8 WATER

8.1 Introduction

8.1.1 Background & Objectives

Hydro-Environmental Services (HES) was engaged by McCarthy Keville O'Sullivan (MKOS), on behalf of Bord na Móna Powergen Ltd. and ESB Wind Development Ltd. to carry out an assessment of the likely significant effects of a Solar Farm and Substation and Grid Connection project at a proposed site at Timahoe, Co. Kildare on water aspects (hydrology and hydrogeology) of the receiving environment.

The Proposed Project site is located in northwest County Kildare, approximately 6.5km (kilometres) north of the village of Allenwood, 6km east of Carbury and 3km south of Johnstownbridge. The site is accessed from the south via the Derrymahon-Drehid local road L1019, which adjoins the R402 Regional Road to the west of the site.

The Proposed Project comprises a large scale solar PV farm with an export capacity of approximately 70 Megawatts (MW). It will consist of a solar photovoltaic array and associated infrastructure, a battery storage facility, inverters, access roads and parking, site compounds and security fencing, amenity trails and landscaping, peat and subsoil storage areas (repositories), site drainage and all associated works. The Proposed Project will also include the construction of a 110 kV substation within the site. It is then envisaged to connect from this substation to the Derryiron-Maynooth 110 kV overhead line that traverses the southern section of the Timahoe North site.

The objectives of the assessment are to:

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

8.1.2 Statement of Authority

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

Our core areas of expertise and experience includes peatland hydrology and drainage design and management. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by Michael Gill and David Broderick.
Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 16 years' environmental consultancy experience in Ireland.

Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. He has substantial experience in surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm related projects. Michael has also worked on over 20 solar projects across Ireland, including Clonfad Solar, Sronagh Solar, Tiglin Solar, Kilsallaghan Solar, Ballymacarney Solar.

David Broderick (BSc, H.Dip Env Eng, MSc) is a hydrogeologist with over 12 years' experience in both the public and private sectors. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIAs for a range of commercial developments. For example, David has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm related projects across Ireland.

8.1.3 Relevant Legislation

The EIAR is carried out in accordance with the follow Irish legislation:

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1995, S.I. No. 352 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001), S.I. No. 30 of 2000, the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/373/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 Act, 2000, as amended;
- S.I. No. 94 of 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 of 1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least 'good' status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of 'Good' status for these depends also on the achievement of 'good' status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been completed or are ongoing. In 2015 it

will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;

- S.I. No. 41 of 1999: Protection of Groundwater Regulations, resulting from EU Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances (the Groundwater Directive);
- S.I. No. 249 of 1989: Quality of Surface Water Intended for Abstraction (Drinking Water), resulting from EU Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (repealed by 2000/60/EC in 2007);
- S.I. No. 439 of 2000: Quality of Water intended for Human Consumption Regulations and S.I. No. 278 of 2007 European Communities (Drinking Water No. 2) Regulations, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the Drinking Water Directive) and WFD 2000/60/EC (the Water Framework Directive);
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009;
- S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010; and,
- S.I. No. 296 of 2009: European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

8.1.4 Relevant Guidance

There is no one specific guidance document for environmental assessment of solar projects. However, there are several documents that can be used, and as such the water section of the EIAR is carried out in line with guidance contained in the following:

- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU);
- Environmental Protection Agency (August 2017) Draft - Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation on Environmental Impact Statements);
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation on Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2009): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Eastern Regional Fisheries Board (2016): Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters;
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006); and,

- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006.

8.2 Methodology

8.2.1 Desk Study

A desk study of the proposed development site, third party land and third party turbary lands, and surrounding area was largely completed prior to the undertaking of field mapping and walkover assessments. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the study area. This included consultation with the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive catchments.ie/maps/ Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 16 (Geology of Kildare – Wicklow); Geological Survey of Ireland;
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie); and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

8.2.2 Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES on various dates, including 11th October 2017, 03rd January 2018, 11th January 2018, 08th February 2018, 22nd March 2018, and 18th and 23rd July 2018. The field assessments included a detailed site walkover survey, water features survey, and an inspection of all relevant hydrological features, such as existing drainage ditches and outfall streams.

In summary, assessments to address the water, hydrology and hydrogeology section of the EIAR included the following:

- Walkover surveys and hydrological mapping of the proposed Solar Farm site, substation location and grid connection route, and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;
- A flood risk assessment for the proposed development was completed by Hydro-Environmental Ltd;
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows;
- Spot measurement of flow, and continuous water level monitoring was completed at the site between January and July 2018; and,

- 1 no. surface water sample was taken at location F1 on 22nd July 2018.

In addition to the above, the baseline site geology for the proposed Solar Farm and the Substation and Grid Connection has been characterised using a significant quantity of site investigation data. This site investigation data, as referenced in Chapter 7, are relevant to the Water and Hydrology assessment completed in this Chapter.

8.2.3 Impact Assessment Methodology

Please refer to Chapter 1 of the EIAR for details on the impact assessment methodology (EPA, 2002 & 2003, & 2017). In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 8.1 are then used to assess the potential effects that the Proposed Project may have on the local baseline water environment (*i.e.* water receptors).

Table 8.1 Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

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

8.3 Receiving Environment

8.3.1 Site Description & Topography

The Proposed Project is located in northwest Co. Kildare, approximately 6.5km (kilometres) north of the village of Allenwood, 6km east of Carbury and 3km south of Johnstownbridge. The Grid Reference coordinates for the centre of the site are E 275,810 N 235,200. The Timahoe North site comprises the northern half of the Bord na Móna Timahoe bog unit, which forms part of the Allen bog group.

The Proposed Project is located in the townlands of Drehid, Mulgeeth, Mucklon, Ballynamullagh, Kilmurry (Carbury by), Killyon and Timahoe East.

The site topography is predominantly flat, with minor local variations, and lying at an elevation of approximately 79 mOD to 85 mOD. Some small outcrops of higher elevation are located in the surrounding landscape, up to a height of 93 metres O.D.

The proposed site for the Solar Farm aspect of the development is within the Timahoe Bog as indicated in Figure 4.1. The total site area is approximately 807ha, and the Proposed Project site footprint is approximately 238ha.

As noted in Section 8.1.1, the Proposed Project comprises a largescale solar PV farm with an export capacity of approximately 70 MW and an associated Substation and Grid Connection. It will consist of a solar photovoltaic array and associated infrastructure, inverters, a battery storage compound, access roads and parking, site compounds and security fencing, amenity trails and landscaping, peat and material storage areas (repositories), site drainage and all associated works. The Proposed Project will also include the construction of a 110 kV substation. It is then envisaged to connect from this substation to the Derryiron-Maynooth 110 kV overhead line that traverses the southern section of the Timahoe North site.

Land use in the surrounding area includes more cutover/cutaway bog to the south and east of the proposed Solar Farm site with the remainder a combination of agriculture, forestry and scattered rural pattern of residential dwellings along the local roads to the east and north of the site. There is also an operational waste management facility at Drehid, located to the south of the Proposed Project site.

Large-scale peat harvesting ceased at the site in the early 1990's. Some infrastructure still exists on site including decommissioned railway lines and drainage system. The vast majority of the site comprises heavily drained cutover raised bog. The high voltage Derryiron to Maynooth 110 kV overhead electricity line crosses the main access route within the site, approximately 500 m from the site entrance.

The bog has large wide man-made drains running in a northwest to southeast direction. There are 11 main drains in total, and these are spaced at ~250m centres. These drains are c3-5m wide and of various depths. There are a number of other, similarly orientated, drains that are discontinued with standing water only. The remains of two raised disused rail line tracks which ran transversely across the bog from the southwest to northeast exist at the site. These previously facilitated a narrow-gauge rail line access to the site during peat production and harvesting.

The bog is bounded to the northwest and north by a tributary of the Fear English River which flows northwards away from the site and joins the Kells Blackwater (Boyne River System). To the south the bog is bounded by open drains that form the Mulgeeth tributary which flows southeast away from the site past Doran Nurseries before heading northeast and north to eventually join the Kells Blackwater.

8.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 20-year annual average rainfall (AAR) recorded at Edenderry 13.3km southwest of the proposed development site, are presented in Table 8.2.

Table 8.2 Local Average long-term Rainfall Data (mm)

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		
Edenderry		262,700		262,700		85		1951		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
81.0	59.2	68.2	60.9	60.1	66.9	73.1	83.7	67.6	93.0	80.6	80	874

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Casement Aerodrome, approximately ~28km southeast of the site. The long-term average PE for this station is 510mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 485mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE
= 874mm/yr – 485mm/yr
ER = 389mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie), *i.e.* a peatland site with a low vulnerability rating, an estimate of 19mm/year average annual recharge is given for basin peat in this area (recharge coefficient of ~5%). This means that the hydrology of the site is characterised by very high surface water runoff rates and very low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the site are estimated to be 19mm/yr and 370mm/yr respectively.

8.3.3 Background on Local Geology

A brief review of the local geology is provided in this section in order to put the succeeding description of the local hydrological and hydrogeological regime into perspective. Please refer to Chapter 7 (Land, Soils and Geology Section) for a detailed characterisation of the Proposed Project site geology.

The GSI soils map (www.gsi.ie) for the area shows that the entire area of the Proposed Project site is mapped as cutover/cutaway peat (Cut). Similarly, the GSI subsoils map for the area shows that the entire Proposed Project site is mapped as Cutover raised peat (Cut).

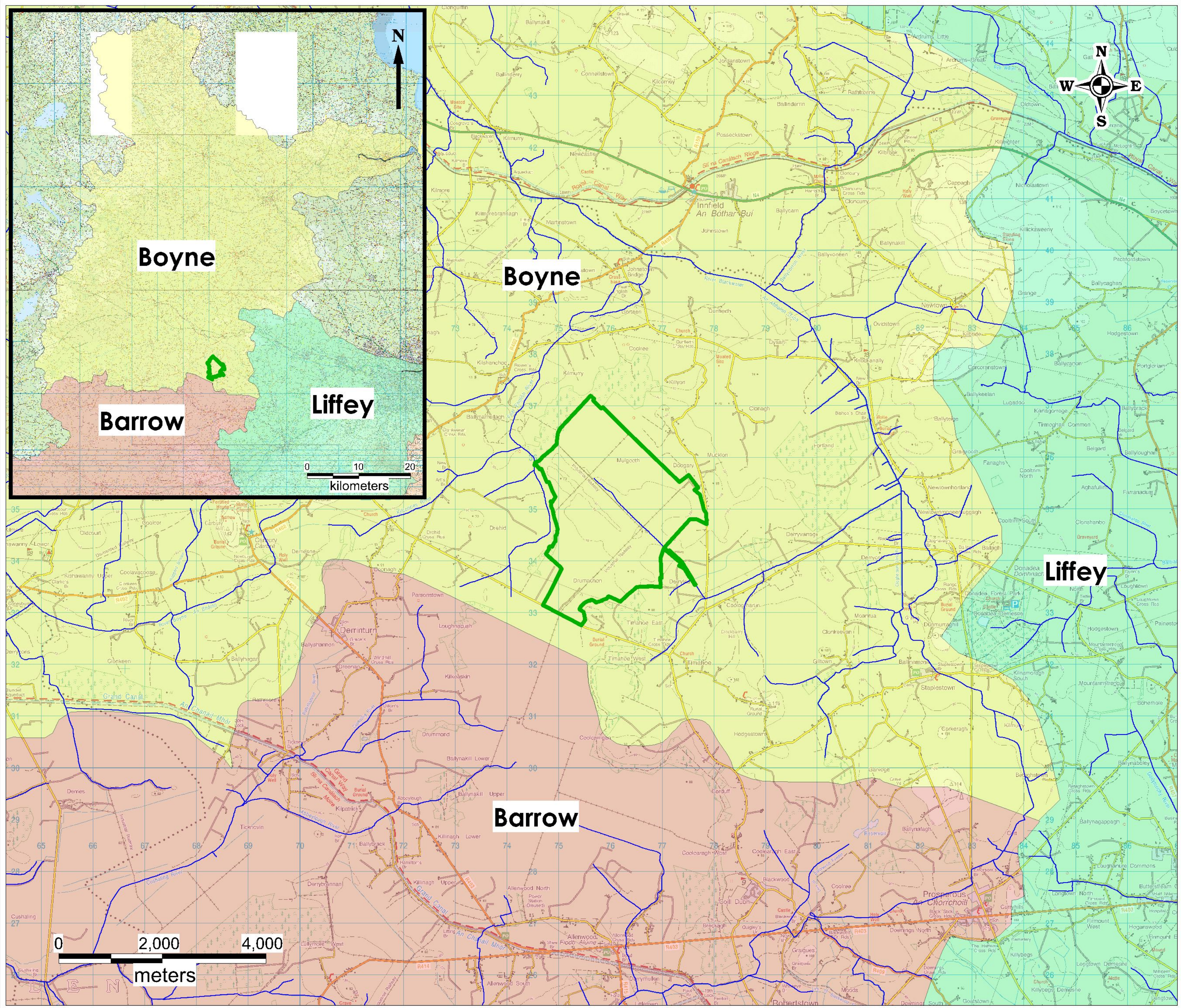
Peat depths at the site range between 0.05 to 5.2m. The peat is underlain by glacial deposits interbedded with glacio-fluvial deposits over limestone bedrock. The glacial deposits generally consist of soft to very stiff grey gravelly clay/silt. These deposits are interbedded with gravels and sands within the stratum.

The underlying bedrock is mapped as Limestone.

8.3.4 Hydrology

8.3.4.1 Regional & Local Hydrology

Regionally the Proposed Project site, is in the River Boyne surface water catchment within Hydrometric Area 07 of the Eastern River Basin District (ERBD). A regional hydrology map is shown as Figure 8.1.



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web: www.hydroenvironmental.ie

Title: Regional Hydrology Map

Client: McCarthy Keville O'Sullivan

Job: Timahoe, Co. Kildare

Project No: P1418-0

Figure No: 8.1

Sheet Size: A4

Drawing No: P1418-0-1218-A4-801-0A

Date: 03/12/2018

Scale: 1:100,000

Drawn By: GD | Checked By: MG

There are two outfalls from the Timahoe North bog. One to the southeast, and a second (smaller) one to the northwest.

The majority of the bog currently (and historically) drains to the Mulgeeth stream (to the southeast). The Mulgeeth stream is a tributary of the River Blackwater and it flows southeast from the centre of the proposed site. Southeast of the site, ~1.3km downstream, the Mulgeeth changes direction and flows in a northeast direction to join the River Blackwater ~4.6km downstream of the southern site outfall.

A small portion of the northern and northwestern section of the Timahoe bog drains to the Fear English River. The Fear English River flows to the north just outside the western boundary of the Proposed Project site. The Fear English River (Blackwater (Longwood)_020) flows northwards to join the River Blackwater just to the east of Johnstownbridge.

A local hydrology map is shown as Figure 8.2.

8.3.4.2 Site Drainage

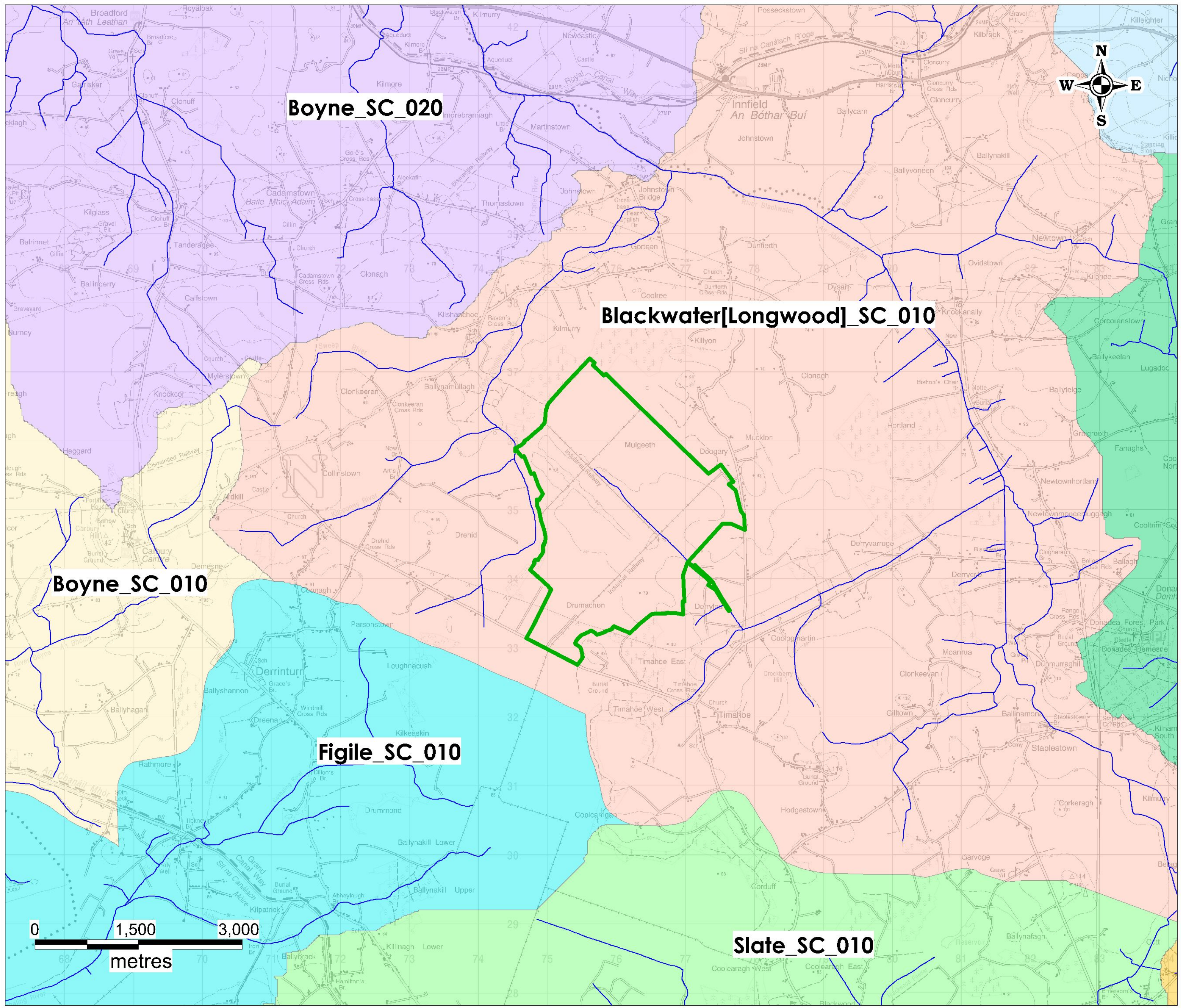
The Timahoe North bog has large wide man-made drains running in a northwest-southeast longitudinal direction, spaced c. 250m apart and totalling 11 main (continuous) longitudinal drains across the full width of the bog. There are a number of other, similarly orientated, drains that are discontinuous with standing water only. Two raised disused rail line tracks running transversely across the bog from the southwest to northeast are present which facilitated a narrow gauge rail line to the site during peat production.

As described above, the Timahoe North bog is bounded to the northwest and north by a tributary of the Fear English River which flows northwards away from the site and joins the River Blackwater (Boyne River System). To the south the bog is bounded by open drains that drain to the Mulgeeth stream which flows southeast away from the site past Doran Nurseries before heading northeast and north to eventually also joining the River Blackwater.

During the various site inspections, the majority of field ditches did not show significant signs of clear flow and in some places only contained standing water. It is likely that many of the culverts that connect the drain under railway lines are blocked or partially collapsed at this stage. The Mulgeeth watercourse was the only watercourse that demonstrated effective drainage discharge from the site. As a result of the impeded drainage at the site a permanent wetland area was observed around the Mulgeeth watercourse and the southern railway line which is likely to be a result of the watercourse backing up during heavy flow events. The lack of flow from the site's field drains has resulted in a large quantity of water attenuating on site throughout the year.

It should be noted that the proposed Solar Farm development areas, including the Substation and Grid Connections elements, all drain southeast via the longitudinal drains to the Mulgeeth Stream, therefore there will be no potential impacts to existing drainage outfall to the northwest of the Timahoe North bog.

During historical peat extraction operations, the site was continuously drained via 8 no. pumping stations. These no longer exist at the site and all site drainage is via gravity outfall. A history of the site drainage is provided in Timahoe North Solar Farm – Site Drainage Report (ESBI, 2018). This report is attached as Appendix 8-1.



Legend

Project Boundary

Rivers/Streams

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Title: Local Hydrology Map

Client: McCarthy Keville O'Sullivan

Job: Timahoe, Co. Kildare

Project No: P1418-0

Figure No: 8.2

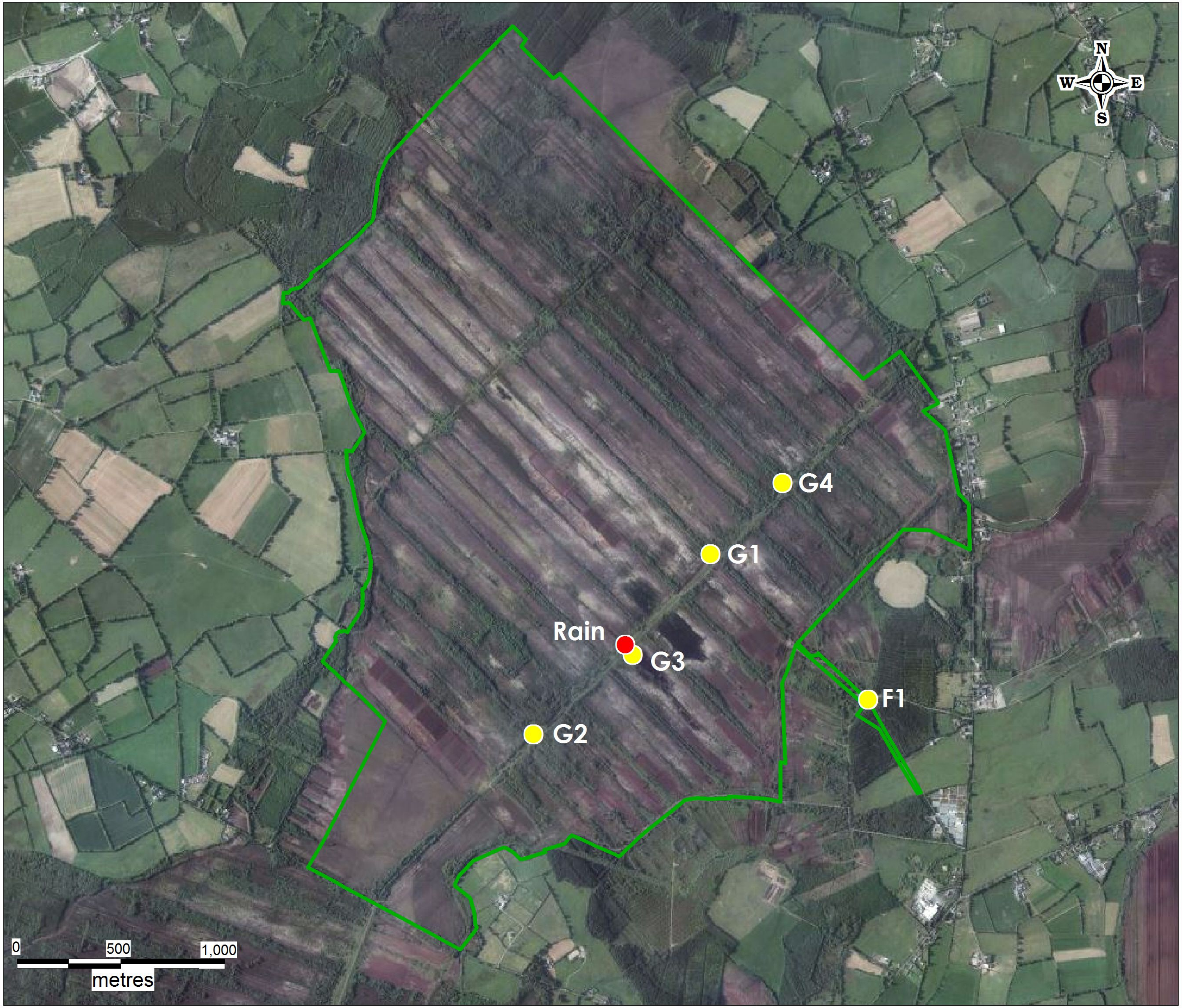
Sheet Size: A4

Drawing No: P1418-0-1218-A4-802-0A

Date: 03/12/2018

Scale: 1:75,000

Drawn By: GD | Checked By: MG



Legend

Project Boundary

SW Level Monitoring Locations

Rainfall Monitoring Locations

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Title: Surface Water Level Monitoring Location Map

Client: McCarthy Keville O'Sullivan

Job: Timahoe, Co. Kildare

Project No: P1418-0

Figure No: 8.3

Sheet Size: A4

Drawing No: P1418-0-1218-A4-803-0A

Date: 03/12/2018

Scale: 1:25,000

Drawn By: GD | Checked By: MG

8.3.4.3 Hydrological Monitoring

Continuous water level monitoring was completed at five locations at the site. These locations (G1, G2, G3, G4 and F1) are shown on Figure 8.3. Water level data for the EIAR was collected between 03rd January to 18th July 2018. A plot of this data is presented as Figure 8.4. Rainfall data was also collected at the site during this period up to 22nd March 2018, and these data are also included on Figure 8.4.

A summary of the recorded water level data is presented in Table 8.3.

Table 8.3 Gauged water levels at Timahoe (January – July 2018)

Location	Water level range (m)	Max water level (mOD)
G1	0.42	78.01
G2	0.56	79.83
G3	0.44	78.29
G4	0.69	78.95
F1	0.73	76.99

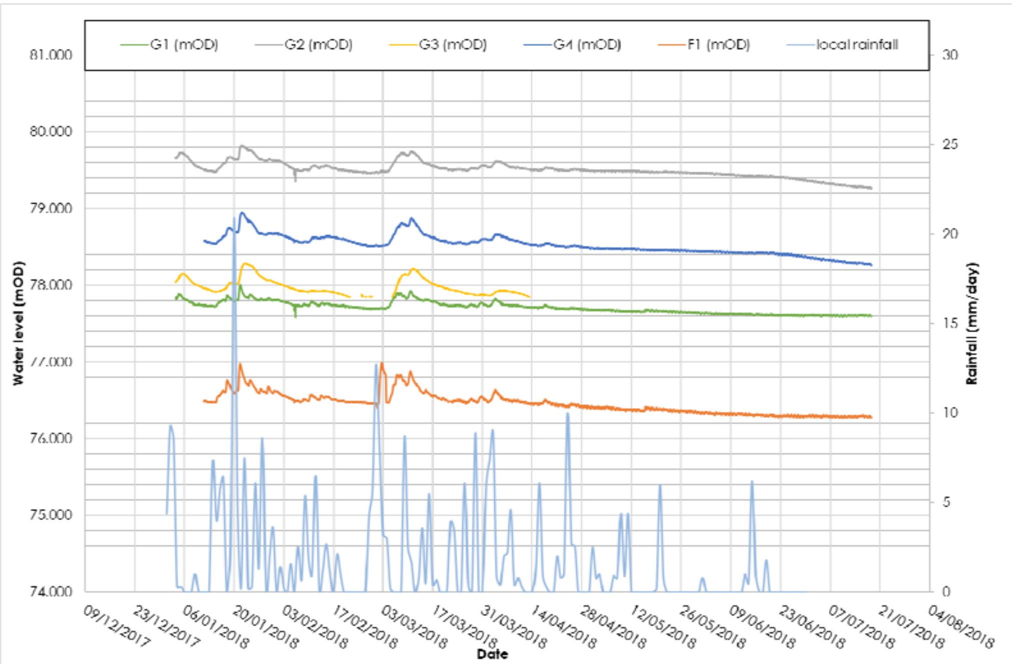


Figure 8.4: Surface water level monitoring data plot
**Gaps in G3 plot are where the open water level was dry at G3 location.*

The plot indicates that water levels recorded at F1 respond relatively quickly to direct rainfall onto the bog, as do other monitoring locations. Water levels do recede after all rainfall events which also indicates that while there may be some impeded drainage within the site, there is, at least, some ability for water to get away (drain), even within drainage channels that appear isolated/perched or partially blocked.

Flow measurements were also recorded at location F1 using the velocity area method. A Valeport Model 002 flow meter was used for data recording. These data are presented in Table 8.4.

Table 8.4 Flow measurements recorded at location F1

Location	Date	Flow (L/s)
F1	03/01/2018	75
F1	08/02/2018	48
F1	22/03/2018	56
F1	18/07/2018	<5*
F1	23/07/2018	<5*

**Not possible to make an accurate measurement due to low flow conditions.*

8.3.5 Flood Risk Assessment Overview

This section presents an overview of the flood risk assessment undertaken for the Proposed Project. The full flood risk assessment report for the proposed Timahoe Solar Farm is provided as Appendix 8-2. The attached FRA was completed by Hydro Environmental Ltd (Galway).

To identify those areas as being at risk of flooding, historical mapping (i.e. 6" and 25" base maps), OPW's indicative river and coastal flood map (www.floodmaps.ie), CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie), and Eastern CFRAM Study maps were consulted.

The available historical 25" mapping and historical 6" mapping for the area of the proposed site contains no text that identify areas that are "prone to flooding" within the EIAR site boundary, or downstream of the site.

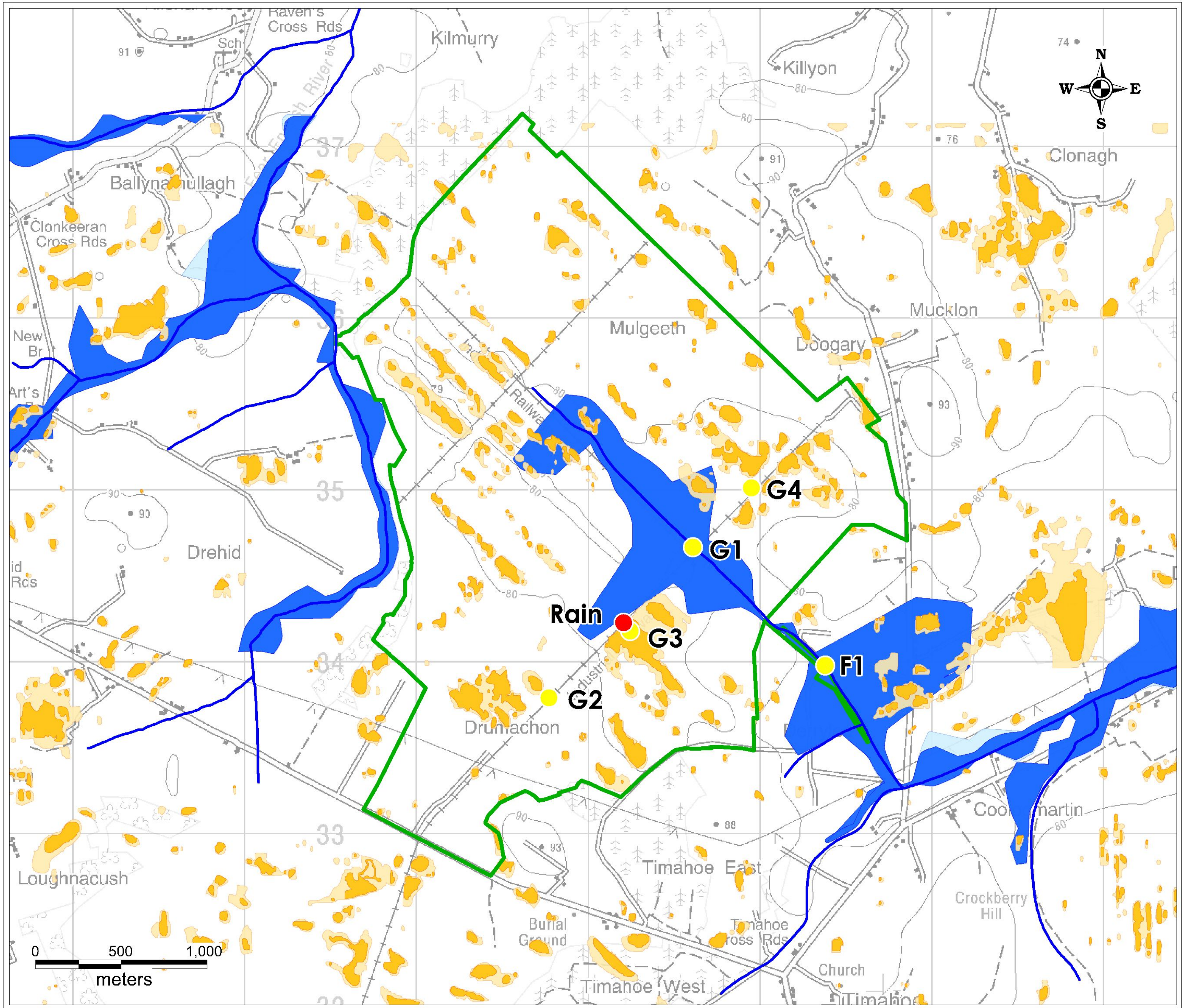
No recurring flood incidents in the area of the proposed site were identified from OPW's indicative flood map. The closest recurring flood incidents that are connected to the hydrology of the proposed site are mapped in the Knockanally Area ~4.3km east of the proposed site which is identified as a "flood plain of tributaries of River Blackwater" by the Kildare County Council Area Engineer. However, the surface water connection between the Proposed Project site and this area of recurring flooding is indirect as the unnamed watercourse within the Proposed Project site first joins the Mulgeeth stream and then the Blackwater River upstream of this area.

The entire area of the Proposed Project site is mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

Also shown on the PFRA mapping is the indicative extent of pluvial flooding (*i.e.* flooding from rainfall ponding). As seen from Figure 8.5, pluvial flooding appears to occur in clusters within the site and this is as result of surface water runoff backing up in the drainage routes when the capacity of the outfalls are exceeded.

Where complete the CFRAMS[1] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the PFRA maps However, CFRAM mapping is not currently available for the area of the proposed development site.

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



Legend

- Project Boundary
- SW Level Monitoring Locations
- Rainfall Monitoring Locations
- Fluvial - 100-yr AEP Event
- Fluvial - Extreme Event
- Pluvial - 100-yr AEP Event
- Pluvial - Extreme Event
- Rivers/Streams

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Title: PFRA Indicative Flood Zone Map	
Client: McCarthy Keville O'Sullivan	
Job: Timahoe, Co. Kildare	
Project No: P1418-0	
Figure No: 8.5	
Sheet Size: A4	
Drawing No: P1418-0-1218-A4-805-0A	
Date: 03/12/2018	
Scale: 1:30,000	
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The Flood Risk Assessment undertaken by Hydro Environmental Ltd (see Appendix 8-2) conclude the following:

- A detailed site-specific Stage 3 Flood Risk Assessment of the Proposed Project was carried out in accordance with the Flood Risk Management Planning Guidelines (2009);
- The completed Flood Risk Assessment shows that the proposed solar sites on the existing Bord Na Mona Bog at Timahoe North are on lands subject to potential flooding;
- The flood risk categories for these lands varies from Flood Zone A to Flood Zone C. The source of flooding is from direct rainwater falling on the bog and from its subsequent collection and drainage from the bog via large longitudinal drains running at 250m centres, orientated northwest to southeast which empty to an existing perimeter collector drain at the southeast end, discharging via small and potentially blockage prone pipe culverts. Therefore, the source of flood risk is generally pluvial in origin;
- The two solar development areas (northeast and southwest areas) within the BNM Timahoe North Bog have been selected on generally higher drier ground so as to avoid the lower-lying flood prone areas of the bog which are associated with the lower central section of the bog. Drawings to illustrate this point are attached in Appendix 8-2;
- Fluvial Flooding from upstream catchments is not a source of flood risk to the proposed solar sites;
- A proposed drainage scheme for the Proposed Project site was developed and shown to suitably mitigate flood risk on the site both potential and residual Flood Risk without impacting the flood risk to adjacent and downstream Third Party lands;
- Residual Flood Risk to the Proposed Project can be minimised through active management of the proposed drainage infrastructure on the site;
- The Proposed Project is considered sustainable and flood management measures designed to cater for recommended future climate change allowances. Management of Flood Risk on the site for the proposed development can be carried out not to cause unacceptable impact on the ecology of the Timahoe North Bog; and,
- The Flood Risk Assessment showed that development of the Proposed Project is justifiable under the Flood Risk Management Planning Guidelines Justification Test Box 5.1 – Development Management.

8.3.6 Surface Water Quality

Q-rating status data for EPA monitoring points on the Blackwater River are shown on Table 8.5 below. Most recent data available (2015) show that the Q-rating for the Blackwater River is Poor Status downstream of the proposed site. Historical data from 1971 to 2016 indicate Q-values varying between 3,3-4, and 4.

Table 8.5 EPA Water Quality Monitoring Q-Rating Values

Water body	EPA Location Description	Easting	Northing	EPA Q-Rating Status
Blackwater River	Br S of Hortland	281180	236195	Q3 Poor
Blackwater River	Br at Johnstown	276618	239946	Q3-4

Surface water samples were also taken from the Mulgeeth watercourse downstream of the bog outfall at the location (F1) identified on Figure 8.3.

Results of the laboratory analysis are shown alongside relevant water quality regulations in Table 8.6 below. In addition, Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) are shown in Table 8.7. Original laboratory reports are attached as Appendix 8-3.

Table 8.6 Analytical Results of HES Surface Water Samples (F1)

Parameter	EC DIRECTIVES			Sample ID	
	2006/44/EC		EC DW Regs 2007	F1 (23/07/18)	F1 (27/09/18)
	Salmonid	Cyprinid			
Total Suspended Solids (mg/L)	≤ 25 (O)	≤ 25 (O)	-	8	<5
Ammonia N (mg/L)	≤0.04	≤0.02	0.3	0.12	0.65
Ortho-Phosphate – P (mg/L)	-	-	-	0.07	0.02
Nitrate - NO_3 (mg/L)	-	-	50	6.8	<5
Chloride (mg/L)	-	-	250	52.3	13.1
BOD	≤ 3	≤ 6	-	4	1

Total suspended solids (TSS) was reported between <5 and 8mg/L, and sample water had a peaty colour, consistent with the catchment being drained.

Ammonia N was recorded between 0.12 and 0.65mg/L. The presence of elevated ammonia is due to natural decomposition of peat.
BOD was recorded between 1 to 4 mg/L, which is below the Freshwater Fish Directive (2006/44/EC) for Cyprinid waters.

Nitrate was recorded between <5 and 6.8mg/L which is typically low and is what would be expected in a peatland environment.

Table 8.7 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)
Ortho-phosphate	High status ≤0.025 (mean)
	High status ≤0.025 (mean) Good status ≤0.035 (mean)

** Environmental Objectives Surface Water Regulations (S.I. 272 of 2009)*

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), results for ammonia, BOD and ortho-phosphate would not fully meet relevant threshold values.

8.3.7 Hydrogeology

The Proposed Project site is entirely located in the Trim Groundwater Body (GWB). As stated previously, the site is divided between two bedrock formations. The Dinantian Upper Impure Limestones which are mapped on the north and west of the site and form part of the Lucan Formation are classified by the GSI as a Locally Important Aquifer – Bedrock which is Generally Moderately Productive (Lm). As this is pure limestone a relatively high permeability could be expected along weathered fractures and faults. However, the available evidence for this bedrock type in this area suggests that this is not always the case and this is because bedding is often poorly developed by weathering (GSI, 2004).

The Dinantian Pure Unbedded Limestones which are mapped on the south and east of the site and form part of the Waulsortian Limestones are classified as a Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones (Ll).

The limestone bedrock in the area of the Proposed Project is covered by glacial deposits interbedded with glacio-fluvial deposits which in turn is overlain by cutaway peat. The glacio-fluvial deposits will likely provide the dominant potential pathway for groundwater movement in the Proposed Project site especially where sands and gravels are present.

As discussed in Chapter 7 (Soils and Geology) the peat is underlain by soft to very stiff grey gravelly clay/silt. These deposits are interbedded with gravels and sands within the stratum. These are generally over consolidated strata. The consistency of these strata typically tends to improve with depth. Groundwater seepages were noted in almost all of the trial pits. Seepage was largely classed as moderate to very slow with fast to moderate in some locations.

Site investigation data indicates that water inflows to trial pits were generally slow to very slow, with some moderate inflows at depth. Groundwater levels recorded in Boreholes installed at the site ranged between 0.39 and 1.92m bgl (below ground level), or between 78.02m OD and 81.57m OD. As would be expected water levels are relatively close to ground level across the site. Water levels recorded in the peat strata are likely to be perched above the underlying regional groundwater table (located within the glacial deposits or underlying bedrock geology).

8.3.8 Groundwater Vulnerability

The vulnerability rating of the bedrock aquifer underlying site is classified as "Low" representing peat subsoil greater than 10m. This vulnerability rating is confirmed by the site-specific data collected during the site investigations works completed at the site.

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 than groundwater at this site.

8.3.9 Groundwater Hydrochemistry

There are no groundwater quality data for the Proposed Project site and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality impacts are not anticipated.

Based on data from GSI publication Calcareous/Non-calcareous classification of bedrock in the Republic of Ireland (WFD, 2004), the groundwater in areas of pure limestone is very hard with total hardness values in excess of 350 mg/l (as $CaCO3$) and electrical conductivity values ranging 590-634 µS/cm, indicating that the groundwater has a calcium bicarbonate hydrochemical signature.

8.3.10 Water Framework Directive Water Body Status & Objectives

The Eastern River Basin District (ERBD) Management Plan was adopted by all local authorities in the ERBD in October/November 2009, as stipulated in the European Communities (Water Policy) Regulations 2003 (S.I. 722 of 2003 as amended). The SERBD Management Plan (2009 – 2015) objectives, which will be integrated into the design of the proposed Solar Farm development, include the following:

- 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 2015;
- Ensure waters in protected areas meet requirements; and,
- Progressively reduce chemical pollution.

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

8.3.11 Groundwater Body Status

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

The Trim GWB (IE_EA_G_002) underlies the development site. This GWB is assigned 'Good Status', which is defined based on the quantitative status and chemical status of the GWB.

8.3.12 Surface Water Body Status

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) in which development is proposed (or immediately upstream of) are shown in Table 8.8 below.

The site is part of the Blackwater Longwood SWB (IE_EA_07B020060) which has an overall status of "Poor".

Poor construction and water management practices during Proposed Project construction, operation, and decommissioning phases has the potential to impact on local surface water quality. Mitigation measures will be implemented (as detailed below) which will ensure that surface runoff from the developed areas of the Proposed Project site will be of a high quality and will therefore not impact on the existing status of downstream surface water bodies.

Table 8.8 Summary WFD Information for Surface Water Bodies

Water Body	General Physico - Chemical Status	Overall Ecological Status	Overall Status	Overall Objective
Blackwater Longwood	N/A	Poor	Poor	Restore 2021

8.3.13 Designated Sites & Habitats

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

There are no designated sites within the Proposed Project site.

The River Boyne and Blackwater SAC is ~26km downstream of the Proposed Project site.

Furthermore, there are no groundwater dependent designated sites of relevance to this hydrological / hydrogeological assessment as all designated sites are sufficiently remote (including: Carbury Bog NHA; Hodgestown Bog NHA; Ballynafagh Lake SAC; and Ballynafagh Bog SAC) from the Proposed Project site to state with scientific certainty that they are hydrogeologically disconnected from the Proposed Project site, and therefore cannot be impacted by the Proposed Project.

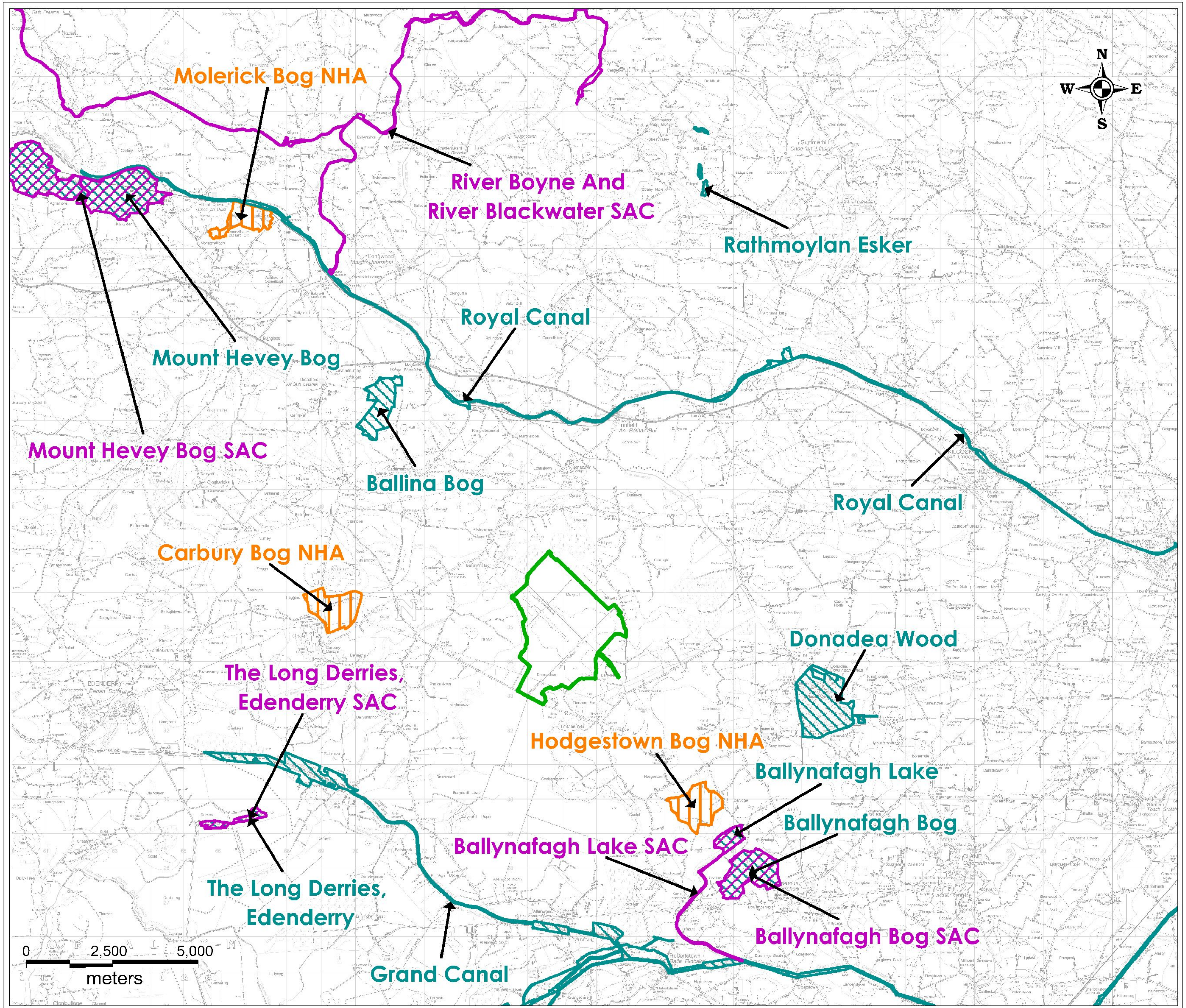
Designated sites are shown on Figure 8.6.

8.3.14 Water Resources

Johnstown Public Water Supply (PWS) spring source and its groundwater protection zone (Zone of Contribution or ZOC) exist approximately 2.1km and 480m respectively to the northeast of the Proposed Project site. The Proposed Project site is not located in the groundwater protection zone to this source. The location of the ZOC relative to the Proposed Project is shown on Figure 8.7.

A search of private well locations (wells with location accuracy of 1 – 50m were only sought) was undertaken using the GSI well database (www.gsi.ie). No wells with an accuracy of 1 – 50m were mapped in the area of the Proposed Project site. There are a cluster of wells centred around Doogary to the east of the site and Timahoe village to the southeast that are mapped to an accuracy of 2km and 5km respectively. Given their low locational accuracy, assessing potential impacts on these wells cannot be undertaken in any reliable manner.

To overcome the poor accuracy problem of the GSI mapped wells it is assumed that every private dwelling/farmyard in the area of the Proposed Project has a groundwater well and this conservative impact assessment approach is described further below. The locations of local private dwellings/ farmyards are illustrated on Figure 8.8.



Legend

- Project Boundary
- SAC
- pNHA
- NHA

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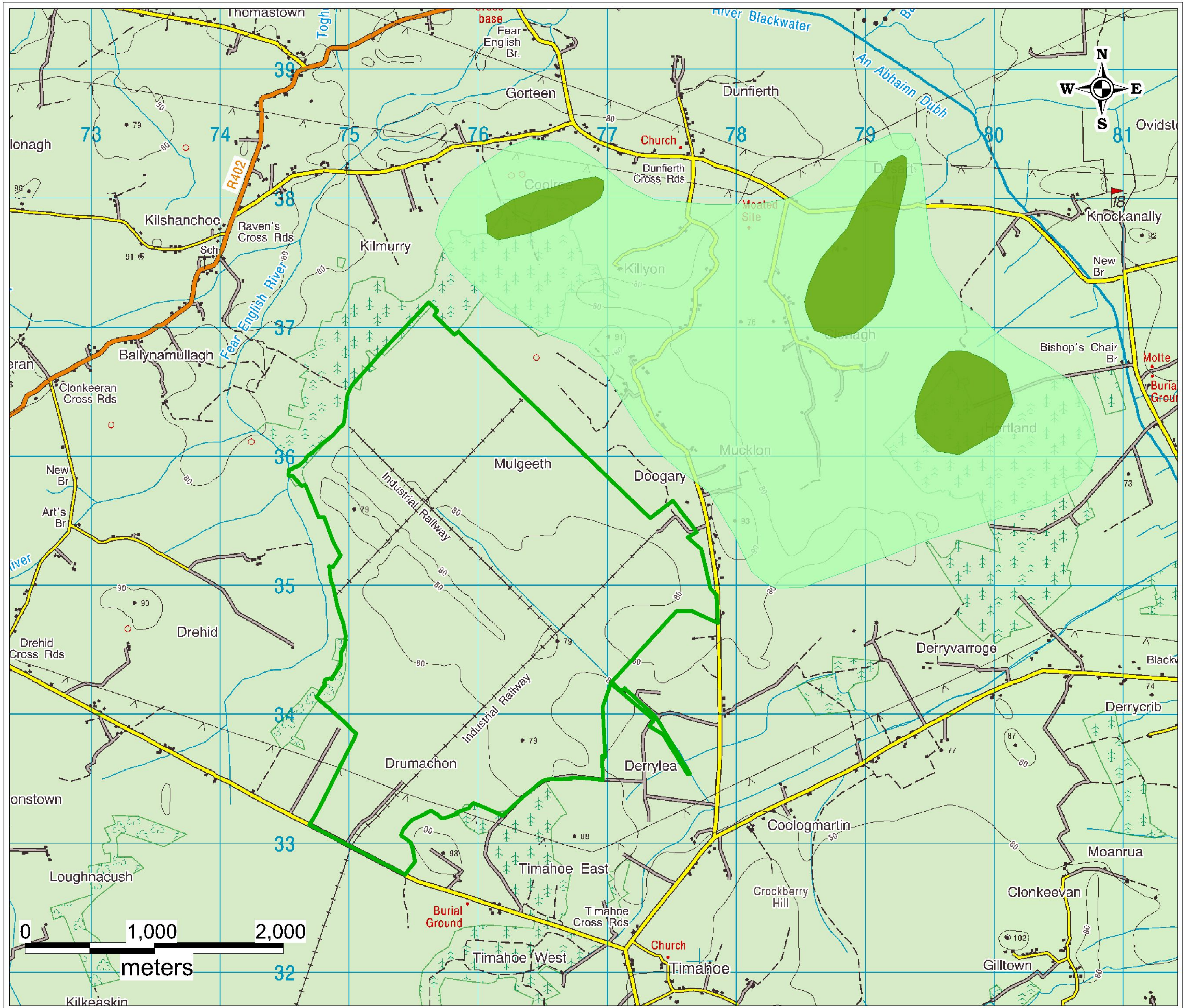
Title: Designated Sites Map	
Client: McCarthy Keville O'Sullivan	
Job: Timahoe, Co. Kildare	
Project No: P1418-0	
Figure No: 8.6	
Sheet Size: A4	
Drawing No: P1418-0-1218-A4-806-0A	
Date: 03/12/2018	
Scale: 1:150,000	
Drawn By: GD	Checked By: MG



Legend

- Project Boundary
- Inner SPZ
- Outer SPZ

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Title: Zone of Contribution Map

Client: McCarthy Keville O'Sullivan

Job: Timahoe, Co. Kildare

Project No: P1418-0

Figure No: 8.7

Sheet Size: A4

Drawing No: P1418-0-1218-A4-807-0A

Date: 03/12/2018

Scale: 1:40,000

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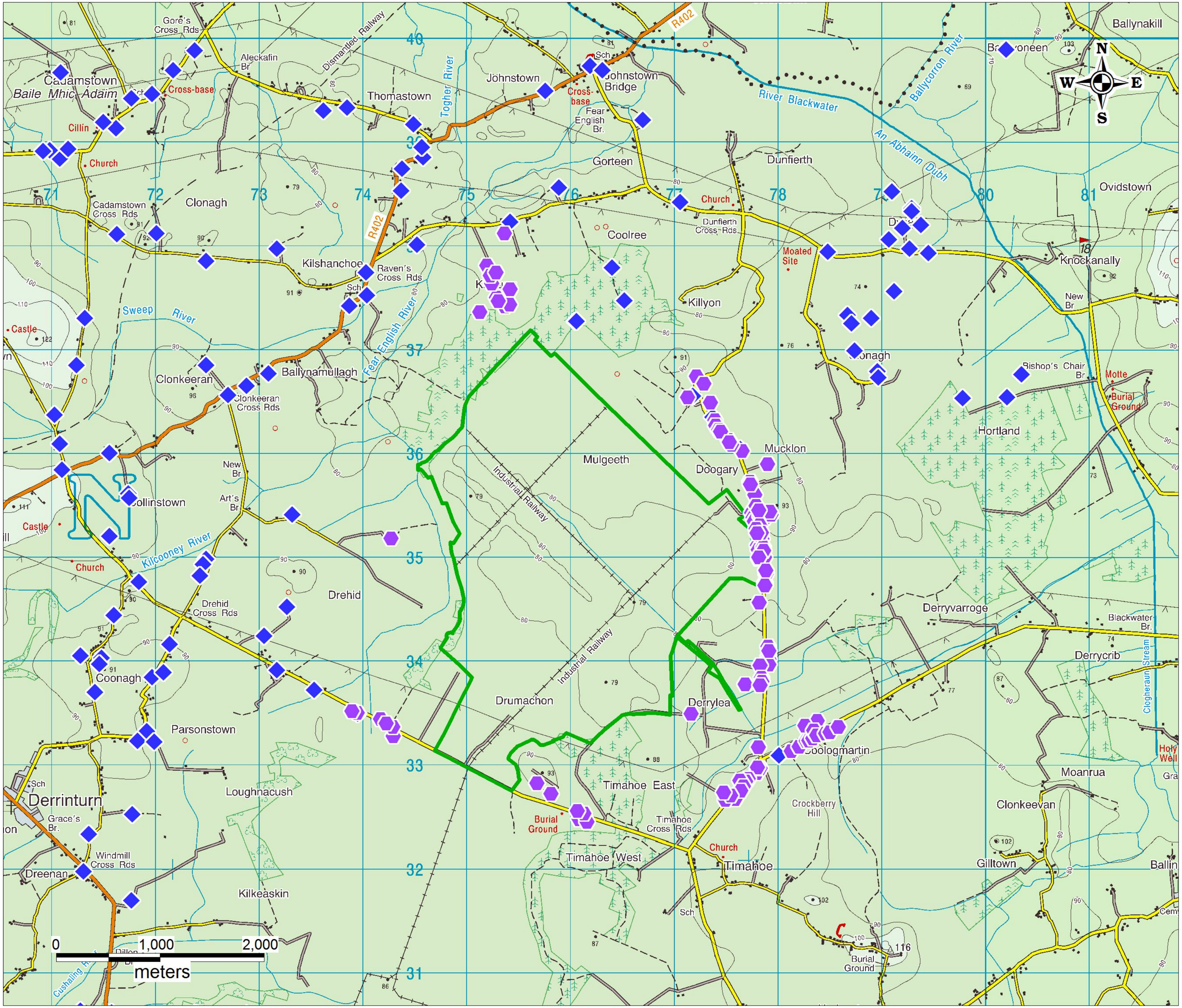

Legend

- Project Boundary
- Private Dwelling Locations
- GSI Mapped Wells (<50m accuracy)

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Title: Local Private Dwellings and Farmyards Map

Client: McCarthy Keville O'Sullivan

Job: Timahoe, Co. Kildare

Project No: P1418-0

Figure No: 8.8

Sheet Size: A4

Drawing No: P1418-0-1218-A4-808-0A

Date: 03/12/2018

Scale: 1:50,000

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8.3.15 Receptor Sensitivity

Due to the nature of Solar Farm developments/Substation and Grid Connection works, being near surface or at surface construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the site would be from cementitious materials, piling works, hydrocarbon spillage and leakages. These are common potential impacts on all construction sites (such as road works and industrial sites). All potential contamination sources are to be carefully managed at the site during the construction, operational and decommissioning phases of the development and mitigation measures are proposed below to deal with these potential minor impacts.

Based on criteria set out in Table 8.1 above, the Locally Important Aquifer can be classed as Not Sensitive to pollution. The majority of the site is covered in cutover peat which in turn is underlain by silt/clay glacial deposits and these layers act as a protective cover to the underlying bedrock aquifer. The glacial deposits are not mapped as an aquifer to the northeast of the Proposed Project site, but they are likely to be used locally as a water supply and therefore they can also be classed as Sensitive to pollution.

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

8.3.16 Proposed Project Drainage Management

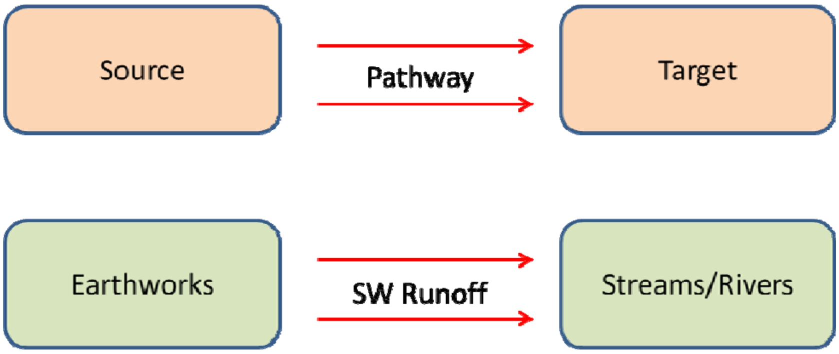
Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the Proposed Project. The first method involves 'keeping clean water clean' by avoiding disturbance to existing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

During the construction, operation and decommissioning phases all runoff from works areas (*i.e.* silt laden water) will be attenuated and treated to a high quality prior to being released. A detailed drainage report and set of drainage plans showing the layout of the proposed development drainage design elements is attached in Appendix 8-1 of the EIAR.

8.4 Potential Impacts and Mitigation Measures

8.4.1 Overview of Impact Assessment Process

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



Where potential significant 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):

- Environmental Protection Agency (2017): Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- 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 source, namely its character, magnitude, duration, likelihood and whether it is of a direct or indirect nature.

In order to provide an understanding of the stepwise impact assessment process applied below (Section 8.4.2 and 8.4.3), we have firstly presented below a summary guide that defines the steps (1 to 7) taken in each element of the impact assessment process (refer to Table 8.9). 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 the Proposed Project construction, operation and decommissioning activities which have the potential to generate a source of significant adverse effect on the hydrological/ hydrogeological (including water quality) environments.

Table 8.9 Steps taken during the impact assessment process

Step 1	**Identification and Description of Potential Impact Source** **This section presents and describes the activity that brings about the potential significant effects 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 solar farm developments and associated works, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential significant effect is generated.
Step 3	**Receptor:**	A receptor is a part of the natural environment which could potentially be impacted upon, *e.g.* human health, plant / animal species, aquatic

		habitats, soils/geology, water resources, water sources. The potential significant effect 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 significant effect before mitigation is put in place.
Step 5	**Proposed Mitigation Measures:**	Control measures that will be put in place to prevent or reduce all identified significant adverse effects. In relation to solar farm developments, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	**Post Mitigation Residual Impact:**	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential significant effect 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.

8.4.2 Construction Phase Potential Effects

8.4.2.1 Earthworks and potential effects on water quality – Solar Farm

Construction phase activities including clearing of vegetation, access track construction, hardstanding construction, inverter construction, peat repository placement and landscaping, piling works and solar panel placement will all require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from road excavation;
- 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 watercourses and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream surface water bodies. Potential effects could be significant if not mitigated against.

There are no natural watercourses present within the site and therefore there was no requirement to avoid any natural streams or rivers as would normally be required on say an upland wind farm site. All the natural local streams and rivers are located at significant distances off-site. There are however physical connections between the on-site drainage systems and off site natural watercourses, therefore pathways for off-site impacts exist.

Pathways: Drainage and surface water discharge routes.
Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Effects
Indirect, negative, significant, temporary, medium probability effect.

Proposed Mitigation Measures

Mitigation by Avoidance:
The proposed site layout avoids the areas of the site that are most prone to flooding. And the site layout also incorporates the use of buffer zones to avoid existing site drainage and downstream natural watercourse.

Mitigation by Design:
Presented below are temporary and construction drainage control measures that will be utilised during the construction phase of the Solar Farm. As stated above there is an existing established drainage network at the site which comprises field drains, main collector drains, and outfall drains. The measures outlined below will be used in conjunction with the existing drainage network to ensure protection of streams and rivers downstream of the Proposed Project site. Drainage on site will be managed using SuDS techniques. The 'management train approach' is central to the surface water drainage strategy of the Proposed Project. The main objective is treatment and control of runoff as near to the source as possible protecting downstream habitats. This concept uses a hierarchy of drainage techniques to incrementally reduce pollution, flow rates and volumes of storm water discharge from the site, and is as follows:

- Prevention – the use of good site design, construction practices and housekeeping measures to prevent runoff and pollution;
- Source Controls – control of runoff at source or as close to source as possible (e.g. permeable or semi-permeable surfacing); and
- Site Control – management of water in a local area (within the Proposed Project site) which will include a combination of settlement ponds, silt fences and filter strips.

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

The main elements of the drainage design include the following:

1) Drainage management
- Solar field drainage – to manage rainwater runoff from below the solar panels and prevent erosion
- Connector Drain – will allow field drainage to flow freely across the site and allow management of site discharges at a controlled rate
- Invertor drainage – including an approved oil sensitive bund dewatering system, and an approved full retention oil separator at each invertor station
- Amenity area drainage – will mimic the current drainage in the area, pedestrian pathways will be permeable floating road construction and culverts will be constructed where required
- Surface water attenuation and Inundation – a detailed 2D flood model was constructed to model current and future drainage at the site. The output of this modelling was to determine the required levels for sensitive infrastructure at the site. Under the proposed case the computed peak water

level in the drains at the Solar Farm sites for the 100-year and 1000-year flood events vary from 78.73m to 79.07m for the 100-year and 79.11m to 79.45m for the 1000-year.

2) Water quality management

- Flow separation – separation of clean water from silt laden water and treating silt laden water prior to discharge
- Use of Buffers - a key mitigation measure is to protect the existing watercourse and field drains on site. A self-imposed buffer zone for peat storage will be established around the existing field drains on site. This will allow sufficient room for the silt mitigation measures described below to function. Also, a buffer zone around field ditches and watercourses where no peat can be stored will be implemented. A 25 m buffer around field ditches and a 50 m buffer around the Mulgeeth watercourse is recommended as per industry best practice.
- Vegetation filter strips - installed for flow and sediment control is the use of vegetation filter strips. This measure allows the vegetation to act as a drainage area for the storm water and operational surface runoff throughout some areas of the site. This method of collecting and treating operational runoff is the preferred method wherever possible.
- Swales/Collector drains - A swale or collector drain is an open gently sloping grassed drainage channel. Collector drains are incorporated into the design to convey drainage water, trap sediment, enhance filtration and slow down the rate and magnitude of runoff that could enter the local watercourses.
- Settlement ponds - Provision is made for additional protection measures in areas where vegetation filter strips and swales are not considered sufficient on their own, due to the nature or availability of the vegetation and the volume of surface runoff that needs to be treated. In these cases, settlement ponds will be constructed. Settlement ponds reduce the turbulence of drainage discharges and facilitate the settlement of solid particles entrained in the water. Settlement ponds may be built in-situ and sized depending on expected flows. They need relatively flat areas for construction. 4 types of ponds are proposed for the development.
- Check dams - Check dams are small temporary barriers which can be constructed across areas of concentrated flow. The purpose of check dams is to reduce the velocity in areas of concentrated flow. Examples of soil erosion are apparent due to the action of existing natural streams on the site. Check dams can be installed in drainage channels at steep areas on the site. Their purpose in clean drainage channels is to minimise erosion and to slow the rate of runoff. Criteria utilised in the design of check dams include drainage area, height, side slopes, spacing and geotextile requirements. However, engineering judgement on site will determine the final design and layout of the check dams. Due to the relatively flat topography within the Solar Farm it is not foreseen that a significant number of check dams will be needed.
- Silt fences - Silt fences will be emplaced along drains and parallel to access roads edges as required and at stream / watercourse crossings. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to watercourses of sand and gravel sized sediment, released from excavation of peat and entrained in surface water runoff.

Pre-emptive Site Drainage Management:

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

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

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

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

Works should be suspended if forecasting suggests any of the following "heavy rainfall events" are likely to occur:

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

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

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

Drainage Maintenance:
It is critical that the drainage measures listed above are regularly inspected and maintained during both the construction and operational phases of the Solar Farm.

During construction the Contractor shall produce a drainage inspection and maintenance plan as part of the CEMP to ensure that measures function effectively. In the operational phase of the Solar Farm a site-specific O&M plan shall be established.

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

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

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs should be undertaken for each primary watercourse, and specifically following heavy rainfall events (*i.e.* weekly, monthly, and event-based monitoring is proposed).

Residual Effects
Negative, indirect, imperceptible, temporary, low probability effect

Significance of Effects
No significant effects on the surface water volumes or surface water quality are anticipated.

8.4.2.2 Earthworks and potential effects on water quality –Substation and Grid Connection

Construction phase activities including Substation and Grid Connection and all associated earthworks, and peat repository placement and landscaping, will all require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from substation/grid connection related excavations;
- Stockpiled excavated material providing a point source of exposed sediment; and,
- Erosion of sediment from emplaced drainage channels relating to Substation and Grid Connection works.

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

There are physical hydraulic connections between the on-site drainage systems and off site natural watercourses, therefore pathways for off-site water quality impacts exist.

Pathways: Drainage and surface water discharge routes.
Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Effects
Indirect, negative, significant, temporary, medium probability effect.

Proposed Mitigation Measures
The Substation and Grid Connection works will use the same drainage design and mitigation for the earthworks phase as outlined in Section 8.4.2.1 above.

In addition, at the substation site the following additional drainage features will be installed:

- Surface water drainage - The substation drainage will consist of an underground surface water pipe system. This system will include a number of surface water manholes, rain water pipes for the compound building roof, Class 1 Full Retention Oil Separator, an oil sensitive bund dewatering system and ACO Drains. The system will discharge into an adjacent field ditch. It is also proposed to construct a land drain, 150 mm in diameter, around the perimeter of the substation. The land drain will discharge into the same location as the surface water system. In accordance with SuDS best practice, it is proposed to include two rainwater harvesting tanks within the surface water system which will comprise of a filter, an underground tank and a pump. The system allows rainwater to run down the roof and into the guttering and downpipes in the normal way before passing through the filter, which removes any leaves and debris. Rainwater is then stored in the underground tank for reuse. The proposed tanks will have a capacity of 3,800 litres.
- Foul water system – A foul system is proposed within the station to cater for the wastewater generated in the welfare facilities of the control building. The foul system will consist of an underground pipe network, foul manholes and an 18 m^3 full retention foul effluent storage tank. The tank will have an associated high-level alarm which will be connected to the control building. A foul holding tank to be maintained and emptied bi-annually is the most preferable means of treating and disposing of foul waste from the site. The licensed contractor charged to empty and dispose of the waste will be the holder of a valid waste collection permit. The foul holding tank will also be vented to the atmosphere to avoid the build-up of noxious and dangerous gases.
- Potable water supply - The proposed substation site is remote from the public roadway and the public water supply system. It is proposed to provide the required potable water demand of the station with a well on the site. The impact of this proposed water well on local hydrogeology is assessed below in Section 8.4.2.3.

The drainage systems at the substation and along the grid connection works will be maintained and monitored in the same manner as outlined in Section 8.4.2.1 above.

Residual Effects
Negative, indirect, imperceptible, temporary, low probability effect.

Significance of Effects
No significant effects on the surface water volumes or surface water quality are anticipated.

8.4.2.3 Earthworks and potential effects on water quality – Proposed Project

Construction phase activities including access track construction, hardstanding construction, invertor construction, peat repository placement and landscaping, piling works and solar panel placement, Substation and Grid Connection works will all require varying degrees of earthworks resulting in excavation of peat and mineral subsoil where present. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from road excavation;
- 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 watercourses and could result in an increase in the suspended sediment load, resulting in increased turbidity which in turn could affect the water quality and fish stocks of downstream surface water bodies. Potential effects could be significant if not mitigated against.

There are no natural watercourses present within the site and therefore there was no requirement to avoid any natural streams or rivers as would normally be required on say an upland wind farm site. All the natural local streams and rivers are located at significant distances off-site. There are however physical connections between the on-site drainage systems and off site natural watercourses, therefore pathways for off-site impacts exist.

Pathways: Drainage and surface water discharge routes.
Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Effects
Indirect, negative, significant, temporary, medium probability effect.

Proposed Mitigation Measures

Mitigation by Avoidance:
The Proposed Project layout avoids the areas of the site that are most prone to flooding. And the site layout also incorporates the use of buffer zones to avoid existing site drainage and downstream natural watercourse.

Proposed Mitigation:
The proposed Solar Farm uses the mitigation outlined in Section 8.4.2.1.

The Substation and Grid Connection works will use the same drainage design and mitigation for the earthworks phase as outlined in Section 8.4.2.1 and also the additional measures outline at Section 8.4.2.2.

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

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

During the construction phase field testing and laboratory analysis of a range of parameters with relevant regulatory limits and EQSs should be undertaken for each primary watercourse, and specifically following heavy rainfall events (*i.e.* weekly, monthly, and event-based monitoring is proposed).

Residual Effects
Negative, indirect, imperceptible, temporary, low probability effect.

Significance of Effects
No significant effects on the surface water volumes or surface water quality are anticipated.

8.4.2.4 Excavation Dewatering and Potential Effects on Surface Water Quality

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

Groundwater seepages will likely occur in some areas of excavation and this will create additional volumes of water to be treated by the drainage management system. Groundwater inflows will be more significant where lenses of sand and gravel are intercepted in deeper (below peat) excavations.

Site investigation data indicates that water inflows to trial pits were generally slow to very slow, with some moderate inflows at depth. Groundwater levels recorded in Boreholes installed at the site ranged between 0.39 and 1.92m bgl (below ground level), or between 78.02m OD and 81.57m OD. As would be expected water levels are relatively close to ground level across the site.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore no pollution issues are anticipated in this respect.

Pathway: Overland flow and site drainage network.
Receptor: Down-gradient surface water bodies.

Pre-Mitigation Effects
Indirect, negative, significant, temporary, low probability effects to surface water quality.

Proposed Mitigation Measures
Mitigation by Design:
Management of excavation seepages and subsequent treatment prior to discharge into the existing field drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build-up of water in the excavation;
- The interceptor drainage will be discharged to the existing field drainage system or onto the bog surface via a settlement pond;
- The pumped water will be discharged via settlement pond/silt bags adjacent to excavation areas;
- There will be no direct discharge to the existing drainage network and therefore no risk of hydraulic loading or contamination will occur; and,

- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should be stopped immediately, and a geotechnical assessment undertaken to determine the most appropriate course of action required.

Residual Effects
Indirect, negligible, temporary, low probability effects on local surface waters.

Significance of Effects
No significant effects on the surface water quality are anticipated.

8.4.2.5 Potential Release of Hydrocarbons during Construction and Storage

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

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

Construction plant will be used right across the Proposed Project site during all aspects of construction.

Pathway: Groundwater flowpaths and site drainage network.
Receptor: Groundwater and surface water.

Pre-Mitigation Effects
Indirect, negative, slight, short term, medium probability effect to local groundwater quality.
Indirect, negative, significant, short term, low probability effect to surface water quality.

Proposed Mitigation Measures:
Mitigation by Design:

- Storage of fuels, lubricants and hydraulic fluids will occur mainly at the contractor's compound(s), which will be fenced and have a lockable gate, thereby ensuring that the area in which fuels, lubricants and hydraulic fluids are stored will be properly secured against unauthorised access or vandalism;
- The storage area within the compound will contain a small bund lined with an impermeable membrane in order to prevent any contamination of the surrounding soils and vegetation and of groundwater;
- Fuels and oils will be carefully handled to avoid spillages;

- Any spillage of fuels, lubricants or hydraulic oils will be immediately contained and the contaminated soil removed from the site and disposed of appropriately;
- Any waste oils and hydraulic fluids will be collected in leak-proof containers and removed from the site for disposal or recycling;
- As a minimum, simple spill protection equipment that will be held locally and will include specialist absorbent mats / pillows and granules for containment / clean-up of oil. Adequate quantities will be held in stock and be available for immediate use;
- Appropriate spill control equipment, such as oil soakage pads, will be available on site to deal with any accidental spillage and emergency response procedures will be put in place;
- Designated contractors' personnel will be trained and certified in oil spill control and clean up procedures and in the proper and safe disposal of any waste generated through such an event;
- On site re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the time period of the construction;
- Site plant will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

Residual Effect
Indirect, negative, imperceptible, temporary, low probability effect on groundwater and surface water.

Significance of Effects
No significant effects on surface water or groundwater quality are anticipated.

8.4.2.6 Groundwater and Surface Water Contamination from Wastewater Disposal

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

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

Pathway: Groundwater flowpaths and site drainage network.

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

Pre-Mitigation Effect
Indirect, negative, significant, temporary, low probability effect to surface water quality.
Indirect, negative, slight, temporary, low probability effect to local groundwater.

Proposed Mitigation Measures
Mitigation by Avoidance:

- A self-contained port-a-loo with an integrated waste holding tank will be used at each of the site compounds, maintained by the providing contractor, and removed from site on completion of the construction works;
- All stored foul water will be removed from site to a licenced facility for appropriate treatment and disposal; and,
- No foul water will be discharged at the site.

Residual Effect
No effect

Significance of Effects
No significant effects on surface water or groundwater quality are anticipated.

8.4.2.7 Release of Cement-Based Products

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

Concrete will be used on site for building foundations, pad footings, steel tower foundations and stayblocks for overhead polesets.

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

Pathway: Site drainage network.
Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Effect
Indirect, negative, moderate, short term, medium probability effect to surface water.

Proposed Mitigation Measures
Mitigation by Avoidance:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products will be used and where possible;
- Pre-cast elements for culverts and concrete works will be used;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute need be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be directed into a dedicated lined washout area. This lined area will be removed from site once the construction phase is complete;
- Weather forecasting will be used to plan dry days for pouring concrete; and,
- Ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

Residual Effect
Negative, indirect, imperceptible, short term, low probability impact.

Significance of Effects
No significant effects on surface water quality are anticipated.

8.4.2.8 Potential Impacts on Hydrologically Connected Designated Sites

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

The Proposed Project site is not located within any designated conservation site. The River Boyne and Blackwater SAC is ~26km downstream of the site.
There are no groundwater dependent designated sites of relevance to this hydrological / hydrogeological assessment as all designated sites are sufficiently remote (including: Carbury Bog NHA; Hodgestown Bog NHA; Ballynafagh Lake SAC; and Ballynafagh Bog SAC) from the Proposed Project site to state using scientific certainty that they are hydrogeologically disconnected from the Proposed Project site, and therefore cannot be impacted by the Proposed Project.

Pathway: Surface water flowpaths.
Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Effect
Indirect, negative, moderate, temporary, medium probability effect. surface water quality in River Boyne and Blackwater SAC.

Mitigation Measures
The mitigation measures outlined in Section 8.4.2.1 in particular the engineered drainage system and associated controls will be implemented to ensure that water quality will be good.

There are more than sufficient drainage controls included within the site design, and there is a considerable distance downstream to the SAC which further mitigates potential effects.

Residual Effects
No residual effects on designated sites are anticipated.

Significance of Effects
No significant impacts on designated sites are anticipated.

8.4.2.9 Potential Impacts on Local Groundwater Well Supplies

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

Johnstown Public Water Supply (PWS) spring source and its groundwater protection zone (Zone of Contribution or ZOC) exist approximately 2.1km and 480m respectively to the northeast of the Proposed Project site. The Proposed Project site is not located in the groundwater protection zone to this source.

There is houses to the east, west, southeast, north, and south of the Proposed Project site. For ease of reference, we have formed these into clusters (as outlined in the table below) for assessment purposes.

Based on site topography and surrounding drainage patterns we expect groundwater below the bog to be flowing towards the Mulgeeth stream, in a general south-easterly direction.

Pathway: Groundwater flowpaths.
Receptor: Groundwater Supplies.

Pre-Mitigation Effect
Indirect, negative, imperceptible, short term, low probability effect.

Impact Assessment
Johnstown Public Water Supply (PWS) spring source and its groundwater protection zone (Zone of Contribution or ZOC) exist approximately 2.1km and 480m respectively to the northeast of the Proposed Project site. The Proposed Project site is not located in the groundwater protection zone to this source.

As stated in Section 8.3.14 above, the private dwellings surround the Proposed Project site are all assumed to have on-site water supply from groundwater. In considering impacts to groundwater we have reviewed the geology of the site, peat, over glacial tills over bedrock. The glacial deposits generally consist of soft to very stiff grey gravelly clay/silt. These deposits are interbedded with gravels and sands within the stratum. We have also considered the peat depths at the site which range between 0.05 to 5.2m, and the perched water table within the peat, and the likely direction of regional groundwater flow below the bog, and the distances between proposed development areas and surrounding houses and Public Water Supply source locations. We have also considered the type of development proposed, which will include various shallow excavations, formation of roads and hard standing areas (compounds, substation), near surface drainage controls on peatland that is perched above the regional groundwater table, and a network of piles to support the solar panel frames. All of the construction works will be completed over a finite period, so the potential impacts on groundwater will all be temporary in nature, and local to the point of construction.

Based on the above the Proposed Project is not considered to have significant potential to interact with groundwater in a way that will cause any significant off-site impacts to any water supplies.

The risk to any potential well source on the east, south, and southeast of the Proposed Project site from potential contaminant release within any excavation (across the entire project footprint, including the Solar Farm, and the Substation and Grid Connection) at this distance is negligible. Due to the relatively low bulk permeability of mineral soils beneath the peat (*i.e.* predominately silts and clays with some interbedded gravels), the low recharge characteristics (due to the overlying peat) and the low groundwater gradients (flat topography), groundwater travel times are expected to be very slow. The relatively low permeability and the diffuse nature of groundwater flow in the mineral soils would mean that a pollutant would take months/years to travel this distance as demonstrated below by means of the Darcy mean velocity equation:

$$q = k.i$$

$$v = q/ ne$$

$$T = L / v$$

where:
q = specific discharge (m/day)
k = permeability m/day (a value of 1m/day for low permeability subsoils is used).
ne = porosity (a value of 0.025 is used for silts/clays).
i =slope of the water table in the subsoil can be estimated from on topography (a value of 0.005 is used down-gradient of substation B (70mOD -65mOD)/1000m = 0.005).
v = Darcy velocity (m/day).
L = Distance (metres).
T = Time of travel (days)

Based on a groundwater flow velocity of 0.2m/day, the time of travel (ToT) for a potential pollutant to flow from the development location to the dwelling house would be in the order of 9 years. During this time any discharge would be assimilated and attenuated by natural groundwater flow, and diluted by rainfall recharge. Also any entrained sediment would be filtered within the low permeability subsoils.Therefore the risk posed to potential well sources at this distance from potential spills and leaks from excavations is negligible.

In addition, there are proposed mitigation measures (outlined above) which will be implemented and that will minimise and prevent potential groundwater contamination from hydrocarbons and other chemicals.

Our assessment is summarised in the following table:

Well Cluster/Source	Distance from development (m)	Downgradient/across gradient/Upgradient	Assessment
South/southwest	~550-950	Across gradient	No significant impact potential
Southeast/east	~480-2000	Across gradient/	No significant

		downgradient	impact potential
East/northeast	~480-720	Across gradient/ upgradient	No significant impact potential
North/northeast	~800-1000	Upgradient	No significant impact potential
Johntownbridge PWS ZOC	~600m to outter source area >1300m to nearest inner source area	Across gradient/ upgradient	No significant impact potential

Residual Effects
No residual effects on groundwater supplies are anticipated either in terms of quality or quantity.

Significance of Effects
No significant impacts on potential groundwater supplies are anticipated.

8.4.3 Operational Phase Potential Effects

8.4.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

Progressive replacement of the bare peat or vegetated/partially vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. In reality, the access tracks are designed to be permeable and will likely have a higher permeability than the underlying peat.

In relation to surfaces of lower permeability, the footprint comprises substation compound, inverter hardstand and access roads. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.
Receptor: Surface waters and dependant ecosystems.
Pre-Mitigation Effect
Direct, negative, moderate, permanent, likely effect.

Impact Assessment
The area of hardstand footprint is negligible in comparison to the area of the proposed site. There are significant attenuation design proposals for the permanent drainage design for the Proposed Project site, and therefore this potential effect is considered to be negligible.

Proposed Mitigation Measures
Mitigation by Design:

The operational phase drainage system will be installed and constructed in conjunction with the existing bog drainage network and will include the following:

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed existing downstream field drains;
- Collectors drains will be used to gather runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to new local settlement ponds for sediment settling, and these will then outfall to existing field drains;
- Check dams will be used along sections of access road drains to intercept silts at source. and,
- Finally, all surface water runoff from the development will have to pass through existing site drainage features along the boundary of the bog prior to final discharge from the site.

Residual Effect
Negative, direct, negligible, long term, likely effect.

Significance of Effects
No significant effects on surface water quality or quantity are anticipated.

8.4.3.2 Potential Impacts on Groundwater Levels during Operation of on-site Water Well

[Please note, the assessment of this potential effect is completed here in one section, as there is no separable difference between the various elements of the Proposed Project. For clarity, we have assessed the PV Solar Farm and associated infrastructure, the Substation and Grid Connection, and the Proposed Project in its entirety. The assessment is presented in this way to avoid repetition, as the potential effects, mitigation, and residual impact is the same for each element of the Proposed Project].

A groundwater supply well is proposed at the substation site. Operation of this well could impact on groundwater levels below the bog. However, groundwater level impacts are not anticipated to be significant due the local hydrogeological regime (*i.e.* high water table below the bog, and significant distances to any potential off-site receptors such as wells or natural rivers/streams) which comprises relatively low permeability glacial deposits.
Pathway: Groundwater flow paths.
Receptor: Groundwater levels.

Pre-Mitigation Effect
Direct, negligible, slight, long term, low probability effect

Impact Assessment / Mitigation Measures
The proposed extraction volumes are very small, and the distance between the substation and any other local groundwater user (at local houses etc) is significant. There will be no measurable impact from such a small proposed extraction volume (~24 Litres /week). Rainwater storage tanks will also be used to further reduce the required supply volume.

Residual Effects
No residual effects are anticipated.

Significance of Effects
No significant effects on groundwater levels or groundwater volumes are anticipated.

8.4.4 Decommissioning Phase Potential Effects

Decommissioning phase impacts will potentially be very similar to construction phase impacts but the overall potential for impact will be much lower as less excavation work will be taking place.

As in the construction phase, temporary surface runoff control measures will again be put in place during decommissioning works. The drainage system will remain operational during the decommissioning phase and will serve to treat any sediment laden surface water run-off due to a renewed disturbance of soils. Re-vegetation will be monitored. No significant residual effects on the water environment are anticipated during the decommissioning phase.

It should be noted that the substation will remain in situ during the decommissioning as it will form part of the national network and therefore will be retained.

8.4.5 Do Nothing Scenario

Previous land use practices, which the site was set aside for, such as peat cutting/milling may recommence in the future. However, this use for the site of commercial peat harvesting would be restricted by the expiry of any existing IPC licence (P0503-01) and the licence Peat Rehabilitation Plan would be implemented to stabilise the site. It is more likely that the revegetation that has been observed on the site would continue.

8.4.6 Cumulative Impacts

The preceding impact assessment has assessed all of the Proposed Project components cumulatively. We have reviewed and assessed (from a water, hydrology and hydrogeology perspective) other existing local developments cumulatively and in combination with the Proposed Project including:

- Turf cutting
- Drehid Waste Management Facility
- Other solar developments within 5km of the site

Due to the localised and shallow nature of the proposed construction works which will be kept within the Proposed Project site boundary, there is no potential for significant cumulative effects on the water environment in-combination with other local developments. The construction of the Solar Farm and the Substation and Grid Connection and all associated site infrastructure will only require relatively localised excavation works the output of which will be retained onsite and therefore will not contribute to any significant cumulative effects on water.

8.4.7 Conclusion

The baseline hydrology/hydrogeology for the Proposed Project has been characterised using a significant quantity of site investigation data and monitoring data.

The Proposed Project will consist of a solar photovoltaic array and associated infrastructure, battery storage facility, inverters, access roads and parking, site compounds and security fencing, amenity trails and landscaping, peat and material storage areas (repositories), site drainage and all associated works, including a substation, battery storage and grid connection works. All proposed construction works will be at or within a couple of metres (*i.e.* shallow earthworks) of existing ground surface.

Peat depths at the site range between 0.05 to 5.2m. The peat is underlain by glacial deposits interbedded with glacio-fluvial deposits over limestone bedrock. The glacial deposits generally consist of soft to very stiff grey gravelly clay/silt. These deposits are interbedded with gravels and sands within the stratum. As a result of the site geology the peat water table across the Proposed Project site is expected to be high (confirmed by monitoring), and also perched above the underlying regional groundwater table. The ability of the shallow peat water to interact with the underlying regional groundwater flows is limited by the permeability of the underlying glacial deposits. As such the potential for the Proposed Project works to interact or effect underlying groundwater is very limited, and the main potential impacts will be via the surface water environment, i.e. drainage and discharges from the Proposed Project site. The Proposed Project, including the Solar Farm and the Substation and Grid Connection will not impact on local groundwater quantity (flows) and groundwater wells, and will not effect local or regional groundwater quality.

A comprehensive and detailed surface water management design proposal is included with this assessment, and implementation of these proposals, as outlined, will ensure protection of downstream surface water streams and rivers (quantity of flow and quality of water). The proposed surface water management will be implemented, and it will also ensure prevention of any significant impact on the downstream designated sites.

Storage and handling of hydrocarbons/chemicals will be carried out using best practice methods. Measures to prevent surface water impacts from these potential sources are outlined and assessed in detail and will be implemented.

There will be no cumulative impacts on the water environment as a result of the proposed Solar Farm and Substation and Grid Connection and other local developments.