at the installed monitoring wells; and,
- A total of 36 no. surface water samples were undertaken to determine the baseline water quality of the primary surface waters originating from the proposed site.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, 2022) for the assessment of likely significant effects require that likely effects are described with respect to their quality (i.e. negative, positive or neutral), significance, extent, context, probability, duration, frequency and reversibility. The descriptors used in this environmental impact assessment are those set out in the EPA (2022) Glossary of effects as shown in Chapter 1 of this EIAR. In addition, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Table 9-1 and Table 9-2 define levels of sensitivity for hydrology and hydrogeology respectively, and are used to assess the potential effect that the Proposed Development may have on them.

Table 9-1: Estimation of Importance of Hydrology Criteria (NRA, 2008)

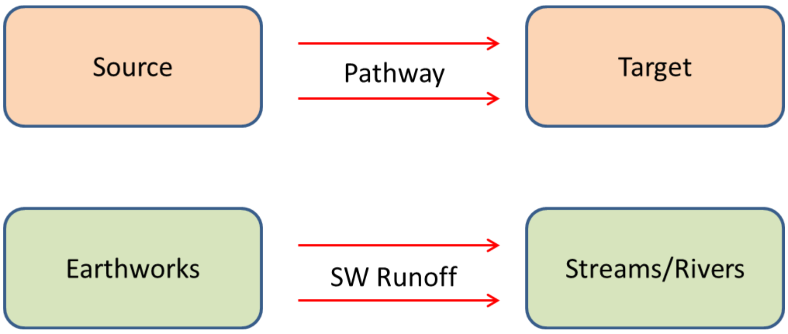
Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	River, wetland or surface water body ecosystem protected by EU legislation, e.g. 'European sites' designated under the Habitats Regulations or 'Salmonid waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	Attribute has a high quality or value on a regional or national scale	River, wetland or surface water body ecosystem protected by national legislation – NHA status. Regionally important potable water source supplying >2500 homes. Quality Class A (Biotic Index Q4, Q5). Flood plain protecting more than 50 residential or commercial properties from flooding. Nationally important amenity site for a wide range of leisure activities.
High	Attribute has a high quality or value on a local scale	Salmon fishery locally important potable water source supplying >1000 homes. Quality Class B (Biotic Index Q3-4). Flood plain protecting between 5 and 50 residential or commercial properties from flooding.
Medium	Attribute has a medium quality or value on a local scale	Coarse fishery. Local potable water source supplying >50 homes Quality Class C (Biotic Index Q3, Q2-3). Flood plain protecting between 1 and 5 residential or commercial properties from flooding.
Low	Attribute has a low quality or value on a local scale	Locally important amenity site for small range of leisure activities. Local potable water source supplying <50 homes. Quality Class D (Biotic Index Q2, Q1) Flood plain protecting 1 residential or commercial property from flooding. Amenity site used by small numbers of local people.

Table 9-2: Estimation of Importance of Hydrogeology Criteria (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation, e.g. SAC or SPA status.
Very High	Attribute has a high quality or value on a regional or national scale	Regionally Important Aquifer with multiple wellfields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation - NHA status. Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source.
High	Attribute has a high quality or value on a local scale	Regionally Important Aquifer Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source supplying >1000 homes. Outer source protection area for regionally important water source. Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale	Locally Important Aquifer. Potable water source supplying >50 homes. Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale	Poor Bedrock Aquifer Potable water source supplying <50 homes.

9.2.4 Overview of Impact Assessment Process

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



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

- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003); and,
- Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 2002).

The description process clearly and consistently identifies the key aspects of any potential impact, namely its source, character, magnitude, duration, likelihood and whether it is of a direct or indirect nature (i.e., using EPA, 2022 EIAR terminology).

In order to provide an understanding of the stepwise impact assessment process applied below (Sections 9.4.2 to 9.4.4), a summary guide is presented below, which defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model and the EPA impact descriptors are combined.

Using this defined approach, this impact assessment process is then applied to all construction, operation and decommissioning activities for the Proposed Development which have the potential to generate significant adverse impact on the hydrological and/or hydrogeological environment.

Table 9-3: Impact Assessment Process Steps

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway / Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of this type of development, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which potential impacts are generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, e.g. human health, plant / animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to the Proposed Development, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by (engineering) design.
Step 6	Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post-mitigation effects of the identified potential impact source on the receiving environment.

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Hydrology and Hydrogeology Chapter of the EIAR.

9.3 Baseline/Receiving Environment

9.3.1 Site Description and Topography

The Ballivor Wind Farm site ("the proposed site") comprises 4 no. Bord na Móna bogs which form part of the larger Derrygreenagh Bog Group situated between the towns of Kinnegad and Delvin, Co. Westmeath. The bogs comprising the proposed site include Ballivor Bog to the south, Carranstown and Bracklin Bogs towards the centre and Lisclogher Bog at the northern end of the proposed site. Lisclogher West Bog exists to the west of Lisclogher Bog and forms part of the Ballivor Sub-Group of bogs (a sub-group of the Derrygreenagh Group), however this bog does not form part of the proposed site. In addition, the western section of Bracklin Bog (Bracklin West) and the eastern section of Carranstown bog are omitted from the proposed site. The total area of the proposed site is 1,770ha (17.70km^2) and the area of each bog included within the proposed site is shown in Table 9-4.

The Meath-Westmeath county boundary runs through the centre of Lisclogher Bog, along the eastern boundary of Bracklin Bog and through the centre of both Carranstown and Ballivor Bogs. The closest settlements to the site are Delvin located 5km north, Raharney, 4km west and Ballivor, 3.5km east of the site.

The south of the proposed site is dissected by the R156 which joins the villages of Ballivor in the east to Raharney in the west. Ballivor Bog lies to the south of this regional road with the other 4 no. bogs which comprise the Ballivor Bog Sub-Group lying to the north. A Bord na Móna works area lies in the northwest of Ballivor Bog, in the townland of Grange More and contains offices, storage sheds, roads and a peat loading area. The remainder of Ballivor Bog is located in the townlands of Robinstown and Clonycavan in the east and Riverdale, Clondalee More and Derryconor in the west. Ballivor Bog has a total area of 635ha, all of which is included within the proposed site, and it was served by a Bord na Móna railway network which still extends from the loading area into the bog.

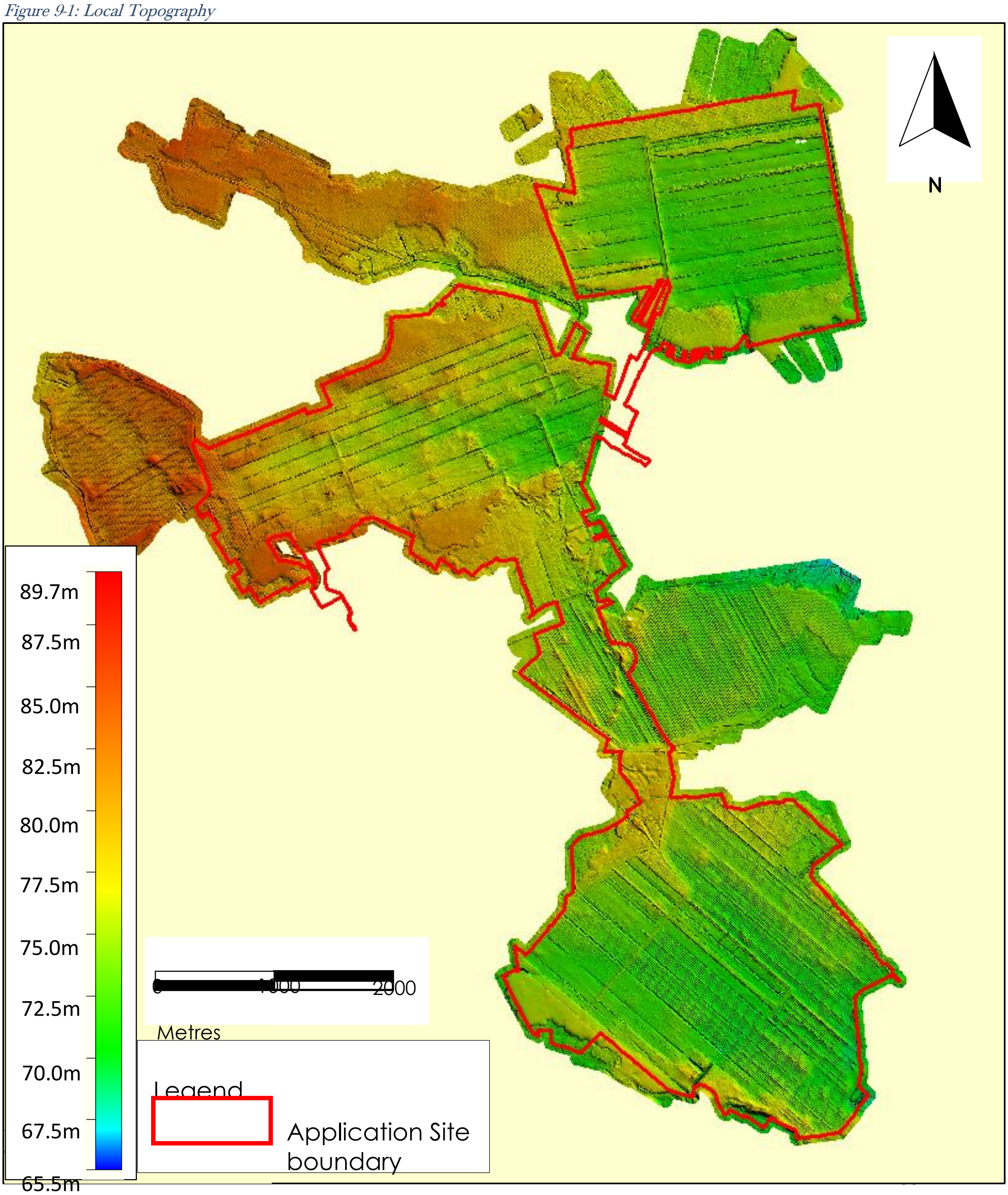
To the north of the R156, Carranstown Bog has an area of 306ha and lies in the townlands of Grange More in the West and Carranstown Great, Carranstown Little and Killaconnigan in the east. Approximately 79ha in the west of Carranstown Bog forms part of the proposed site. The Bord na Móna railway links Carranstown Bog to Ballivor Bog to the south and Bracklin Bog to the north. Towards the centre of the proposed site, Bracklin Bog has an area of 620ha, all of which is included within the proposed site. Bracklin Bog lies in the townlands of Coolronan in the east, Craddanstown and Bracklin in the centre and Ballynaskeagh, Mucklin and Killagh in the west. An extension of Bracklin Bog, referred to as Bracklin West is not included within the proposed site. A small bogland (~22ha) referred to as the Hill of Down lies to the east of Bracklin Bog in the townlands of Coolronan and Bracklin. Lisclogher Bog is located to the northeast of Bracklin Bog, approximately 4.3km southeast of the town of Delvin and has an area of 484ha, of which 436ha is included within the proposed site. This bog is located in the townlands of Lisclogher Great, Coolronan, Bracklin, Cockstown and Clonleame.

The current topography of the proposed site is relatively flat with an elevation range of between approximately 69 and 84mOD (metres above Ordnance Datum). Topography at the proposed site has been modified through the previous peat extraction activities and associated drainage. The highest elevations are found at headlands and remnant peat banks which create elevated boundary berms, forming a basin effect within the former extraction areas of the bogs. A local topography map is included as Figure 9-1.

Table 9-4: Proposed Site Area within the Ballivor Bog Sub-Group

Bog Name	Total Bog Area (ha)	Area included in Proposed Site (ha)
Ballivor Bog	635	635
Carranstown Bog	306	79
Bracklin Bog (excluding Bracklin West)	620	620
Lisclogher	484	436

Figure 9-1: Local Topography



9.3.2 Water Balance

Long term rainfall and evaporation data were sourced from Met Éireann. The 30-year annual average rainfall (AAR) recorded at the Ballivor rainfall station, located approximately 4.5km east of the proposed site are presented in Table 9-5.

Table 9-5 Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Ballivor		268500		254200		68		1943		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
86	61	65	55	62	58	54	76	75	83	80	85	839

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 17km west of the proposed site. The long-term average PE for this station is 445mm/yr. This value is used as the best estimate of the proposed site PE. Actual Evaporation (AE) at the proposed site is estimated as 423mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 839 mm/yr – 423mm/yr

ER = 416mm/yr

The GSI estimate that the groundwater recharge coefficient for the proposed site is 4% (www.gsi.ie), with this estimate being provided based on the occurrence and extent of basin peat at the proposed site. Based on this recharge coefficient (4%) the average annual groundwater recharge for the proposed site is estimated to be 17mm/year (*i.e.* 4% of the effective rainfall (416mm) for the proposed site). This means that the hydrology of the proposed site is characterised by very high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the proposed site are estimated to be 17mm/yr and 399mm/yr respectively.

In addition to average long-term rainfall data, extreme value rainfall depths are available from Met Éireann (www.met.ie). A return period is an estimate of how long it will be between rainfall events of a given magnitude. For example, a 15 minute rainfall event of 5.7mm has the probability of occurring at the proposed site on an annual basis. However, a 15 minute rainfall event resulting in 19.9mm of precipitation has the probability of once every one hundred years. A summary of various return periods and duration rainfall depths for the proposed site are presented in Table 9-6. This data was used in the design of the Proposed Development drainage system.

Table 9-6 Return Period Rainfall depths (mm) for the proposed site

Return Period (Years)				
Storm Duration	1	5	30	100
5 mins	3.5	5.5	9.0	12.1
15 mins	5.7	9.1	14.7	19.9
30 mins	7.4	11.6	18.5	24.6
1 hour	9.6	14.8	23.1	30.4

Return Period (Years)				
Storm Duration	1	5	30	100
6 hours	19.1	28.0	41.3	52.6
12 hours	25.0	35.8	51.8	65.1
24 hours	32.6	45.7	64.8	80.5
2 days	38.5	52.8	73.2	89.5

9.3.3 Regional and Local Hydrology

On a regional scale, the proposed site is located in the River Boyne surface water catchment within Hydrometric Area 7[1] of the Eastern River Basin District. The River Boyne surface water catchment has a total area of 2,694km^2 and includes all areas drained by the River Boyne. The source of the Boyne is the Trinity Well, southeast of Carbury, Co. Kildare approximately 18km southeast of the proposed site. The Boyne flows west from the Trinity Well, turning north at Edenderry, passing through the raised bog landscape of north Kildare, after which it is joined by the Yellow River. The River Boyne continues to flow towards the northeast and the town of Trim, flowing approximately 5km east of the proposed site. In the vicinity of the proposed site, the main tributaries which discharge into the Boyne include the Deel (Raharney) and Stoneyford rivers. Further downstream the Athboy River confluences with the Boyne before flowing to the east through the town of Trim. The Boyne then flows towards Navan after which it continues eastwards before becoming tidal to the west of my M1 motorway. The Boyne then flows through Drogheda and out to the Irish Sea between Haven and Mornington Point. Figure 9-2 shows regional hydrology.

On a local scale, the majority of the proposed site is located in the River Boyne_SC_050 sub-catchment. Meanwhile, the southwest of the proposed site, including much of Ballivor Bog and small areas of Carranstown and Bracklin bogs, is located in the River Boyne_SC_040 sub-catchment. The west of Bracklin Bog (i.e. Bracklin West), which is not included in the proposed site is situated in the Deel[Raharney]_SC_010 sub-catchment.

The Deel River (EPA Code: 07D01) flows southwards approximately 2.1km west of the proposed site. The Deel River flows southwards through the town of Raharney and confluences with several small streams which drain the southwest of the proposed site. While these watercourses are largely unnamed, the Curris River is located immediately to the west of Ballivor Bog and flows to the south before discharging into the Deel River approximately 1.4km south of the proposed site. The Deel then continues to the southeast and confluence with the River Boyne (EPA Code: 07B04) approximately 4.5km south of Ballivor village.

The eastern section of the proposed site is drained by the Stonyford River (EPA Code: 07S02). The Stonyford River flowing to the southeast, approximately 700m east of Lisclogher Bog and continues to the southeast before it discharges into the River Boyne approximately 7km east of proposed site (Ballivor Bog). The proposed site is drained by several small 1st and 2nd order streams which flow to the east and discharge into the Stonyford River.

[1] *Ireland's hydrometric areas are used as management units for hydrological areas (EPA, OPW, ESBI, Local Authorities etc) and they are made up of an amalgamation of large river basins.*

An error has been observed in the EPA blueline watercourse mapping database in Lisclogher Bog. The EPA map a small watercourse (figure 9-3), referred to as the Cartenstown stream, to flow to the southeast across Lisclogher Bog. However, site walkover surveys and drainage mapping have shown that this watercourse does not exist on-site. The true drainage regime and flow directions in this area of the proposed site are shown on Figure 9-4. This drainage map has been produced following walkover surveys and drainage mapping of Lisclogher Bog. The on-site inspections were supplemented with the analysis of lidar data. A cross-section along the (original) EPA mapped watercourse has been produced and shows topographic variations along the course of the Cartenstown stream from Point A in the northwest to Point D in the south of Lisclogher Bog (Figure 9-5). The cross section profile does not indicate the presence of any channel that may be associated with a surface watercourse. Indeed there are several topographic highs located along the cross-section meaning that it would be impossible for surface water to flow unimpeded from Point A to D. This lidar analysis supports the on-site observations and drainage mapping meaning that there is a local error in the EPA watercourse mapping in Lisclogher Bog. Such small local errors are infrequent in EPA mapping, however they do exist where manmade drainage has been imposed upon natural drainage regime.

A local hydrology map is shown in Figure 9-6. (Note, this map includes the corrections to the drainage on and around Lisclogher bog).

Table 9-7 summarises the location and receiving waterbodies of each of the 5 no. bogs which comprise the site in accordance with the Water Framework Directive (WFD). Due to the error in EPA watercourse mapping, the WFD river subbasins are incorrectly mapped at Lisclogher Bog with the northwest of Lisclogher Bog draining northwards into the Stonyford_020 river waterbody.

Table 9-7: WFD Catchments, sub-catchments and river-basins and receiving waterbodies of the bog areas comprising the proposed site

Bog Name	WFD Catchment	WFD Sub-Catchment	WFD River Sub-Basin	Proposed Development Infrastructure
Ballivor	River Boyne	West: Boyne_SC_40 sub-catchment	Deel(Raharney)_060	T1, T2, T5, T6, T8-T12, 1 no. met mast, & 2 no. construction compounds
		East: Boyne_SC_050 sub-catchment	Boyne_060	T3, T4, T7
Carranstown	River Boyne	Boyne_SC_050 sub-catchment	South: Boyne_060	-
			North: Stonyford_040	1 no. construction compound, 2 no. borrow pits (BP1a and BP1b), onsite 110kV Substation, and the new transmission line pylons
Bracklin	River Boyne	East and Centre: Boyne_SC_050 sub-catchment	Stonyford_040	T13-T18, 2 no. construction compounds, 1 no. met mast & amenity car park
		Small area in SW located in Boyne_SC_040	Small area in the southwest of the bog is located in Deel(Raharney)_060	1 no. borrow pit (BP2)

Bog Name	WFD Catchment	WFD Sub-Catchment	WFD River Sub-Basin	Proposed Development Infrastructure
Lisclogher	River Boyne	Boyne_SC_050	Stonyford_040	T19-T21, T23-T26
			Small area in the north of the bog is located in Stonyford_030	T22
			Stonyford_020 EPA mapping and WFD river-sub basins are incorrectly mapped at Lisclogher Bog and some of the proposed site drains to the northwest into the Stonyford_020 SWB.	

Figure 9-2: Regional Hydrology Map

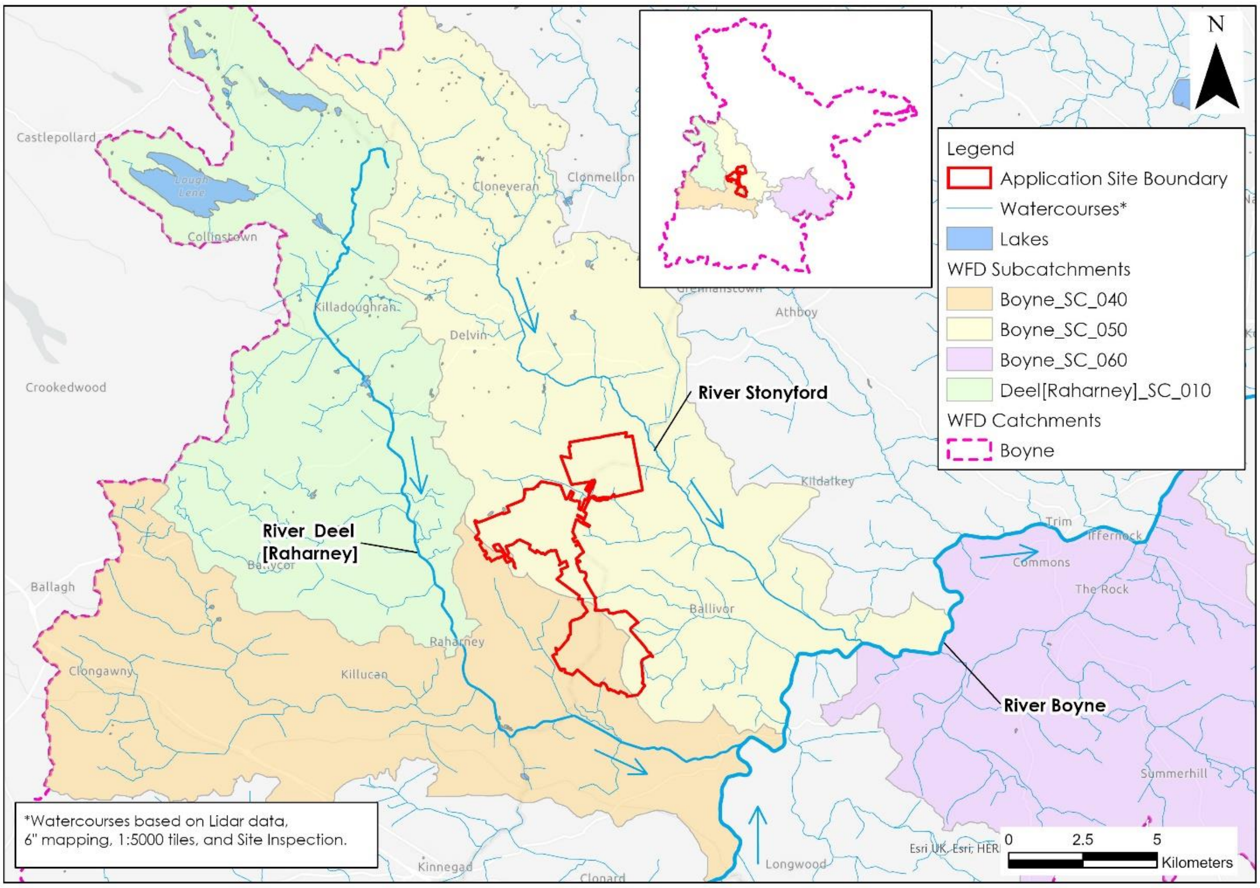


Figure 9-3: EPA Watercourse Mapping in Lisclogher Bog

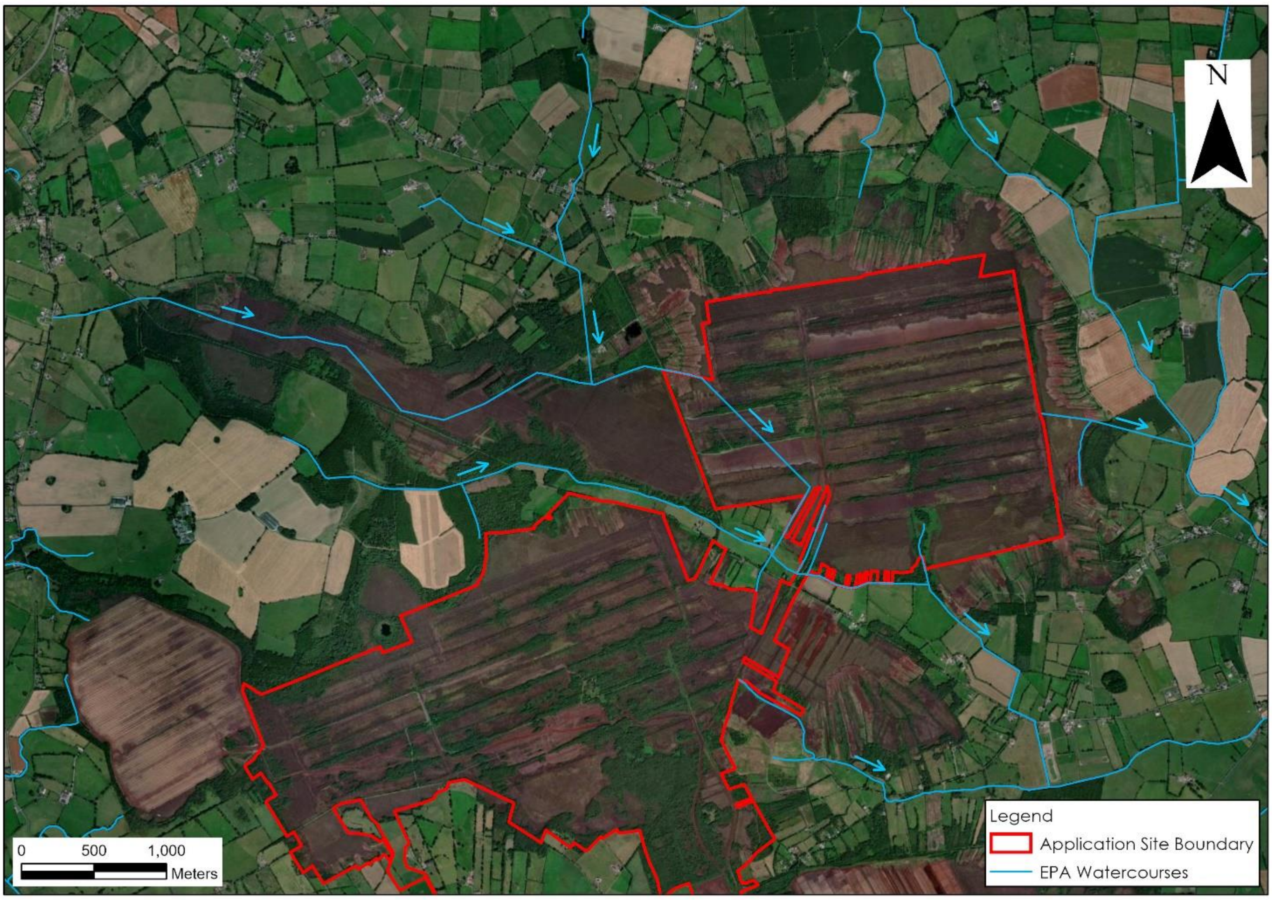


Figure 9-4: True Drainage of Lisclogher Bog Based on Site Walkovers and Lidar Data

Figure 9-5: Lidar Data along EPA Mapped Watercourse in Lisclogher Bog

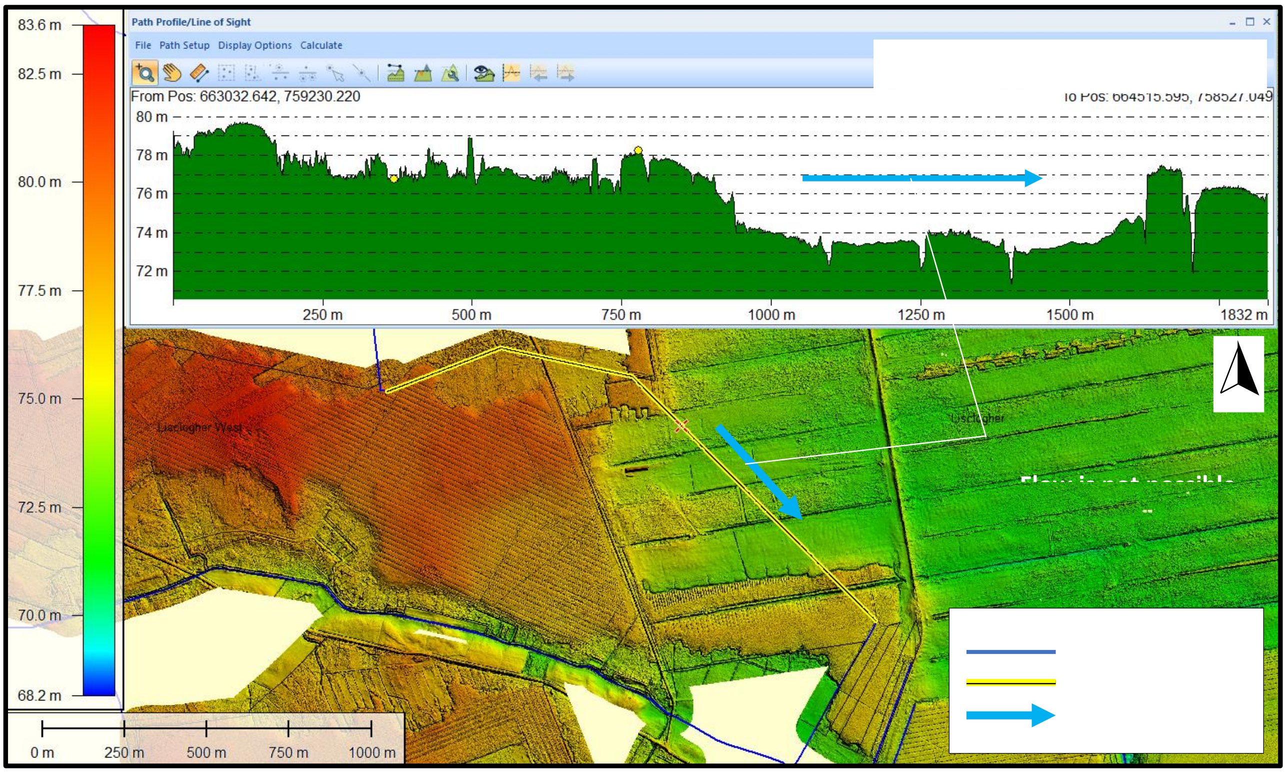
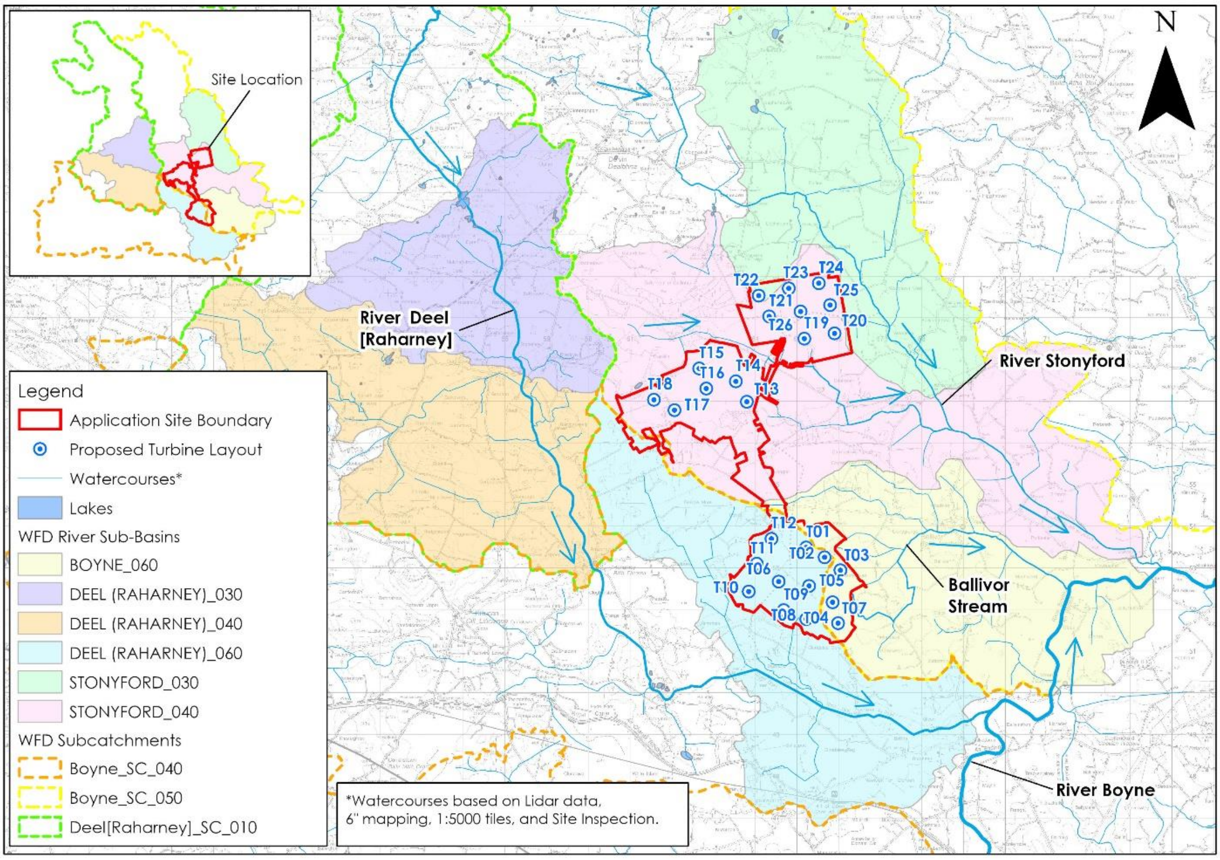


Figure 9-6: Local Hydrology Map



9.3.4 Wind Farm Site Drainage

Due to the historic peat extraction activities at the proposed site, the bogs comprising the proposed site (and the wider Ballivor Bog Group) have been artificially drained in order to lower the peat water table. Drainage ditches were inserted into the upper surface of the bogs at different stages. Ballivor Bog was the first bog to be drained between 1948 and 1953. Clearance and drainage work commenced at Bracklin Bog in 1952. Lisclogher was drained by 1960 while Carranstown Bog was drained between 1974 and 1987.

Currently surface water (or runoff water) is drained from the proposed site via a network of field drains typically spaced at 15 to 20m intervals, piped drains, main drains, headland drains, and silt ponds. The 4 bogs of the proposed site are all drained via gravity, with no pumping stations currently utilised at the proposed site. The field drains discharge to main drains which flow via gravity towards the perimeter of the bog where they discharge to larger headland drains. These headland drains eventually discharge to large silt (settlement) ponds. The silt ponds were used to trap sediment and prevent elevated levels of suspended sediment arising in effluent from the drained peatland. Treated surface water is then discharged at outfall points where the effluent flows into off-site drainage channels which in turn discharge into the local stream and river network.

Drainage of the proposed site and the wider Ballivor Bog Group is currently operating under licence from the EPA (P0501-01). The drainage system has been operating in accordance with this existing Integrated Pollution Control licence, with all drainage water from the bogs being discharged via an appropriately designed silt pond treatment arrangement. A surface water outflow map which formed part of the EPA application recorded a total of 25 no. silt ponds across the entire Ballivor Bog Group (7 no. silt ponds in Ballivor, 6 no. silt ponds in both Bracklin and Lisclogher West, 5 no. ponds in Carranstown and 1 no. pond in Lisclogher Bog). A total of 9 no. silt ponds are located within the proposed site boundaries (7 no. in Ballivor bog, 1 no. in Carranstown Bog and 1 no. in Lisclogher Bog). Whilst several silt ponds associated with the drainage of the Ballivor bog Group are located outside of the proposed site boundary, the drainage system of the proposed site is interlinked with the wider drainage system of the Ballivor Bog Group. A flow diagram of the existing drainage system is shown in Figure 9-7 below. Figure 9-8 to 9-11 illustrate existing drainage maps for each individual bog within the proposed site.

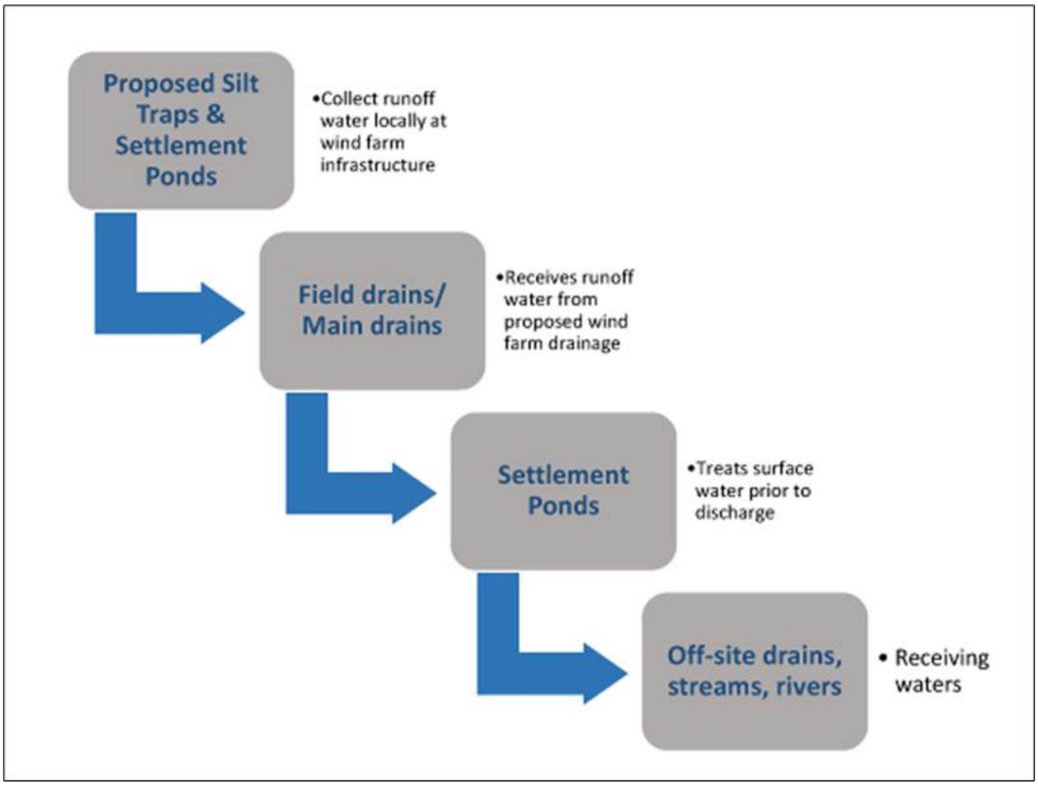


Figure 9-7: Process Flow Diagram for the Existing Drainage System

Figure 9-8: Existing drainage within Ballivor Bog

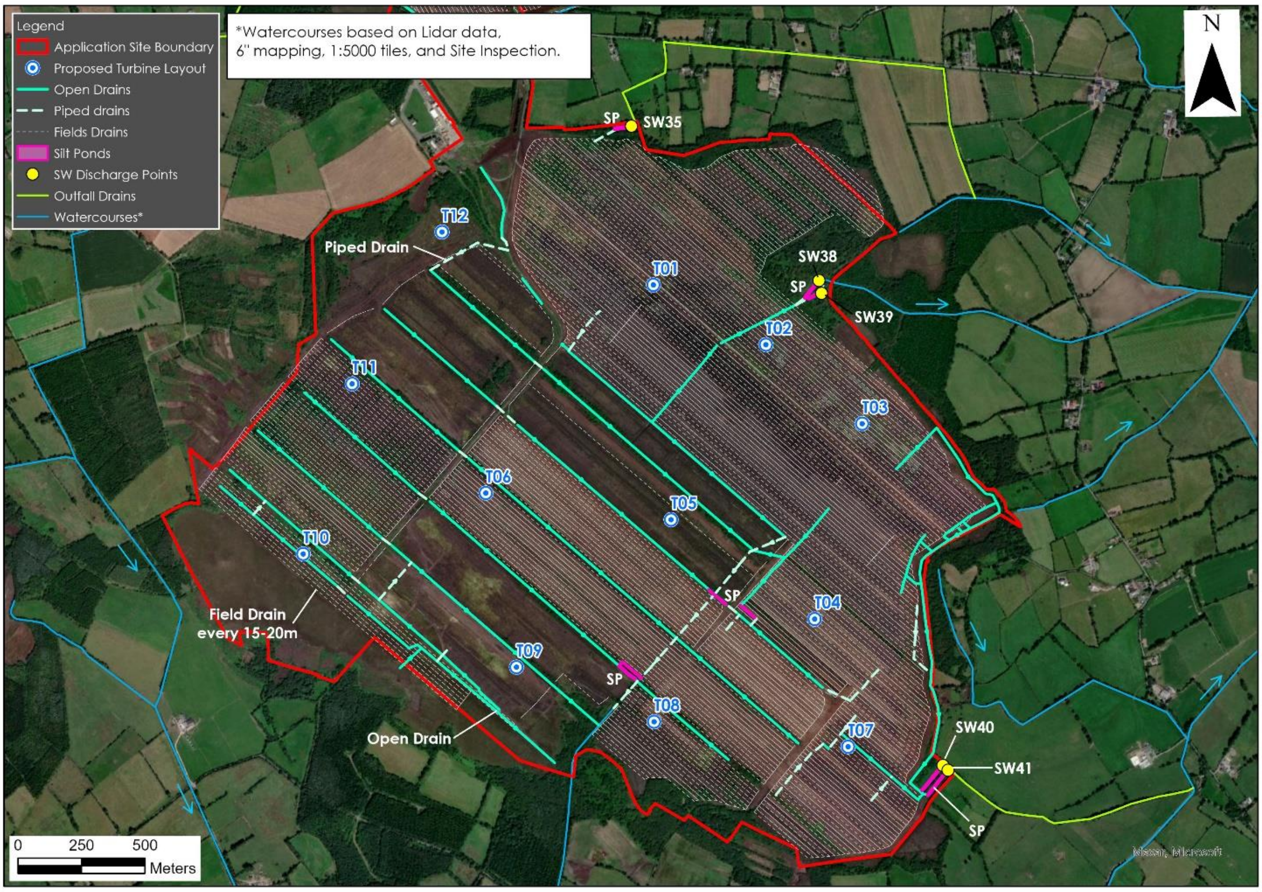


Figure 9-9: Existing drainage within Carranstown Bog

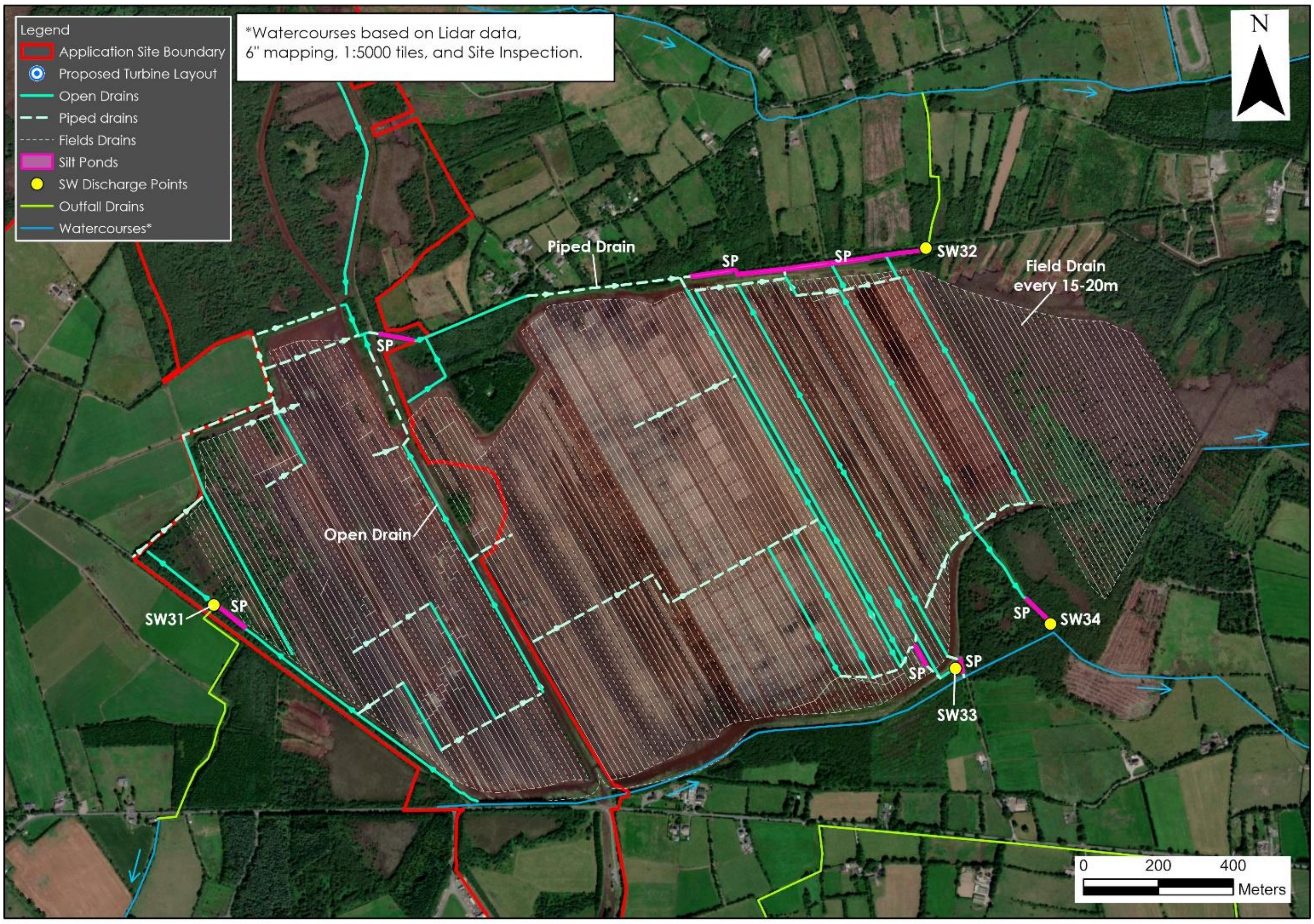


Figure 9-10: Existing drainage within Bracklin Bog

Figure 9-11: Existing drainage within Lisclogher Bog

Detailed hydrological audit of flow paths from each bog to its eventual discharge point at the regional catchment scale was conducted for the 4 no. bogs comprising the proposed site. The flowpaths have been traced using the River Waterbodies classification as outlined by the WFD. The flowpaths are shown as Figure 9-12 to Figure 9-15 below.

The surface of Ballivor Bog is drained by a network of northwest/ southeast orientated drains that are typically spaced every 15 to 20m. All 7 no. settlement ponds which form part of the drainage system for Ballivor Bog are located within the proposed site. Drainage from Ballivor Bog discharges through 6 no. outfalls (SW35, SW38, SW39, SW40, SW41 and SW41A) which discharge to off site drains and small local watercourses. Several of these watercourse have been named by the EPA (www.EPA.ie). In the southwest of Ballivor Bog, SW41A discharges to Clondalee_More stream which discharges to the Deel River. These waterbodies are mapped by the WFD as the Deel(Raharney)_060 surface waterbody (SWB). Further downstream, the Deel River discharges into the Boyne_050 SWB. The SW35, SW38 and SW39 outfalls, located in the northeast of the bog, discharge to several unnamed drains/streams, which then discharge to the Ballivor River. In the southeast of the bog outfalls SW40 and SW41 outfall to the Derryconor stream, which then discharges to the Ballivor River. The Ballivor River at this location is mapped as the Boyne_060 SWB by the WFD. Further downstream the Ballivor River confluences with the River Boyne (i.e Boyne_060 SWB). The River Boyne then continues through segments Boyne_070 to Boyne_180 before becoming tidal in the Boyne Estuary to the west of Drogheda.

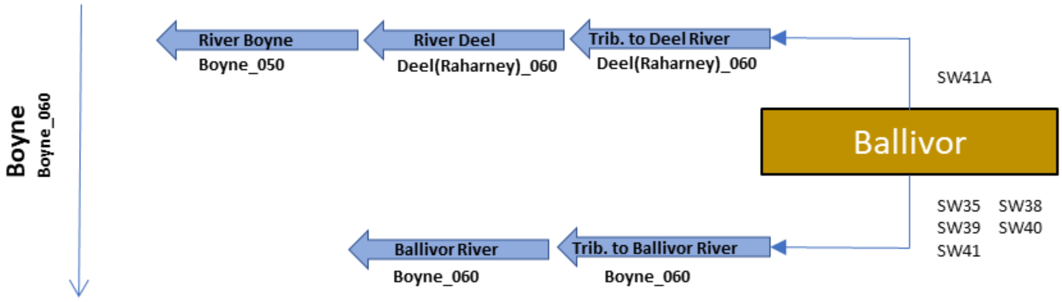


Figure 9-12: Hydrological Flow Path for Ballivor Bog

The surface of Carranstown Bog is drained by a network of northwest-southeast oriented drains, typically spaced at 15m intervals. Drainage from Carranstown Bog discharges via 4 no. outfalls (SW31, SW32, SW33 and SW34). In the west, SW31 discharges to the Grange More stream which in turn discharges to the Craddanstown stream before discharging into the Deel River to the southwest of Ballivor Bog. These waterbodies are mapped within the Deel(Raharney)_060 SWB. Downstream, the Deel River discharges into the Boyne_050 SWB. In the southeast of Carranstown Bog, and outside of the proposed site boundary, the SW34 outfall discharges to the Killaconnigan stream, which in turn discharges to the Ballivor River southwest of Ballivor village. Here the Ballivor River is mapped within the Boyne_060 SWB. In the northeast of the bog, and outside of the proposed site boundary, SW32 outfalls to the Craddanstown Little stream which discharges into the Cartenstown stream and eventually into the Stonyford River to the east of the Carranstown Bog. These waterbodies are mapped within the Stoneyford_040 SWB. Further downstream the Stoneyford River reaches a confluence with the River Boyne (Boyne_070 SWB). The river Boyne then continues through segments Boyne_080 to Boyne_180 before becoming tidal to the west of Drogheda.

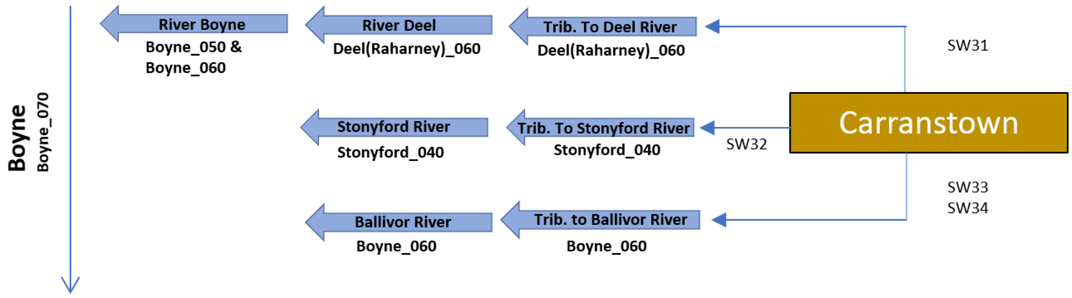


Figure 9-13: Hydrological Flow Path for Carranstown Bog

Bracklin Bog is drained by a series of drains spaced at approximately 15m intervals. These drains have become overgrown since production stopped within this bog. Mineral soil can be observed from aerial photographs, indicating the peat has been essentially stripped. The western portion of Bracklin Bog (i.e. Bracklin West) contains east-west oriented drains. Drainage from Bracklin Bog discharges via 5 no. outfalls (SW26, SW27, SW28, SW29 and SW30), with all outfalls being located in Bracklin West and outside of the proposed site boundary. SW28, SW29 and SW30 discharge to the Greenan stream and the Ballynaskeagh stream respectively before discharging into the Deel River. These waterbodies are mapped in the Deel(Raharney)_030 SWB. The Deel River continues through segments Deel(Raharney)_040 and Deel(Raharney)_050. SW26 and SW27 outfall to the Craddanstown stream which forms part of the Deel(Raharney)_060 SWB. Downstream the Deel River discharges into the Boyne_050 SWB.

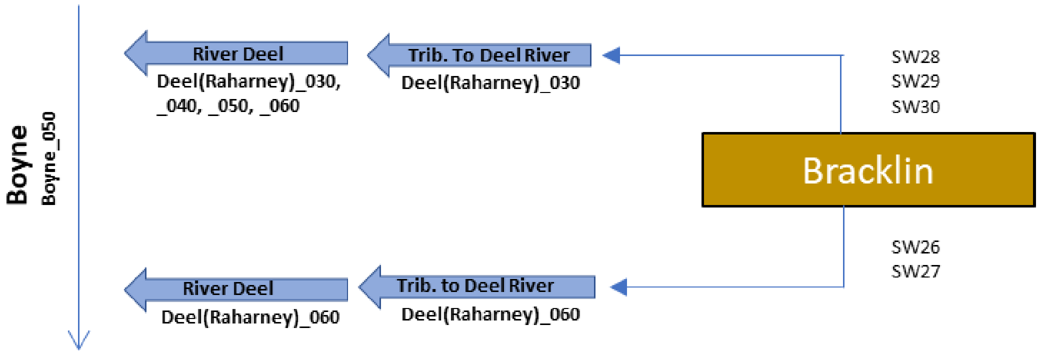


Figure 9-14: Hydrological Flow Path for Bracklin Bog

Lisclogher Bog is drained by east-west oriented drains, spaced at approximately 15m intervals. There are larger arterial drains running east-west also, but much of the drainage channels have become overgrown since production ceased in the 1990s. The Bord na Móna Decommissioning and Rehabilitation Plan for Lisclogher Bog (2022) states that the drainage system is beginning to break down with many drains becoming blocked and filling with water. Some minor drains along the northwestern perimeter of Liclogher Bog flow northwards towards the Stonyford_020 SWB. However, no dranage from within the proposed site is directed towards these perimeter drains and there is no outfall in this area of Lisclogher Bog. Drainage from Lisclogher Bog discharges via 1 no. outfall (SW25) located in the northeast of the bog. SW25 discharges to an unnamed stream which in turn discharges to the Stoneyford River. These waterbodies are mapped in the Stoneyford_030 SWB. The Stoneyford River continues through the Stoneyford_040 waterbody before discharging into the Boyne_070 SWB.

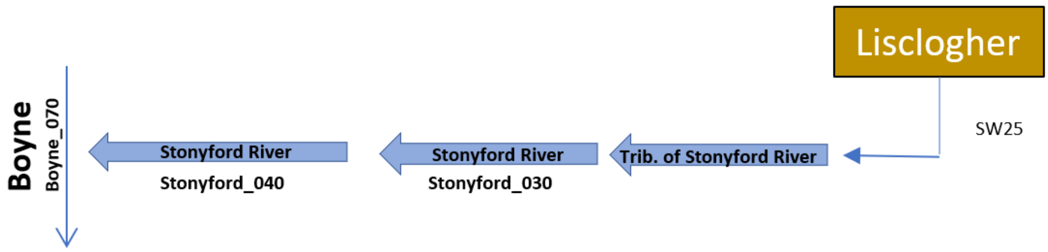


Figure 9-15: Hydrological Flow Path for Lisclogher Bog

9.3.5 Baseline Assessment of Site Runoff

This section presents a long-term water balance assessment and surface water runoff assessment for the baseline conditions at the proposed site.

The rainfall depths used in this water balance, are long-term averages. Please note that the long term averages are not used in the design of the sustainable drainage system for the Proposed Development as described in Section 9.4.1 below. The extreme rainfall depths shown in Table 9-5 above will be the basis of the Proposed Development drainage design which is described in Section 9.4.1.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (Table 9-8). It represents, therefore, the long-term average wettest monthly scenario in terms of volumes of surface water runoff from the proposed site pre-wind farm development. The surface water runoff co-efficient for the proposed site is estimated to be 96% based on the predominant peat coverage (refer to Section 9.3.2).

The highest long-term average monthly rainfall recorded at Ballivor over 30 years occurred in the month of January, at 86mm. The average monthly evapotranspiration for the synoptic station at Mullingar over the same period in January was 0.8mm. The water balance presented in **Table 9-9** indicates that a conservative estimate of surface water runoff for the proposed site during the highest rainfall month is approximately 1,332,810m^3/month or 42,993m^3/day.

Table 9-8: Water Balance and Baseline Runoff Estimates for Wettest Month (January)

Water Balance Component	Depth (m)
Average January Rainfall (R)	0.086
Average January Potential Evapotranspiration (PE)	0.008
(AE = PE x 0.95)	0.0076
Effective Rainfall January (ER = R - AE)	0.0784
Recharge (4% of ER)	0.0031
Runoff (96% of ER)	0.0753

Table 9-9: Baseline Runoff for the Proposed Site

Study Area	Approximate Area (ha)	Approximate Baseline Runoff per Wettest month (m^3)	Approximate Baseline Runoff per day (m^3/day) in wettest month
Proposed Site	1,770	1,332,810	42,994

9.3.6 Flood Risk Assessment

This section provides a summary of the Flood Risk Assessment (FRA) which has been undertaken by HES for the proposed site. The full FRA report is attached as Appendix 9.1. The FRA is completed in line with the guidelines provided in "The Planning system and Flood Risk Management" (OPW, 2009).

To identify those areas as being at risk of flooding, OPW's River Flood Extents Map, the National Indicative Fluvial Mapping, Past Flood Event Mapping (www.floodinfo.ie) and historical mapping (i.e. 6" and 25" base maps) were consulted.

No recurring flood incidents or instances of historical flooding were identified within the proposed site in historic OS maps or in OPW flood maps. Identifiable map text on local available historical 6" or 25" mapping for the proposed site does not identify any lands that are "liable to flood".

The closest mapped historical flood event is located approximately 300m to the east of Ballivor Bog where flooding occurred in August 2008 following "very heavy and prolonged rainfall in the Boyne Catchment".

The GSI's Winter 2015/2016 surface water flood map shows areas of fluvial and pluvial flooding during the Winter 2015/2016 flood event, which was the largest recorded flood event in many areas. This map does not record any flooding within the proposed site. In addition, the GSI Groundwater Flood mapping (available at www.floodinfo.ie) does not record any historic or predictive groundwater flood zones within the proposed site.

The Local Authority Strategic Flood Risk Assessment (SFRA) (www.floodinfo.ie) mapping indicates that areas in the northwest of Lisclogher Bog are vulnerable to fluvial flooding and mapped within Flood Zone A (100-year flood event) (refer to Figure 9-16). However, site walkovers have revealed that this section of the mapped watercourse does not exist (refer to Section 9.3.3 above and see existing drainage map for Lisclogher Bog included as Figure 9-11). This error also indicates that the SFRA flood zones mapped in this region are incorrect as they assume the presence of a surface watercourse. It is concluded that based on site observation, lack of flooding in winter 2015/2016, and the high drainage density within the bog at this location, that the actual flood risk in this area is the same for the entire Lisclogher Bog, and it should be mapped in Flood Zone C.

CFRAM mapping (www.floodinfo.ie) includes modelled flood levels for the 10-year and 100-year flood events. These levels, modelled near Ballivor village, range from 64.19 – 65.34m OD and are well above the current outfall pipe elevations at the proposed site (67.97 – 79.13m OD). Therefore the risk of fluvial flooding along the Ballivor River, located to the east of the proposed site, backing up into the site drainage network is currently very low. Local CFRAM mapping is shown below as Figure 9-17.

The main risk of flooding across much of the proposed site is via pluvial flooding due to the low permeability peat soils and subsoils. The surface of the cutover bog contains an extensive network of peat drains with surface water outflows from the bogs. This existing drainage network has reduced the risk of pluvial flooding across much of the proposed site. However, following periods of intense and prolonged rainfall events localised surface water ponding is still likely to occur in places.

Site walkover indicates the surface of the cutover bog contains an extensive network of peat drains with surface water outflows from the bogs. This existing drainage network has reduced the risk of pluvial flooding across much of the proposed site. However, following periods of intense and prolonged rainfall events localised surface water ponding is still likely to occur in places. Proposed site infrastructure will be raised above existing ground levels by approximately 1m, therefore risk from pluvial flooding is negligible.

The Proposed Development substation is particularly sensitive to flooding. A site-specific flood analysis has been completed for the substation location. Conservative volumetric analysis has determined the peak flood levels at the proposed substation site for 100-yr and 1000-yr rainfall events to be 74.3 and 74.6m OD respectively. The primary control in the analysis is the expanse of the bog in Carranstown West Bog which needs to fill with pluvial flood water before the substation site can flood. It is therefore recommended to give the substation a floor level of >74.9mOD (74.6mOD + 0.3m freeboard). The proposed final floor level of the substation is 75.9mOD. At this elevation the risk of flooding at the substation site is negligible.

Figure 9-16: Local Authority SFRA Flood Mapping

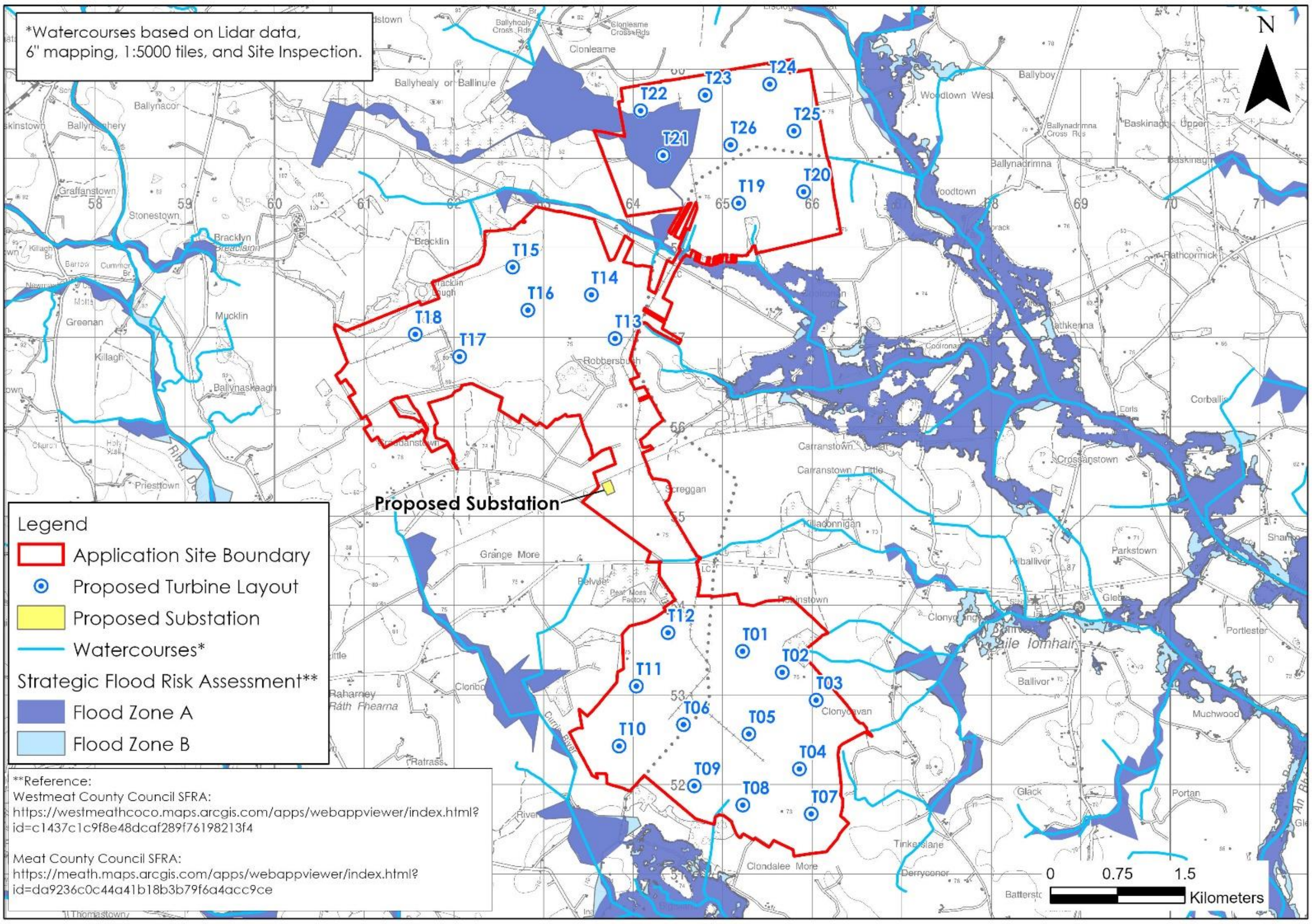
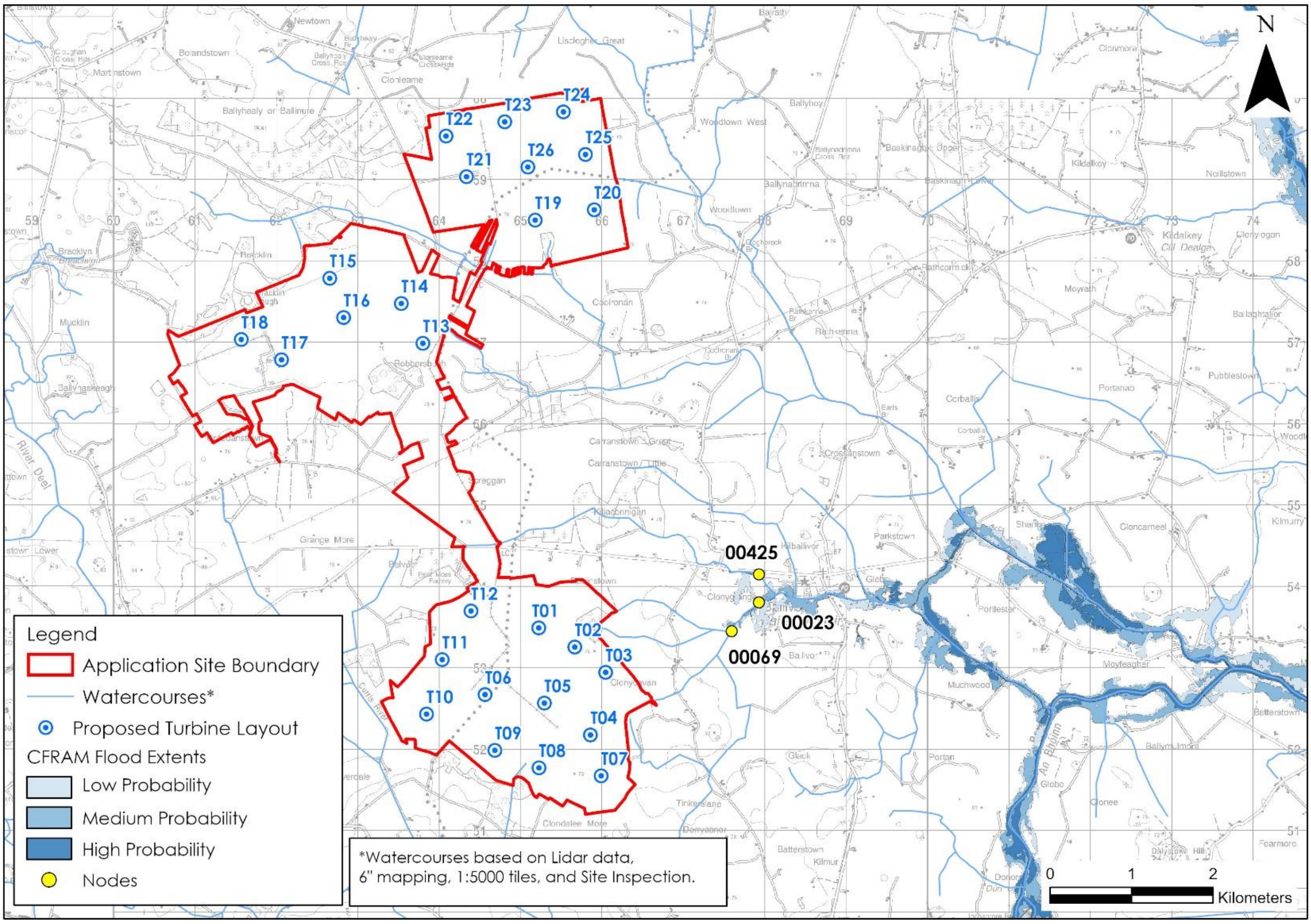


Figure 9-17: Local CFRAM Flood Zone Mapping



9.3.7 Surface Water Quality

Biological Q-rating data for EPA monitoring points on the Stonyford, Deel, Ballivor and Boyne rivers are shown in Table 9-10 below. 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 Q-rating for the rivers (Deel(Raharney), Stonyford and Boyne Rivers) in the vicinity and downstream of the proposed site range from 'Poor' to 'Good' in the latest WFD monitoring round (2020). No Q-ratings are available for any of the smaller watercourses which receive discharge from the proposed site.

To the west of the proposed site, the Deel(Raharney) River achieved 'Good' status at Cummer Bridge (Station ID: RS07D010200) and at Raharney Bridge (Station ID: RS07D010300) in 2020. Further downstream to the southwest of Ballivor Bog, the Deel(Raharney) River achieved a Q-score of Q3-4, *i.e.* Moderate status, at Inan Bridge (Station ID: RS07D010400). Upstream of its confluence (Station ID: RS07D010600) with the River Boyne, the Deel(Raharney) was of 'Good' status in 2020. Downstream of this confluence the Boyne was of 'Good' status (Station ID: RS07B040800 and RS07B040900).

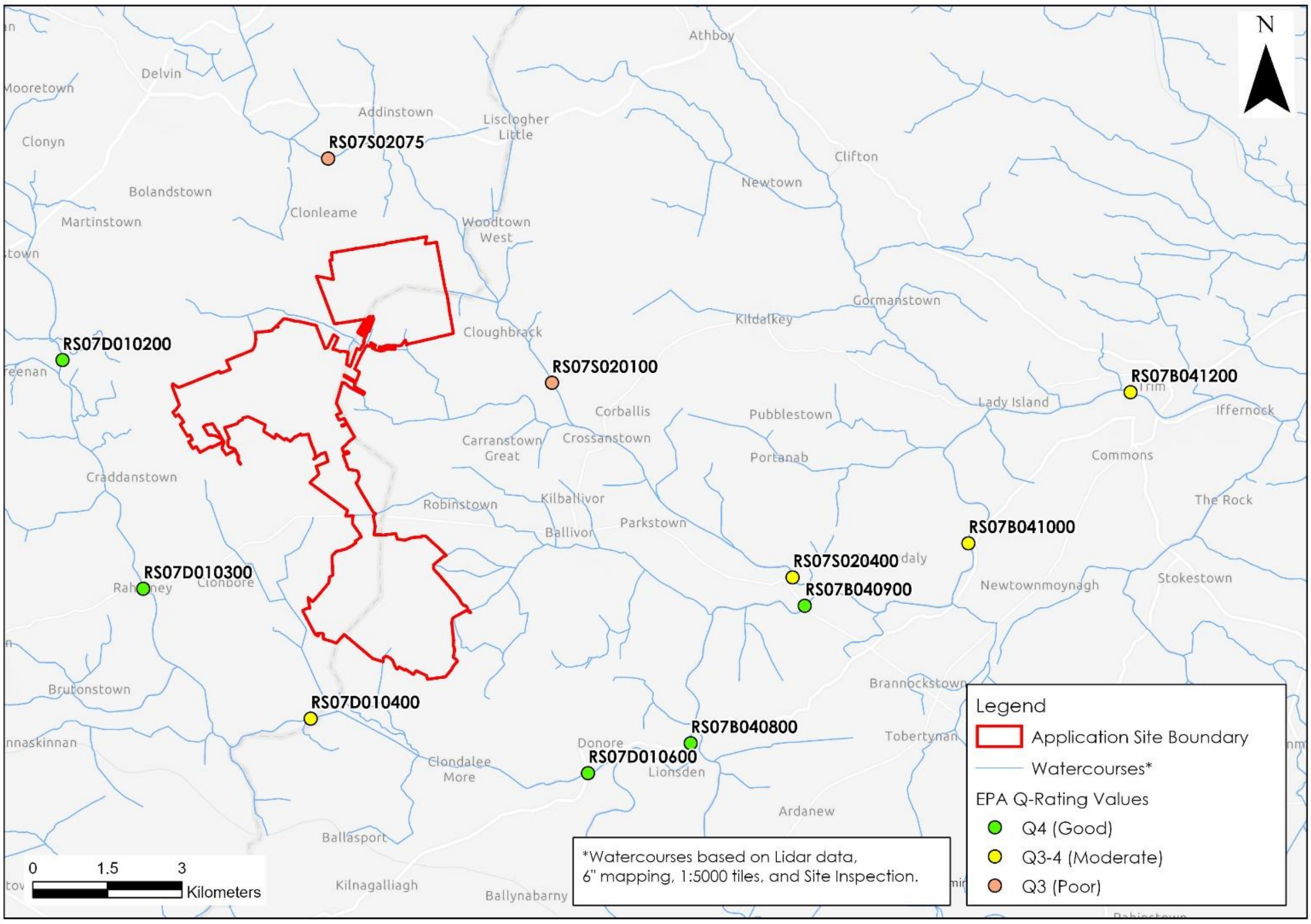
The Stonyford River was of 'Poor' status (Q3) at Stonestown Bridge (Station ID: RS07S020075) to the north and upstream of the proposed site. Further downstream the Stonyford also achieved 'Poor' status at a bridge upstream of Rathkenna Bridge (Station ID: RS07S020100). Upstream of its confluence with the Boyne River the Stonyford River was assigned a Q-status of Q3-4 (Station ID: RS07S020400). Downstream of this confluence the River Boyne was found to be of 'Moderate' status (Station ID: RS07B041000 and RS07B041200).

A map of local EPA monitoring stations is attached as Figure 9-18 below.

Table 9-10: Latest EPA Water Quality Monitoring Q-Rating Values (2020)

WFD SWB	Station ID	Easting	Northing	EPA Q-Rating Status
Deel(Raharney)_030	RS07D010200	258458	257621	Q4 (Good)
Deel(Raharney)_040	RS07D010300	260085	253021	Q4 (Good)
Deel(Raharney)_050	RS07D010400	263452	250407	Q3-4 (Moderate)
Deel(Raharney)_060	RS07D010600	269031	249313	Q4 (Good)
Boyne_050	RS07B040800	271093	249913	Q4 (Good)
Boyne_060	RS07B040900	273392	252679	Q4 (Good)
Stonyford_020	RS07S02075	263805	261681	Q3 (Poor)
Stonyford_030	RS07S020100	268303	257165	Q3 (Poor)
Stonyford_040	RS07S020400	273148	253252	Q3-4 (Moderate)
Boyne_070	RS07B041000	276679	253937	Q3-4 Moderate
Boyne_080	RS07B041200	279942	256977	Q3-4 Moderate

Figure 9-18: Map of EPA Monitoring Stations



Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken at 18 no. surface water sampling locations during 3 no. monitoring rounds on 01st April 2021, 28th October 2021 and 19th January 2022 within surface watercourses directly downstream of the proposed site. The results are listed in Table 9-12. The monitoring locations were typically in small streams and drainage channels and are shown in Figure 9-19 below.

Electrical conductivity (EC) values at the monitoring locations ranged between 126 and 814µS/cm, with an average conductivity value of 581µS/cm. Turbidity ranged from 3.1 to 67.3NTU, with an average of 8.6NTU. The highest turbidity was recorded at SW1 within the Stonyford_030 SWB to the west of Lisclogher Bog. This (67.3NTU) turbidity value is anomalously high and most likely due to disturbance of sediment within the water column prior to sampling. Excluding this value, the turbidity ranged between 3.1 – 16.2NTU. Dissolved Oxygen ranged from 4.72 to 11.04mg/l.

The pH values were generally slightly basic, ranging between 6.57 and 7.94, with an average pH of 7.54. Slightly acidic pH values of surface waters would be typical of peatland environments due to the decomposition of peat.

Surface water samples were also taken at these locations for laboratory analysis. Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 9-13 below. In addition, the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272/2009, as amended) are shown in Table 9-11. Original laboratory reports are attached as Appendix 9.2.

Suspended solid concentrations ranged from <5 to 80mg/l. Suspended solids were above the S.I 293/1988 threshold limits of 25 mg/L in 8 of the 52 no. samples. Ammonia ranged between 0.03 to 0.74 mg/l, and were often above the threshold values for High (≤0.04 mg/L) and Good (≤0.065 mg/L) quality as set out in SI 272/2009. The presence of elevated ammonia is likely due to natural decomposition of peat.

Biological Oxygen Demand (BOD) ranged between <1 and 4 mg/l, with an average value of 2.07 mg/L, above the Good status[1] threshold value of 1.5 mg/L. Nitrate ranged between <5.0 and 35.4 mg/l and results were typically between 5-15 mg/l which is what would be expected in a peatland environment. Nitrite was below the limit of detection of the laboratory in 67% of the samples, with the nitrite concentration in the remaining samples ranging from <0.05 to 0.15mg/l.

In comparison to S.I. No. 272/2009, 33 of 52 results (63%) for BOD exceeded the "Good Status" and "High Status" threshold values. In relation to ammonia, 41 of 52 samples (79%) exceeded the "Good Status" threshold of -≤0.065mg/l. For orthophosphate, 19 of the 52 no. samples (37%) were below the laboratory limit of detection (0.02mg/L), while a total of 13 of the 52 no (25%). no samples exceed the "Good Status" threshold of 0.035mg/l.

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

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

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

Table 9-12: Field Parameters - Summary of Surface Water Chemistry Measurements (01/04/2021, 28/10/2021 and 19/01/22)

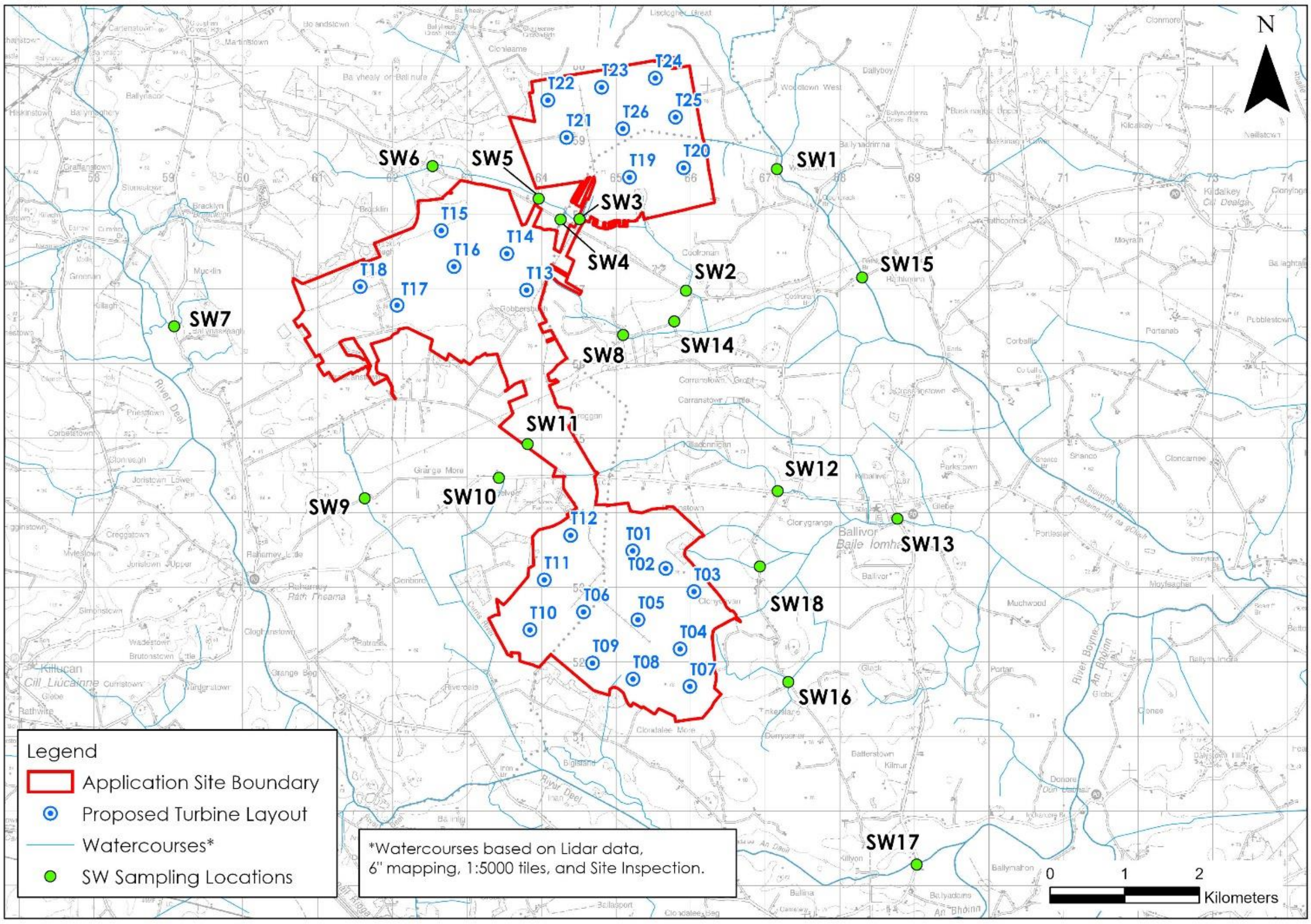
Location ID	Easting	Northing	Temp °C	DO (mg/l)	SPC (µS/cm)	pH	Turbidity	Flow (l/s)
SW1	267157	258608	7.7 – 12.7	7.7 – 8.74	602 – 655	6.98 - 7.43	6.4 - 67.3	5 – 20
SW2	265941	256979	8.4 – 12.6	7.76 - 10.5	488 – 620	7 - 7.74	4.2 - 7.34	250 – 500
SW3	264510	257940	8.6 – 12.5	7.82 - 10.41	520 – 655	6.73 - 7.7	6.4 – 11.3	40 – 200
SW4	264256	257932	9.1 – 12.4	7.21 - 7.38	240	6.5 - 6.8	6.6 – 7.2	Dry – 15
SW5	263963	258213	8 – 12.5	7.68 - 10.31	534 – 653	7.1 - 7.72	4.5 - 6.9	150 – 500
SW6	262538	258647	8.1 – 12.4	6.08 - 10.52	635 – 747	6.9 - 7.84	5.07 – 16.2	150 – 200
SW7	259076	256500	8.4 – 12.9	9.32 - 9.48	561 – 582	7.47 – 7.62	6.03 – 11.4	60 – 150
SW8	265096	256383	9.3 – 12.8	7 - 9.9	438 – 538	6.75 - 7.67	9.05 - 13.5	100 – 300
SW9	261633	254196	8.5 – 12.7	7.57 - 9.94	667 - 752	7.33- 7.65	4.71 – 7.9	50 – 150
SW10	263431	254466	7.7 – 12.3	6.59 - 8.18	668 – 818	7.05 – 7.37	5.03 - 5.8	20 – 50
SW11	263814	254919	5.4 – 11.7	4.72 - 7.87	126 - 169	6.9 - 7.42	7.3 – 8.7	0
SW12	267169	254292	7.8 - 12.9	7.92 - 9.98	695 – 760	7.52 - 7.65	4.55 - 7.26	30 – 180
SW13	268774	253917	7.4 – 13.1	7.62 - 9.81	656 – 759	7.49 - 7.77	6.52 – 6.9	240 – 500
SW14	265783	256564	10 - 12.4	7.48 - 7.74	304	6.77 - 7.24	6.1 - 6.42	Dry - 20
SW15	268302	257158	8.4 – 12.9	8.27 - 11	725 -814	7.58 - 7.94	3.1 - 3.43	5000
SW16	267309	251730	7.8 – 13.3	7.32 - 8.85	504 -733	7.34 - 7.53	3.7 - 5.73	50 – 250
SW17	269032	249280	8.2 – 12.9	7.64 - 10.09	663 – 708	7 - 7.89	6.45 - 6.56	5000
SW18	266930	253281	7.1 – 12.9	9.75 - 11.04	357 - 422	7.76 - 7.91	7.4 - 8.36	15 - 75

Table 9-13: Surface water quality data (01/04/2021, 28/10/2021 and 19/01/2022)

Location ID	Suspended Solids (mg/l)	BOD5 (mg/l)	Orthophosphate (mg/l)	Nitrate (mg/l NO3)	Ammonia (mg/l)	Chloride (mg/l)
EQS	≤25(2)	≤ 1.3 to ≤ 1.5(3)	-≤ 0.035 to ≤0.025(2)	-	-≤0.065 to ≤ 0.04(2)	-
SW1	13 - 40	1 - 4	<0.02 – 0.09	<5 – 13.2	0.2 – 0.6	12.9 – 22
SW2	6 - 19	1 - 4	0.02 - 0.09	11.8 – 21.5	0.13 - 0.25	11 – 15.2
SW3	<5 – 10	1 - 4	0.02 – 0.04	14.8 – 27.9	0.09 - 0.12	12.5 - 15.8
SW4[4]	6 - 80	2 - 3	0.11 - 0.33	<5	0.03 – 0.05	10 - 18.4
SW5	<5 - 5	1 - 2	<0.02 – 0.03	<5 – 28.4	0.12 – 0.2	11 - 15.9
SW6	<5 - 6	1 - 4	<0.02 – 0.03	19.7 – 35.4	0.11 – 0.13	17.3 - 17.6
SW7	<5 - 14	1 - 3	<0.02 - 0.03	<5 – 5.2	0.23 - 0.46	4.6 - 13.6
SW8	<5 - 32	1 - 4	<0.02 - 0.03	6.3 – 8.5	0.14 - 0.74	8.1 - 10.8
SW9	<5	1 - 3	<0.02 – 0.02	5.5 – 10.2	0.03 - 0.08	8 – 13.1
SW10	<5 - 14	1 - 2	<0.02 – 0.05	6.1 – 21.8	0.04 - 0.39	22.8 – 28.5
SW11	<5 - 8	2 - 4	<0.02	<5	0.12 – 0.22	6.5 - 13.6
SW12	11 - 29	1 - 3	<0.02	<0.05 - 11.9	0.05 – 0.11	16.9 - 23.9
SW13	<5 - 13	1 - 3	0.02 - 0.04	7 – 11.8	0.06 – 0.18	13.7 – 20.9
SW14[5]	6 - 9	2 - 4	0.06 - 0.3	<5	0.14 - 0.56	9.7 - 13
SW15	6 - 31	<1 - 3	<0.02	11.4 – 20.3	0.06 – 0.11	15.6 – 18.3
SW16	<5 - 6	<1 - 3	0.02 - 0.04	<5 – 9.8	0.2 - 0.37	10.7 - 18.3
SW17	5 - 12	<1 - 4	<0.02 – 0.03	9 – 15.3	0.04 – 0.09	12 - 15.5
SW18	6 - 51	1 - 3	0.02 – 0.04	<5 – 6.2	0.03 – 0.12	8.3 – 12.3

[2] *S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations*
[3] *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).*
[4] *Only 2 no. rounds of sampling completed on 21/04/2021 and 28/10/2021.*
[5] *Only 2 no. rounds of sampling completed on 21/04/2021 and 28/10/2021.*

Figure 9-19: Surface Water Monitoring Locations



9.3.8 Hydrogeology

The majority of the bedrock geology underlying the proposed site is mapped as the Dinantian Pure Unbedded Limestones of the Waulsortian Limestone Formation and the Dinantian Upper Impure Limestones of the Lucan Formation. These bedrock geology formations are classified by the GSI as a Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones (Ll). The Tober Colleen Formation which is mapped to underlie sections of Lisclogher Bog and Bracklin Bog is classified as a Poor Aquifer – Bedrock which is Generally Unproductive except for Local Zones (Pl). A bedrock geology aquifer map is attached as Figure 9-20.

The 4 no. bogs comprising the proposed site are underlain by the Athboy Groundwater Body (GWB) (IE_EA_G_001) which is characterized by poorly productive bedrock. This is a large GWB that extends from Navan in the northeast to Tyrrellspass in Westmeath. The topography of the GWB is relatively low, with overall elevations falling from northwest to southeast. The GWB is composed primarily of moderate permeability rocks, although localized zones of enhanced permeability do occur. Groundwater flow will mainly occur laterally through the upper weathered zone of the aquifer. Below this, flow occurs along fractures, faults and karstic conduits. Recharge occurs diffusely through the subsoils and via outcrops and in some local areas direct recharge may be possible where via sinking streams. The aquifers are generally unconfined but may be locally confined where the subsoil is thicker and/or less permeable. Regional groundwater flow is from northwest to southeast, but locally, groundwater discharges to the streams and rivers crossing the aquifer. In general, groundwater flow paths will be less than a kilometre from recharge to discharge point; longer groundwater flow paths may develop where there is a higher degree of karstification. Groundwater discharges to the numerous small streams crossing the aquifer, and to the springs and seeps. There may also be some discharge to the Trim GWB to the east of this body.

Due to the presence of the peat at the proposed site and the bulk low permeability of the underlying mineral subsoil deposits, local groundwater recharge will be minimal. Recharge is likely to be limited to the perimeter of the bog where the peat is thin or absent (the presence of peat will prevent rapid recharge to underlying regional groundwater systems). Groundwater movement through the underlying subsoil glacial deposits will be relatively slow unless higher permeability sands and gravels are present. Based on topography and regional surface water drainage flows, local groundwater flow direction towards the southeast of the proposed site, towards the River Boyne. As stated above more localised groundwater flow directions will occur, with groundwater discharging to nearby streams and rivers such as the Deel(Raharney) river to the west of the proposed site and the Stonyford river to the east.

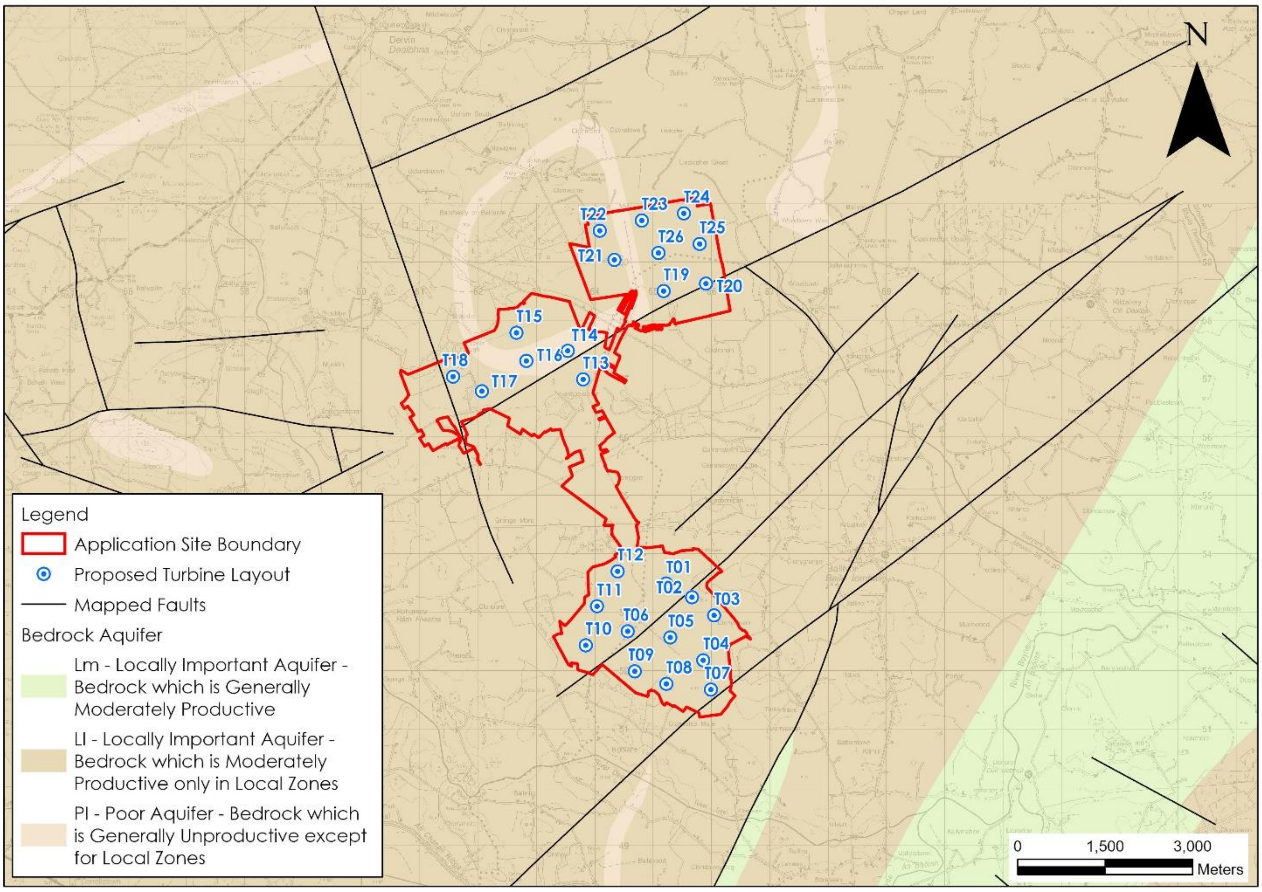
A shallow perched ground water table exists in the peat and is largely isolated from the underlying regional groundwater system (which occurs in the underlying till and bedrock). Groundwater monitoring has been completed at the 3 proposed borrow pit locations and at the proposed substation location. Summary data for the site investigations and groundwater monitoring are included in Table 9-14 below. Within the peat bog, the perched water table was generally encountered close to the ground surface. In the vicinity of the proposed substation groundwater levels ranged from 74.66 – 75.03mOD (2.03 – 2.4metres below ground level (mbgl)) at BH5 from 20th September 2021 to 22nd February 2023. Further to the west, groundwater levels are closer to the surface at BH8 (0.3 – 0.63mbgl) and BH12 (0.42 – 0.75mbgl). Groundwater levels at the 2 no. proposed borrow pits in Carranstown Bog ranged from 72.28 – 73.85mOD (2.51 – 4.78mbgl).

Table 9-14: Groundwater Monitoring at Borrow Pit and Substation Locations

Location	Location ID	Ground level (mOD)	BH depth (mbgl)	WL Range (mOD) (01/09/2021 – 22/02/2023)	Summary of Mineral Subsoil Lithology
BP2	FBP-W03	82.35	11.0	79.00 – 79.85	0-1.5 - no recovery 1.5-11.0 - Brown slightly gravelly silty fine and medium SAND with cobbles.
	FBP-W04	85.88	11.0	78.82 – 79.86	0-1.5 - no recovery 1.5-11.0 – Brownish grey slightly fine to coarse SAND with cobbles.
Carranstown BP (BP1B)	BPA-BH1	78.01	5.1	73.24	0-2.6 – peat 2.6-5.1- Greyish Brown limestone GRAVEL.
Carranstown BP (BP1a)	BPA-BH3a	76.36	4.5	73.57 – 73.85	0-0.6 – peat 0.6-2.5 - Greyish brown gravelly SILT 2.5-4.5 – Dark grey sandy/silty GRAVEL
	CMP-W05	76.84	11.0	72.28 – 72.48	0-1.5 - no recovery 1.5-11.0 – Greyish Brown limestone GRAVEL.
~130m S of Substation	BH12	74.85	4.6	74.1 – 74.4	0-2.4 – Soft Peat 2.4-4.3 - Greyish gravelly SILT

Location	Location ID	Ground level (mOD)	BH depth (mbgl)	WL Range (mOD) (01/09/2021 – 22/02/2023)	Summary of Mineral Subsoil Lithology
					4.3-4.6 – angular cobbles
~50m SE of Substation	BH8	74.7	6.4	74.08 – 74.4	0-3.4 – Soft Peat 3.4-5.0 - Grey slightly gravelly sandy clayey SILT 5.0-6.2 - Grey slightly sandy slightly gravelly CLAY 6.2-6.4 – angular cobbles
Substation	BH5	77.06	7.2	74.66 – 75.03	0-3.0 – Soft Peat 3.0-5.6 – Greyish green slightly sandy gravelly SILT 5.6-7.0 - Grey slightly sandy slightly gravelly CLAY 7.0-7.2 – angular cobbles

Figure 9-20: Bedrock Geology Aquifer Map



9.3.9 Groundwater Vulnerability

Groundwater Vulnerability is a term used to represent the natural ground characteristics that determine the ease with which groundwater may be contaminated by human activities. Groundwater vulnerability is mapped by the GSI and groundwater vulnerability maps are available to view at www.gsi.ie.

The vulnerability rating of the bedrock aquifer underlying the proposed site is classified as "Moderate" to "Low" which is consistent with the presence of basin peat underlain by lacustrine/mineral soil clays and glacial deposits. This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore surface water bodies, such as drains and streams, are more vulnerable to pollution than groundwater.

Groundwater vulnerability is extremely high in karst areas due to the high degree of interconnection between surface and groundwaters in these areas. The GSI does not record the presence of any karst features within the proposed site or in its immediate vicinity. The closest mapped karst feature is a spring (GSI Identifier: 2325SEK005) located in the townland of Dardistown, approximately 2.7km northwest of Bracklin Bog.

9.3.10 Groundwater Hydrochemistry

There is no groundwater quality data for the aquifers underlying the proposed site.

Groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality effects are extremely unlikely. There are also no proposed discharges to ground associated with the Proposed Development.

Based on data from GSI on the Athboy GWB, groundwaters in this area are typically hard with a calcium-bicarbonate signature and alkalinities of over 250mg/l. Hardness generally ranges from 250 - 350 mg/l as $CaCO_3$, with high electrical conductivities (600 – 700 µS/cm). Table 9-15 provides a summary of the hydrogeological characteristics on each of the bogs comprising the proposed site.

Table 9-15: Hydrogeological characteristics of the Ballivor Bog Group.

Bog Name	Aquifer Type	GWB	GW Vulnerability	GW Hydrochemistry	Nearest Mapped Karst Feature
Ballivor	LI	Athboy	Generally Low, some Moderate vulnerability in south and east	Generally: $Ca\text{-}HCO_3$, with hard water	Spring located ~7.7km to the west
Carranstown	LI	Athboy	Moderate in the east and north, Low in the South and West.	Generally: $Ca\text{-}HCO_3$, with hard water	Spring located ~8.5km to the west
Bracklin	LI, PI	Athboy	Generally Moderate, Low in the West	Generally: $Ca\text{-}HCO_3$, with hard water	Spring located ~2.7km to the northwest
Lisclogher	LI, PI	Athboy	Low	Generally: $Ca\text{-}HCO_3$, with hard water	Spring located ~7km to the west

9.3.11 Water Framework Directive Water Body Status & Objectives

The River Basin Management Plan was adopted in 2018 and has amalgamated all previous river basin districts into one national river basin management district.

The Third Cycle River Basin Management Plan (2022-2027) objectives include the following:

- Ensure full compliance with relevant EU legislation;
- Build on the achievements on the 2nd Cycle;
- 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 restoring impacted waters and protecting waters from deterioration.

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

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

9.3.12 Groundwater Body Status

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

The Athboy GWB (IE_EA_G_001) underlies the Ballivor Bog Group. This GWB has been assigned 'Good Status' in all 3 no. WFD cycles (2010-2015, 2013-2018 and 2016-2021) (Table 9-16). This status is defined based on the quantitative status and chemical status of the GWB. The draft 3rd Cycle Boyne Catchment Report lists states that the Athboy GWB is "at risk" of not meeting its WFD objectives, and is under significant pressure from agricultural activities (EPA, 2021).

Table 9-16: WFD Groundwater Body Status

GroundWaterbody	Status 2010-2015	Status 2013-2018	Status 2016-2021	3rd Cycle Risk Status	WFD Pressures
Athboy	Good	Good	Good	At Risk	-

9.3.13 Surface Water Body Status

Table 9-17 is a summary of the WFD status and risk result of Surface Water Bodies (SWBs) in the vicinity and downstream of the proposed site. The western section of Bracklin Bog is drained by the Deel(Raharney)_030 SWB. The status of this SWB has improved from "Moderate" in the 2013-2018 cycle to "Good" in the latest cycle (2016-2021). Further downstream the Deel(Raharney)_040 SWB achieved "Good" status in all 3 no. monitoring rounds while the Deel(Raharney)_050 SWB was assigned "Moderate" status. The Deel(Raharney)_060 SWB drains the western section of Ballivor Bog and its status has increased from "Moderate" status in the 2010-2015 round to "Good" in the 2013-2018 round and has remained of "Good" status in the latest round. Further downstream the Boyne_050 achieved "good" status in all 3 no. WFD rounds.

The Boyne_060 SWB drains the eastern section of Ballivor Bog and Carranstown Bog. This SWB has also experienced an improved status from "Moderate" in 2010-2015 to "Good" in 2013-2018 and 2016-2021. The Stonyford River drains Lisclogher Bog, Lisclogher West Bog and Bracklin Bog. The Stonyford_020 and _030 SWBs have consistently deteriorated in status throughout each of the WFD rounds, having "Good" status in 2010-2015, to "Moderate" in 2013-2018, to "Poor" in 2016-2021. The Stonyford_040 however, received a deterioration in status from "Good" in 2010-2015 to "Moderate" in 2013-2018 and remained to be of "Moderate" status in 2016-2021. Further downstream the Boyne_070 and Boyne_080 both achieved "Moderate" status in the latest WFD round.

The majority of these SWBs have been deemed to be "At risk" of not meeting their WFD objectives.

The 3rd cycle Draft Boyne Catchment Report (EPA, 2021) states that agriculture is the most significant pressure in the Boyne Catchment. Agriculture has been identified as a significant pressure on several SWBs downstream of the proposed site. The primary issues relating to agricultural activities are phosphorus loss to surface waters, organic pollution associated with run-off from farmyards and the entrainment of sediment in surface waters due to land drainage works and bank erosion.

Hydromorphological (or physical) is also listed as a significant pressure in the Boyne Catchment, impacting SWBs downstream of the proposed site. Hydromorphological conditions including the input of excessive fine sediment and poor habitat quality are major issues for several SWBs in the vicinity of the proposed site (i.e. Deel(Raharney)_050, Deel(Raharney)_060 and Boyne_060). The River Basin Management Plan states that these SWBs have been subject to excessive modification due to the presence of drainage schemes. In addition, dams, barriers, locks and weirs were identified as a pressure on the Stonyford_020 SWB.

Meanwhile, the 3rd Cycle Draft Boyne Catchment Report (EPA, 2021) lists peat (peat drainage and extraction) as a significant pressure on 13 no. river waterbodies within the Boyne Catchment. This is a reduction from 18 no. waterbodies from the 2nd WFD Cycle. Downstream of the proposed site the Stonyford_030 SWB is listed as being under significant pressure from peat related activities in 3rd Cycle Draft Report. Meanwhile, peat was listed as a pressure on the Boyne_060 SWB in the 2nd Cycle. This SWB has been deemed to be no longer impacted by peat related activities in the 3rd Cycle. Peat pressures are related to increased sediment loads which alter habitats, morphology and hydrology. Peat extraction activities also result fluctuation in downstream ammonia concentrations.

Table 9-17: Summary WFD Information for Surface Water Bodies

River Waterbody	Status 2010-2015	Status 2013-2018	Status 2016-2021	3rd Cycle Risk Status	WFD Pressures
Deel (Raharney)_030	Good	Moderate	Good	At Risk	Agriculture
Deel (Raharney)_040	Good	Good	Good	Not at Risk	-
Deel (Raharney)_050	Moderate	Moderate	Moderate	At Risk	Hydromorphology
Deel (Raharney)_060	Moderate	Good	Good	Under Review	-
Boyne_050	Good	Good	Good	Not at Risk	-
Boyne_060	Moderate	Good	Good	At Risk	Hydromorphology
Stonyford_020	Good	Moderate	Poor	At risk	Agriculture & Hydromorphology
Stonyford_030	Good	Moderate	Poor	At Risk	Agriculture & Peat
Stonyford_040	Good	Moderate	Moderate	At Risk	Agriculture
Boyne_070	Good	Moderate	Moderate	At Risk	Agriculture
Boyne_080	Moderate	Moderate	Moderate	At Risk	Hydromorphology

9.3.14 Designated Sites and Habitats

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

Designated sites that lie downstream of the proposed site include:

- Natura 2000 sites:
  - River Boyne and River Blackwater SAC (Site Code: 002299), Deel (Raharney), Stonyford and Boyne rivers are mapped within this SAC;
  - River Boyne and River Blackwater SPA (Site Code: 004232), Deel (Raharney), Stonyford and Boyne rivers are mapped within this SPA; and,
  - Boyne Coast and Estuary SAC and pNHA(Site Code: 001957), 48km northeast of the Lisclogher Bog.
- NHA/pNHAs
  - Boyne Woods pNHA (Site Code: 001592), 26km northeast of Lisclogher Bog and to the east of Navan Town along the River Boyne;
  - Crewbane March pNHA (Site Code: 000553), 35km northeast of Lisclogher Bog along the River Boyne;

- Dowth Wetland pNHA (Site Code: 001861), 40km northeast of Lisclogher Bog; and,
- Boyne River Islands pNHA (Site Code: 001862), 42km northeast of Lisclogher Bog and to the west of Drogheda.

The proposed site is hydrologically connected to the River Boyne and River Blackwater SAC and SPA via several drains and streams which flow from the bog areas into the Deel (Raharney), Stonyford and Boyne rivers. These flowpaths are outlined in detail in Section 9.3.4.

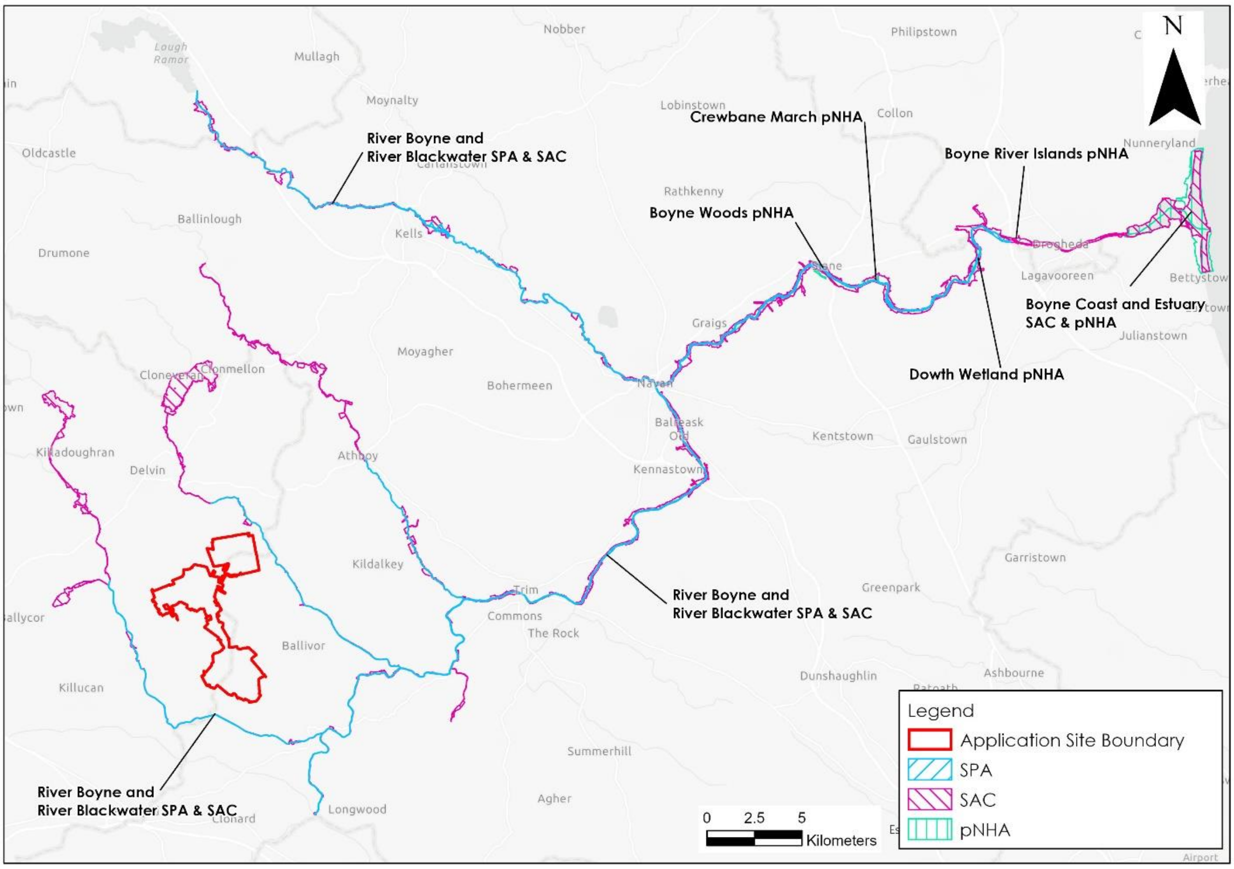
Several other designated sites are located downstream along the River Boyne and are therefore also hydrologically connected with the proposed site. However, these sites are located significant distances (>25km) from the proposed site. Consequently, the River Boyne and River Blackwater SAC/SPA remain the primary sensitive receptors due to their proximity to the proposed site and the direct hydrological linkage. This site was designated as a SAC in June 2003 and a SPA in November 2010.

Other sites located in the vicinity of the proposed site but are not directly linked via surface water pathways are considered below:

- Mount Hevey Bog SAC and Mount Hevey Bog pNHA is located approximately 3.4km west of the proposed site. This is a raised bog and is located upgradient of any drainage from the proposed site. In addition, the River Deel acts as a hydraulic barrier between the site and Hevey Bog. Therefore no hydrological or hydrogeological effects will occur on this designated site.
- The Royal Canal pNHA is located approximately 1.3km southwest of the proposed site. The River Deel acts as a hydraulic barrier between the proposed site and the pNHA. Therefore no hydrological or hydrogeological effects will occur on this designated site.

A map of local designated site is attached as Figure 9-21 below.

Figure 9-21: Designated Sites



9.3.15 Water Resources

9.3.15.1 Surface Water

There are 12 surface waterbodies within the Boyne catchment which have been identified as Drinking Water Protected Areas (DWPA).

The Stonyford_040 SWB in the vicinity of the proposed site is listed in Article 7: Abstraction for Drinking Water. Further downstream, and downstream of Trim, the Boyne River (Boyne_100) is also listed as a DWPA.

9.3.15.2 Groundwater

As outlined above, the groundwater body which underlies the Proposed Development is the Athboy GWB.

There is 1 no. mapped PWS (Public Water Supply Scheme) within 3 km of the proposed site. The Source Protection Area (SPA) for the Ballivor PWS is located to the east of Carranstown and Bracklin bogs, approximately 1.5 km north of Ballivor village. This SPA is more than 2km from the boundary of the proposed site.

The GSI well database, available at www.gsi.ie, was consulted in order to identify the occurrence of known and mapped groundwater wells within the proposed site and in the surrounding lands. The GSI well database maps wells with varying degrees of locational accuracy. Within the GSI database some well locations have a very good location accuracy of 50-100m while others have a poor location accuracy of 1km.

A search of private well locations, with a good location accuracy of 1–100m, were sought using the GSI well database (www.gsi.ie). One well (GSI Name: 2625SWW072) was identified in the east of Ballivor Bog in the townland of Clonycavan. This well reports a poor yield class of 8.7m^3/day. This well is not located within the Ballivor bog (based on inspection during site walkover surveys), and we expect that its location is likely associated with the house to the east.

Several additional wells with a location accuracy of 1km are mapped in the vicinity of the proposed site. These wells all have a poor yield class. As these wells are mapped only to an accuracy of 1km and therefore assessing potential effects on these wells cannot be undertaken in any reliable manner.

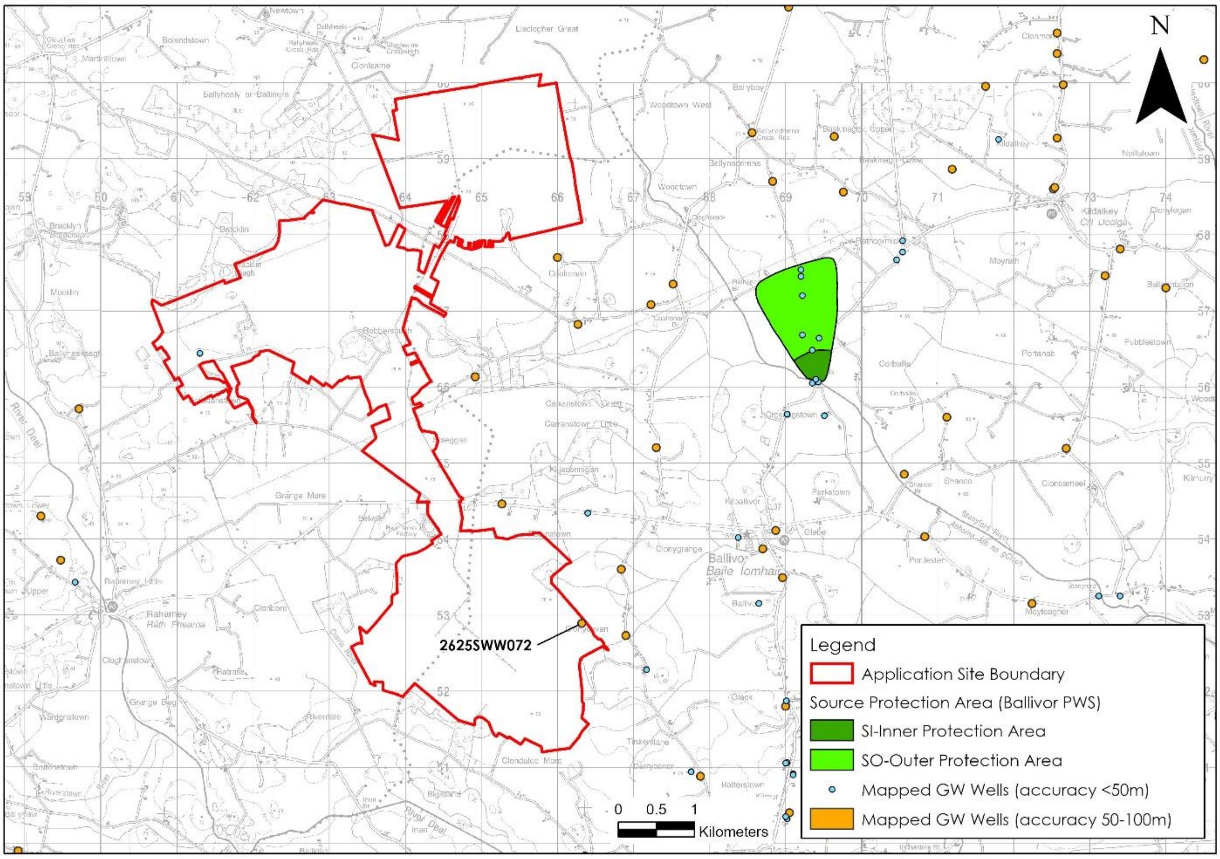
A map of local wells identified in the GSI database is attached as Figure 9-22.

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

In addition to the above, a search of the EPA's groundwater Abstraction Register database[6] was also completed, and it was found that no registered groundwater abstractions are located within 4.8km of the proposed site (allowing for the 1km rounding to grid coordinates from the abstraction register database).

[6] The information / data provided (i.e. the Abstraction Register) have been generated from the Environmental Protection Agency's Water Abstraction Registration Database and relate to those water abstractions of 25 cubic meters (25,000 litres) or more per day that have been registered with the Environmental Protection Agency. In accordance with the protection of critical national infrastructure direction included under the EU Directive 2016/1148, the data do not include those water abstractions where the abstraction purpose has been identified as being for drinking water. Additionally, grid references are rounded to the nearest kilometre to protect the identity of individual households and businesses, who may also use the abstracted water for private domestic use.

Figure 9-22: Map of Groundwater Wells (www.gsi.ie)



9.3.16 Receptor Sensitivity

Due to the nature of wind farm developments, being near surface construction activities (i.e., shallow excavations and foundations), effects on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during water impact assessments. Piling works are proposed for foundations at the proposed site, and therefore in this instance the underlying groundwater aquifer is identified as a sensitive receptor.

The following sensitive groundwater receptors are identified for impact assessment:

- The Poor and Locally Important Aquifers underlying the proposed site can be classed as being of Low to Medium Importance (refer to Table 9-2).
- The local public and private groundwater abstractions in the lands surrounding the proposed site.

Surface waters are the main sensitive receptors associated with the Proposed Development due to the local hydrological regime which is characterised by high runoff rates and low rates of groundwater recharge. The primary potential contamination downstream surface waters is via elevated concentrations of suspended solids and nutrient enrichment.

The following surface water receptors are identified for impact assessment:

- The local surface waters downstream of the proposed site, including the Deel, Stonyford and Boyne rivers. These waters can be considered to be of Extremely High

Importance (refer to Table 9-1) due to their designation as part of the River Boyne and River Blackwater SAC/SPA.

- Downstream drinking water protected areas including the Stonyford_040 SWB.

Further to the information presented in Section 9.3.14, the following designated site is identified for impact assessment:

- River Boyne and River Blackwater SAC/SPA.

The Proposed Development has the potential to effect water quality in the River Boyne and therefore effect the qualifying interest of this designated site.

9.4 Characteristics of the Proposed Development

The Proposed Development consists of 26 no. wind turbines and associated infrastructure including hardstands, 2 no. meteorological masts, 4 no. temporary construction compounds, 2 no. borrow pits, a 110kV substation, 3 no. permanent amenity carparks as well as access roads and all associated development and drainage works. Please refer to Chapter 4 for a full description of the Proposed Development.

The main characteristics of the Proposed Development that could effect the hydrological and hydrogeological environment are:

- Opening of the 3 no. proposed on-site borrow pits (BP1a, BP1b and BP2), which will involve the stripping of peat and spoil (152,280m^3). No rock breaking or blasters are proposed for the extracting material from these borrow pits. However, it is likely that processing and crushing of cobbles and boulders will be required. The estimated volume of material to be extracted from the 3 no. borrow pits is 674,000m^3. Runoff and discharge from the borrow pits have the potential to effect surface water quality. Extraction at the borrow pits will be above and below the groundwater table and some pumping will be required to ensure borrow pits do not flood.
- Establishment of the 4 no. construction compounds (1 in Ballivor Bog, 2 in Bracklin and 1 in Carranstown) which will comprise of temporary site offices, staff welfare facilities, storage areas and car-parking. These compounds will be constructed using excavate and replace methods and may be floated or partially floated. All compounds are mapped on peat and it is estimated that construction will require the removal of ~28,000m^3 of peat and spoil. Runoff these construction areas have the potential to effect surface water quality. In addition, welfare facilities will be provided at the temporary construction compounds. Wastewater effluent will be collected in a wastewater holding tank and periodically emptied by a licenced contractor.
- Construction of ~28km of internal site access roads the site access roads. The proposed new access roads will be constructed predominantly using a floated technique. While some new excavated roads are also proposed. The construction methodologies are provided in the Peat and Spoil Management Plan attached as Appendix 4-2.The construction of the proposed roads will involve the removal of ~7,700m^3 of peat and spoil and will require the use of aggregate, sourced from the on-site borrow pits and imported from local quarries where required. Construction of these access tracks has the potential to effect surface water quality.
- Construction of the crane hardstand areas and turbine assemblage areas. This too will involve the use of aggregate, sourced from the onsite borrow pits and imported from local quarries where required. Construction of these areas has the potential to effect surface water quality.

- Construction of the 110kV on-site substation in the northwest of Carranstown Bog will likely be completed using a founded technique, and will require the excavation of ~50,000m^3 of peat and 5,500m^3 of non-peat materials. Welfare facilities will be provided at the substation. Wastewater effluent will be collected in an underground concrete holding tank and periodically emptied by a licenced contractor for the operational phase of the Proposed Development. Construction of the sub-station and associated parking area has the potential to effect surface water quality.
- Construction of the foundations for the 26 no. proposed wind turbines and the meteorological masts. Volumes of peat/subsoil to be removed at the turbine locations is estimated to be 376,900m^3 peat and 95,000m^3 of non-peat subsoils. The movement of large volumes of peat and spoil have the potential to effect surface water quality. Construction of the turbine foundations will require large volumes of concrete could effect surface water and groundwater quality.
- The majority of the foundations for the turbine and meteorological masts are expected to be piled. Where piled foundations are required, there is the potential groundwater quality effects.
- Construction of the underground grid cable trench which will connect to the 26 no. turbines to the substation. This will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling with aggregate, lean-mix concrete and excavated material, as appropriate (depending on the location of the cable trench). The ground will be reinstated once the works are completed. These works have the potential to effect surface water quality.
- Construction of the proposed new transmission cable which will connect the proposed substation to the existing Mullingar-Corduff 110kV overhead line. Construction activities include the excavation of peat and spoil at the proposed towers. Construction of the tower foundations will involve the use of concrete. These activities have the potential to effect surface and groundwater quality.
- Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning.
- Grey water will be supplied by rainwater harvesting and water tankered to the site where required. Bottled water will be used for potable supply.
- Temporary and permanent road improvement works along the Turbine Delivery Route (TDR).

9.4.1 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation measures to reduce potential effects on downstream surface water bodies. Drainage management with the proposed site will be risk based, and will employ various methods, building on the existing drainage systems within the proposed site. The main tenet of the proposed drainage plan is ensuring to 'keep clean water clean' by avoiding unnecessary or significant disturbance to existing drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas through the construction of interceptor drains. Where possible (depending on orientation), existing field drains can be used as interceptors drains. Otherwise new interceptors drains will be excavated and they will outfall to field drains downstream of the works areas.

The second method involves collecting main construction areas such as from turbine base/hardstand areas, construction compounds, and the substation) and routing that water through new proposed temporary wind farm settlement ponds (or stilling ponds) prior to controlled release into the existing field drain network. There will be no discharges to the existing field drains without prior treatment from the main construction areas.

Within the Proposed Development layout there are section of proposed floating road between turbine infrastructure. In these sections, and depending on intermediate topography, a collector drain (dirty water system as described above) may be used during construction stage, or over the edge (OTE) drainage will occur. Over the edge drainage allows runoff from access tracks to flow into local field drains and be managed via the existing site drainage system. OTE drainage will only occur where topography allows, and it is only proposed in areas of low risk and remote from outfall locations (at least 150m from bog outfall locations. Silt traps and check dams will be installed in field drains downstream of OTE drainage areas, and these will provide attenuation and treatment of dirty water.

During the construction phase, all runoff from works areas (i.e., dirty water) will be attenuated and treated prior to being released within the proposed site. All drainage outfall from the proposed site is routed through existing settlement ponds that remain in-situ from the previous site use.

9.4.2 Development Interaction with the Existing Bog Drainage Network

The Proposed Development drainage will not significantly alter the existing drainage regime at the proposed site. Moreover, the proposed drainage system will be fully integrated into the existing bog drainage systems.

Existing field drains and main drains will be routed under/around proposed access tracks using culverts as required.

Runoff from access tracks, turbine bases and hardstand areas (construction compounds, substation, and meteorological masts) will be collected and treated in local (proposed) wind farm settlement ponds and then discharged to existing peat field drains. From there this water will flow towards the relevant bog boundaries in existing field drains and main drains, and then be treated further in the existing main (bog) settlement ponds prior to discharge from the bog group in accordance with the existing IPC Licence.

One of the proposed ecological aspects of the drainage design is to re-wet the proposed site in small areas, where possible, to create wet areas as such wetland features which are good for overall site biodiversity. Ponding would occur in these areas to a very shallow depth, and only intermittently following heavy rainfall. No large open bodies of water are proposed, and where intermittent ponding occurs this will be broken up into small areas using peat berms.

9.5 Likely Significant Effects and Associated Mitigation Measures

9.5.1 Do -Nothing Scenario

If the Proposed Development were not to proceed, the proposed site would continue to be managed under the requirements of the relevant IPC licence and therefore the ongoing site management and environmental monitoring, peat stockpile removal (due to be completed by 2024), and wind measurement would continue. In addition, if the Proposed Development were not to proceed, the implementation of peatland rehabilitation plans as required under IPC License would occur. Likewise, the PCAS scheme in adjacent Bogs (where selected) would continue to be implemented. Other existing land use practices including local small scale turbary activities would continue along the margins of the proposed site. These land uses and activities will also continue if the Proposed Development does proceed.

Now that peat extraction activity has ceased across the Ballivor Bog Group, including the 4 no. bogs which comprise the proposed site, Bord na Móna's Decommissioning and Rehabilitation Plans will be implemented in accordance with the IPC licence requirements. These plans aim to environmentally stabilise the bogs through the encouragement of re-vegetation of bare peat areas, with targeted active management being used to enhance re-vegetation and the creation of small wetland areas (if required). The Rehabilitation Plan aims to rehabilitate the bogs as much as possible by placing the existing peatland environments on a path towards becoming naturally functioning peatlands. Certain targeted management techniques such as drain blocking would aim to alter the current baseline hydrology and hydrogeology of the proposed site, establishing conditions more suitable for colonisation by more typical bog communities. In addition to improving the local bog hydrogeological regime by raising the peat water table, the proposed rehabilitation will also have an indirect effect on downstream surface water quality as rehabilitated peatlands are associated with surface water quality improvements linked to reduced concentrations of suspended solids and nutrients in runoff from rehabilitated bogs. Rehabilitation of the proposed site will also provide improved surface water attenuation, thereby reducing the flood risk downstream.

In addition to the standard rehabilitation required by the IPC licence, enhanced rehabilitation measures will be implemented in certain areas of the Ballivor Bog Group (Carranstown East and Bracklin West). The enhanced decommissioning, rehabilitation and restoration measures, referred to as the Peatlands Climate Action Scheme (PCAS), are designed both to exceed/meet the standard requirements as defined by the IPC licence and to enhance ecosystem services by optimising climate action benefits. We note that work associated with PCAS has already begun in Carranstown East. The enhanced restoration, which will include more intensive drain blocking and ground re-profiling, will optimise hydrological conditions and will have benefits for water quality and storage attenuation as well as increased carbon storage and reduced emissions.

If the Proposed Development were not to proceed, the cumulative effect of the Do Nothing Scenario and the implementation of the Decommissioning and Rehabilitation Plans for the Ballivor Bog Group (including the PCAS scheme) would result in a moderate, positive, direct, long-term effect on bog hydrogeology and a moderate, positive, indirect, long-term effect on downstream surface water quality and quantity.

9.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

9.5.2.1 Earthworks Resulting in Suspended Solids Entrainment in Surface Waters

Construction phase activities including access road construction, turbine base/hardstanding construction, construction compound construction, meteorological mast construction, substation and grid connection construction, internal cable route excavations, amenity paths construction, entrance locations and amenity car parks will require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. It is estimated that construction works will require the excavation of approximately 732,000m^3 of peat and non-peat materials which will be a significant potential source of sediment laden water. Other potential sources include:

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Deel, Ballivor, Stonyford and Boyne rivers and their associated tributaries) and associated dependent ecosystems (see chapter 6 - Biodiversity (excluding Birds).

Pre-Mitigation Potential Effect: Negative, significant, indirect, temporary, likely effect on down-gradient rivers and associated dependent ecosystems.

Proposed Mitigation Measures:

Mitigation by Avoidance:

The key mitigation measure during the construction phase is the avoidance of sensitive hydrological features where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). All of the key Proposed Development areas (turbines, hardstands, substation, construction compounds etc.) are located significantly away from the delineated 50m watercourse buffer zones except for the upgrading of the existing watercourse crossings, new drain crossings and upgrades to the existing site access tracks. The Proposed Development includes upgrades to existing watercourse crossings and site access roads and a new proposed amenity path which cross EPA mapped watercourses at 3 no. locations within the proposed site:

- Upgrades to the existing crossing over the Killanconnigan stream between Ballivor and Carranstown bogs;
- Upgrades to the existing crossing over the Cartenstown stream between Bracklin and Lisclogher bogs;
- Proposed amenity path over the Cartenstown stream in the centre of Lisclogher bog. However as stated above in Section 9.3.6, walkover surveys have confirmed that there is no watercourse in this area of the proposed site).

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

- Minimise physical damage (river/stream banks and river/stream beds) to watercourses (where possible, this cannot be avoided at the watercourse crossing discussed above) and the associated release of sediment;
- Minimise excavations within close proximity to surface watercourses;
- Minimise the entry of suspended sediment from earthworks into watercourses; and,
- Minimise the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone.

In addition, and as outlined above the Proposed Development drainage system will link into the existing bog drainage system, and discharge from each of the bog sites via existing large settlement ponds, which are some distance from the Proposed Development footprint. As such, there is significant distance for Proposed Development related surface water to travel before it reaches the edge of the bogs and is released from the existing bog drainage system into downstream watercourses.

Mitigation by Design:

There is an extensive network of drains already existing at the 4 no. bogs comprising the proposed site. The existing drainage infrastructure is operating in accordance with IPC licence requirements, with environmental monitoring and silt control measures being implemented at these bogs. The existing drainage system at the proposed site will be maintained and expanded locally as required for use within the Proposed Development drainage system. The key elements are the upgrading and improvements to water treatment elements, such as in-line controls and treatment systems, including wind farm related silt traps and settlement ponds.

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

- Interceptor drains will convey clean runoff water around works areas to the existing downstream drainage system (field drains and main drains). Where required, interceptor drains will be installed in advance of any construction works commencing. This will ensure that clean water is kept clear by diverting surface water flow around excavations, construction areas and temporary storage areas. Where possible (depending on orientation), existing field drains can be used as interceptors drains;
- Collector drains will be used to intercept and collect runoff from construction areas (from turbine base/hardstand areas, construction compounds, and the substation). During the construction phase temporary settlement ponds will be used to attenuate and treat runoff from the construction areas (from turbine base/hardstand areas, construction compounds, and the substation) and treated water will then discharge into existing field drains and main drains. Temporary settlement ponds will be removed at the end of the construction phase (end of high risk period), and wind farm runoff will discharge into existing field drains and main drains;
- During the construction phase, temporary silt traps (silt fences) will be used as an additional water protection measures around the existing bog drainage network, particularly where works are proposed within 50m of a natural watercourse. The silt fences will be placed in the existing drains downstream of construction works, and the associated construction area run-off water will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the construction phase, dewatering silt bags will also be used as required. They can be used downgradient of turbine bases, where temporary pumping is required. Discharge from dewatering silt bags will flow into settlement ponds and treated water from settlement ponds will outfall to existing field drains and main drains;

- Within the proposed site layout there are section of proposed floating road between turbine infrastructure. In these sections, and depending on intermediate topography, a collector drain (dirty water system as described above) may be used during construction stage, or over the edge (OTE) drainage will occur. Over the edge drainage allows runoff from access tracks to flow into local field drains and be managed via the existing site drainage system. OTE drainage will only occur where topography allows, and it is only proposed in areas of low risk and remote from outfall locations (at least 150m from bog outfall locations. Silt traps and check dams will be installed in field drains downstream of OTE drainage areas, and these will provide attenuation and treatment of dirty water; and,
- Culverts will be required where site roads and proposed hardstands cross the main bog drainage networks. These will be installed with a minimum gradient to reduce the entrainment of suspended solids. All culverts will be inspected regularly and maintained where appropriate. Culverts will remain in-situ during the Operational Phase of the Proposed Development.

Water Treatment Train:

If the discharge water from construction areas fails to be of a high quality, then a filtration treatment system (such as a 'siltbuster' or similar equivalent treatment system) will be used to filter and treat all required surface discharge water collected in the dirty water drainage system. This will apply to all of the construction phase.

Silt Fences:

Silt fences will be located within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to the existing drainage network of sand and gravel-sized sediment, released from the excavation of mineral sub-soils of glacial and glacio-fluvial origin and entrained in surface water runoff. Regular inspection and maintenance of silt fences during the construction phase are critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase.

Silt Bags:

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

Adverse Weather Management:

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

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

- General Forecasts: Available on a national, regional and county level from the Met Éireann website (www.met.ie/forecasts). These provide general information on weather forecasts including rainfall, wind speed and direction but do not provide any quantitative rainfall estimates;
- MeteoAlarm: Alerts to the possible occurrence of severe weather for the next 2 days. Less useful than general forecasts as only available on a provincial scale;
- 3-hour Rainfall Maps: Forecast quantitative rainfall amounts for the next 3 hours but does not account for possible heavy localised events;

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

Using the safe threshold of rainfall values given below will allow planned works to be safely executed (from a water quality perspective) or works to be postponed if a high rainfall intensity event is forecast.

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

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

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

- All open peat/spoil excavations will be secured and sealed;
- Temporary or emergency drainage will be created to prevent back-up of surface runoff; and,
- Working during heavy rainfall and for up to 24 hours after heavy events will not be allowed to ensure drainage systems are not overloaded.

Management of Runoff from Peat and Subsoil Storage Areas:

It is proposed that excavated peat will be used for landscaping close to its original extraction point. During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from the storage areas as required. Interceptor and collector drains will be used at storage areas. 'Siltbuster' treatment trains will be employed if previous treatment is not of a high quality.

Timing of Site Construction Works:

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

Proposed Drainage and Water Quality Monitoring

An inspection and maintenance plan for the on-site drainage system will be prepared in advance of the commencement of any works and will be included in the CEMP. Regular inspections of all installed drainage systems will be undertaken, especially before and 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 sediment levels at 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 (visual, supplemented with pH, electrical conductivity, temperature, dissolved oxygen and turbidity monitoring), sampling and laboratory analysis of a range of parameters[7] with relevant regulatory limits and EQSs will be undertaken for each primary watercourse, and specifically following heavy rainfall events (i.e. weekly, monthly and event-based). The data will be processed and analysed and works will cease if elevated turbidity concentrations are recorded. In this event, all upstream silt traps and drainage routes will be inspected to identify the cause of the elevated turbidity levels. Works will not recommence until any issues have been resolved and the turbidity concentrations have returned to background concentrations.

Post-Mitigation Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of release of sediment have been proposed above and will reduce the concentration of suspended sediment to acceptable levels. The residual effect is considered to be - Negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality and aquatic habitats.

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

9.5.2.2 Potential Effects on Groundwater Levels During Excavation Works

4 no. borrow pits are proposed at the proposed site and associated dewatering works have the potential to effect local groundwater levels. In addition, smaller-scale temporary dewatering may occur at some excavations (i.e. turbine bases, cable trenches), and these also have the potential to affect local groundwater levels. However, temporary reductions in groundwater levels by temporary dewatering will be very localised and of small magnitude due to the nature and permeability of the local peat and subsoil geology, which comprises moderate to low permeability lacustrine and glacial deposits.

The installation of turbine bases in the underlying glacial deposits is also likely to require some temporary dewatering arrangements, where deeper excavations are required. However, due to the dominance of moderate to low permeability glacial till subsoils and lacustrine deposits below the bogs the effects on groundwater levels will be localized to the excavation and only for a temporary basis during the construction work. Water level impacts will be temporary and are unlikely to be significant beyond 50m from any excavation (the GSI do not record any groundwater wells within 100m of the proposed borrow pits, refer to Section 9.5.2.8).

Pathway: Groundwater flow paths.

Receptor: Groundwater levels.

Pre-Mitigation Potential Effect: Slight, direct, negative, temporary, unlikely effects on local groundwater levels.

Impact Assessment:

- There are large separation distances between proposed works and local houses, and associated water wells. Except for houses located approximately 100m south of BP2, the closest houses are at least 450m from any proposed dewatering works associated with the borrow pits. The GSI does not map any groundwater wells in the properties to the south of BP2;
- Similarly, main streams and rivers are at least 150-500m away from any turbine and mast bases, and at these distances potential effects will be imperceptible;

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

- The proposed underground cable trench is designed to be shallow and will only be approximately 1.2m in depth. At this depth, it will only potentially interact with shallow perched water within the peat profile. No interaction with deeper regional groundwater will occur. Therefore, no effects on the local groundwater table or flows will occur from this element of the development;
- The construction of the proposed electrical substation and grid connection (pylons), the temporary construction compounds, roads and amenity carparks will be relatively shallow and will only have the potential to interact with the shallow perched water table within the peat bog. No interaction with the deeper regional groundwater regime will occur. Therefore, no impacts on the local groundwater table or flows will occur; and,
- The potential effect of the proposed piling works on groundwater is assessed separately in Section 9.5.2.4.

Post-Mitigation Residual Effects: Due to large separation distances between proposed works and water wells and local streams and rivers, and the relatively shallow nature of the proposed works, and also the prevailing geology of the proposed site the potential for water level drawdown impacts at receptor locations are considered negligible. The residual effect is considered to be - Imperceptible, direct, temporary, unlikely effects on local groundwater levels.

Significance of Effects: For the reasons given above, no significant effects on groundwater levels are likely to occur.

9.5.2.3 Excavation Dewatering and Potential Effects on Surface Water Quality

Groundwater seepages will likely occur in turbine base, substation and construction compound excavations and at the borrow pits, and these will create additional volumes of water to surface water (i.e. rainfall water) to be treated by the drainage management system. Groundwater inflows may be more significant where lenses of sand and gravel are intercepted within the glacial till deposits.

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

Pathway: Groundwater pumped into the site drainage network.

Receptor: Down-gradient surface water bodies (Deel, Stonyford, Ballivor and Boyne rivers and their associated tributaries).

Pre-Mitigation Potential Effect: Negative, significant, indirect, temporary, unlikely effects on surface water quality.

Proposed Mitigation Measures:

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

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent the build-up of groundwater in the excavation;
- The interceptor drainage will be discharged to the existing drainage system or onto the bog surface within the overall bog drainage and treatment system;

- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a "Siltbuster" unit;
- There will be no direct discharge to the existing bog drainage network and therefore no risk of hydraulic loading or contamination will occur; and,
- Daily monitoring of excavations and the water treatment system by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work will immediately be stopped, and a geotechnical assessment will be undertaken.

Post-Mitigation Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality of these receptors. Proven and effective measures to minimise the levels of sediment from the proposed site have been proposed above and will maximise the drainage pathway length between the potential sources and the receptor. The residual effect is considered to be - Imperceptible, indirect, temporary, unlikely effects on local surface water quality within the Deel, Stonyford, Ballivor and Boyne rivers and their associated tributaries.

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

9.5.2.4 Potential Effects Associated with Piled Foundations

Due to the depth of peat at the proposed turbines locations, a range of foundation scenarios are proposed, including:

- Gravity foundations;
- Piled foundation with a configuration of up to 50 no. 300mm square concrete driven piles. These piles could extend to a depth of between 5 to ~18metres below ground level; and,
- Piled foundation with a configuration of up to 20 no. 900 to 1200mm cylindrical bored piles. These piles could extend to a depth of between 5 to ~18metres below ground level.

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

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

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

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

Receptor: Groundwater quality in the underlying Athboy GWB and groundwater hydrochemistry at the surface of the within the peat bog.

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

Proposed Mitigation Measures:

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

- Mitigation measures for sediment control are detailed in Section 9.5.2.1.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.6.

Proposed mitigation measures relative to piling works will comprise:

- Where driven piles are used, they will have a cross section without re-entrant angles;
- Strict QA/QC procedures for piling works will be followed;
- Piles will be kept vertical during piling works;
- Good workmanship will be employed during all piling works; and,
- Where required use bentonite seal to prevent upward/downward movement of surface water/groundwater.

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

- **Peat** – Typically described as orangish brown to dark brown amorphous to fibrous peat. Peat thicknesses from ranged from 1.1 to >4.5m from trial pits and 0.4 to 3.8m from the boreholes.
- **Lacustrine Clay** – Light grey to brown, soft to stiff slightly gravelly organic Silt/Clay with some cobbles. The thickness of the layer is variable across the proposed site.
- **Fluvioglacial Sand and Gravel** – Typically described as grey silty sandy Gravel/silty fine Sand with cobbles and some boulders. The thickness of the layer is variable across the proposed site.
- **Glacial Till** – Typically described as soft to stiff greenish grey to blueish grey slightly sandy slightly gravelly Silt/Clay. The thickness of the layer is variable across the proposed site.
- **Groundwater** - was recorded in thirty-two of the trial pits and boreholes on site and varied between 0.0 and 7.4mbgl.

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

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

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

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

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

Scenario 1: Creating a Pathway for Downward Flow

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

Scenario 2: Creating a Pathway for Upward Flow

No upwelling of groundwater to the peat surface water recorded in any of the site investigation locations recorded across the proposed site.

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

Scenario 3: Blocking Regional Groundwater Flow

The scale of the proposed site is important, and it means that the development footprint (including temporary works) occurs over ~2.9% (51.17 Ha) of the proposed site (1,770 Ha) (refer to Section 9.5.3.1). Note the permanent footprint is 32.4ha or 1.8% of the proposed site.

If a piling array of 50 no. 300mm piles is applied at each turbine base (as piling Option 1), this combined area of piling footprint amounts to ~92m^2, or 3.53m^2 per turbine base. Each turbine base is >490m apart (with the average distance between turbines being 786m). The area of the piles driven into the ground is distributed over a very large area, and that area only amounts to 0.02% of the development footprint, or 0.0005% of the proposed site area. Also, none of the proposed piles would penetrate into the underlying bedrock aquifer, as they will find sufficient resistance, either in the over lying glacial tills/mineral subsoils or upon reaching the top of bedrock. At such wide separation distance, the ability of clusters of piles, with a plan area of ~3.53m^2 per turbine, to alter or affect regional groundwater flow is imperceptible.

If a piling array of 20 no. 900 to 1200mm cylindrical bored piles is applied at each turbine base (as piling Option 2a and 2b), this combined area of piling footprint amounts to:

- **Option 2a (900mm piles)** – this combined area of piling footprint amounts to ~265m^2, or 10.180m^2 per turbine base. Each turbine base is >490m apart (with the average distance between turbines being 786m). The area of the piles bored into the ground is distributed over a very large area, and that area only amounts to 0.05% of the development footprint, or 0.001% of the proposed site area.
- **Option 2b (1200mm piles)** – this combined area of piling footprint amounts to ~470m^2, or 18.10m^2 per turbine base. Each turbine base is >490m apart (with the average distance between turbines being 786m). The area of the piles bored into the ground is distributed over a very large area, and that area only amounts to 0.09% of the development footprint, or 0.003% of the proposed site area.

Also, none of the proposed piling options would penetrate into the underlying bedrock aquifer, as they will find sufficient resistance, either in the over lying glacial tills/mineral subsoils or upon reaching the top of bedrock. At such wide separation distance, the ability of clusters of piles, with a plan area of between ~3.53m^2 per turbine to 32.17m^2 per turbine, to alter or affect regional groundwater flow is imperceptible. Groundwater will simply flow through and/or around these very localised insertions.

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

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

9.5.2.5 Potential Release of Hydrocarbons

Accidental spillage of petroleum hydrocarbons during refuelling of construction plant can cause significant pollution risk to groundwater, surface water quality and associated aquatic ecosystems, and to terrestrial ecology (refer to Chapter 6). In addition, the accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbons have a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in the death of aquatic organisms.

Pathway: Groundwater flowpaths and site drainage network.

Receptors: Surface water quality in down-gradient rivers (Deel, Ballivor, Stonyford and Boyne rivers and their associated tributaries) and groundwater quality in the peat bog.

Pre-Mitigation Potential Effects: Negative, direct, slight, short term, likely effect on local groundwater quality in the peat bog. Indirect, negative, significant, short term, likely effect on downstream surface water quality.

Proposed Mitigation Measures:

- All plant will be inspected and certified to ensure they are leak free and in good working order prior to use on site;
- On-site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer or truck will be re-filled off site and will be towed/driven around the proposed site to where machinery is located. The 4x4 jeep/fuel truck will also carry fuel absorbent materials for the event of any accidental spillages. The fuel bowser will be parked in a designated location 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 available during all refuelling operations and used when required;
- Fuel volumes stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume during the construction phase;

- An emergency plan for the construction phase to deal with accidental spillages will be contained within the Construction Environmental Management Plan (Appendix 4-3). Spill kits will be available to deal with accidental spillages.

Post-Mitigation Residual Effect: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, temporary, unlikely effect on groundwater quality within the peat bog and surface water quality in down-gradient rivers (Deel, Ballivor, Stonyford and Boyne rivers and their associated tributaries).

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

9.5.2.6 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative effects on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, with artificial variations not in excess of $\pm$ 0.5 of a pH unit. Entry of cement-based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to water quality.

Peat ecosystems are dependent on low pH hydrochemistry. They are extremely sensitive to the introduction of high pH alkaline waters into the system. Batching of wet concrete on site and the washing out of concrete transport and placement machinery are the activities that will generate a risk of cement-based pollution.

Pathways: Site drainage network and groundwater flows.

Receptors: Peat water hydrochemistry and downstream surface watercourses including the Deel, Stonyford, Ballivor and Boyne rivers and their associated tributaries.

Pre-Mitigation Potential Effect:

Negative, moderate, indirect, short term, likely effect to surface water quality.

Negative, imperceptible, indirect, short term, likely effect on peat water hydrochemistry.

Proposed Mitigation Measures:

Mitigation by Avoidance:

- No batching of wet-cement products on-site is proposed. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will be the design approach;
- Where possible pre-cast elements for culverts and concrete works will be used;
- No washing out of the main body of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the concrete truck chute will be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water will be isolated in temporary lined wash-out pits located

near proposed site compounds. These temporary lined wash-out pits will be removed from the site their utility is no longer required or at the end of the construction phase;
- Any washing out of concrete pumping plant will also be into the temporary lined wash-out pits.
- Weather forecasts will be used to plan dry days for pouring concrete; and,
- Construction contractors will ensure each concrete pour site is free of standing water and plastic covers will be available in case of a sudden rainfall event.

No specific mitigation measures are required for potential groundwater impacts as the proposed mitigation measures will ensure minimal release of cement based products to ground. Furthermore the potential groundwater effects are imperceptible at the outset.

Post-Mitigation Residual Effect: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely effect on peat water hydrochemistry and the hydrochemistry of downstream surface watercourses including the Deel, Stonyford, Ballivor and Boyne rivers and their associated tributaries, and – Negative, indirect, imperceptible, long-term, unlikely effect on peat water hydrochemistry.

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

9.5.2.7 Groundwater and Surface Water Contamination from Wastewater Disposal

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

Pathways: Groundwater flowpaths and site drainage network.

Receptors: Down-gradient well supplies, groundwater quality (Athboy GWB) and surface water quality in the Deel, Stonyford, Ballivor and Boyne rivers and associated tributaries.

Pre-mitigation Effects:

Negative, significant, indirect, temporary, unlikely effect on surface water quality.

Negative, slight, indirect, temporary, unlikely effect on local groundwater.

Proposed Mitigation Measures:

- There are a total of 4 no. proposed construction compounds associated with the Proposed Development;
- During the construction phase, self-contained port-a-loo with an integrated waste holding tank will be used at each of the site compounds, maintained by the providing contractor, and removed from the 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 by a licensed contractor 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.

Post-Mitigation Residual Effects: The potential for contamination resulting from wastewater disposal is a risk to surface and groundwater quality. This is a risk common to all construction sites containing staff welfare facilities. Proven and effective measures to prevent the release of wastewater on site have been proposed above and will the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely effect on surface water (Deel, Stonyford, Ballivor and Boyne rivers and associated tributaries) or groundwater quality (Athboy GWB).

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

9.5.2.8 Potential Effects on Local Groundwater Well Supplies

As stated in Section 9.3.8 above, the groundwater flow in the mineral soil deposits (silts, sands and gravels) beneath the peat at the proposed site is expected to discharge into the local surface waterbody network, i.e. the existing bog drainage network which discharges to tributaries of the Deel, Stonyford and Boyne river. Groundwater flow in the western section of the proposed site will discharge into the River Deel while groundwater flow in the east of Ballivor Bog and Carranstown Bog will discharge into the Ballivor River (a tributary of the River Boyne) to the east. Further north in the east of Bracklin Bog and in Lisclogher Bog groundwater flow directions will be to the east towards the Stonyford River.

Using this conceptual model of groundwater flow an impact assessment for local wells is undertaken below. This assessment is completed in accordance with “Wind farms and groundwater impacts - A guide to EIA and Planning considerations” (DoE/NIEA, 2015).

There are no public or group scheme or EPA registered abstraction groundwater supplies down-gradient of the proposed site that can be impacted by the Proposed Development.

The GSI map one well with a location accuracy of up to 100m in the east of Ballivor Bog and within the proposed site boundaries. Well ID 26255WW072, as illustrated on Figure 9-22, does not exist within the proposed site boundary. We expect that this well is associated with the dwelling house to the east, and that house is ~800m from T3. The GSI also map several additional wells surrounding the Ballivor Bog Group with varying locational accuracies.

The biggest risk to groundwater wells will be from where deep excavations are required such as the borrow pits and turbines bases. Construction of the Proposed Development site access road, underground cable route trench between the turbines and the substation and the construction of substation and the grid connection will not have the potential to affect local wells due to the shallow nature of the works.

We have completed an assessment of private wells in the lands surrounding the proposed site. In order to be conservative and following the worst case assumption, we have assumed that all dwellings in the surrounding lands have a private groundwater well. A number of private dwelling houses were identified along the local roads near to and down-gradient (i.e., downslope) of the Proposed Development, specifically the proposed borrow pit and substation locations).

Using the conceptual model of groundwater flow detailed above, dwellings that are potentially located down-gradient of the Proposed Development footprint are identified and an impact assessment for these actual and potential well locations is undertaken as outlined below.

The majority of proposed key infrastructure elements (i.e. Proposed Development elements which have deep excavations and a potential to effect the regional groundwater system below the peat basin) are located a significant distance (>500m) from dwellings. Due to the high drainage density of the peat bog and the surrounding lands, it is expected that the majority of groundwater flow will discharge to local watercourses, as well as to the larger drainage ditches around the bog. These drainage systems and water bodies will act as hydraulic barriers between the development locations and the location of potential groundwater wells.

However, there are a number of dwellings situated along the local road to the south of BP2. Groundwater flow direction in this area is assumed to be southwest from Bracklin Bog towards the Craddanstown stream (a tributary of the Deel River). Therefore, these dwellings are downgradient and within close proximity (150-600m) to the proposed borrow pit (BP2). There is no hydraulic boundary (local stream/watercourse) between these dwellings and the proposed borrow pit. Consequently, this excavation has the potential to impact local groundwater wells if they are present.

The other 2 no. proposed borrow pits (BP1a and BP1b) in Carranstown Bog, are located a significant distance from dwellings (>650m). Meanwhile, a dwelling is located approximately 450m northwest of the proposed construction/substation compound in the northwest of Carranstown Bog. This dwelling is not located downgradient of the development location. Due to the shallow nature of the excavation works associated with the substation, no effects on groundwater levels or local wells will likely occur.

All turbines are located in excess of 800m from surrounding dwellings. Access roads and the internal cable networking trench and the grid connection works and amenity path are not considered a potential risk due to the shallow nature of those works.

The closest proposed infrastructure up-gradient of the dwellings within the setback distance is shown in Table 9-18 below.

Table 9-18: Excavations and distances to nearby dwellings and potential groundwater wells

Development Footprint Location	WFD River Sub-Basin	Approximate Distance from Closest Private Dwelling (m)	Comments
BP2	Deel(Raharney)_060	~100m	Dwellings are located downgradient (south) of the development location. No surface watercourse to act as a hydraulic barrier.
Substation in NW of Carranstown Bog	Stonyford_040	~460m	Dwelling is not located downgradient of groundwater flow. Groundwater flow paths are likely to be towards the east and south.
BP1a	Stonyford_040	~580m	Dwelling is located to the SE of the proposed BP1a location. Local bog drainage network and the Killconnigan stream act as hydraulic boundaries.
BP1b	Stonyford_040	~540m	Dwelling is located to the NE of the proposed BP1b location

Note:
1. Distance from closest Proposed Development Infrastructure (including borrow pits, construction compound, or substation (i.e. excavation/earthworks location). Access roads and the cable trench nor amenity path are not considered a potential risk due to the shallow nature of those works. The distances listed above are from the nearest wind farm infrastructure within the same surface water catchment as the dwelling.
2. Each dwelling is assumed to have an on-site private water well as outlined above (this is for assessment purposes only, wells may or may not actually exist).

Pathway: Groundwater flowpaths.

Receptor: Groundwater Supplies.

Pre-Mitigation Potential Effect: Negative, imperceptible, indirect, long term, unlikely effect.

Impact Assessment

BP2 will be adjacent to an existing borrow pit. No significant groundwater effects have been reported in relation to this borrow pit. Therefore the proposed BP2 will not have the potential to significantly effect local groundwater supplies. All other wells are located at sufficient distance from the Proposed Development to be affected by any of the proposed works.

Post-Mitigation Residual Effects: For the reasons given in the impact assessment above (separation distances, and prevailing geology, topography and groundwater flow directions), we consider the residual effects to be - negative, imperceptible, indirect, long term, unlikely effect in terms of quality or quantity on local groundwater abstractions.

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

9.5.2.9 Potential Effects on Surface Water Drinking Supplies

The Stonyford River in the vicinity of the proposed site has been identified as a Drinking Water Protected Area (DWPA.

Surface water connections from the proposed site to the Stonyford River could transfer poor quality surface water that may affect this DWPA.

Due to physical and hydrological and hydrogeological separation all other DWPAs have no potential to be affected by the Proposed Development.

Pathways: Surface water flowpaths, and groundwater levels.

Receptors: Down-gradient water quality in the Stonyford_040 DWPA.

Pre-Mitigation Potential Effect: Negative, significant, indirect, short term, likely effect on downstream DWPA.

Proposed Mitigation Measures:

Mitigation measures for sediment control are detailed in Section 9.5.2.1.

Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.

Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.6.

Implementation of these mitigation measures will ensure the protection of water quality in receiving waters.

Furthermore, groundwater from below the proposed site may also discharge as baseflow to the Deel, Stonyford, Ballivor and Boyne Rivers or their tributaries, thus entering the Stonyford and Boyne rivers. Groundwater quality and quantity will not be affected by the Proposed Development as detailed in Section 9.5.2.2, Section 9.5.2.5, Section 9.5.2.6, and Section 9.5.2.8.

Post-Mitigation Residual Effects: Construction activities at the proposed site pose a threat to surface water DWPA linked with the Proposed Development. Proven and effective measures to mitigate the risk of surface and groundwater contamination have been proposed which will break the pathway between the potential source and the downstream receptor. These mitigation measures will ensure that surface water runoff from the proposed site will be equivalent to baseline conditions and will therefore have no effect on downstream water quality. The residual effect is considered to be Negative, imperceptible, indirect, short term, unlikely effect on downstream water quality within the Stonyford_040 DWPA.

Significance of Effects: For the reasons given above, no significant effects on any designated sites will occur.

9.5.2.10 Potential Effects of the Proposed Amenity Links

Approximately 28 km of internal roads will be provided as part of the construction of the Proposed Development. This internal road network will link all infrastructure together and following construction will form the amenity pathways when the wind farm becomes operational. The roads will be repurposed to form amenity pathways which will be surface with granular material. An additional 3.3km of a dedicated amenity link is also proposed to provide greater variety of walking loops.

The construction of these dedicated amenity tracks, the repurposing of the Proposed Development access roads and the upgrading of the site entrances to form car parking facilities have the potential to effect downgradient surface water quality.

Pathway: Extraction/excavation of soil/subsoil.

Receptor: Surface water quality in downstream rivers including the Deel, Stonyford and Boyne rivers and their associated tributaries and groundwater quality in the peat bog.

Pre-Mitigation Potential Effect:

Negative, slight, indirect, unlikely, short-term effect on surface water quality.

Negative, imperceptible, indirect, unlikely, long-term effect on groundwater quality.

Proposed Mitigation Measures:

Detailed mitigation measures for sediment control are outlined in Section 9.5.2.1. and detailed mitigation measures for control of hydrocarbons during construction works are outlined in Section 9.5.2.5.

No additional mitigation measures are required due to the small scale nature of the proposed works.

Post-Mitigation Residual Effects: For the reasons outlined in the impact assessment above, we consider the residual effects to be - Negative, imperceptible, indirect, unlikely, short-term effects on surface water quality in downstream rivers including the Deel, Stonyford and Boyne rivers and their associated tributaries and groundwater quality in the peat bog.

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

9.5.2.11 Potential Effects Due to Turbine Delivery Route Works

Minor temporary haul route works are required at 2 no. locations listed below, however all proposed road works are small-scale and localised, and no significant water quality effects are anticipated.

- Junction accommodation between the R156 and R161 ~6.5km southwest of Trim.
- Road widening east of Ballivor village on the R156.

Permanent road improvement works are also proposed on the R156 between the proposed entrances to Ballivor and Carranstown Bogs for 44m and will involve the lowering of the road by ~0.5m for 44m in order to improve sightlines.

Due to the shallow nature of the temporary and permanent works effects on groundwater flows and levels are not anticipated. However there is a potential for effects on groundwater and surface water quality from fuels and other chemicals during the construction phase.

Pathway: Surface water and groundwater flow paths.

Receptor: Down-gradient water quality.

Pre-Mitigation Potential Effects:

Indirect, negative, slight, temporary, unlikely effect on surface water quality.

Indirect, negative, slight, temporary, unlikely effect on groundwater quality.

Proposed Mitigation Measures

The following mitigation measures are proposed:

Mitigation by Avoidance:

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

The purpose of the constraint zone is to:

- Avoid physical damage to surface water channels;
- Provide a buffer against hydraulic loading by additional surface water run-off;
- Avoid the entry of suspended sediment and associated nutrients into surface waters from excavation and earthworks;
- Provide a buffer against direct pollution of surface waters by pollutants such as hydrocarbons; and,
- Provide a buffer against construction plant and materials entering any watercourse.

General Best Practice Pollution Prevention Measures will also include:

- No stock-piling of construction materials will take place within the constraints zone. No refuelling of machinery or overnight parking of machinery is permitted in this area;
- No concrete truck chute cleaning is permitted in this area;
- Works shall not take place at periods of high rainfall, and shall be scaled back or suspended if heavy rain is forecast;
- Plant will travel slowly across bare ground at a maximum of 5km/hr.
- Machinery deliveries shall be arranged using existing structures along the public road;
- All machinery operations shall take place away from the stream and ditch banks, although no instream works are proposed or will occur;
- Any excess construction material shall be immediately removed from the area and taken to a licensed waste facility or the on-site spoil management areas;
- No stockpiling of materials will be permitted in the constraint zones;

- Spill kits shall be available in each item of plant required; and,
- Silt fencing will be erected on ground sloping towards watercourses at the stream crossings if required.

Mitigation Measures relating to the use and storage of fuels and chemicals in terms of groundwater protection:

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser, as described in Section **Error! Reference source not found.**. No maintenance of c onstruction vehicles or plant will take place along the temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

Post-Mitigation Residual Effect: The temporary road improvement works has the potential to negatively impact the local surface water and groundwater quality, through increased sediment supply to the river channel, and the potential for fuel/oil spills which could impact surface water and groundwater. Proven and effective measures to mitigate the risk of excess runoff and fuel/oil spills have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Indirect, negative, imperceptible, temporary, unlikely effect on surface water quality.

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

9.5.2.12 Potential Effects on Hydrologically Connected Designated Sites

The proposed site is not located within any designated conservation site. However, as stated in Section 9.3.14 above, the proposed site is located in the River Boyne regional catchment and the River Boyne and River Blackwater SAC and SPA is located immediately downstream and is hydrologically linked with the proposed site. The surface water connections from the proposed site to the Deel, Stoneyford and Boyne rivers could transfer poor quality surface water that may affect the conservation objectives of the designated sites.

Due to physical and hydrological and hydrogeological separation all other designated sites have no potential to be affected by the Proposed Development.

The potential effects of the Proposed Development on designated sites as also been completed as part of a detailed WFD Compliance Assessment Report and is included in Appendix 9-3.

Pathways: Surface water flowpaths, and groundwater levels.

Receptors: Down-gradient water quality in the River Boyne and River Blackwater SAC and SPA.

Pre-Mitigation Potential Effect: Negative, significant, indirect, short term, likely effect on downstream designated sites.

Proposed Mitigation Measures:

Mitigation measures for sediment control are detailed in Section 9.5.2.1.

Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.

Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.6.

Implementation of these mitigation measures will ensure the protection of water quality in receiving waters.

Furthermore, groundwater from below the proposed site may also discharge as baseflow to the Deel, Stonyford, Ballivor and Boyne Rivers or their tributaries, thus entering the designated sites. Groundwater quality and quantity will not be affected by the Proposed Development as detailed in Section 9.5.2.2, Section 9.5.2.5, Section 9.5.2.6, and Section 9.5.2.8.

Post-Mitigation Residual Effects: Construction activities at the proposed site pose a threat to designated sites hydrologically linked with the Proposed Development. Proven and effective measures to mitigate the risk of surface and groundwater contamination have been proposed which will break the pathway between the potential source and the downstream receptor. These mitigation measures will ensure that surface water runoff from the proposed site will be equivalent to baseline conditions and will therefore have no effect on downstream water quality. No adverse effects are anticipated on hydrologically connected Designated Sites. Please see Chapter 6 Biodiversity for details.

Significance of Effects: For the reasons given above, no significant effects on any designated sites will occur.

9.5.2.13 Assessment of Potential Effects on WFD Objectives

The WFD status for GWBs and SWBs underlying and downstream of the Proposed Development are defined in Section 9.3.12 and Section 0 respectively. The WFD status for the Deel, Stonyford and Boyne rivers in the vicinity and downstream of the proposed site are typically of "Good" or "Moderate" status, while the Stonyford_030 SWB achieved "Poor" status in the latest WFD round. Many of these SWBs have been deemed to be "at risk" of failing to meet their respective WFD objectives. Meanwhile, the Athboy GWB is also of "Good" status and is " not at risk".

Changes in surface water of groundwater flow regimes and water quality has the potential to impact on the objectives and status of the associated GWB and SWBs.

A detailed WFD Compliance Assessment Report has been completed in combination with this EIAR Chapter and is included in **Appendix 9-3**.

Pathways: Groundwater flowpaths and surface water flowpaths within the proposed site.

Receptors: WFD Groundwater Bodies and Surface Water Bodies.

Pre-mitigation Potential Effect:
Indirect, negative, moderate, temporary, unlikely effect on downstream SWBs.

Indirect, negative, slight, temporary, unlikely effect on the underlying Athboy GWB.

Proposed Mitigation Measures:

- Mitigation measures for sediment control are detailed in Section 9.5.2.1.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.6.

Implementation of these mitigation measures will ensure the protection of water quality in receiving waters.

Furthermore the mitigation measures previously outlined for the protection of groundwater quality and groundwater quantity are detailed above:

- Mitigation measures for excavation works and dewatering are detailed in Section 9.5.2.2.
- Mitigation measures for the control of hydrocarbons during construction works are detailed in Section 9.5.2.5.
- Mitigation measures for the control of cement-based products during construction works are detailed in Section 9.5.2.6.

Post-Mitigation Residual Effects:
There is no direct discharge from the proposed site to downstream receiving surface waters or the underlying GWB. Mitigation for the protection of surface and groundwater during the construction phase of the Proposed Development will ensure the qualitative and quantitative status of the receiving waters will not be altered by the Proposed Development.

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

The residual effect on Groundwater Bodies is considered to be - No residual effect.
The residual effect on Surface Water Bodies is considered to be - No residual effect.

Significance of Effects: For the reasons outlined above, no significant effects on WFD Groundwater Bodies and Surface Water Bodies status, risk or future objectives will occur as a result of the Proposed Development.

9.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

9.5.3.1 Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the peat or vegetated surface with impermeable surfaces will likely result in an increase in surface water runoff rates in the surface water drainage network. This could potentially increase discharge rates from the proposed site and increase flood risk downstream of the development. In reality, the access roads will have a higher permeability than the underlying peat. However, in the baseline scenario runoff rates are high as a result of the prevailing peat soils (96% runoff). In order to assess the potential change as a result of access road and hardstand footprints we have increased the runoff rate to the maximum, i.e., 100% (4% higher than normal). The assessed footprint comprises turbine bases and hardstandings, access roads, amenity links and carparks, site entrances, substation and temporary construction compounds. During storm rainfall events, additional runoff coupled with the increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on water quality.

The emplacement of the proposed permanent development footprint within the proposed site, as described in Chapter 4 of the EIAR, (assuming emplacement of impermeable materials result in an increase from 96% to 100% runoff) could result in an average total site increase in surface water runoff of approximately 1,606m^3/month (Table 9-19). This represents a potential increase of approximately 0.12% in the average daily/monthly volume of runoff from the site in comparison to the baseline pre-development site runoff conditions (Table 9-9). This is a very small increase in average runoff and results from the naturally high surface water runoff rates and the relatively small area of the proposed site being developed, with the proposed development footprint including temporary works being approximately 52.17ha, representing 2.9% of the total proposed site (1,770ha), while the permanent development footprint is approximately 32.4ha or 1.8% of the total proposed site.

Table 9-19: Baseline Site Runoff V Development Runoff

Development Type	Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff/month (m^3)	Hardstanding Area 96% Runoff/month (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions at Hardstands (m^3)	% Increase from Baseline Conditions across Site (m^3)
Wind Farm	1,332,810	42,993	521,700	40,889	39,284	1,606	51.8	3.9%	0.12%

The additional water runoff volume is low due to the fact that the runoff potential from the proposed site is naturally high (96%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate. The increase in runoff from the Proposed Development will, therefore, be negligible. This is even before mitigation measures are considered. Therefore, there will be no risk of exacerbated flooding downstream of the proposed site.

The onsite substation and temporary construction compounds are located within the proposed site and, as such, as discussed above.

Pathway: Site drainage network.

Receptor: Surface waters and dependent ecosystems.

Pre-Mitigation Potential Effect: Negative, slight, direct, permanent, unlikely effect on all downstream surface water bodies.

Proposed Mitigation Measures:

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

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed into downstream field drains;
- Collector drains will be used to gather runoff from access roads and turbine hardstanding areas of the site likely to have entrained suspended sediment, and channel it to new local settlement ponds for sediment settling;

- On sections of access road transverse drains ('grips') will be constructed where appropriate in the surface layer of the road to divert any runoff off the road into swales/roadside drains;
- Check dams will be used along sections of access road drains to intercept silt at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of access road sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to existing drains;
- Settlement ponds will be designed in consideration of the greenfield runoff rate, existing bog settlement ponds will also buffer discharges from the bogs; and,
- Finally, all surface water runoff from the development will pass through the existing settlement ponds at the existing bog outfall locations.

Post-Mitigation Impact Assessment

As stated above in Section 9.3.4 there are existing surface water control measures at the proposed site which comprise high level bog surface drains, low level main drains and settlement ponds. All these existing drainage measures offer some surface water attenuation during rainfall events. However, as part of the Proposed Development drainage (which is detailed further in Section 9.4.1 and Section 9.4.2 above), it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed collector drains, silt traps and settlement ponds prior to release into the existing drainage network. The new proposed drainage measures will then in effect create significant additional attenuation to what is already present at the proposed site. The net effect of this will be a reduction in the overall runoff coefficient of the bog as demonstrated by the use of the Rational Method in

Table 9-20 below. Based on a conservative reduction in the runoff coefficient from 0.96 to 0.85 for the proposed site, there would a potential 11% reduction in runoff volumes from the proposed site. This assessment demonstrates that there will be no risk of exacerbated flooding down-gradient of the proposed site as a result of the Proposed Development. The Proposed Development will in effect retain water within the bog for longer periods.

Table 9-20: Surface Water Runoff Assessment for Proposed Wind Farm Drainage

Site Area	C(1)	Area (m^2)	Rc (2)	100-Year 6hr Rainfall Depth (m)	Runoff Volume (m^3)	Total Site Runoff Volume (m^3)
Without Wind Farm Drainage Control						
Undeveloped Area	2.78	17,178,300	0.96	0.0526	867,435	894,876
Development Footprint	2.78	521,700	1.00	0.0526	27,441	
With Wind Farm Drainage Control						
Undeveloped Area	2.78	17,178,300	0.85	0.0526	768,041	794,110
Development Footprint	2.78	521,700	0.95	0.0526	26,069	
Estimated Potential Reduction in Site Runoff Volumes (%)						11%

Notes: 1 – Constant, 2- Runoff Coefficient

Post-Mitigation Residual Effect: With the implementation of the Proposed Development drainage measures as detailed above, and based on the post-mitigation assessment of runoff, we consider that residual effects are - Negative, imperceptible, direct, long-term, likely effect on all downstream surface water bodies.

Significance of Effects: For the reasons given above, no significant effects on downstream flood risk will occur.

9.5.3.2 Runoff Resulting in Contamination of Surface Waters

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

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers (Deel, Stonyford, Ballivor, Boyne rivers and their associated tributaries) and dependent aquatic ecosystems in the River Boyne and River Blackwater SAC/SPA.

Pre-Mitigation Potential Effect: Negative, slight, direct, temporary, unlikely effect.

Proposed Mitigation Measures:

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

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

Post-Mitigation Residual Effects: With the implementation of the Proposed Development drainage measures as detailed above, and based on the post-mitigation assessment of runoff, we consider that residual effects are - Negative, imperceptible, indirect, temporary, unlikely effect on downstream water quality in the Deel, Stonyford, Ballivor, Boyne rivers and their associated tributaries.

Significance of Effects: For the reasons given above, no significant effects on the surface water quality are likely to occur.

9.5.3.3 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative effects on water quality. They generate very fine, highly alkaline silt (pH 11.5) that can physically damage fish by burning their skin and blocking their gills. A pH range of $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988: European Communities (Quality of Salmonid Waters) Regulations, with artificial variations not in excess of ± 0.5 of a pH unit. Entry of cement-based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to water quality.

Placed concrete in turbine bases and foundations can also have minor local effects on groundwater quality over time. However, due to the limited surface area of exposed concrete, the anoxic conditions below ground, and the high rate of dilution from the wider groundwater system relative to the small volumes of groundwater that would come in contact with the concrete, the potential for impacts considered to be imperceptible.

Pathways: Site drainage network and groundwater flows.

Receptors: Peat water hydrochemistry and downstream surface watercourses including the Deel, Stonyford, Ballivor and Boyne rivers and their associated tributaries.

Pre-Mitigation Potential Effect:

Negative, slight, indirect, short term, likely effect to surface water quality.

Negative, imperceptible, indirect, short term, likely effect on peat water hydrochemistry.

Proposed Mitigation Measures:

None required. The concrete in turbine bases sets within 3 days of concrete pour.

Post-Mitigation Residual Effect: Negative, imperceptible, indirect, long term, likely effect to surface water quality. Negative, imperceptible, indirect, long term, likely effect on peat water hydrochemistry.

Significance of Effects: For the reasons given above, no significant effects on the surface water quality are likely to occur.

9.5.3.4 Water Supply at Substation

It is proposed to install a groundwater well adjacent to the substation in accordance with the Institute of Geologists Ireland, *Guide for Drilling Wells for Private Water Supplies* (IGI, 2007). The well will be flush to the ground and covered with a standard manhole. An in-well pump will direct water to a water tank within the roof space of the control building.

The proposed groundwater well and associated extraction has the potential to effect local groundwater levels in the surrounding lands.

Pathway: Groundwater flowpaths

Receptor: Groundwater levels

Pre-Mitigation Potential Effect: Direct, negative, imperceptible, permanent, likely effect on local groundwater levels.

Impact Assessment

The abstraction rate for the proposed groundwater well at the substation will be comparable to a domestic well, with a well supplying a single household typically abstracting less than 1m^3/day. The well is proposed in a locally important aquifer which is moderately productive only in local zones. This aquifer forms part of the Athboy GWB which is comprised of only moderate permeability rocks where groundwater flow is concentrated in the upper weathered zone of the aquifer. Therefore due to the nature of the bedrock aquifer and the proposed extraction rate, no effects on local groundwater levels will occur.

For these reasons no mitigation measures are required.

Post-Mitigation Residual Effects: Due to the scale of the proposed abstraction and the nature of the bedrock aquifer, we consider the residual effect to be direct, negative, imperceptible, permanent, likely effect on local groundwater levels.

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

9.5.3.5 Potential Contamination Due to Wastewater

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

Pathways: Groundwater flowpaths and site drainage network.

Receptors: Down-gradient well supplies, groundwater quality (Athboy GWB) and surface water quality in the Deel, Stonyford, Ballivor and Boyne rivers and associated tributaries.

Pre-mitigation Effects:

Negative, significant, indirect, temporary, unlikely effect on surface water quality.

Negative, slight, indirect, temporary, unlikely effect on local groundwater.

Proposed Mitigation Measures:

It is proposed to install a sealed underground holding tank for effluent (wastewater) from the substation building. The tank shall be routinely emptied by a licensed contractor. A level sensor will be installed in the tank which shall be linked to the on-site SCADA system. If the level of the tank contents rise to a predetermined 'high' level a warning shall appear on the overall SCADA system for the site and automatic notification shall be sent to the facility manager. A formal service agreement will be entered into with a suitably permitted waste contractor, in relation to the servicing and de-sludging of the wastewater holding tank on site. There will be no discharge of wastewater to ground at the proposed site, and therefore there is no potential to impact groundwater or surface water quality.

Post-Mitigation Residual Effects: The potential for contamination resulting from wastewater disposal is a risk to surface and groundwater quality. This is a risk common to all wind farm sites containing staff welfare facilities. Proven and effective measures to prevent the release of wastewater on site have been proposed above and will the potential source and each receptor. The residual effect is considered to be - Negative, imperceptible, indirect, short term, unlikely effect on surface water (Deel, Stonyford, Ballivor and Boyne rivers and associated tributaries) or groundwater quality (Athboy GWB).

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

9.5.3.6 Assessment of Effects on WFD Objectives

There is no direct discharge from the Proposed Development to downstream receiving waters. Mitigation for the protection of surface water during the operational phase of the Proposed Development will ensure the qualitative status of the receiving SWBs will not be altered by the Proposed Development.

Similarly there is no direct discharge to groundwaters associated with the Proposed Development. Mitigation for the protection of groundwater during the operational phase of the Proposed Development will ensure that the qualitative status of the receiving GWB will not be altered by the Proposed Development.

A full assessment of the potential effects of the operational phase of the Proposed Development on the status of the receiving waterbodies is included in WFD Compliance Assessment Report attached as **Appendix 9-3**.

9.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The Proposed Development is expected to have a lifespan of ~30 years. Upon decommissioning, the wind turbines the wind turbines and meteorological masts will be dismantled and all above ground components would be removed off-site for recycling.

The potential effects associated with decommissioning of the Proposed Development will be similar to those associated with construction but of a reduced magnitude, due to the reduced scale of the proposed decommissioning works in comparison to construction phase works. Turbine and mast foundations will remain and will be covered with earth and allowed to revegetate. Site roads will continue to be used as amenity pathways and will therefore not be removed. The underground cables will be cut and tied and the ducting will be left in place. Excavation and removal of this infrastructure would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increased sedimentation (if turbine foundations and hardstands are being reinstated there is a risk of silt-laden run-off entering receiving waters) and an increased possibility of contamination of local groundwater.

A decommissioning plan will be agreed with Meath and Westmeath County Council prior to decommissioning of the Proposed Development. A decommissioning plan is included as Appendix 4-5.

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

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

Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

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

9.5.5 Risk of Major Accidents and Disaster

The main risk of MADs at peatland sites is related to peat stability. However, there is no record of peat instability or historic peat slides at the proposed site. A peat stability risk assessment (Appendix 8-1) has been completed for the proposed site and it concludes that with the implementation of the proposed mitigation measures that the risk of a peat failure at the proposed site is negligible/none.

Flooding can also result in downstream MADs. However, the rehabilitation and restoration of the proposed site will increase surface water retention/attenuation at the proposed site through drain blocking, re-profiling and the restoration of the bog hydrogeological regime. This will reduce the risk of flooding downstream of the proposed site.

9.5.6 Assessment of Health Effects

Potential health effects arise mainly through the potential for surface and groundwater contamination which may have negative effects on public and private water supplies. There are no mapped public or group water scheme groundwater protection zones in the area of the proposed site. Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for effects on the water environment will not be significant.

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues. A detailed Stage III Flood Risk Assessment has been caried out for the Proposed Development, summarised in Section 9.3.6. This Flood Risk Assessment, combined with the assessment of changes in permeable surfaces (Section 9.5.3.1) demonstrates that the risk of the Proposed Development contributing to downstream flooding is insignificant. On-site (construction and operation phase) drainage control measures will ensure no downstream increase in local flood risk.

9.5.7 Cumulative Effects

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

The main likelihood of cumulative effects is assessed to be hydrological (surface water quality) rather than hydrogeological (groundwater). Due to the hydrogeological setting of the proposed site (i.e. low permeability peat, silts and clays overlying a poor bedrock aquifer) and the near surface nature of construction activities, cumulative impacts with regard groundwater quality or quantity arising from the Proposed Development are assessed as not likely.

9.5.7.1 Cumulative Effects with Turbary Peat Cutting

Private peat cutting on turbary plots will likely continue at the Ballivor Bog Group. The construction phase of the Proposed Development may interact with these turbary activities and result in a deterioration of downstream surface water quality through the emissions of elevated concentrations of suspended solids and ammonia.

However, the areas of private peat cutting will be infinitely small, significantly limiting the potential for cumulative effects to arise with the Proposed Development. Nevertheless, the mitigation measures detailed in Section 9.5.2, 9.5.3 and 9.5.4 for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

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

9.5.7.2 Cumulative Effects with Agriculture

The proposed site and the wider Ballivor Bog Group is situated in the River Boyne surface water catchment within which agriculture is the largest land use. Corine land cover maps (1990 – 2018) show that the majority of lands in the Boyne catchment are being used for agricultural purposes.

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

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

However the mitigation measures detailed in Section 9.5.2, 9.5.3 and 9.5.4 for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

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

9.5.7.3 Cumulative Effects with Commercial Forestry

There are a total of 9 no. approved private felling licences and 2 no. approved Coillte felling licences in the lands surrounding the proposed site and the wider Ballivor Bog Group. In addition there are 5 no. approved licences for afforestation.

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

Due to the close proximity of these areas of these forestry activities to the proposed site and given that they drain to the same river waterbodies (Deel, Stonyford and Boyne rivers) as the proposed site, the potential cumulative impacts on downstream water quality and quantity need to be assessed.

However the mitigation measures detailed in Section 9.5.2, 9.5.3 and 9.5.4 for the construction, operation and decommissioning phases of the Proposed Development will ensure the protection of downstream surface water quality.

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

9.5.7.4 Cumulative Effects with One Off Housing Developments

A detailed cumulative assessment has been carried out for all planning applications (granted and awaiting decisions) within a combined river sub-basin zone within the vicinity of the proposed site. This combined sub basin area encompasses the area of the Deel([Raharney]_SC_010, the Boyne_SC_040 and the Boyne_SC_050 sub-catchments. There will be no potential for cumulative impacts within the Boyne_SC_060 sub-catchment due to increased flow volume (as the catchment area increases) and increased distance from the Proposed Development. All sections of the river Boyne downstream of the Boyne_060 SWB have a total upstream catchment area in excess of 1,000km^2 and have no potential to be effected by the Proposed Development.

Planning applications have been consulted within the sub-basin zone described above. These applications are for new dwellings or renovations of existing dwellings, as well as for the erection of farm buildings. Based on the scale of the works, their proximity to the proposed site and the temporal period of likely works, no cumulative effects will occur as a result of the Proposed Development (construction, operation and decommissioning phases).

9.5.7.5 Cumulative Effects with Proposed Decommissioning and Rehabilitation Plans for the Ballivor Bog Group

Bord na Móna intend to utilise the Ballivor Bog Group for both peatland rehabilitation and wind energy infrastructure in order to facilitate environmental stabilisation of the bog group. In addition PCAS will be implemented in certain areas of the bog group (Carranstown East and Bracklin West) and will optimise climate benefits.

The Decommissioning and Rehabilitation Plans will be implemented in order to meet the requirements of the IPC licence. These plans, attached as Appendix 6-6, detail the proposed restoration and rehabilitation measures to be implemented, and will be subject to consultation as well as input from the EPA prior to their implementation.

The overall footprint of the Proposed Development is <2% of the total area of the Ballivor Bog Group (2,419ha). The decommissioning and rehabilitation plans for each of the bogs comprising the proposed site will be updated to incorporate the Proposed Development infrastructure, with the key objectives of the rehabilitation plans *i.e.* rewetting and revegetation, occurring between and surrounding the Proposed Development infrastructure.

The main risk to downstream surface water quality and the underlying groundwater quality will occur whilst the restoration measures are being implemented. The construction phase of the Proposed Development will overlap with the implementation of the rehabilitation plans. This will result in increased activity at the proposed site and in the wider bog area. The increased activity will result in greater peat disturbance which has the potential to result in elevated concentrations of suspended solids in runoff. The increased activity will also heighten the risk of hydrocarbon spills and leaks. However, all works completed as part of the Decommissioning and Rehabilitation Plans, including PCAS actions, will be completed in accordance with IPC licence requirements and using standard best practice measures. This will ensure that there will be no negative effect on downstream surface water quality or quantity or underlying groundwater quality.

During the operational phase of the Decommissioning and Rehabilitation Plans, the majority of the remedial works, such as drain blocking, will have been completed and there will be little activity on-site with the exception of monitoring and maintenance. The additional volumes of surface water runoff created by the construction of the Proposed Development infrastructure will be further attenuated within the proposed site following the implementation of the rehabilitation measures. The rehabilitation plans will improve both surface water quality and attenuation within the proposed site and in the wider bog area, by slowing the movement of water and the stabilisation of substrates.

There will be no cumulative effects associated with the construction, operational or decommissioning phases of the Proposed Development and the existing Decommissioning and Rehabilitation Plans and PCAS actions for the Ballivor Bog Group.

9.5.7.6 Cumulative Effects with the Consented Bracklyn Wind Farm

The consented Bracklyn Wind Farm development comprises of a 9 no. turbine wind farm and associated site development works together with ~6.3km of an underground grid connection. The Bracklyn Wind Farm site is located in the townland of Bracklyn, Co. Westmeath, immediately to the northwest of Bracklin Bog. Meanwhile the grid connection infrastructure will be located within the townlands of Bracklin, Co. Westmeath and Coolronan, Co. Meath, with the underground connection passing along a local road which separates Bracklin and Lisclogher bogs.

A 10-year planning permission has been granted for the construction of Bracklyn Wind Farm with a 30-year operational period from the date of first commissioning of the wind farm. Therefore, if the Proposed Development is permitted the construction phases of these 2 no. wind farms will likely overlap. The Bracklyn Wind Farm site and the grid connection route are located in the catchment to the Stonyford River. A small area of the Bracklyn Wind Farm site is located in the catchment to the Deel River, however no infrastructure is located in the River Deel surface water catchment.

In terms of the likely effects of wind farm developments on downstream surface water bodies, the greatest risk is during the construction phase as this is the phase when earthworks and excavations will be undertaken at the sites. Therefore, in the absence of mitigation measures, cumulative effects may arise. The Stonyford River will be particularly vulnerable to potential cumulative effects due to its small upstream catchment while the River Boyne will be less vulnerable due to the increased flow volumes in this waterbody.

The EIAR for the consented Bracklyn Wind Farm development details the potential hydrological and hydrogeological issues relating to the construction, operation and decommissioning phases of the proposed wind farm and proposes a suite of best practice mitigation measures designed to ensure that the development does not in any way have a negative impact on downstream surface water quality and quantity. Similarly, the mitigation and best practice measures proposed in this EIAR chapter will ensure that the Proposed Development does not have the potential to result in significant effects on the hydrological environment.

Therefore, with the implementation of the proposed mitigation measures (both for the Proposed Development and for the Bracklyn Wind Farm development) there will be no cumulative effects associated with the construction, operational or decommissioning phases of the Proposed Development and the consented Bracklyn Wind Farm.

9.5.8 Post Consent Monitoring

Environmental monitoring will continue as per the existing IPC licence conditions at the Ballivor Bog Group until the current IPC Licence is surrendered.

This monitoring will encompass surface water sampling to ensure that the discharge from the bogs remains below the existing IPC emission limit values, thereby protecting downstream surface water quality.