Energy for generations

Derrybrien Wind Farm Project

Gort Windfarms Ltd.

Remedial Environmental Impact Assessment Report

Chapter 11 - Hydrology and Hydrogeology

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11 Hydrology and Hydrogeology

11.1 Introduction

11.1.1 Chapter Scope

The Derrybrien Wind Farm Project comprises the wind farm, grid connection and works undertaken in response to the peat slide which occurred during construction. This chapter provides an assessment of the significant effects of the Project which have occurred, are occurring and are likely to occur with respect to hydrology and hydrogeology. It should be noted that assessment of the surface water quality associated with the Project is discussed in detail in Chapter 8 Biodiversity – Aquatic Ecology. Figures are contained in A4 format as they are referenced within the chapter. Where necessary for clarity these are reproduced at A3 in Appendix 11.C.

11.1.2 Statement of Authority

This chapter has been prepared by Harry Griffin BA BAI, MSc Hydrology and Climate Change, C.Eng., MIEI, ESB Engineering and Major Projects (EMP). Mr. Griffin has 6 years of experience in hydrological/hydrogeological assessment, flood risk analysis and drainage design. He is appropriately experienced and competent to undertake the assessment having worked on flood risk assessments associated with Grousemount and Crockahenny Wind Farms and, drainage design for Cappawhite, Castlepook and Crockdun Wind Farms and a large number of hydrological and hydrogeological assessments for electrical substations, power stations and other ESB developments across the country.

The assessments undertaken with this chapter were carried out in association with Anthony Cawley B.E. M.EngSc. C.Eng. M.I.E.I Consulting Hydrologist and director of Hydro Environmental Ltd. Mr. Anthony Cawley has 28 years professional consulting experience in the water engineering field, in a wide variety of activities relating to hydrology, hydrogeology, flooding, and hydrodynamic and water quality assessments. Over that period, he has carried out well over 100 flood risk assessment studies which included groundwater, rivers, estuarine and coastal flooding throughout Ireland and also in the UK. He has over the past twenty years been involved in preparing the Hydrological Impact Assessments for over 20 major road schemes throughout Ireland, hydrological and flood risk assessment of two major solar farm projects and five large wind farm developments. He has been an expert witness on hydrology and flooding related issues at numerous oral hearings for major infrastructure projects (such as the M6, M20/M21, N23, Lansdowne Stadium redevelopment, Galway Harbour Development). He was also retained as an expert consultant to An Bord Pleanála for large housing development proposals at Kilcock, the Dublin Docks Gateway and Alexandra Basin projects in respect to flooding and hydrodynamic processes and is experienced in the requirements of strategic environmental assessments (SEA) and environmental impact assessments (EIA).

11.1.3 Legislative Context

The principal European and National legislation and other statutory policies and guidance relevant to hydrology and the water environment are identified in the following paragraphs.

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy or, for short, the EU Water Framework Directive (WFD), established a framework for the protection of both surface and groundwater. Transposing Irish legislation with regard to surface waters, namely S.I. 272 of 2009, European Communities Environmental Objective (Surface Water) Regulations 2009 (as amended), outlines the water protection and water management measures required in Ireland to maintain high status of surface waters where it exists, prevent any deterioration in existing water status and achieve at least good status for all waters i.e. requirement to implement the WFD. The original grant of development consent for the Derrybrien Wind Farm Project was made prior to the coming into force of the WFD. The construction of the wind farm commenced in June 2003, prior to the date on which the WFD was required to be transposed.

A number of River Basin Management Plans (RBMPs) were developed to address the requirements of the WFD. The first cycle RBMP of relevance to this assessment (the Western RBMP 2009-2015) was adopted in 2009 and this included a programme of measures required to facilitate the achievement of the WFD objectives. This programme of measures included full implementation of existing legislation including the Water Pollution Acts, Water Services Act, Bathing Water Quality Regulations, Integrated Pollution Prevention and Control (IPPC) Regulations, Urban Wastewater Treatment Regulations and the Birds and Habitats Directives (particularly the Appropriate Assessment (AA) process).

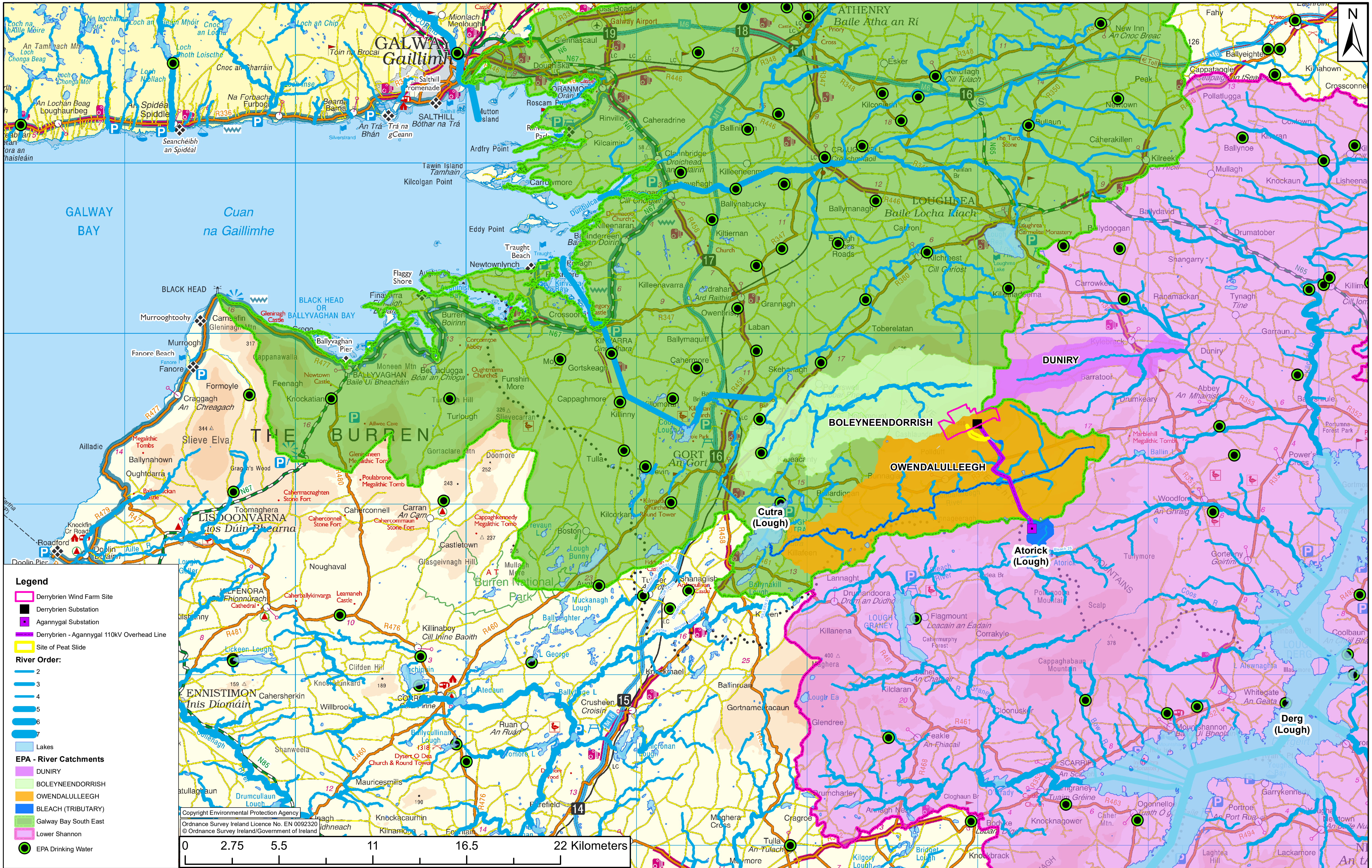
The second cycle of the river basin management planning is completed, and the Government has published the River Basin Management Plan for Ireland 2018 – 2021 which merges the Eastern, South Eastern, South Western, Western and Shannon River Basin Districts to form one national River Basin District. As outlined in the RBMP this "Irish River Basin District" is "*…broken down into 46 catchment management units. These units are, in the main, based on the hydrometric areas in use by authorities– with, for example, the Shannon District being sub-divided on the basis of the catchments of its major tributaries. The 46 catchment management units have been broken down further into 583 subcatchments*".

The Derrybrien Wind Farm Project location in relation to adjacent Water Management Units (WMU) as defined by the EPA (Environmental Protection Agency) is shown in Figure 11.1

Individual catchment assessments for each of the 46 WMUs have been developed and published by the EPA's Catchment Science and Management Unit. The area encompassing Derrybrien Wind Farm Project is captured entirely in the Galway Bay South East Catchment Assessment 2010-2015 (HA 29) with the exception of a small area at the northeast corner of the wind farm which lies in the neighbouring Lower Shannon Catchment (HA 25C) (EPA, 2018).

Other relevant EU and national legislation pertaining to the hydrological environment and the Wind Farm Project include:

- The EU Floods Directive 2007/60/EC;
- Consolidated EIA Directive 2011/92/EU and 2014/52/EU;
- S.I. 122 of 2010, European Communities (Assessment and Management of Flood Risks) Regulations;



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CLIENT: Gort Windfarms Ltd

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DRAWING TITLE: Figure 11.1 - Catchments in relation to Derrybrien Wind Farm Project

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- S.I. 722 of 2003, European Communities (Water Policy) Regulations, as amended;
- S.I. 350 of 2014, European Union (Water Policy) Regulations 2014;
- S.I. 9 of 2010, European Communities Environmental Objectives (Groundwater) Regulations;
- S.I. 538 of 2001, European Communities (Environmental Impact Assessment) (Amendment) Regulations;
- Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances;
- Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration;

11.1.4 Relevant Guidance

This assessment was carried out having regard to the following guidance:

- EPA Guidelines on the Information to be Contained in Environmental Impact Statements (EPA, 2002);
- Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EPA, August 2017);
- EPA Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA, 2003);
- Draft Advice Notes for Preparing Environmental Impact Statements (EPA, September 2015);
- National Roads Authority (NRA) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (NRA 2009);
- "The Planning System and Flood Risk Management - Guidelines for Planning Authorities (DECLG/OPW, 2009)" and
- Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions (European Commission, 1999).

11.1.5 Methodology

11.1.5.1 Baseline Data Gathering

A desk study was carried out to collate the available information on the surface water and groundwater environments of the study area with the following data sources referenced:

- Available contemporaneous information;
- Periodic (predominantly performed annually) Geotechnical Inspection Reports from the beginning of operational stage onward.
- Ordnance Survey of Ireland (OSI) - current and historic mapping;
- Aerial photography;
- LIDAR survey carried out by Fugro in 2012;

- Met Éireann (www.met.ie) for local and regional rainfall data;
- Office of Public Works (OPW) Flood Studies Update (FSU) portal (opw.hydronet.com) for catchment analyses and flood risk assessment;
- Water Framework Directive Ireland Database (www.wfdireland.ie);
- The Western RBMP 2009-2015;
- Geological Survey of Ireland (GSI) Groundwater Mapping and records for the Project location;
- OPW floodinfo.ie predictive and historical flood mapping;
- The River Basin Management Plan for Ireland 2018-2021 (Department Housing, Planning, Community and Local Government (DHCLG), (2018);
- The Western River Basin District Catchment Flood Risk Assessment and Management Study (CFRAMS).
- EPA Mapviewer (https://gis.epa.ie/EPAMaps/)

Much of the information on the baseline (pre-construction) environment within the Project site was gathered through a desktop review of literature prepared from 1998 to 2003 from various sources and an analysis of aerial photography (OSI Aerial Photography dated 1995 and 2000).

11.1.5.2 Site investigations

Substantial field work in the form of geotechnical investigations from prior to construction of the Project onward have informed the establishment of baseline data for this chapter.

Site investigations carried out by the specialist consultant IGSL Ltd. in 2001 indicated consistent sub-soil conditions over the areas spread across the wind farm site which were investigated. In general, sub-soil consisted of very soft to soft fibrous silty peat extending from surface to depths varying from 1.00 to 4.50 metres, with an average thickness of 2.75 m. The peat overlaid firm, occasionally stiff, glacial till deposits or dense granular soil

Trial pits consistently indicated seepage into trial pits occurring at either 1.0 or 1.5 m below ground level (mBGL).

Following the October 2003 peat slide, standpipes were installed by AGL Consulting Ltd. at 6 no. locations along a north-south axis from the centre to the south of the site in the vicinity of the peat slide to get a profile of the depth of groundwater down the slope. The readings taken between mid-November and early December 2003 indicated that the depth to groundwater ranged from 0.1 m to 1.1 m mBGL. As part of these supplemental site investigations, in February 2004 10 no. push-in piezometers were installed by AGL to record water levels in the peat. The piezometers were comprised of 19 mm internal diameter uPVC tubing with a 300 mm long perforated tip with a ceramic inner porous filter. They were installed by initially pre-forming a hole to about 1 m and gently pushing the standpipe down to the base of the peat.

In addition to this, in January 2005 12 no. electronic vibrating-wire piezometers were installed to the base of the peat layer in clusters of three at 4 no. locations across the site to get continuous readings of water levels in the peat. The piezometers were situated at points which, due to their proximity to turbine bases and the need to protect the bases from flooding, received substantial new drainage. The piezometers were installed adjacent to turbines T2 and T18 near the western boundary and near T34 in the middle of the turbary land at the eastern end of the site (Figure 11.2). Piezometers installed at the northern end of the site at T49 and T50 malfunctioned and provided no useful measurements. All piezometers indicated that the depth to groundwater generally fluctuated between 0.3 and 1.1 mBGL at the end of construction on the win farm site, which was consistent with the pre-construction site investigation.

Piezometers / Turbine No.	Piezo Distance from Nearest Drain (m)	Drain depth (m)	Fall in Groundwater Level (m)	Years of data
P1 – P3 / T2	4.5	0.85	0.7 (0.6 – 0.8)	Jan-05 to Nov-11
P4 – P6 / T18	13	1.4	0.4 (0.2 – 0.6)	Jan-05 to Nov-11
P7 – P9 / T34	5	1.3	0.6 (0.4 – 0.85)	Jan-05 to Feb-10

Table 11-1 Summary information of piezometers installed on site between 2005 and 2011

In the years following commissioning, groundwater levels in the peat at these monitoring locations gradually reduced by between 0.2 and 0.85 m (Figure 11.3). This gradual reduction is consistent with the very low permeability and correspondingly slow reaction time of groundwater levels in peat to newly excavated drainage. The ultimate reduction in groundwater levels was dependent on the depth to which the channels were excavated and the distance of measuring points from the channels. For instance, piezometers 4 – 6 are further away from the nearest excavated drains and therefore have taken longer to reduce towards a final drawdown level. Piezometers 7 – 9, given their relative proximity to a drain, should stabilise at no lower than 0.85 mBGL. Given the baseline level in this area was close to the surface it was already close to stabilising by 2010 At T34 the nearby drain was a pre-existing turbary drain which was cleaned out and most likely deepened as part of the wind farm construction, resulting in a drawdown in groundwater levels.

Field work carried out in 2018/2019 for the purpose of assessing the current state of the Project site specifically involved a series of walkover surveys of the wind farm site, the peat slide area, the overhead line (OHL) route and two electrical substations that comprised the Project. These were carried out in tandem with topographical and drone surveys. Detailed surveys were carried out on the wind farm site of the drainage channels and on the in-stream structures. A Light Detection and Ranging (LIDAR) survey of the entire wind farm site was carried out in 2012 and informed the flood risk assessment for the site including the 110 kV Derrybrien substation compound (See Appendix 11.A – Flood Risk Assessment). Following on from these field surveys, the results were reviewed in ArcGIS software in conjunction with publicly available hydrological and hydrogeological data from the GSI, EPA, and OPW historical records.

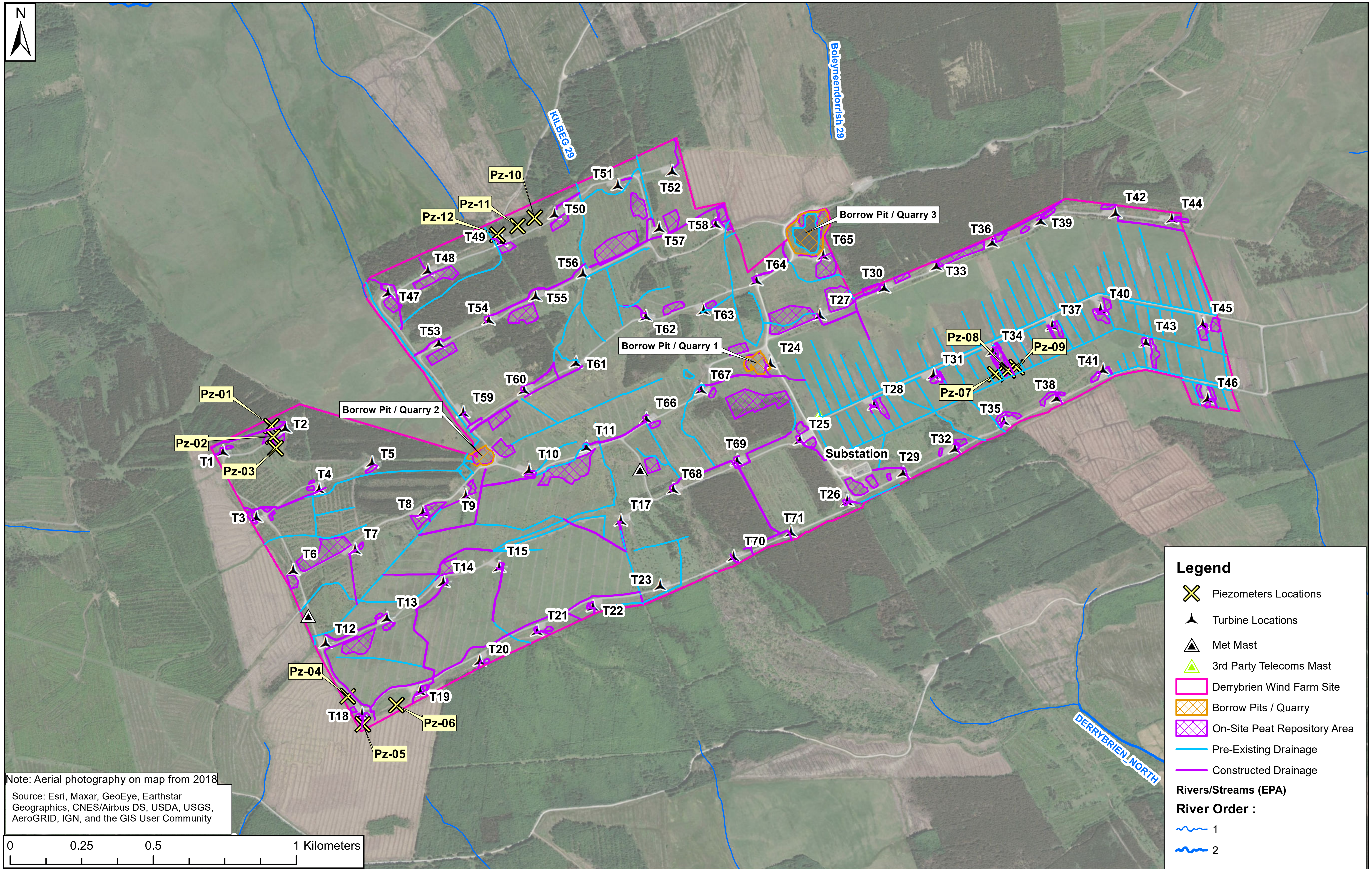

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Figure 11.2 - Approximate Locations of Piezometers on Site 2005-2011

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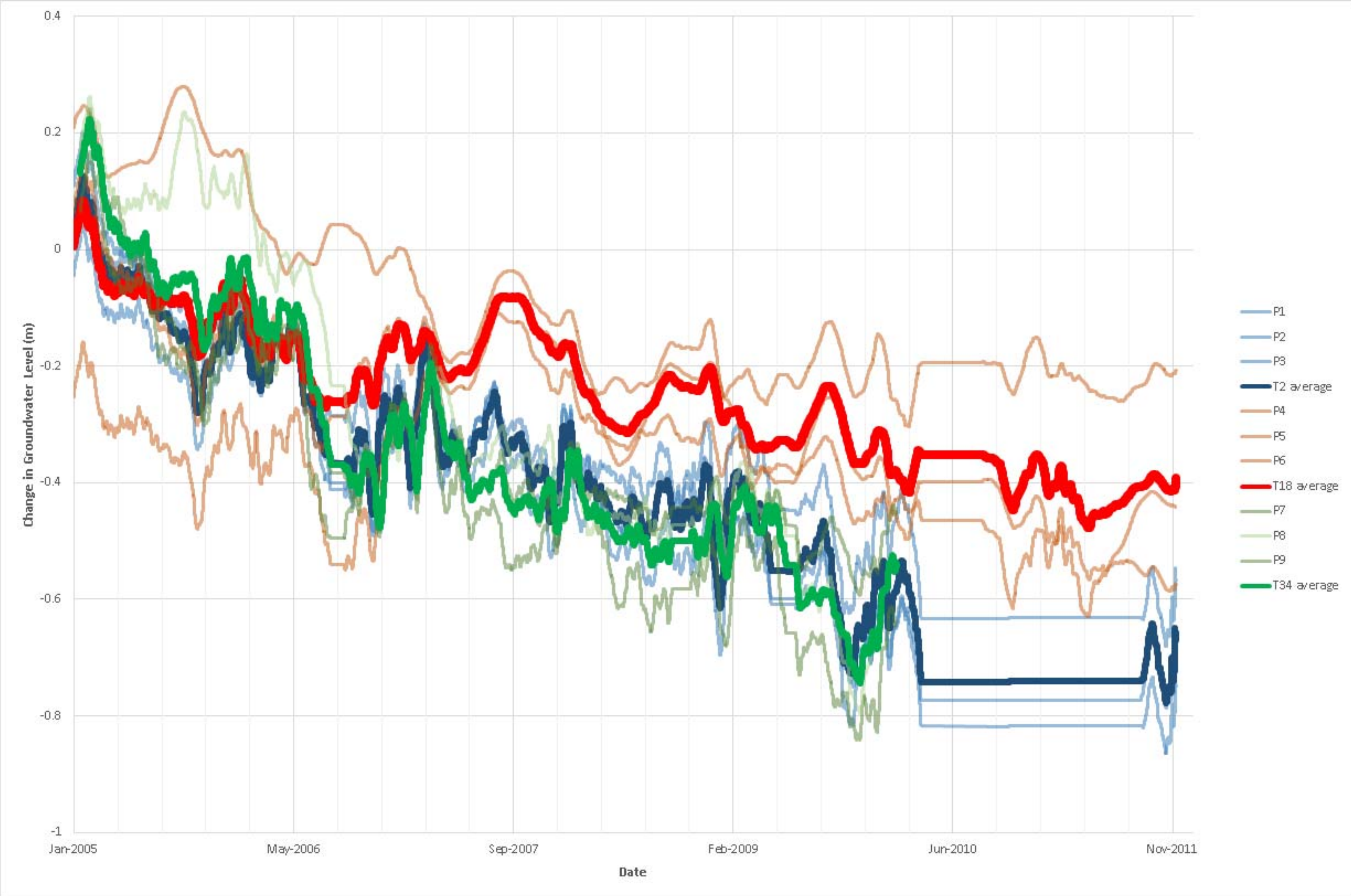
Figure 11.3 Changes in groundwater level relative to baseline 2005-2011



11.1.5.3 Significance and Magnitude Criteria

Figure 2.1 of the EPA Draft EIAR Guidelines (EPA, 2017) demonstrates how the identification of impacts leads to effects which should be classified and addressed accordingly. The significance of effects of the Project has been assessed in accordance with the EPA Draft Guidelines (EPA, 2017). The descriptors used for describing the quality and significance of effects are from the 2017 EPA guidance and are reproduced in Table 11-2.

Impact Characteristics	Degree / Nature	Description
Quality	Positive	A change which improves the quality of the environment.
	Neutral	No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.
	Negative	A change which reduces the quality of the environment
Significance	Imperceptible	An effect capable of measurement but without significant consequences
	Not significant	An effect which causes noticeable changes in the character of the environment but without significant consequences.
	Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities
	Moderate	An effect that alters the character of the environment in a manner consistent with existing and emerging baseline trends
	Significant	An effect, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment
	Very significant	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment
	Profound	An effect which obliterates sensitive characteristics
Extent & Context	Extent	Describe the size of the area, the number of sites, and the proportion of a population affected by an effect

	Context	Describe whether the extent, duration, or frequency will conform or contrast with established (baseline) conditions
Probability	Likely	The effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented
	Unlikely	The effects that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented
Duration and Frequency	Momentary	Effects lasting from seconds to minutes
	Brief	Effects lasting less than a day
	Temporary	Effects lasting less than a year
	Short-term	Effects lasting one to seven years
	Medium-term	Effects lasting seven to fifteen years
	Long-term	Effects lasting fifteen to sixty years
	Permanent	Effect lasting over sixty years
	Reversible	Effects that can be undone, for example through remediation or restoration
	Frequency	Describe how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually).

Table 11-2 Descriptors for effects

11.1.5.4 Flood Risk Assessment Methodology

The methodology used to assess the flood risk associated with the Project is based on The Planning System and Flood Risk Management - Guidelines for Planning Authorities (OPW, 2009). It is discussed comprehensively in Appendix 11.A.

The Guidelines set out a staged approach for the consideration of flood risk in relation to developments as follows: -

"*Stage 1: Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and LAP's or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels;*"

"*Stage 2: Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding* *elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped;*" and

"*Stage 3: Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.*"

This flood risk assessment considers the flood risk of the proposed development in relation to all three stages of the staged approach outlined above.

11.1.6 Difficulties Encountered

The EIA Directive states that difficulties encountered should refer to the forecasting methods or evidence, used to identify and assess the significant effects

"…*including details of difficulties (for example technical deficiencies or lack of knowledge) encountered compiling the required information and the main uncertainties involved*"

This chapter has been prepared many years after the commencement of the construction phase of the wind farm project.

Certain specific information was no longer available or could not be sourced, including:

- Detailed information on the condition of the 27 km of pre-existing drainage channels within the wind farm site prior to construction of Project, in particular the depth and width of these drains;
- Information on site controls from the construction period prior to the peat slide;
- Information in relation to temporary barrages which were removed some time after the peat slide. Following the 2003 peat slide event, a number of temporary barrages were constructed at intervals downstream to intercept the path of the peat slide debris. These barrages were constructed immediately following the peat slide and a number were subsequently removed prior to completion of construction. Details of the extent of these structures is not known, and a 2019 inspection of their known locations showed no evidence of them;
- Private lands in the immediate vicinity of the slide area were not accessible.

Despite this constraint, it is considered that the data available is adequate for the purposes of carrying out this assessment.

11.2 Baseline Receiving Environment

The decisions in relation to planning applications and appeals for the wind farm and grid connection were made in the period 1998-2001. Therefore, for the purposes of this rEIAR the baseline date is circa 1998.

11.2.1 Study Area Location

The boundaries of the Project area on a regional scale lie almost entirely in the Galway Bay South-East WFD Catchment (hydrometric area 29). A small area (<0.02 km^2) to the northeast corner of the wind farm site lies within the neighbouring Lower Shannon WFD Catchment (hydrometric area 25C) (Figure 11.1).

The Derrybrien Wind Farm site lies on Cashlaundrumlahan Mountain in south County Galway, 12.7 km east-northeast of Gort,11 km due south of Loughrea and 25 km west of Portumna. The lands within the wind farm site comprise disturbed peat bog, all of which was formerly used either for commercial Coillte forestry plantation (263 ha) or turbary and other bog lands (81 ha). The overall area of the wind farm site is approximately 344 ha (3.44 km^2) while the wind farm infrastructure only comprises approximately 9% of the site area in terms of tracks, turbine bases and access areas. Site elevations range from 320–365 mOD on the upper slopes forming the wind farm, which form a gently sloping plateau aligned on a northeast to southwest axis.

Slopes range from less than 3 degrees up to 7.5 degrees locally, increasing up to 10 degrees in places (Figure 11.4). There is a broad zone that runs across the full width of the site for a distance of approximately 250 – 300 m to the north and south of the peak of the mountain where the ground surface slopes gently away from the peak at slope angles of less than 3 degrees. This is within the central three rows of turbines. To the south of this zone the slope is convex in profile with slopes generally increasing up to 4 – 5 degrees and locally 5.0 – 7.5 degrees within the site boundary, particularly between Turbines T21 and T41 along the southern boundary.

Downslope from the site in this area the slopes increase up to 7.5 degrees more consistently and locally up to 10.0 degrees. The peat slide during construction occurred within this zone of locally steeper slopes between Turbines T68 and T70.

The northern upper slopes of the mountain within the site boundary are characterised by a terraced profile with broad flat areas where the slope angles are less than 3 degrees, separated by benches where the slopes are locally steeper at up to 5.0 – 7.5 degrees, locally up to 10 degrees. In general, the depth of peat is inversely proportional to the slope angles, i.e. peat is deeper across the middle of the site and shallower around the boundaries.

At the peat slide source area there is a natural shallow valley which drained to a tributary stream of the Owendalulleegh River (sometimes referred to as Derrywee River) at which point the valley becomes more distinct before widening above the Black Road Bridge on the Black Road.

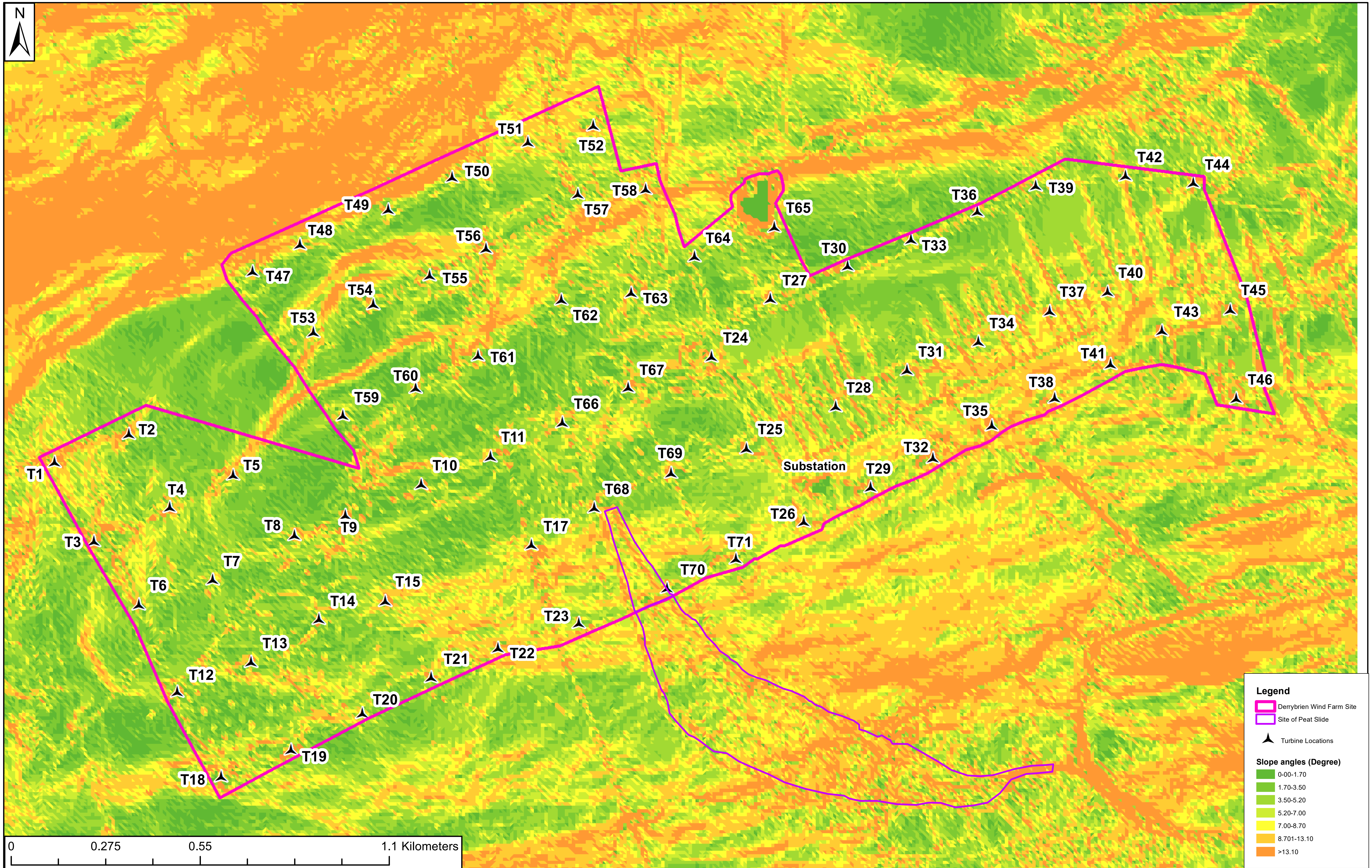


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Figure 11.4 - Ground surface slope angles based on post-construction LIDAR survey

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The elevation of the OHL route falls from Derrybrien Substation on the southern end of the wind farm to a flat-bottomed valley where it crosses the R353 road and the tributaries of the Owendalulleegh River at an elevation of approximately 130 mOD. From here, the route skirts around the Slieve Aughty Bog Natural Heritage Area (NHA – site number 001229) before gaining elevation again as it passes Lough Agannygal, at about 195 mOD. The route ends at the Agannygal Substation, just to the north of Lough Atorick, at an elevation of approximately 190 mOD.

11.2.2 Baseline Drainage Network

Blanket bogs such as that on which Derrybrien Wind Farm is sited are wetlands that are fed directly by rainfall to give rise to their characteristic saturated surface conditions and water logging. The living surface peat layer (0.1 – 0.3 m thick), the acrotelm, can have a moisture content of 90 – 98% and features the peat-forming vegetation, i.e. sphagnum moss, cotton grass and other materials including purple moor grass, heather stems and roots. The acrotelm supplies plant material which then slowly forms peat in the underlying catotelm layer. Typically, active peat bogs grow slowly at 0.5 – 1.0 mm per annum. In active bogs sphagnum mosses form a protective carpet which is a mosaic of sphagnum species growing as dense hummocks, low growing lawns and as hollows that create the characteristically undulating bog surface. In these undrained conditions the saturated bog promotes increased surface ponding as pools and mires, also generating overland runoff as sheet flow across the surface of the bog. Active blanket bog generally remains close to saturation throughout the year and therefore has limited available storage except in depressions where larger pools can form before spilling overland.

In the case of Derrybrien the baseline land use was primarily –

i) turbary bog, and

ii) commercial forestry

which both represent a drained bog situation, i.e. where active blanket bog has been degraded. The wind farm site had been extensively drained in the past, prior to any wind farm construction, by a series of parallel open ditches to facilitate commercial forestry and turf cutting under turbary rights. Turf cutting has and continues to take place on the eastern part of the site. Farming is also undertaken in the lower lying areas. The principal economic activity in the immediate area is forestry and farming, the latter being dominated by grazing of cattle. The ditches and drains in the worked bog and forestry discharge to the natural drainage and watercourses in the area (Plate 11.1 and Plate 11.2).

i) Turbary Bog

In a damaged or degraded bog, the acrotelm has been lost because of drainage, burning, trampling / grazing, afforestation or agriculture (which includes fertiliser application as well as drainage). The degradation exposes the unprotected underlying catotelm layer more acutely to atmospheric conditions including surface water environment. Subsequently, non-wetland vegetation becomes established, accelerating the aeration, drying and shrinkage process (primary consolidation).

Plate 11.1 Typical site land at Derrybrien Wind Farm

Plate 11.2 Drainage channel at Derrybrien

The loss of moisture and thus buoyancy in the upper layers further squeezes water from the catotelm layer (secondary compression). Drainage of peat bogs is generally focused on lowering the water table through a network of deep connecting drains often for domestic and commercial peat production, for forestry production or for agricultural grassland reclamation to provide an unsaturated soil root zone that enables plant growth to succeed. The construction of drainage ditches in a bog provide shorter pathways for surface water to run off and depending on the density of the drainage network will ultimately reduce waterlogging and overtime dry out the surface acrotelm layer and more gradually the upper layers of the catotelm. The acrotelm layer offers relatively low resistance to vertical and lateral water movement and, consequently, drainage tends to empty water reasonably readily from the acrotelm layer. However, given this layer is relatively thin, the drainage effects on the surrounding water table are minor. The drying process will over time alter the surface topography and increase the range in the water table between summer and winter levels.

ii) Commercial Forestry

Forestry plantations such as that which occupied the majority of the wind farm site prior to 2003 cannot tolerate permanently waterlogged conditions such as the saturated conditions found in active blanket bogs. For forestry to flourish it is necessary to drain the peat and remove excess surface water to locally lower the perched water table level. It is also necessary to plough the surface to provide a slightly raised ridge that acts as a micro-habitat for tree seedlings to establish with the ploughed furrow conveying the drainage away from the planted ridge. Tree planting takes place in rows parallel to the ploughed furrow with the areas in between the ridges often an efficient avenue for runoff to migrate downgradient to receiving watercourses. As such, the overall effect of forestry plantations like this is to increase peak winter flood runoff rates from upland areas. It should be noted however that this only applies when antecedent conditions are wet such as during winter. In drier conditions, the soil moisture deficit may be greater where the root zone promotes drying of the underlying peat, thus effectively providing a degree of attenuation.

Given the upland nature and gradients of the area, the site on which the wind farm was developed represented high runoff category land. This classification is further discussed in Appendix 11.A.

The pre-existing drainage network on the wind farm site shown in Figure 11.5 overlain on an OSI aerial photograph from 2000, represents a baseline condition for the wind farm. It shows the extent of pre-existing access roads (2.0 km), the extent of conifer plantations, the turbary plots in the open blanket bog at the east end of the site, potential subsurface drainage channels along lines of vegetation and patches of poor tree growth which is generally associated with deep peat and high water tables.

The roads on site prior to the wind farm project generally follow an east-west axis parallel to contour lines. The road layout of the wind farm also generally followed an east-west orientation with a number of spur roads connecting these from north to south, particularly along the internal boundary of the wind farm site.

The study area also comprises the 7.8 km overhead line running southward from the wind farm site and the tee-in substation at Agannygal connecting the wind farm to the National Grid (Figure 11.6).

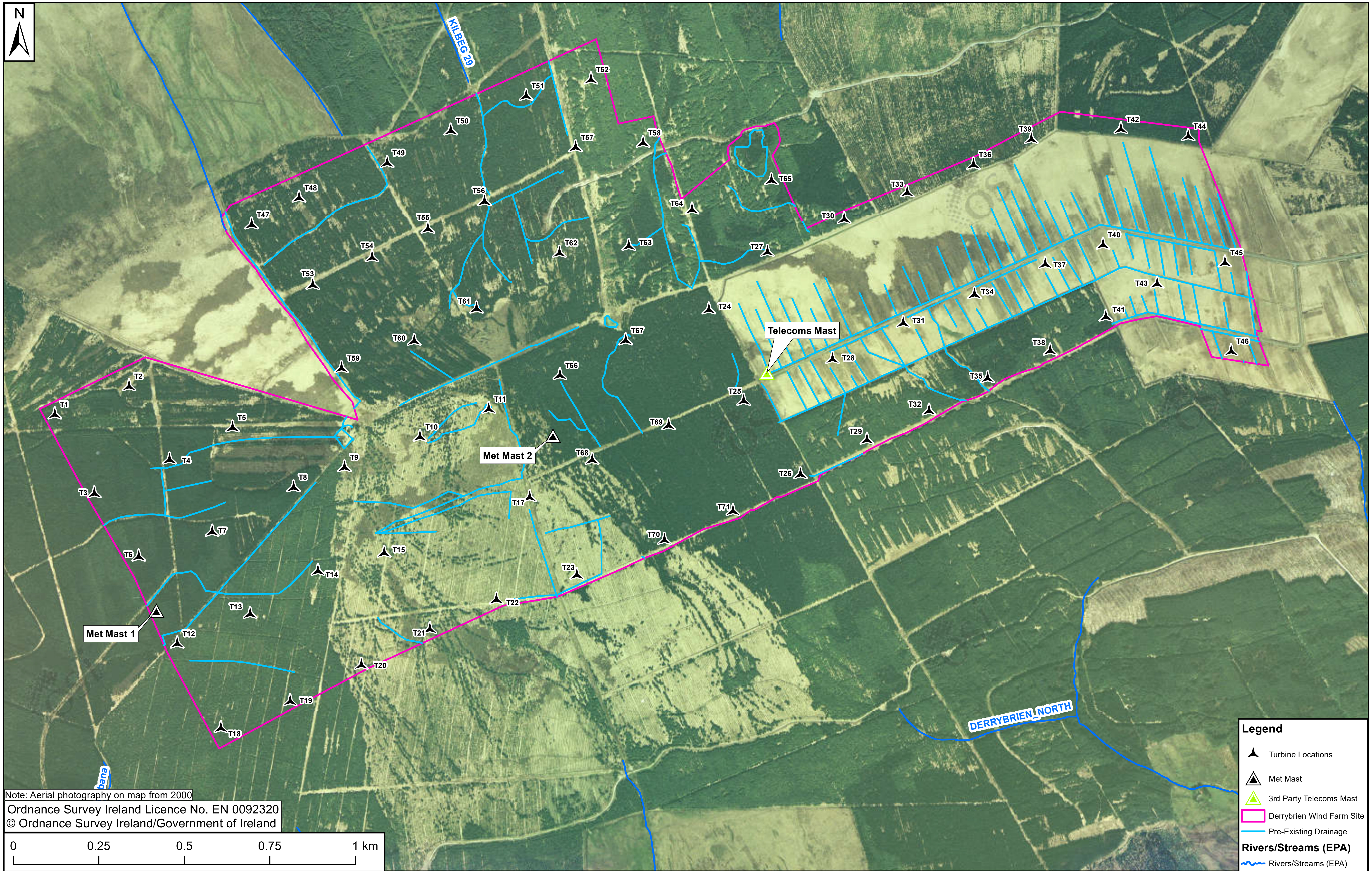

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Figure 11.5 -
Wind Farm Pre-existing Drainage Only

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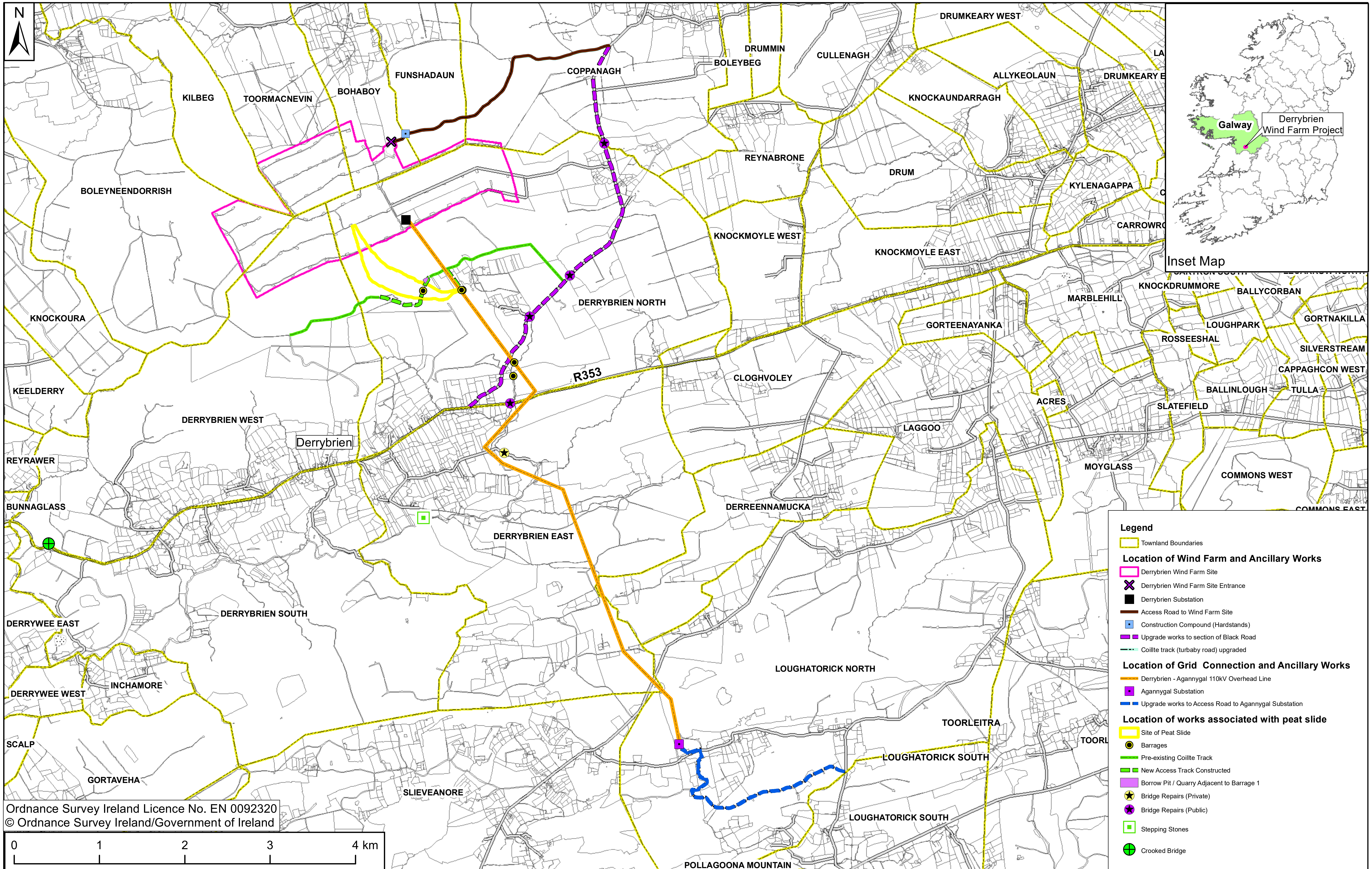

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The elevation along the route falls to a flat-bottomed valley where it crosses the R353 road and the tributaries of the Owendalulleegh River at an elevation of approximately 130 mOD. From here, the route skirts around the Slieve Aughty Bog NHA (site number 001229) before gaining elevation again as it passes Lough Agannygal, at about 195 mOD. The route ends at Agannygal Substation, which is located to the south-east of Cashlaundrumlahan Mountain and north of Lough Atorick, at an elevation of approximately 190 mOD. The substation location prior to construction was in afforested Coillte-owned land. The land is elevated with respect to the surrounding area to the north, west and south.

The peat slide which occurred during project construction in October 2003 extended from within the southern end of the wind farm site further south through Coillte land and onto private land between the wind farm site and Flaggy Bridge on the R353. Man-made drains within the source area of the slide comprised a series of narrow open drains 1 – 2 m deep with closely spaced furrows. These drains connected to the natural valley drainage in the area and flowed downslope. Emergency works undertaken in response to the peat slide, which were mainly located upstream of Flaggy Bridge to minimise effects on lands and receiving watercourses are discussed in section 11.3.2.2.

The OHL route crosses the site of the peat slide between pole sets 5 and 6, and also crosses two of the remaining in-place barrages (Barrages 2 and 3) installed as a result of the peat slide. Several watercourses cross the footprint along the OHL route, the largest being the main stream of the Owendalulleegh River which passes beneath the OHL between pole sets 25 and 26. Lough Agannygal passes underneath the section between pole set 37 and angle mast 38.

11.2.3 Water Balance

The long-term rainfall and evapotranspiration data relevant to the study area was sourced from Met Éireann. The Standard Annualised Average Rainfall (SAAR, i.e. long-term annual average rainfall) recorded at Gort (Derrybrien II) Met Station 3 km south of the site is 1433 mm. This rain gauge is the closest Met Éireann gauge but is at a lower elevation (155 mOD) than the wind farm (which is at a minimum elevation of 320 mOD) (Table 11-3).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2020	130	348	128	51									
2019	127	99	224	104	48	89	82	247	174	121	166	172	1652
2018	250	76	76	108	69	16	63	100	138	64	125	174	1258
2017	59	112	179	19	54	119	153	112	153	139	130	207	1435
2016	205	206	98	63	87	125	87	137	136	53	94	91	1380
2015	95	98	128	93	178	46	111	122	75	67	268	384	1664
2014	255	285	106	45	149	52	105	126	20	160	151	205	1658
2013	136	71	58	104	125	81	-	79	74	157	111	258	
2012	168	88	38	125	62	224	141	140	106	146	162	179	1580
2011	103	173	65	61	127	158	82	80	184	145	140	234	1553
2010	70	62	115	98	48	52	170	63	174	96	171	37	1156
2009	196	23	96	154	135	97	190	191	58	139	428	113	1820
2008	260	100	149	53	41	149	105	220	124	210	138	114	1662
2007	171	101	99	26	90	121	182	133	77	54	90	199	1341

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2006	96	44	142	53	143	30	57	65	220	139	180	230	1399
2005	164	68	62	107	110	54	72	97	92	116	123	81	1147
2004	147	49	93	75	57	108	85	89	139	157	103	149	1253
2003	98	71	64	65	152	116	104	22	47	80	147	110	1076
2002	197	235	96	105	139	134	64	101	44	164	178	112	1568
2001	67	67	109	101	37	85	97	113	59	132	137	77	1079
2000	123	162	-	53	-	77	92	96	142	220	175	147	
1999	169	99	75	95	102	71	72	85	238	105	169	289	1570
mean	150	109	104	81	98	95	106	115	118	127	161	170	1433

Table 11-3 Monthly Rainfall (mm) at Gort Derrybrien II Met Station

Met Éireann via the Flood Studies Update (FSU) web portal provides a 2 km x 2 km grid of SAAR and rainfall Depth Duration Frequency (DDF) data (Table 11-4). A depth duration frequency model allows for the estimation of point rainfall frequencies for a range of durations for any location in Ireland. The model consists of an index (median) rainfall and a log-logistic growth curve which provides a multiplier of the index rainfall. The Met Éireann SAAR model gives an annual rainfall estimate for the nearest node points to the summit of the site of 1573 and 1591 mm respectively. The latter is taken as the SAAR figure from hereon.

Duration (hrs)	Return Period (years)				
	5	10	50	100	250
1	16.0	19.1	27.5	32.1	39.1
3	24.2	28.4	39.7	45.5	54.7
6	31.4	36.5	49.8	56.7	67.2
9	36.5	42.2	56.9	64.4	75.9
12	40.6	46.7	62.4	70.5	82.6
18	47.2	53.9	71.2	80.0	93.1
24	50.6	57.6	75.5	84.4	97.9
48	63.5	71.4	91.2	101	115.3
96	84.1	93.4	116.3	127.4	143.5

Table 11-4 Rainstorm Depth (mm) Duration Return Period Table for wind-farm site from FSU Web portal

The closest synoptic weather station where the average Potential Evapotranspiration (PE) is recorded is Mellows College Athenry, approximately 25 km to the northwest of the wind farm. Measurement of Penman PE is only generally available at the 25 Met Éireann synoptic weather stations throughout Ireland and average PE rates across the nation vary from 425 mm to 600 mm per annum. The long-term average PE for this station is approximately 514 mm/year (Table 11-5).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2020	13.2	20.4	36.3	64.3	92.0	74.6	26.2						
2019	10.4	20.6	33.7	54.5	75.7	84	85.1	61.8	42.3	25.4	10.8	10	514.3
2018	11.1	17	30.9	51.5	83	101.9	93.4	61.5	39.4	25	14	11.7	540.4
2017	11.7	17.6	36.6	49.2	84.8	76.9	76.1	61.1	42.1	23.5	10.4	8.7	498.7
2016	13.1	17.3	34.5	53.4	80.3	84.2	72.2	61.2	39.9	26.5	9.8	10.2	502.6
mean	11.6	18.1	33.9	52.2	81.0	86.8	81.7	61.4	40.9	25.1	11.3	10.2	514

Table 11-5 Potential Evapotranspiration (mm) at Athenry Synoptic Station

This PE value is used as a best estimate of the site PE. Actual Evapotranspiration (AE) at the site is also estimated as 514 mm/year as there is unlikely to be any soil moisture deficit within the raised bog on the mountain.

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

ER = SAAR – AE = 1591 mm/year – 514 mm/year = 1077 mm/year.

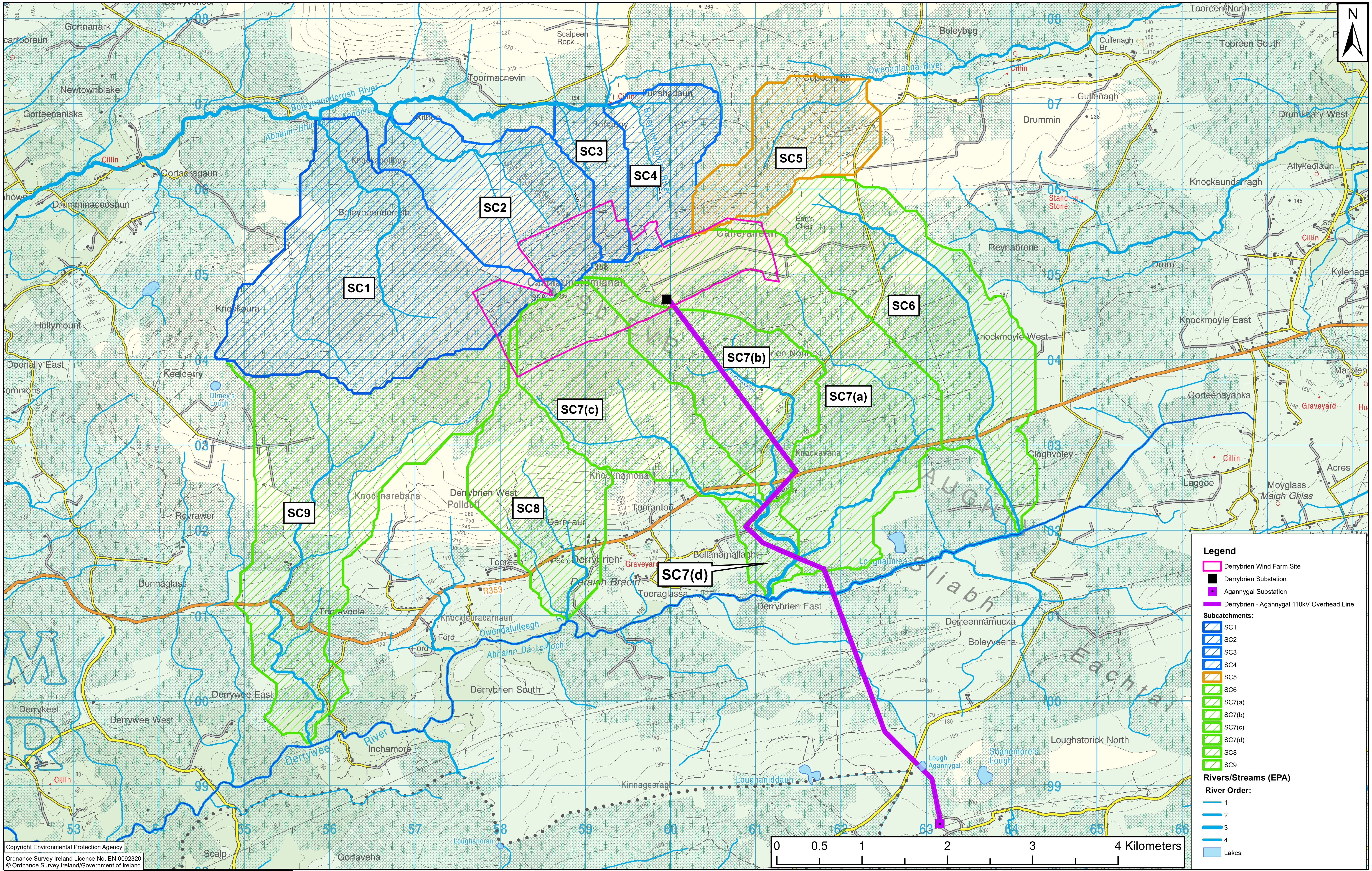
Based on recharge coefficient estimates from the Geological Survey of Ireland (GSI, www.gsi.ie), a conservative estimate of 10% groundwater recharge is taken for the site as an overall average. This value is for “Peat” with a “Moderate” vulnerability rating. Areas of thinner peat or thin peaty soils, i.e. extreme vulnerability, may have slightly higher recharge rates, but on this site these areas are generally on sloping ground with very poor natural drainage. The lowest value in the available range was chosen to reflect the large coverage of peat and poorly draining soil types, and the high stream drainage density. Therefore, annual recharge and runoff rates for the site are estimated to be 108 mm/year (10% x ER) and 969 mm/year respectively. Note that according to the GSI Groundwater Data Viewer, annual recharge rates are approximately 100 mm/year in this area. The baseline hydrology of the site can therefore be expected to be characterised by high surface water runoff rates and a very flashy stream network.

11.2.4 Regional & Local Hydrology

A catchment can be defined as a topographic surface area contributing to a watercourse and its tributaries, with all the water ultimately merging downstream at a single outlet point. The catchment boundary (watershed divide) is simply the dividing line either side of which surface drainage flows towards separate streams to separate outlet points though these may merge downstream.

11.2.4.1 Wind Farm Site

The 344 ha wind farm site partially extends over the catchments of three rivers – Boleyneendorrish and Owendalulleegh in the Galway Bay South East WFD Catchment and Duniry in the Lower Shannon WFD Catchment. These catchments and the associated tributary subcatchments draining to each of the rivers are mapped in Figure 11.7 and tabulated in Table 11-6 and Table 11-7.



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DRAWING TITLE: Figure 11.7 - Subcatchments draining from wind farm site to major rivers

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Each of the subcatchments' boundaries are as defined by the EPA and the OPW Flood Studies Update (FSU) portal with the exception of the boundary between SC7(a) and SC7(b) which has been modified upon examination of OSI 6 inch mapping and up-to-date aerial photography. The FSU methodologies are now recommended by the OPW as being the preferred method for extreme rainfall and flood estimation in Ireland. The land use for all of the small and very small upper tributaries of the catchments that drain the footprint of the wind farm is almost exclusively a combination of coniferous forest in various states of growth or re-growth and open blanket bog moorland which has not been afforested. Details of the three catchments draining from the wind farm site are described below. Within these catchments there are a number of subcatchments (SC) which have been identified for the purposes of this study. See Table 11-7.

Catchment	River Basin (Area km^2)	Drainage Area within wind farm boundary (km^2)	% wind farm site draining to each river	No. of Turbines in catchment	Area of Access Track/roads (km^2)
Boleyneendorrish	Kinvarra (490)	1.15	33.3	26	0.065
Owendalulleegh	Kinvarra (490)	2.28	66.1	43	0.105
Duniry	Kilcrow / Shannon (11461)	0.02	0.6	1	0.003

Table 11-6 Summary of rivers draining from Derrybrien wind farm

Watercourse Name	Subcatchment Designation	Turbines in Subcatchment	Turbine Numbers	Turbines in Catchment
Boleyneendorrish	SC1	7	T1,T2,T3,T4, T5,T6,T59	26
	SC2	10	T47,T48,T49,T50, T53,T54,T55,T56, T60,T61	
	SC3	7	T51,T52,T57, T58,T62,T63	
	SC4	2	T64,T65	
Owendalulleegh	SC6	3	T39,T42,T44	43
	SC7(a)	19	T24, T25, T27, T28, T29, T30,T31, T32, T33, T34,T35, T37,T38,T40, T41,T43,T45,T46, T67	
	SC7(b)	5	T26, T66, T68,T69, T71	
	SC7(c)	14	T8,T9,T10,T11,T13, T14,T15,T17,T18, T19,T20,T21,T22, T23,T70	
	SC7(d)	0	-	
	SC8	0	-	
	SC9	2	T7,T12	
Duniry	SC5	1	T36	1

Table 11-7 Summary of river subcatchments draining from Derrybrien wind farm

- The Boleyneendorrish River drains approximately 33% of the wind farm site via subcatchments denoted SC1, SC2, SC3 and SC4. It flows westward through Blackrock Turlough and Lough Coy, having catchment areas of c. 64 km^2 upstream of its confluence with the Ballylee River and c. 152 km^2 downstream at Ballyloughaun to the east of Kiltartan. It joins up with the Gort River in the Kiltartan Flood Plain area upstream of the Coole Turlough and Special Area of Conservation (SAC) having a combined catchment area of 300 km^2. The Lough Coole system discharges north-west as groundwater flow and overland flow through a heavily karstified region before entering the sea at Kinvarra town.
- The Owendalulleegh River System drains approximately two-thirds (66%) of the wind farm site through a number of small hill slope stream tributaries – Cloghvoley (designated as subcatchment SC6), Derrybrien North (SC7, further divided into SC7(a), (b) and (c) owing to the large portion of the wind farm which drains to the respective streams; SC7(d) is the remaining subcatchment area but is not located within the wind farm itself) and Derrybrien South (SC8 and SC9). The Owendalulleegh River rises in the townland of Gorteenayanka and flows westward to the south of the site to Lough Cutra approximately 22 km further downstream. The catchment area of the Owendalulleegh River to Lough Cutra is 90 km^2

(area to lake outlet is 124 km^2). Downstream of Gort at Kiltartan it joins up with the Ballylee River before entering the Lough Coole system, after which it flows to the northwest through a heavily karstified region where it disappears underground. It reaches Kinvarra town approximately 15 km further downstream, at which point it enters Galway Bay. The entire Kinvarra catchment drains an area of c. 490 km^2.

- The Duniry River drains a very small section of the overall site (<1%) to the northeast, designated as subcatchment SC5. The river is a tributary of the River Kilcrow which flows into Lough Derg on the River Shannon. The Shannon then drains a catchment of 11,641 km^2 before entering the sea at the mouth of the Shannon Estuary. The total area of the Kilcrow catchment upstream of Lough Derg is 394 km^2.

11.2.4.2 OHL and Agannygal Substation

Several watercourses exist within the footprint of the OHL route, the largest being the Owendalulleegh River, approximately 6.0 m wide, which passes beneath the OHL halfway between pole sets 25 and 26, approximately 150 m from both. Major drainage features tend to run east to west in the OHL corridor, with minor tributary features aligned approximately north to south to tie into the major drainage features. There are several flat areas where local ponding of surface water occurs. Such a feature – Lough Agannygal (area 0.85 ha), located between pole set 37 and angle mast 38 – prevents access directly beneath the OHL. The land on which Agannygal substation is located is elevated with respect to the surrounding area to the north, west and south. There is no record of drainage on or in the vicinity of the site prior to construction.

11.2.5 Hydrogeology

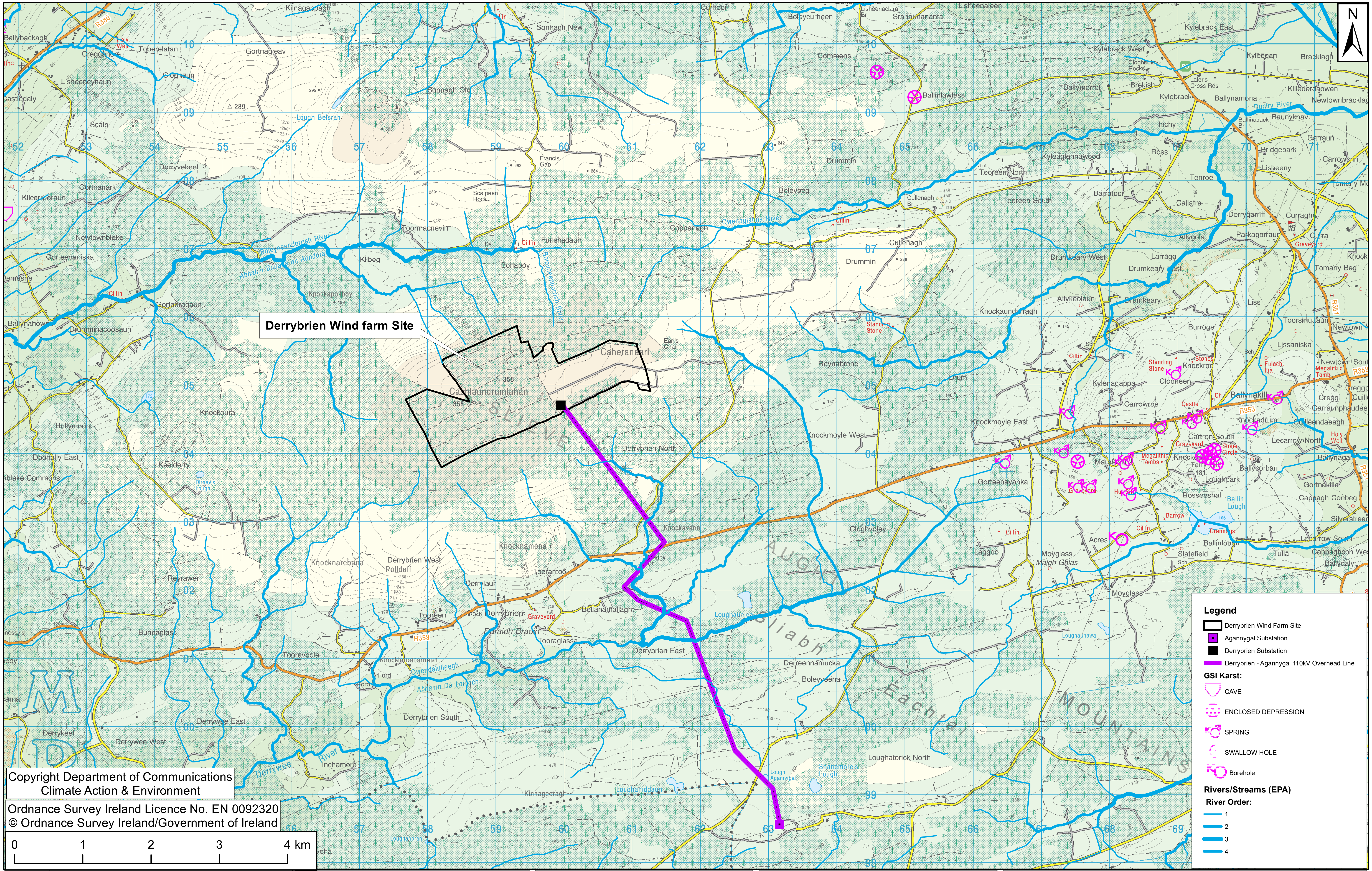
11.2.5.1 Aquifer Classification

The Ayle River Formation, comprising mudstones, siltstones and conglomerates, underlie most of the wind farm site. This bedrock formation is predominantly classified by the GSI (www.gsi.ie) as a poor bedrock aquifer (PI), having bedrock that is generally unproductive except for local zones. This bedrock is a muddy impermeable bedrock that is not very conducive to transmitting and storing groundwater flow. There are no mapped fault lines traversing the site.

The upland areas comprise blanket peat, which underlies all the forestry in the area, with acid brown earths/brown podzolics and acidic peaty gleys underlying most of the agricultural lands farther down the valleys in both the Boleyneendorrish and Owendalulleegh catchments.

The closest karst features to the Project area according to GSI mapping are a number of springs and depressions near Ballynakill, approximately 5 km to the southeast of the wind farm site at its closest point (Figure 11.8). These springs are at the source of the Owendalulleegh River where the bedrock is a combination of dark muddy limestone / shale and massive unbedded lime-mudstone.

The majority of the OHL route including the grid connection at Agannygal is underlain by rock which is considered a poor aquifer (bedrock which is generally unproductive except for local zones).



REV	DATE	REVISION DESCRIPTION	DRN	PROD	VER	APP
0	09/07/20	Issued for substitute consent	E.O'S	E.O'S	H.G	P.K

PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☒ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

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CLIENT: Gort Windfarms Ltd

PROJECT: Derrybrien Wind Farm Project

CONTRACT:

PRODUCTION UNIT: Civil & Environmental Engineering

DRAWING TITLE: Figure 11.8 - Karst features in relation to wind farm project

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DRAWING NUMBER: QS-000280-01-D460-012-007-000

However, the segment of the route underlain by Visean Limestone (between pole sets 23 and 26 approximately) is considered a locally important aquifer (bedrock which is moderately productive only in local zones) although there is little evidence for groundwater usage from this aquifer locally that has been discovered in preparing this report.

11.2.5.2 Groundwater Vulnerability

Groundwater vulnerability represents the intrinsic geological and hydrogeological characteristics that determine how easily groundwater may be contaminated by activities at the surface. Vulnerability depends on the quantity of contaminants that can reach the groundwater, the time taken by water to infiltrate to the water table and the attenuating capacity of the geological deposits through which the water travels. The GSI groundwater vulnerability rating of the aquifer underlying the wind farm ranges from Moderate in the south-west corner of the site to High over most of the site. The High vulnerability rating suggests that the combined thickness of peat and mineral subsoils at the site ranges from 3 – 5 m in these areas (Table 11-8). Ground investigation information showed the depth to the top of the rock was variable but typically ranged from 3.5 to 6.2 m, which generally reflects the GSI vulnerability classification of High and Moderate. However, the rock was shallower (1.3 m to 2.9 m) at the northern part of the site representing extreme vulnerability as per Table 11-8 and there were some locally deeper depths to rock (8 m to 9.1 m) at the north-eastern and central parts of the wind farm site.

Sensitivity	**Hydrogeological Conditions**				
	Subsoil Permeability (Type) and Thickness			**Unsaturated Zone**	**Karst Features**
	High Permeability (Sand and Gravel)	**Medium Permeability (Sandy Subsoil)**	**Low Permeability (Clayey Subsoil/Peat)**	**Sand and Gravel aquifers only**	**<30 radius**
Extreme (E)	0 – 3.0 m	0 – 3.0 m	0 – 3.0 m	0 – 3.0 m	-
High (H)	>3.0 m	3.0 – 10.0 m	3.0 – 5.0 m	>3.0 m	N/A
Moderate (M)	N/A	>10.0 m	5.0 – 10.0 m	N/A	N/A
Low (L)	N/A	N/A	>10.0 m	N/A	N/A

Table 11-8 Groundwater Vulnerability Categories (GSI)

Groundwater within the wind farm site boundary would be expected to flow downslope through a network of natural open pipes within the peat as well as possibly through an open joint network in the underlying bedrock. Several springs have been identified on site, particularly within scarp faces on the northern slopes. Linear tree patterns such as in the south-western corner of the site shown in Figure 11.5 is possibly indicative of areas where subsurface flow is concentrated. Receptor sensitivity criteria are set out in Table 11-9.

Sensitivity Criteria	
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 of high environmental importance, 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. GSI groundwater vulnerability "Extreme" classification and "Regionally" important aquifer

Table 11-9 Receptor Sensitivity Criteria (adapted from www.sepa.org.uk)

Based on the receptor sensitivity criteria, groundwater at the wind farm site can be classed as Not Sensitive to pollution, as the underlying bedrock is classified as a Poor Aquifer. In addition, most of the site is covered in peat and poorly draining soils, which act as a protective cover to the underlying aquifer. Any contaminants that may be accidentally released on site are more likely to travel to nearby watercourses within surface runoff. The relatively low permeability of the bedrock means that contaminants in the overburden will not be very mobile and any contaminant that may reach the bedrock would not disperse and would remain localised to the source or would be diluted and removed as part of runoff during wet periods.

Groundwater vulnerability ranges from low generally up to extreme in pockets of the most low-lying areas across the OHL route and grid connection due to the shallow depth to bedrock in these areas. There are no mapped karst features in these areas.

11.2.6 Flood Risk Identification

A Flood Risk Assessment (FRA) in line with The Planning System and Flood Risk Management - Guidelines for Planning Authorities (OPW, 2009) has been conducted for all the Derrybrien Wind Farm Project areas including the two substations and overhead line corridor route and peat slide location. The FRA was carried out as part of the assessment of the overall Project to provide an overview of the potential flood risks to the Project areas and to assess the impact of the project on flood risk downstream (see Appendix 11.A).

A desktop review of historic flooding was undertaken primarily using OPW website www.floodinfo.ie. The 'Past Flood Events' dataset forms a record of all available flood records held by the OPW, all local authorities and other relevant state organisations such as the EPA and the Department of Communications, Climate Action and Environment. There were no mapped reports of recurring flooding within the Project areas and there is no significant risk of flooding within the Project area due to the elevated nature of the majority of the Project area relative to the surrounding area (Figure 11.9). The nearest area downstream affected by flooding in the catchment which drains the north side of the wind farm site is 15 km downstream at Ballylee on the Streamstown River. The nearest area downstream affected by flooding in the catchment draining the south side of the wind farm is over 20 km downstream close to Gort.

With regard to groundwater, it is likely that groundwater levels across the wind farm site have stabilised since piezometers stopped measuring in 2012. In general, the vast majority of dewatering of the peat took place in the early years following construction, but the degree and rate of change would have varied significantly with the greatest changes most likely taking place in the southwest of the site where most of the new drainage channels were introduced while the relatively undisturbed areas such as the peatland between T62 and T67 in the centre of the site undergoing little evident change and remaining largely intact. The fall in groundwater levels was consistent and gradual at a rate of approximately 0.1 m/year (or 0.03 l/s per ha) across the site and would not have a significant impact on the downstream environment with respect to flood risk.

The FRA concludes that most of the Project areas are not within floodplains and lie within Flood Zone C (Low risk of flooding) as defined by the guidance document to Planning Authorities in relation to Flood Risk Management. Furthermore, the existing flood risk in the downstream catchment has not to date and is not expected to be increased by any works over the operational life of the wind farm. Several elements of the wind farm infrastructure are vulnerable to pluvial flooding in extreme rainfall events. However, it is judged that the Project satisfies the criteria set out in the Justification as part of "The Planning System and Flood Risk Management – Guidelines for Planning Authorities".

11.2.7 Ground Water Abstractions

The EPA have launched a register of water abstractions in accordance with the European Union (Water Policy) (Abstractions Registration) Regulations 2018 (S.I. No. 261 of 2018). People who abstract 25m^3 of water or more per day are required to register their water abstraction. Searches of the GSI well database and the EPA WFD database indicate that there are no known groundwater abstraction wells within 5 km of the wind farm site boundary. The nearest mapped well is located 7 km to the south-west of the site boundary.

However, given the rural location many houses obtain their water supply from private wells. The 2016 census showed the percentage of private water supplies to houses in the surrounding Electoral Divisions (EDs) is in the order of 20-40%.

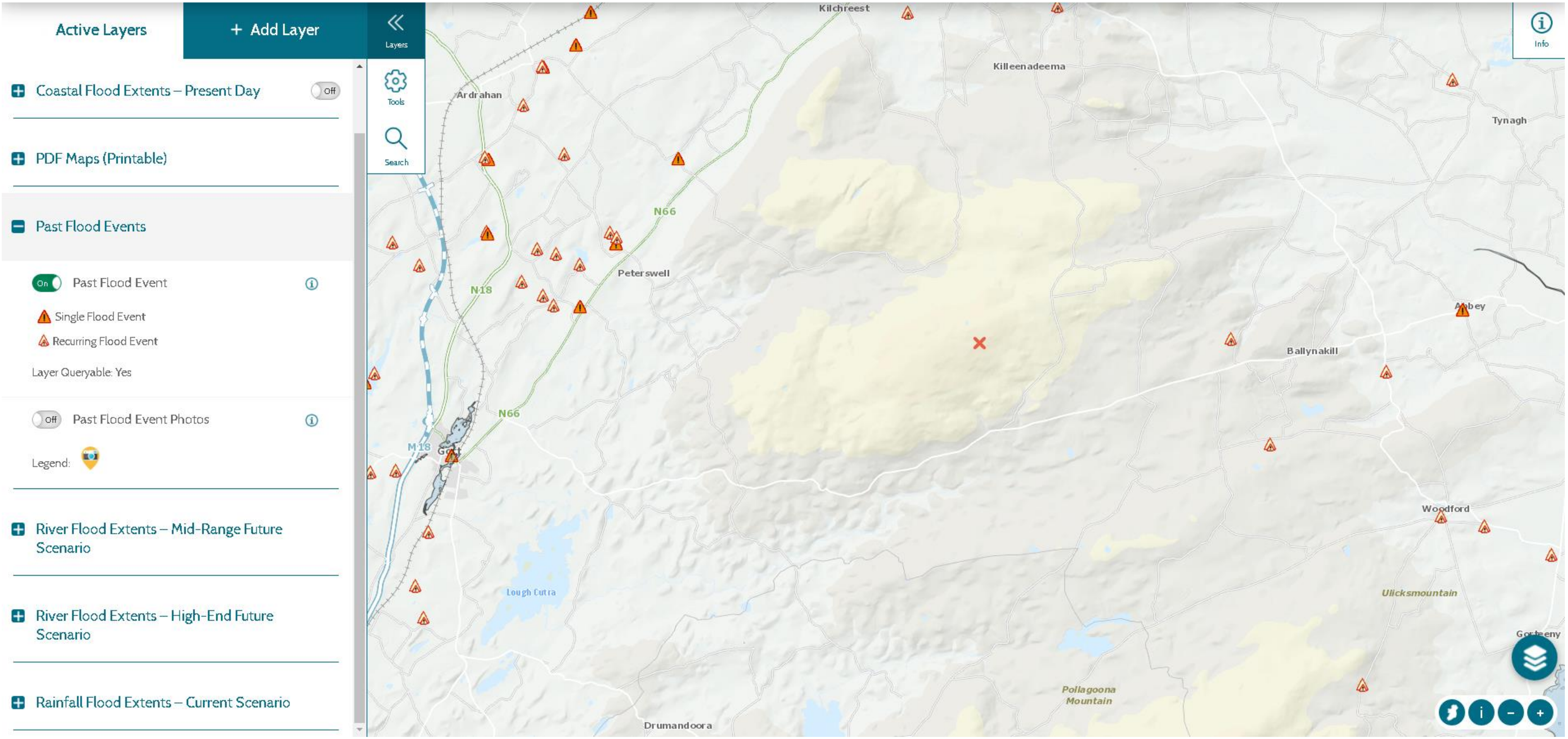
Communication with local authorities and the local community has yielded information that Derrybrien village is the only area identified in the vicinity of the wind farm requiring water supply. A number of private dwellings here are part of a group scheme covering 10 houses, while others have their own independent wells and some others harvest rainwater from their roofs. The local church gathers its own water supply from its roof

11.2.8 Surface Water Quality

The EPA regularly monitors water bodies in Ireland as part of their remit under the WFD which requires that rivers are maintained or restored to good/favourable status. Assessment of the surface water quality associated with the Project is discussed in detail in Chapter 8 Biodiversity – Aquatic Ecology. EPA Q-value data for the main channels of the Owendalulleegh and Boleyneendorrish rivers reveal that the water quality in these channels was High Status in the years immediately prior to the construction of the wind farm. Later surveys carried out by Inland Fisheries Ireland (IFI) would suggest that prior to the Project construction all these channels would have had at least as high a water quality and as healthy a fish population. In the absence of any baseline data for the channels draining from the wind farm, several macroinvertebrate and fisheries surveys undertaken since 2011 for the Aquatic Ecology assessment have shown that the water quality in these minor watercourses ranges from High to Good mainly, but with some instances of slightly impaired (Moderate) quality also.

There is some very limited water chemistry data available which would indicate that Lough Cutra was oligotrophic before the wind farm construction. However, the data is fairly sparse and ever since then it seems to be leaning more toward a mesotrophic state. More importantly, the EPA in its 3-year monitoring cycles has determined that its ecological status between 2010 and 2018 has changed from Good to Moderate back up to Good again.

Figure 11.9 Historical Flood Mapping (floodinfo.ie); wind farm site marked by red X


Active Layers
+ Add Layer
Layers
Tools
Search
Info
Coastal Flood Extents – Present Day
Off
PDF Maps (Printable)
Past Flood Events
On
Past Flood Event
Single Flood Event
Recurring Flood Event
Layer Queryable: Yes
Off
Past Flood Event Photos
Legend:
River Flood Extents – Mid-Range Future Scenario
River Flood Extents – High-End Future Scenario
Rainfall Flood Extents – Current Scenario
Kilchreest
Killeenadeema
Ardrahan
Tynagh
N66
Peterswell
N18
Ballynakill
N66
M18
Woodford
Lough Cutra
Ulicksmountain
Pollagoona Mountain
Drumandoora

11.3 Impact of the Development

11.3.1 Introduction

This section addresses the impacts on the hydrological and hydrogeological environment of the Wind Farm Project. The impacts may comprise the changes in volume and rate of surface water flow and direct or indirect impacts on the quality of surface waters and groundwater. All available records of construction activities and operational infrastructure were reviewed to identify how different activities were likely to impact upon identified water bodies including watercourses within and downstream of the Project areas. Following the identification of sensitive waterbodies, the extent and severity of construction, operational and decommissioning impacts were evaluated considering all previously installed, existing and proposed control measures.

The sensitivity of surface environmental receptors is discussed in detail in Chapter 8 – Biodiversity – Aquatic Ecology. Overall, the EPA monitoring data results demonstrate that for all the main channel sites on the Boleyneendorrish River and the Owendalulleegh River, at least as far upstream as the confluence of subcatchment SC7, and the most upstream EPA sites on the Boleyneendorrish, that High Status has been the rule rather than the exception. These results have generally been confirmed by the Aquatic Ecology assessment.

The most notable exception to the positive trend on the Owendalulleegh was for the 2003 survey undertaken within a month of the peat slide, when the quality dropped significantly at several main channel sites. However, as the 2006 results indicated, this interruption in the High Status quality norm was mainly short lived. Results for the many smaller tributaries in the upper regions of the three study catchments (including the Duniry) have shown more variable results ranging from High Status, to Good, to Moderate Status mainly, with a very rare drop to Poor status (at just two sites).

Due to the nature of wind farm developments, which are “near surface” construction activities, impacts on groundwater are generally negligible and surface water is generally the main sensitive receptor. The primary risks to groundwater at wind farm sites are during construction stage while risks at operational stage are generally much lower because of the limited work activities that take place in maintaining the site.

11.3.2 Impacts which have occurred

11.3.2.1 Construction Phase: circa June 2003 – March 2006

The goals of this section is to describe construction operations in the context of their potential to generate pollutant material and their resultant implications for surface and subsurface runoff. The different elements of the construction are summarised below with respect to hydrology and hydrogeology.

The construction of the temporary site compound areas, site access tracks, turbine foundations, turbine hardstands, substation compounds, underground low-voltage (LV) cables and ducting, borrow pits / quarries and drainage channels involved the removal of vegetation and forestry and the excavation of peat and mineral subsoil.

There were 70 no. turbines of two different types constructed on the wind farm site. The foundation of 64 no. turbines measured 9.8 m x 9.8 m and 6 no. foundations measured 11 m x 11 m. The foundations consisted of 1 m depth of reinforced concrete from the formation layer. Hardstanding areas located adjacent to each wind turbine were designed to support the load of the large mobile cranes used to erect the turbines, to facilitate any large-scale maintenance activity involving the use of cranes that arise over the lifetime of the wind farm and for decommissioning of the turbines. Each individual hardstanding covers an area of approximately 47 m x 18 m.

The turbine bases were excavated to the required bearing level after any trees had been removed. This entailed removal of the peat layer and any boulder clay or rock using a mechanical digger on wide tracks or bog mats to protect the underlying peat from damage. All excavated peat and boulder clay material was sidecast (for works undertaken prior to the peat slide) and / or removed to a peat repository (works after the peat slide). Once a base was prepared and shuttering and steel reinforcing installed, concrete was poured to form the pads. The concrete was provided by an external supplier with no concrete batched on site. Once in place the surrounds of the base were backfilled with the boulder clay originally stripped from the footprint and then topped with crushed stone from the borrow pits. At this time also a buried land drain was installed around the base, the outlet of which was connected into the surface drainage network. Water ponding in any of the turbine foundation excavations was pumped out to nearby surface drainage, often over the vegetated surface to filter out solids.

The 3 no. borrow pits / quarries developed on site had the potential to be the source of mineral solids due to the washout of dust and mineral particles associated with concentrated heavy vehicle movements with residual solids generated from the excavation of stone and boulder clay. Crushed stone in itself would be unlikely to generate high levels of solids and any generated would be amenable to rapid deposition due to it being coarser in nature. Frequent movement of heavy machinery at entrances and blasting in the case of borrow pit / quarry 3 could increase the amount of fines available to be washed out at these locations.

There were 32 no. peat repositories dotted throughout the wind farm which were maintained on level ground with no more than 1 m of deposited material. While active, these could have been the source of some peat silt runoff some of which would have been filtered out in surface vegetation and some eventually reaching the surface drainage system. After completion, these repositories would have rapidly been revegetated by pioneer species such as bulbous rush and successively by other species thereby reducing and eventually preventing further erosion of peat solids. Some of the peat silt washed from the repositories while they were still being used would have been intercepted in vegetation at the margins of tracks and between these and the drainage system. However, the assumption is being made that at least a portion of the mobilised solids would have left the site in all drainage channels during heavy rainfall events despite the presence of silt traps on outlet drains.

The 17.5 km of internal access tracks were laid in a primarily east-west orientation in parallel rows to provide access to the turbine locations. Over 90% of these roads were floating built on top of the existing peat layer, with just a short length of non-floating road between T68 and T70 and in the vicinity of Borrow Pit / Quarry 3. Floating roads were composed of a number of layers as follows:

i. A base layer of timber from felled trees, laid at right angles to the direction of travel, and 1 - 2 layers of geogrid, laid directly onto the peat surface;
ii. A regulation layer of crushed rock from an onsite borrow pit;
iii. Another layer of geogrid;
iv. A 500 mm layer of crushed rock from the borrow pits on site; and
v. A 50 mm layer of imported Clause 804. This was overlain in place by a thin layer of quarry dust.

Non-floating roads were constructed by:

i. Stripping the thin overlying vegetated peat layer and side casting it,
ii. Trimming the underlying boulder clay to the formation level
iii. Laying a layer of 1000 gauge filter membrane followed by a 225 mm layer of crushed rock from the onsite borrow pits and
iv. Finishing with a 50 mm layer of imported crushed stone.

Drainage associated with these roads are discussed in the next section.

The site compound hardcore area for the construction phase (77 m x 38 m) was established at the north-east corner of the site not far from Borrow Pit / Quarry 3 on an existing Coillte track turning area. The site compound area was formed by stripping and sidecasting the excavated peat and backfilling with crushed rock from the nearby borrow pit. The surface was finished with imported hardcore. The construction of this compound area would have generated some silt at the time, mainly associated with washout of fines from the hardcore surface layer.

The 2 no. substations each consisted of a control building with associated electrical equipment and an outdoor area including concrete footings. The on-site 110 kV substation also included a step-up transformer. Both substation compounds are finished on 50 mm single-size clean compound limestone. The permeable compound stone provides a means of attenuation of runoff and allows rainwater to infiltrate to ground as it would prior to development. A drainage ditch was dug around the northern and eastern perimeter of Derrybrien substation compound set back between 7 - 13m from its perimeter. This drain exited site to the south via an existing Coillte drain. The edge of the substation is set back 75 m from the southern perimeter of the wind farm. Therefore, assuming that the new perimeter drain was not inserted until after the compound had been completed, solids-contaminated runoff from the construction area would not have quickly exited the wind farm site without having time to settle and/or be captured by treatment features onsite. However, given the frequent movements of heavy traffic in and around the compound during construction which was undertaken in winter, it is likely that some suspended solids would have reached surface drainage downstream from this site i.e. into sub-catchment SC7(a) during construction.

The 8 no. cable routes constructed within the wind farm site generally ran east-west, close to and parallel to the access tracks, all of them eventually linking to the substation. They were laid in shallow peat trenches (without ducting) which were being backed-filled as soon as the cables were being laid with the excavated peat that had been temporarily side cast when opening the trenches. This procedure is likely to have given rise to the washout of small amounts of peat solids which would have entered the drainage network throughout the site with residual amounts exiting the site via the sub-catchments draining the site. Where the trenches had to cross under existing cross drains the potential for solids washout would have been higher. Overall, however, given that this was a continuous cut, lay and back-fill exercise, it is unlikely to have given rise to appreciable amounts of peat silt washout. Whatever amount would have exited the site would have been distributed across all subcatchments rather than concentrated in any one. Note the washout of silt and how this was addressed more generally during construction is explained in more detail in a later section.

Works to improve and maintain sections of local roads and bridges included (a) minor widening works and resurfacing of sections of the Black Road used for construction and operational access and (b) road widening for a distance of approximately 30 m on either side of the Crooked Bridge on the R353 to facilitate the delivery of equipment to the wind farm site. Road widening included extension of existing drains which passed underneath these road sections.

11.3.2.1.1 Flood Risk / Flow rates

The surface drainage patterns at Derrybrien wind farm generally follow the natural hill slope gradients and the overland flow regime of the site which existed prior to the Project. The pre-existing drainage on the site is associated with forestry (generally in the western and northern part), turbary (eastern part) or the wind farm Project itself.

Progressive replacement of vegetated surfaces with hardstanding surfaces had the potential to result in:

- An increase in the proportion of surface water runoff reaching the surface water drainage network; and
- A reduction in the response times between rainfall and runoff during storm events.

The extent of construction works to extend and / or enhance the pre-existing wind farm drainage network is, in comparison to similar developments of this type and scale, minor relative to the overall extent of pre-existing drainage that already was present on the baseline site. The site, being located near the watershed boundaries, has a small number of upstream contributing catchment areas and consequently the wind farm project had limited potential to affect hydrological regimes downstream of the site during the construction stage. The new drainage works were carried out by hand or with a wide-tracked hydraulic excavator suitable for working on the peat. Works on the drainage system were carried out on a non-continuous basis to lessen the impact on ground conditions.

During construction there was no engineered storage or attenuation of storm runoff provided on site before discharging to receiving watercourses. Runoff water from the gravelled turbine bases and roads was discharged as over-the-edge drainage distributed over the entire site with limited concentration of development drainage to single point outfalls.

The relevant footprint of new works associated with the Project comprises turbine bases and hardstanding, access tracks, one electrical substation compound on the wind farm site, Agannygal substation compound and the OHL line. During storm events increased runoff from the new areas of hardstanding (although minor in the context of the overall wind farm site area) coupled with higher velocities of flow from newly constructed drains could have had the potential to increase hydraulic loading, resulting in localised erosion of watercourses and impact on aquatic ecosystems. Precipitation affecting the undisturbed area of the wind farm site continued as prior to construction to either infiltrate or flow across the ground. Increased runoff was restricted to areas of the site being converted to gravel access tracks, concrete pads and hardstands. During periods of average or low flow there was negligible impact on downstream watercourses from the construction of the new tracks, concrete pads and hardstands.

11.3.2.1.2 Felling of Forestry

The felling license granted to Gort Windfarms Ltd. in 2003 for the felling associated with the wind farm was granted subject to a number of standard conditions including the requirement to carry out operations in accordance with 'Forestry and Water Quality' and 'Forest Harvesting and the Environment' guidelines published by the Department of Agriculture, Food and the Marine, as well as the 'Irish National Forest Standard' and the 'Code of Best Forest Practice – Ireland'.

Where peat and steep slopes occur together such as at Derrybrien wind farm, there is a greater risk of soil erosion and subsequent sedimentation. Correct buffer zone management helps to reduce these risks. A buffer zone is an area adjacent to an aquatic zone and managed for the protection of water quality and aquatic ecosystems. Ground preparation and other forest operations are curtailed in the zone and drainage channels leading from the felling area must taper out before entering the zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. Brash mats should be used where risk of erosion is high to avoid soil damage, erosion and sedimentation (Forestry Service, 2000a).

The guidelines include the requirement to prevent accumulation of brash, logs and debris in drains and aquatic zones. Temporary crossing points are to be examined regularly and removed, if necessary, to avoid blockages and localised flooding. Following completion of harvesting works debris and sediment should be removed from drains, sediment traps and culverts. Drains damaged during the course of operations should also be repaired. Any temporary structures such as log bridges should be removed immediately after use (Forestry Service 2000b).

The methodology agreed for carrying out felling between ESBI and Coillte included the requirement that existing drains be regularly inspected and maintained. Immediately following clearance of plots on site, the drainage in that area was to be evaluated and any required drainage works carried out. The suitability of new drain designs for the terrain of any given felling area was also to be re-evaluated on site following felling. Silt traps were installed along all newly constructed drains before they entered any pre-existing drainage systems or watercourses and were subject to regular maintenance. Drainage discharges were monitored for suspended solids content to determine the effectiveness of silt traps. All available records of this monitoring noted no cause for concern.

Tree felling was the first action on site in preparation for the construction and installation of the wind farm infrastructure. It began in June 2003, a month prior to civil works commenced, but was interrupted in October 2003 due to the peat slide. In this initial felling period, felling was along a 15 – 40 m wide corridor in order to open up the line of the turbine access tracks and for the 3 no. on-site borrow pits. This amounted to approximately 0.31 km^2 of the 2.22 km^2 of forestry felled within the wind farm site.

A significant feature of the felling over the whole construction period was its diffuse distribution across the site with any derived runoff divided across 9 – 11 distinct subcatchments draining the site. During this period, felling at the Agannygal substation site and on the OHL was also beginning at the wind farm end of the OHL route. The first 0.5 km of the route, all within subcatchment SC7(b), was felled before work ceased in mid-October 2003. Between mid-2004 and September 2005, felling of the remaining 1.91 km^2 on the wind farm of mixed maturity stage forestry and along the remaining OHL route were completed.

The total area of forestry felled on the wind farm site has been apportioned between each of those subcatchments draining the wind farm in Table 11-10 along with the percentage of the overall area of each subcatchment to where it joins the major rivers (i.e. Boleyneendorrish, Owendalulleegh and Duniry). This also includes the smaller areas felled along the section of the OHL that drain to the same subcatchments, i.e. in SC7(a), SC7(b) and SC7(d) and from the southern end of the OHL line at Agannygal which drains towards Lough Atorick. The greatest proportion of felling for the Project was in SC2, SC3, SC7(a) and SC7(c).

Sub-catchment	Area (km^2)	Wind farm Site Area (km^2)	Area felled on wind farm site (km^2)	Area felled on OHL route (km^2)	Felled as a % of subcatchment area
SC1	6.44	0.31	0.18	0	2.86%
SC2	3.17	0.53	0.36	0	11.61%
SC3	0.96	0.22	0.20	0	20.73%
SC4	1.74	0.09	0.09	0	5.06%
SC5	2.22	0.01	0.01	0	0.41%
SC6	5.14	0.06	0.02	0	0.33%
SC7	13.04	2.13	1.26	0.20	11.20%
SC7(a)	5.87	1.11	0.34	0.03	6.27%
SC7(b)	3.02	0.23	0.18	0.12	9.85%
SC7(c)	3.60	0.79	0.75	0	21.04%
SC7(d)	0.61	0	0	0.05	8.20%
SC8	2.81	0.04	0.04	0	1.56%
SC9	6.48	0.05	0.05	0	0.71%
Agannygal / Atorick	2.00	na	na	0.04	2%

Table 11-10 Areas felled in subcatchments influenced by Project

In addition, the OHL route further south includes an additional 11.5 ha (0.11 km^2) of felling that drained over an extensive area within the Owendalulleegh catchment. As the felled areas intersect a large number of subcatchments and the total area felled is small in any one of them, it can be reasonably assumed that the impact of this felling on the hydrological flow regimes of the Project areas would likely have been **Slight to Moderate** and **Temporary to Short-term** and not persisted beyond the construction phase of the project.

11.3.2.1.3 Suspended Solids – Wind Farm, OHL Route and Grid Connection

Construction phase activities including access track, turbine foundation and hardstand construction required earthworks resulting in removal of vegetation cover and excavation of soil and mineral subsoil where present.

The majority of the rock used to construct access tracks, crane hardstanding and for backfilling was sourced from on-site borrow pits / quarries. The estimated volume of rock sourced from wind farm site borrow pits / quarries was 232,000 m^3. The stone material imported comprised of Clause 804 stone for track and hardstand surfacing and 50 mm single sized crushed limestone for surfacing inside the substation compound.

The main factors influencing the rate of soil loss and subsequent sediment release include:

- Climate;
- Length and gradient of slopes;
- Soil type / erosion potential;
- Vegetation / cover;
- Duration and extent of works; and
- Construction erosion and sediment control measures.

Identified potential sources of sediment-laden water included:

- Drainage and seepage water resulting from road and turbine base excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of access road culverts resulting in entrainment of sediment from the excavations during construction;
- Erosion of sediment from emplaced site drainage channels and cleared/regraded existing channels.
- Clear unvegetated ground after tree felling and tracking causing ground disturbance for soiled water runoff

The above activities could have resulted in the release of suspended solids to surface watercourses and could have resulted in an increase in the suspended sediment load, resulting in increased turbidity which in turn could give rise to water quality impacts in downstream waterbodies. Potential impacts would have been **Locally Significant**, **Negative** and **Brief to Temporary** throughout the construction stage if not adequately mitigated against.

Pre-peat slide

Across the wind farm site in general, silt traps in the form of in-stream sumps and straw bales were installed in existing drains where there was potential for pollution to watercourses from runoff from works (Figure 11.10, Plate 11.3). The fact that the site as a whole is fairly flat or gently sloping helped facilitate the effectiveness of these control measures.

At each turbine base during construction, in cases where water ponded in the excavation, this was removed using 4-inch or 6-inch mobile pumps and pumped to a nearby existing drain, often over ground on existing vegetation. Any silt resulting from this pumped water was captured by both existing vegetative matter and constructed straw bales which connected into the local existing drainage. When the turbine bases were completed, a buried drain was installed around the turbine bases, the outlets of which were connected into the surface drainage network.

Figure 11.10 Detail of straw bale filters used throughout wind farm

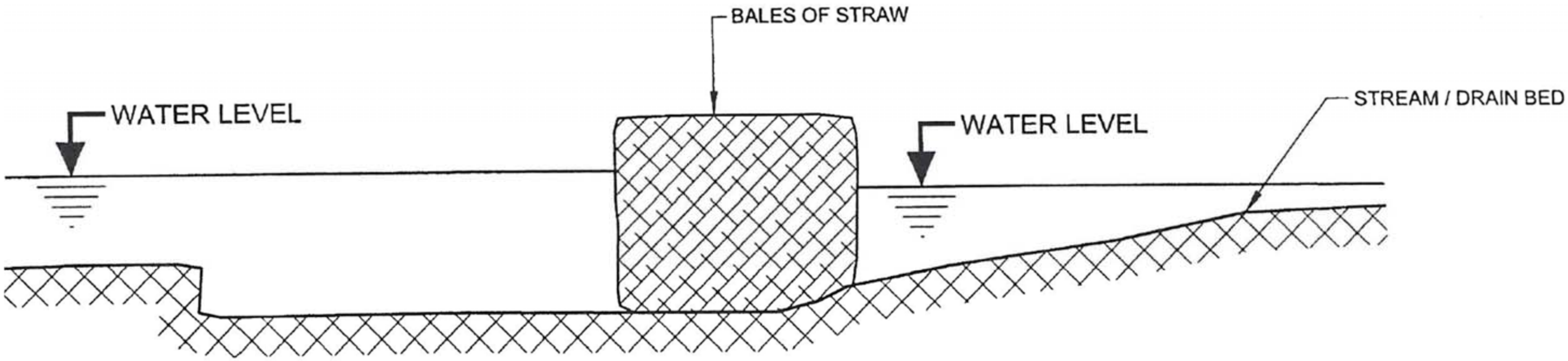


Plate 11.3 Straw bale filter on wind farm site

Given that the new drainage for each of the turbines would not have been inserted until completion of the turbine foundations, the risk of significant washout of solids was minimised.

Post-peat slide

Construction methods associated with all activities were reviewed and revised following the landslide in October 2003. These revised methodologies included additional environmental protection measures. Upon reviewing additional site investigation data collected after the landslide, drainage plans were formulated and agreed between the contractor and ESBI giving due consideration to location of turbine bases, existing site drainage and suitable outfalls points. Where drainage works were designed to provide protection to existing drainage, these were installed before any potentially polluting construction activities commenced.

To specifically address the risk of sediment loss, the main points of interest for remaining works where existing drains exited the site and crossed the site boundary were identified. At all 11 no. of these points silt traps (ST) were installed to manage and control any silt generated by the construction activities (Figure 11.11). ST1 to ST8 were installed on the southern boundary between turbines T12 and T71 where the largest and deepest drains exit the site, and ST9, ST10 and ST11 were installed downstream of T8, T25 and T40 respectively. These silt traps were constructed using straw bale filters to create a settling pond area and filter for the flowing water in the drains. Silt traps were typically 2 m x 2 m x 0.75 m deep depending on the expected flows. Small boulders were placed at the inlet to each silt trap forming permeable barriers at the outlet from the silt trap. 200 mm of single size ¾ inch gravel made up the bed of each silt trap with straw bales placed in front (Figure 11.12, Plate 11.4). A Terram (geotextile) 1000 filter membrane lined the base. Silt traps were monitored on a regular basis to ensure optimal use and when necessary they were cleaned out and/or had the straw filters replaced. These silt traps were removed upon completion of the construction activities.

Some of the peat silt washed from the repositories introduced following the peat slide would have been intercepted in vegetation at the margins of tracks and between these and the drainage system. Residual amounts reaching the surface drains would have been intercepted by silt traps. However, the assumption is made that at least a portion of the mobilised solids would have left the site in all drainage channels draining the site during heavy rainfall events at different stages during the construction phase.

Pre-existing drainage on the wind farm site was maintained and any of this drainage affected by access tracks or turbine base construction was directed into a suitable known watercourse and through a silt trap prior to the water leaving the site. Where works were being carried out in areas of deep peat or poor ground conditions the drains were piped through and backfilled to reduce the risk of sediment loss. Additional measures practised on site to mitigate against the occurrence of silty water included:

- Reducing the amount of mud on haul roads and areas of hardstanding;
- Preventing water entering excavations. Excavations were opened for short periods of time where feasible and drainage water was locally diverted away;
- Controlling surface water runoff from spoil mounds;
- Providing sumps as required for local silt control;

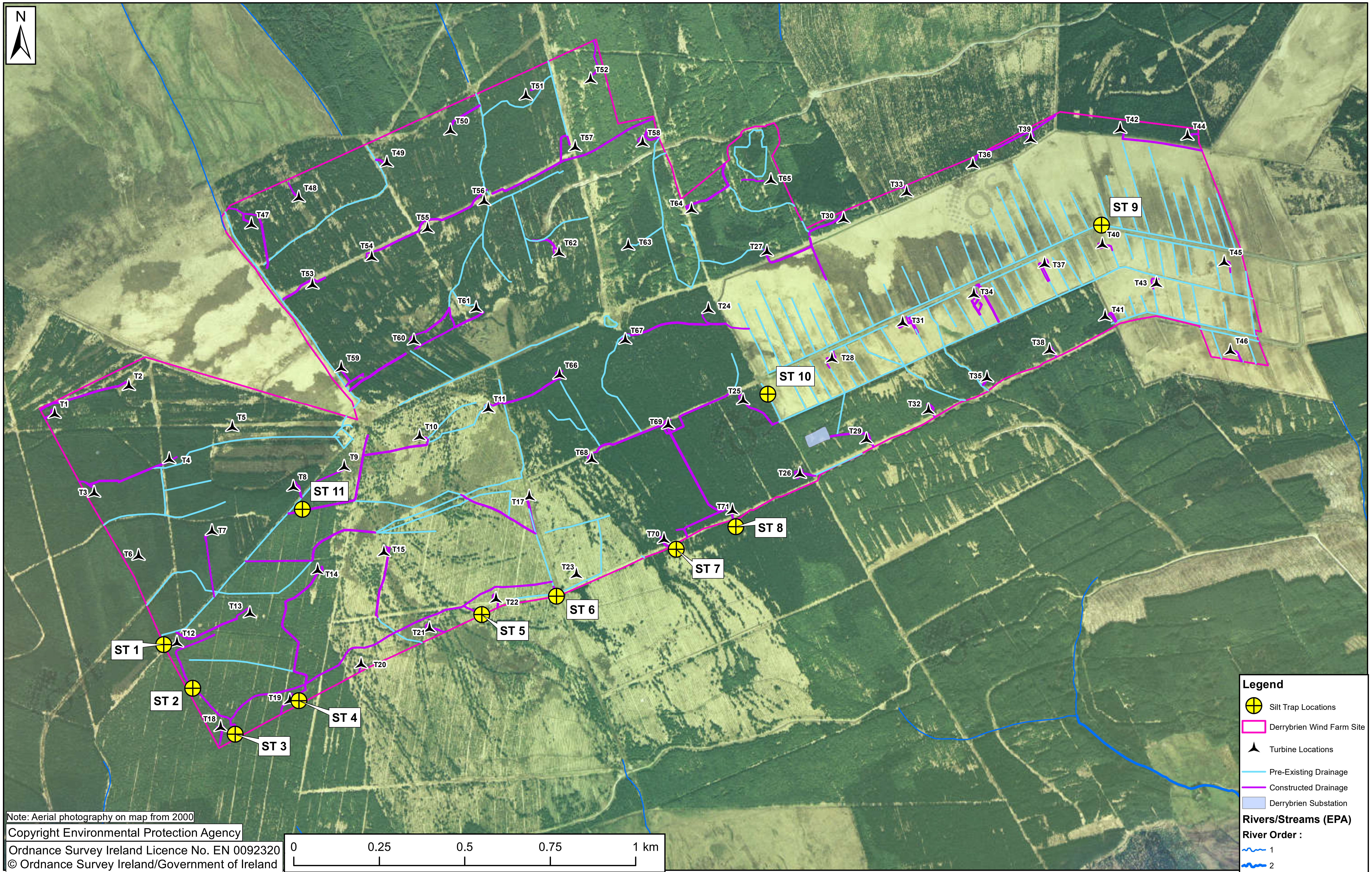


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Figure 11.11 - Locations of Silt Traps during Construction

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Figure 11.12 Construction Detail of silt traps installed at exits from wind farm site

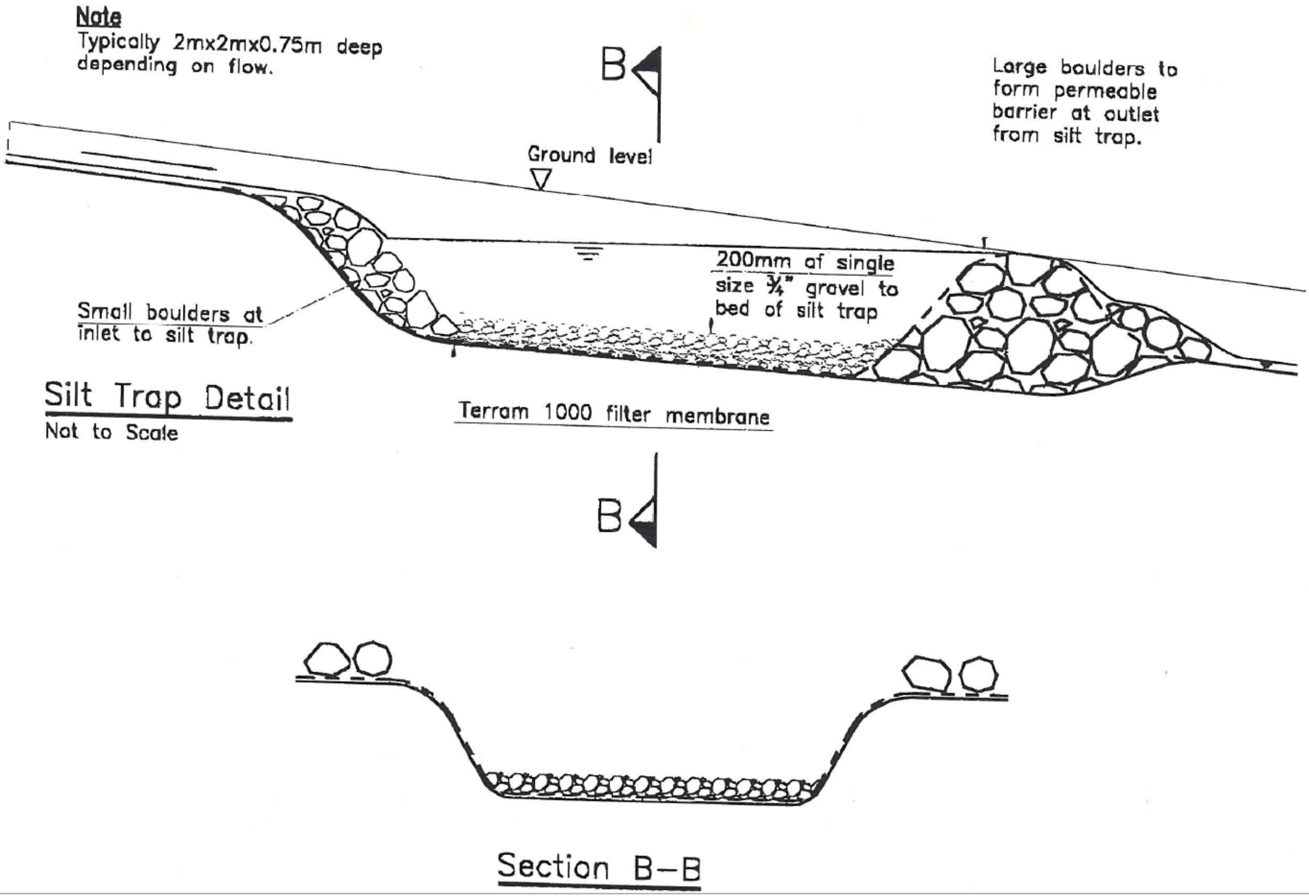

Plate 11.4 Silt trap installed at exits from wind farm site

- Regular monitoring of streams by contractor staff.

Following mitigation, the risk arising from suspended solids is reduced from locally **Significant** to **Not Significant**.

11.3.2.1.4 Suspended Solids - Borrow Pits / Quarries

The 3 no. borrow pits / quarries had the potential to be the source of mineral solids due to washout of dust and mineral solids associated with concentrated heavy vehicle movements, residual solids from the excavation of stone and the excavation of boulder clay. Crushed stone in itself would be unlikely to generate high levels of solids and any generated would be susceptible to rapid deposition as it is coarse in nature. Constant movement of heavy machinery at entrances could increase the amount of fines available to be washed out at these locations. Given the **Temporary** nature of the activity, there was an **Imperceptible to Slight** risk to Local surface water channels as by their nature borrow pits are more likely to retain solids within their boundaries.

Regarding the local hydrogeology there was a potential impact as a result of dewatering borrow pits / quarries and turbine bases on site. Borrow pit / quarry areas were up to 11 - 13 m deep and based on the known shallow groundwater depths from geotechnical investigations, had the potential to encounter a lot of groundwater. Groundwater inflows in this case would therefore have needed to be pumped, resulting in a short-term localised drawdown of the water table and discharges to the surface water channels. The negative potential impact of this on the local groundwater is classified as **Imperceptible to Slight** given the **Temporary** nature of the activity, the poor aquifer and relatively impermeable overburden.

11.3.2.1.5 Hydrocarbons and Cement

Oils and fuels were used in plant and equipment during the construction phase. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to groundwater, surface water and associated ecosystems. The accumulation of small fuels and lubricant spills from site traffic can also be a pollution risk.

Hydrocarbons, at high concentrations, have a high toxicity to humans and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in death of aquatic organisms. Spillages arising from the use of concrete for construction of turbine foundations and hardstanding areas pose a risk if not properly managed. Concrete, particularly the cement component, is highly alkaline and any spillage to a local watercourse would be detrimental to water quality and associated fauna or flora.

The potential impact of spills was **Slight to Moderate** and **Negative** on the **Local** environment and **Brief** throughout the construction stage.

A number of mitigation measures were put in place to address the risk to both surface and groundwater. Concrete wash-out areas were established for the purpose of capturing wash-out water from ready-mix concrete lorries. All concrete lorries delivering ready-mix concrete to the site were required to wash-out their vehicles at these specific wash-out points upon completion of their concrete deliveries and prior to exiting the site. Spill kits were available and used to deal with any minor or localised oils and / or fuels from the machinery in operation at the site and the re-fuelling of that machinery. Drip trays were used during refuelling.

Following mitigation the risk arising from hydrocarbons and cement is reduced from **Slight to Moderate** to **Not Significant**.

There is record of one spill taking place during Project construction when a concrete lorry overturned on the main turbary access track on the eastern side of the wind farm site. The contents of the lorry required washing out by Gort Fire Brigade before the lorry could righted onto the road using a Hyundai 360 tracked excavator. The contractor, after initially unsuccessfully attempting to flush out the concrete from the bottle of the lorry, excavated a hole in the bog into which the concrete was flushed and subsequently removed. The drains in the vicinity were blocked to prevent runoff from the immediate area.

11.3.2.1.6 Wastewater

Release of effluent from domestic wastewater treatment systems has the potential to impact on groundwater and surface waters if site conditions are not appropriate for an on-site percolation unit. Due to the low permeability of the subsoils associated with the Project area, surface waters are more likely to be susceptible to impact than groundwater.

The main toilet facilities on site during construction were at the site compound in the north-eastern corner of the site. The toilet facilities were comprised of a self-contained toilet block with a temporary holding tank for managing sewage and wastewater. These facilities were removed upon completion of the construction works. There were also circa 9 no. self-contained portaloos purpose designed for temporary use located around the wind farm site.

Without appropriate mitigation the impacts from discharging untreated wastewater from these facilities would be expected to be **Slight to Moderate** but **Brief** on the environment throughout construction.

The portaloos were serviced and maintained on a regular basis during the construction activities. All toilet facilities were sealed with no discharge to the surface water or groundwater environment adjacent to the site. This reduces the risk rating to for this impact to **Not Significant**.

11.3.2.2 Offsite peat slide works: October 2003 – March 2006

Following the peat slide event in October 2003, extensive studies and investigations were carried out on the wind farm site, including a full review of the drainage within the site, landslide area and affected areas downstream.. Measures were undertaken as required by geotechnical experts, Galway County Council and Coillte to contain and minimise the impact of the peat slide.

The nature of peat slides such as that which occurred at Derrybrien is that they typically occur upslope from natural watercourses. As such, the failed peat becomes fluidised into a remoulded peat slurry that flows down into the river valleys directly inundating the river. The peat slurry can have significant run-out distances along the river valleys, and where the volume of peat exceeds the capacity of the valley it can spread out over the surrounding land to either side of the valley. Where rivers or streams cross public roads the peat can block culverts or bridges, sometimes overtopping the road and blocking public access.

The offsite measures to minimise the impact of the peat slide included the installation of a 10 no. barrages, two within the wind farm boundary with the remaining eight, (of which four remain in place) along the route of the slide on Coillte land between the wind farm and Flaggy Bridge on the R353.

The assessment of the potential impacts of the offsite peat slide works from a hydrological and hydrogeological standpoint is discussed below. Note that section 11.5.1.1 provides further details on the impacts caused directly by the peat slide and the remediation measures it necessitated.

11.3.2.2.1 Drainage Diversions

Surface runoff from the part of the site where the peat slide originated formed streams of concentrated flow within the slide area that fed into the river downslope from the site. This is the river forming subcatchment SC7(b). Among the emergency measures taken to stabilise the slide area (and which has remained in place since) was the diversion of drains away from both sides of the slide area and upstream of it on the wind farm site. This was achieved by digging new drains along the route indicated in Figure 11.13 in the weeks following the initial slide. These diverted drains would ultimately join up within the same river subcatchment a short distance downstream of the slide area. The work was carried out over a few days from the 30th October 2003. Where new drainage was constructed in a wooded area, minor tree felling within these commercial forestry areas was carried out to create a corridor of sufficient width to allow an excavator to excavate the drain. A watercourse downstream of the peat slide area was also re-routed just upstream of the Black Road bridge around displaced peat in the neighbouring privately-owned land. Approximately 0.012 km^2 (1.2 ha) of tree felling within commercial forestry was required in order to gain access for the diversion drain.

Following the initial peat slide mitigation measures, the contractor was instructed to carry out further precautionary drainage measures as follows:

- Improvement of drainage in the slide area of the wind farm, clearance of obstructions and release of any visibly trapped water and construction of silt traps;
- Cleaning out of 3 no. gorges (pre-existing narrow steep-sided streams adjacent to offsite repositories) including construction of areas locally from available materials (trees, brash, boulder clay, etc.) to store removed peat, removal of sidecasting of the removed peat, provision of silt traps as necessary and possible reduction of rock barrage;
- Re-establishment of the original stream and access road at Black Road Bridge to include construction of areas to store removed peat from available materials (trees, brash, boulder clay, etc.), removal and sidecasting of the removed peat, provision of silt traps as necessary.

In general, the drain diversions had a **Permanent** but **Imperceptible** downstream hydrological impact, both in the short- and long-term.

11.3.2.2.2 Offsite Peat Repositories

Peat displaced by the landslide had accumulated in large quantities on land upstream of Black Road Bridge. This was placed in a newly constructed repository on the left-hand bank of the watercourse. Additional repositories were constructed to store peat excavated for the construction of two barrages.

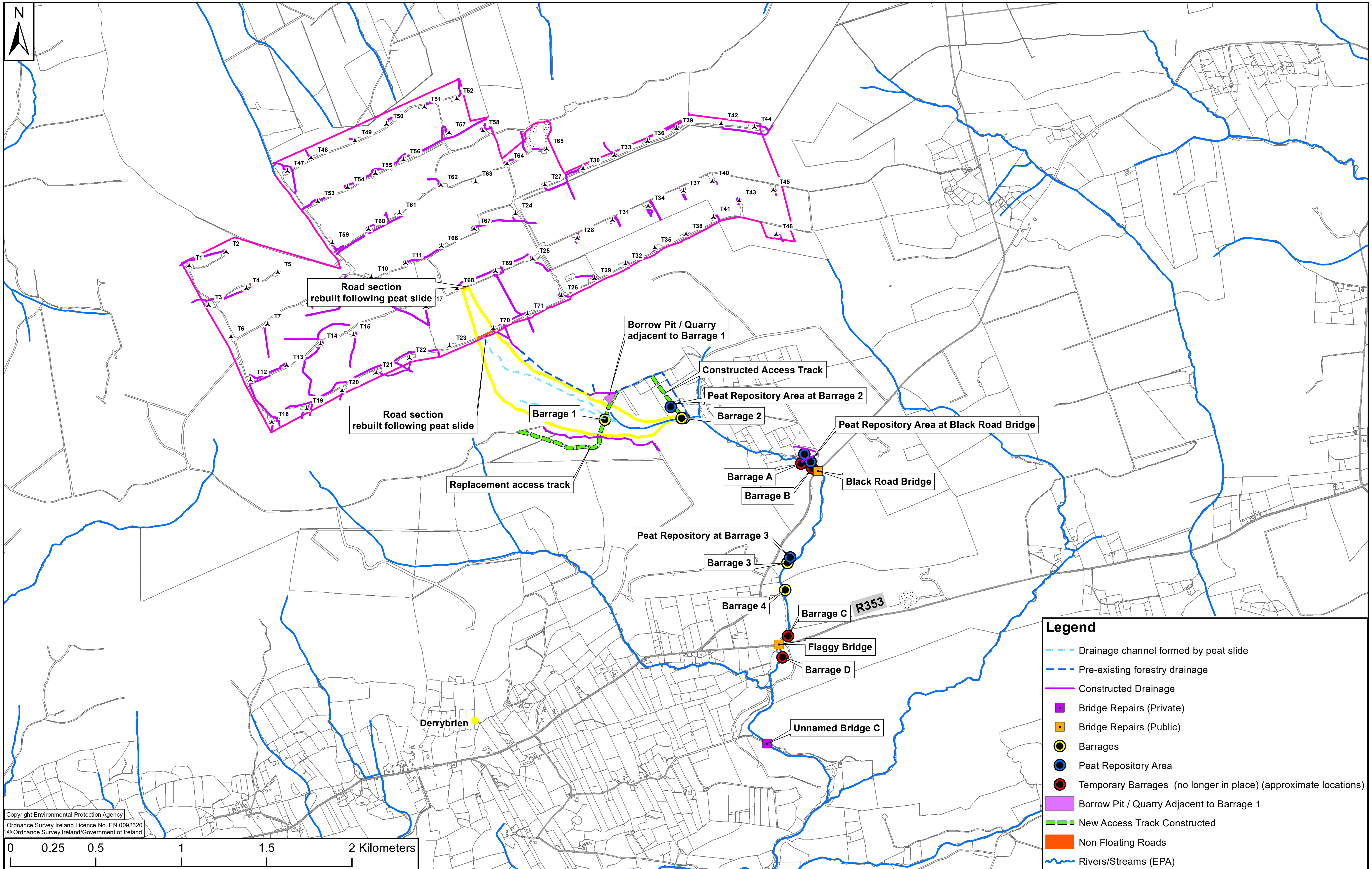

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Figure 11.13 - Emergency Works in aftermath of Peat Slide 2003-2004

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Apart from the requirement to divert drainage around the repository upstream of Black Road bridge (discussed above), there were no hydrological impacts from their construction. As such, the repositories had an **Imperceptible** hydrological impact, both in the short- and long-term.

11.3.2.2.3 Hydromorphology

Hydromorphology refers to the physical form, condition and processes with a surface waterbody. After the heavy rains of October 30th, 2003, a very large mass of peat and associated surface woody and herbaceous vegetation advanced downstream under the weight of the fluidised peat. Just over a month later in December 2003 a walkover survey of the entire 20 km of channel from Flaggy Bridge downstream to Lough Cutra was undertaken by the officers of the then Shannon Regional Fisheries Board (ShRFB) in order to establish the extent to which the peat and debris had progressed down the Owendalulleegh catchment, and to gauge the type and degree of damage to riverine habitats caused. The survey was undertaken over a period of two weeks in favourable weather conditions.

The physical nature of the river downstream of the slide area was altered following the slide. The most detailed available record of these physical impacts on the river is a study undertaken by Inis Environmental Services in association with ESBI and the Shannon Regional Fisheries Board (ShRFB) (Anon, 2004). The most severe impacts associated with the landslide were in the upper reaches of the river. In these areas, the energy of moving peat, water and debris was greatest, and resulted in the near total loss of vegetation and scouring of the riverbed in some parts. Parts of the channel were re-aligned due to the force of the peat flow. Heavy deposition of peat on the banks also occurred in this area. The Inis study did not include the reaches upstream of Flaggy Bridge as part of its survey. The area between Flaggy Bridge and Unnamed Bridge C was noted in the report as being among the most heavily impacted areas of the river with strong scouring and removal of all instream vegetation. There were large amounts of peat deposited on the river margins with sand banks evident at river bends. The riverbed was scoured with gravels and rocks transported downstream.

There was damage noted directly above and around a culvert running under a Coillte access track between the two bridges. However, no repair works were required and water continued to be conveyed downstream here due to the porous nature of the surrounding rock structure. Downstream of Unnamed Bridge C there was less scouring but large amounts of siltation was evident. The peat slide is therefore classified as having a **Slight** (further downstream) to **Moderate** (upstream) effect on the hydromorphology downstream of the slide area. The effect is considered to have only been **Short-Term** as the environment was judged by Inis in subsequent surveys to have recovered back towards pre-slide conditions in the following years.

11.3.2.2.4 Containment Barrages

In order to control the passage of the peat slide, 8 no. barrages were installed along the route of the slide from the boundary of the wind farm site downstream to just below Flaggy Bridge.

Details of each barrage are summarised in Table 11-11. To facilitate these works and to further reduce the risk from the flowing peat, an extension to an existing Coillte track was constructed to access the site of Barrage 1 from the west and another to access Barrage 2 from an existing Coillte track on the eastern side of the slide.

Barrage	**Typical Dimensions (long m x wide m x high m)**	**Comments**
Containment Barrage 1 (Coillte Road)	140 x 6 x 2	Located within slide source area. Access directly from existing Coillte track
Containment Barrage 2	15 x 5 x 6	Located within incised section of stream. Access via constructed floating access track 300 m (long), 3 m (wide)
Containment Barrage 3	15 x 3 x 3	Located across stream. Access via constructed access track from Black Road on Coillte land 100 m (long), 3 m (wide)
Containment Barrage 4	20 x 3 x 3	Located across stream. Access via constructed access track on Coillte land 100 m (long), 3 m (wide)
Temporary Containment Barrage A	Estimated: 80 x 3 x 3	Located upstream of Black Road Bridge. Barrage removed sometime after slide event Access direct from existing road
Temporary Containment Barrage B	Estimated: 80 x 3 x 3	Located upstream of Black Road Bridge. Barrage removed sometime after slide event. Access direct from existing road
Temporary Containment Barrage C	Estimated: 20 x 3 x 3	Located upstream of Flaggy Bridge on R353. Barrage removed sometime after slide event. Access direct from existing road
Temporary Containment Barrage D	Estimated: 20 x 3 x 3	Located downstream of Flaggy Bridge on R353 Barrage removed sometime after slide event Access direct from existing road

Table 11-11 Details of containment barrages

From a hydrological perspective, the deliberately porous nature of the barrage structures allowed water to flow through without any excessive build-up of water on the upstream side of each structure. In a number of cases drainage pipes enabled the flow of water through the structure. The barrages were each constructed to prevent further propagation of the peat slide and to prevent possible further release of debris into the watercourse downstream. As a consequence of this silt, peat and other debris did build up on the upstream side of a number of barrages (Plate 11.5). If this material was not removed the impact of the barrages from a hydrological perspective is classed as **Moderate** due to the knock-on effect of the barrages Upon completion of the construction stage, the four temporary containment barrages were removed while Barrages 1 to 4 were left in place, as shown in Figure 11.13 (Note: the access tracks at T68 and between T23 and T70 also act as rockfill containment barrages but are not considered in isolation due to their position at the top of the subcatchment as part of the overall on-site wind farm drainage system).

Plate 11.5 Sediment build-up at upstream end of Barrage 4 in 2018

11.3.2.2.5 Downstream Water Quality

The impacts of the peat slide event on downstream water quality are discussed in detail in Chapter 8 Aquatic Ecology.

The slide had a **Profound**, **Short-Term**, **Negative** impact on the riverine habitats all along the small tributary of the Owendalulleegh directly impacted by it. The impact in question stretched from the wind farm as far as the confluence with the main channel of the Owendalulleegh and for the first 1 – 2 km of that channel below the confluence of that stream. For most of the remaining 16 – 17 km downstream to Lough Cutra, there was evidence of build-up of peat, silt, woody debris in diminishing concentrations and of sand in slower flowing stretches. At the outlet to Lough Cutra effects from the peat slide were barely perceptible with the 4 km^2 lake effectively acting as a strong buffer to downstream changes in suspended solids concentration and a peat sink.

11.3.2.3 Operation Phase: 2006 – Mid 2020

11.3.2.3.1 Flood Risk / Flow Rates

The pre-existing drainage system (i.e. pre-2003) consisted of previously dug longitudinal drains and stream channels which discharged surface drainage waters off site to the local river systems. The majority (27 km out of 39 km) of drainage channels on site prior to construction were ditches that had been dug prior to the wind farm Project and ran parallel to existing floating access roads on one or both sides of the track to avoid problems of localised ponding. These pre-existing drains were retained as operational drains for the wind farm. The remaining 12 km of road drainage was constructed for the wind farm Project and connected into the pre-existing site drainage. Figure 11.14 shows the network of open drains on the site, both existing former drainage (cyan) and constructed collector drainage (magenta), all of which was retained following commissioning of the wind farm.

All of the constructed channels are narrow open drains (Plate 11.6), typically 0.5 to 1.5 m deep, with culverts under the site access tracks. Where the peat is shallow the drains penetrate into the underlying glacial till. However, in deeper peat (greater than 1 – 2 m deep) the drains are only excavated into the peat and more easily eroded by streamflow. At the east end of the site the drainage network reflects the outline of the turbary plots in that area of the site. Over the rest of the site the pre-existing drains / watercourses have been retained and newly constructed drains connect the turbine foundation drainage to the watercourses.

The use of floating roads, which accounts for 18.8 km of the 19.7 km of on-site access tracks (the 2.0 km of tracks existing on site which pre-existed the Project were all floating roads), facilitate rainwater infiltration into the peat layer beneath and as such generally do not require additional road side drainage with rainwater falling onto the road allowed to spill over the edge into the undisturbed peat. Floating roads are sympathetic to the natural drainage as they act neither as a barrier nor as a deep wide permeable drain that would dewater the adjacent saturated peat into its formation layer and convey elsewhere with the gradient of the road.

However, depending on local topography, some concentration of flows and preferential pathways are unavoidable unless suitable drainage is put in place. The 4.5 m wide roads were comprised of 0.6 – 1.0 m of crushed rock granular fill with 1-2 layers of geogrid reinforcement and a basal reinforcing layer of small trees and branches placed directly on the vegetated surface of the peat.

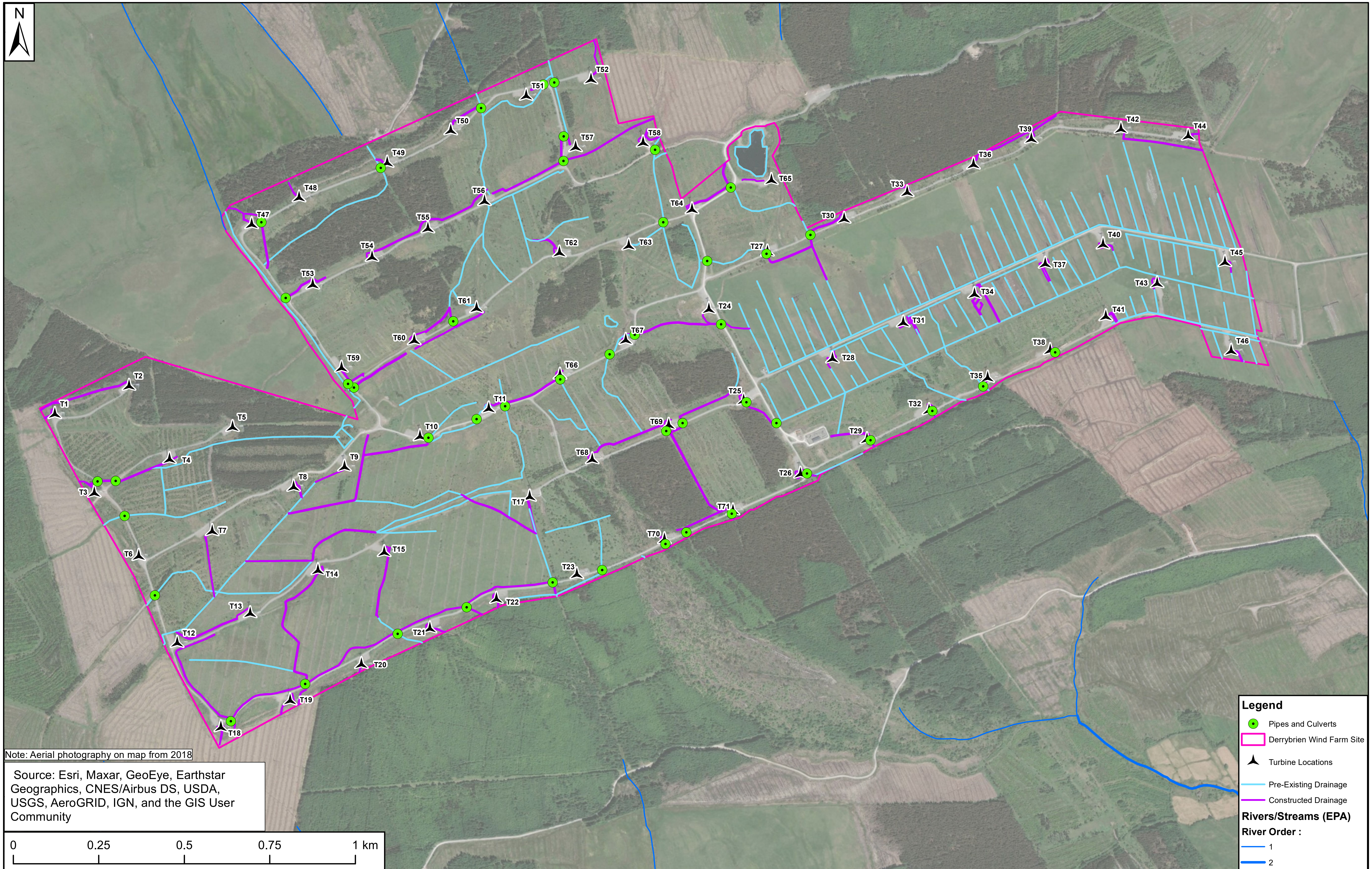

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Figure 11.14 - Wind Farm Pre-existing & Constructed Drainage

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Plate 11.6 Typical drain installed during wind farm construction

Culverts were constructed at various wind farm access road crossings so as to maintain the conveyance path of the pre-existing and constructed drains crossed and thus prevent excessive ponding of water on the uphill sides of these roads. The culverts installed are necessary to maintain the drainage runs and avoid unnecessary diversion of drainage on the site. The culverts are mainly located under tracks on the edge of the site, as indicated on Figure 11.14. The outlet drains exiting the wind farm site are all pre-existing drainage channels with the exception of the drainage channels formed following the October 2003 slide.

During the post-construction phase of the wind farm, the drainage network has experienced a variety of large storm events. These have ranged from intense short-duration events in which approximately 60 mm of rain fell in 24 hours (as measured at Gort Derrybrien II Met Station) (7th June 2012, Storm Desmond on 5th December 2015) to long-duration winter rainfall events which saturated the wider area (November 2009, December 2015 to January 2016, February 2020).

The drainage network on the wind farm has to date demonstrated sufficient capacity to convey heavy flows without excessive flooding of access tracks and turbine bases or erosion of drainage channels. Similarly, the drainage network associated with both substations have no record of flooding issues since commissioning (14 years). The Flood Risk associated with the Project is discussed in more detail in Appendix 11.A.

The change in land use in some areas from pre-construction “Greenfield” to gravel and concrete (with associated drainage efficiency) was, along with tree felling and improvements to the drainage network, responsible for any theoretical increase in flood flows downstream beyond the immediate vicinity of the wind farm. Overall it is considered that the wind farm development through constructed drainage and additional drainage has increased the flood runoff rate over its former forestry and turbary uses from a high runoff category to a very high runoff category. The modelling assessment of the effect of drainage associated with the wind farm (Appendix 11.A) showed a minor local increase in the predicted mean annual flood flows leaving the wind farm site. This synthesised flow increase is not significant in respect of the downstream receiving watercourses and as such did not result in any significant increase in flood risk or changes to river/stream channel morphology. It was concluded based on past studies (refer to Appendix 11.A) on the subject that any impact the tree felling associated with the construction activities would have on downstream flood peaks and volumes could reasonably be expected to dissipate and not have any perceptible impact beyond the local scale. Similarly, at a broader regional scale, where downstream floodplains would be more sensitive to any increased flood risk, it has been concluded in Appendix 11.A that any increases in flood peaks and volumes would be imperceptible. The impact overall this has had on flood risk downstream is described as **Not Significant** at the scale of major rivers and areas prone to flooding to **Slight** within the subcatchments which have undergone the most tree felling. The duration of the impact has been **Momentary to Brief** (i.e. minutes to hours) given the small size of the subcatchments.

11.3.2.3.2 Drainage Issues

The wind farm Project introduced additional drainage and as such required increased maintenance and inspection of a number of on-site drains. The drainage solution for the wind farm was not designed to extensively lower the water table level but focused on collecting and conveying surface water runoff away from the turbine bases and therefore for the scale of the

3.44 km^2 site does not represent a substantial network of drainage channels over its former use.

Poor drainage at turbine bases can give rise to local stability issues. If water levels rise above the base foundation of a turbine during periods of high wind speeds, overturning of the base is a potential risk. There is a potential impact of such a long-term risk if there is not an appropriately designed drainage network put in place at construction stage.

Drainage installed at each of the turbine bases during construction stage generally consisted of a buried land drain around the perimeter of the turbine base. The outlet of each land drain is to an open drainage channel, which was specifically installed to transfer the water to one of the existing main drains within the site. As required at specific turbine excavation locations, existing drains were re-routed around the excavation area when they were present. This ensured the continuing operation of drainage in the area and non-entry of silt into the existing drains.

The permeable area of the 110kV Derrybrien Substation and Agannygal Substation sites constructed as part of the wind farm project were finished on 50 mm single size clean compound stone. The permeable compound stone provides a means of attenuation of runoff and allows rainwater to infiltrate to ground as it would typically on a Greenfield portion of the site. Rainwater from the roof of the control buildings, which is considered the cleanest runoff from hardstanding areas, connects via downpipes away from the compound into the wind farm drainage system. The concrete access road within the compound is cambered to drain to the permeable compound stone. Agannygal substation also includes a system of land drains and catchpits around its perimeter. No drainage issues that have not already been mitigated in the design of the substations are expected to arise going forward through the remainder of the operational life of the Project.

The effectiveness of the surface water drains on the wind farm site had the potential to be reduced due to blockages from peat bank slippages into drains and from heavy vegetation growth either inside the drains or to their side walls. Inadequate falls in some drains could also result in ponding water. It is noted that the potential impact on the stability of foundation bases without an appropriately rigorous inspection and maintenance regime is moderate to significant with respect to peat stability (see Chapter 10 – Soils & Geology) but only **Slight, Local** and **Brief** with respect to hydrology.

Regular maintenance has been carried out as necessary since commissioning of the wind farm. Drainage inspections are carried out monthly and following heavy rainfall or snow events. In addition to this, periodic geotechnical inspections have identified drainage maintenance issues which generally involve localised clearing out and maintaining sections of site drains. This mitigation reduces the risk of drainage issues arising to **Imperceptible**. Most maintenance issues arose in the first few years following commissioning and have reduced since. These included clearing out blocked drains at inlets or outlets, deepening or widening drains to increase capacity and flattening of side slopes along access tracks at the main watercourse crossings, regrading drains that were shown to have insufficient fall and repair or replacement of collapsed culverts.

During the first periodic inspection in November 2006 shortly after commissioning, poor drainage around wind turbines was noted at several locations around the site. This resulted either from the drain around a wind turbine or a drain outside the turbine area impeding water flow due to vegetation growth, inadequate fall or settlement of the drainage pipe at the cable crossing. In some instances, stagnating water was observed around wind turbines while in others, signs of dampness were noted on the turbine foundation.

In one instance, Turbine T35 was at one periodic inspection identified as being vulnerable to a sudden increase in water level due to its level and proximity to one of the existing drains leaving the site and potential blockage of a single 600 mm diameter culvert under the adjacent track road downstream of T35. In response to this risk an additional 600 mm diameter pipe was installed at this location along with a screen upstream of this to capture any removed peat and vegetation debris (Plate 11.7 and Plate 11.8). No further drainage issues have arisen in this area since these works were completed and only routine drainage maintenance is now required.

Road widening on roads in the locality of the wind farm site necessitated lengthening of culverts and other minor modifications of existing drainage crossings below relevant sections of road. This has not led to any known impact with regard to drainage.

11.3.2.3.3 Water Quality - Hydrocarbons

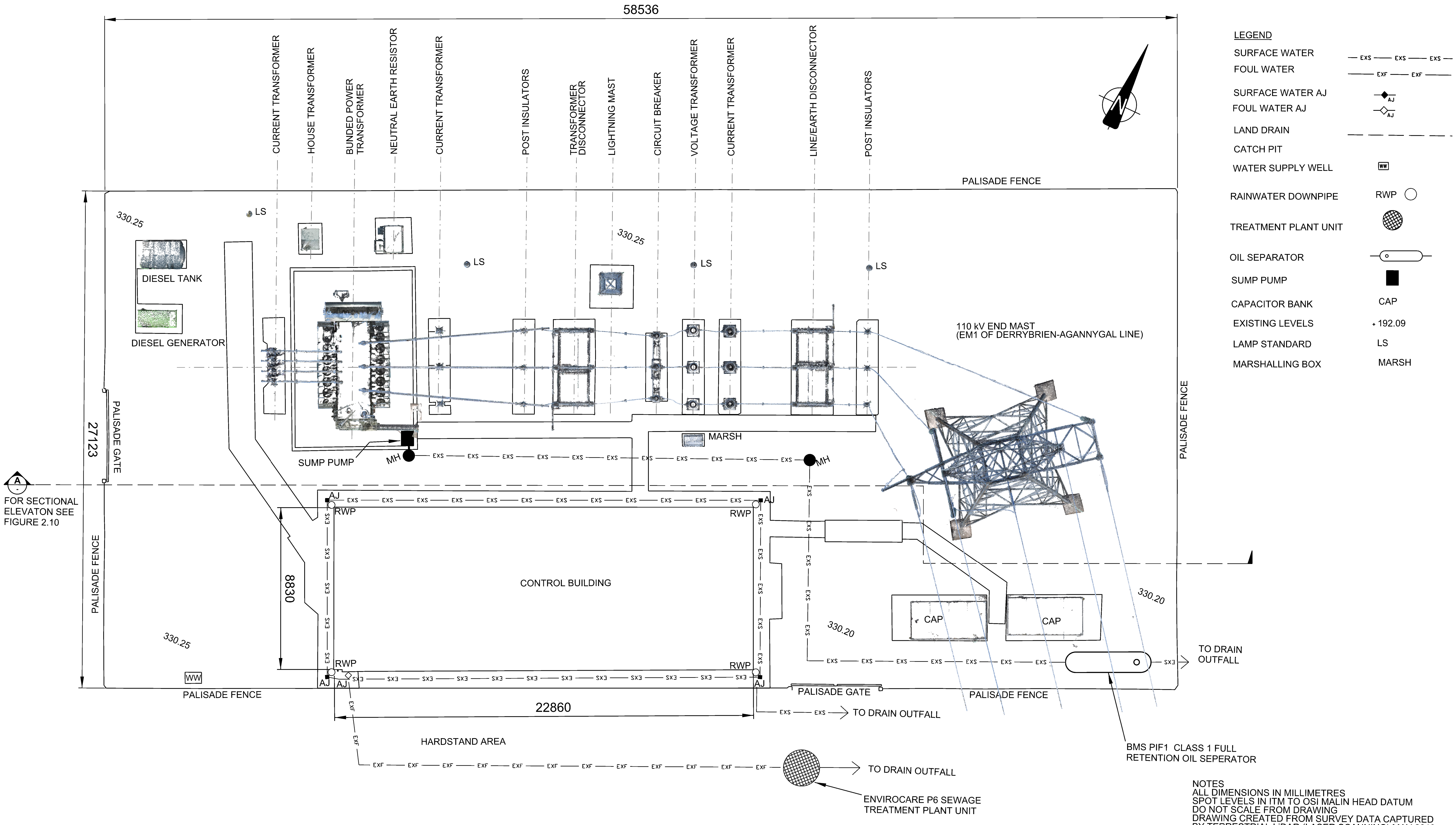
There have been two known past incidents of oil-spills on the wind farm, in 2017 and 2019 respectively. In the first such incident, a spill kit was deployed around the base of turbine T56 before oil reached ground and the leak was subsequently stopped. In the second incident, a bleed screw was left not fully tightened after a service was carried out on T5. This caused 150 litres of oil to leak from the gearbox with some of it leaking down the side of the wind turbine tower and getting to the ground. Vestas technicians contained the spill using the contents of the spill kit.

The Derrybrien 110kV substation consists of a control building and associated electrical equipment with an outdoor area including concrete footings and a step-up transformer inside a fenced off compound area. Other aspects of note relating to drainage include a reinforced concrete transformer bund support, and oil separator, an effluent treatment system and a well supplying non-potable water supply (Figure 11.15). Clean surface water drainage from the control building roof is collected by guttering and downpipes and directed to the substation site drainage system. Elements of the electrical plant, primarily transformers, may contain oil for insulation purposes. The released hydrocarbons would have the potential to percolate to ground or contaminate surface water runoff from the substation if not properly managed. To mitigate this hydrological risk, a pump sump is provided with a float switch outside the transformer bund. This is a proprietary pump that only allows water discharge to take place when no oil is detected. This is connected to a BMS (Butler Manufacturing Services) Ltd. PIF Class 1 Full Retention Oil Separator which discharges to a wind farm drain outside the substation boundary. This provides an adequate treatment prior to discharge to the wind farm drainage network. Regular inspections are carried out to ensure this system is in correct working order. As such, the drainage design put in place has no perceptible effect and requires no further mitigation.

Agannygal Substation includes a control building, an effluent treatment system, and a well supplying non-potable water to the control building (Figure 11.16). Clean surface water drainage from the control building roof is collected by guttering and downpipes and directed

Plate 11.7 Twin 600 mm pipes at crossing near T35

Plate 11.8 Location of T35 in relation to crossing point



NOTES
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Rev.	Date	Revision Description	Drn.	Prod.	Ver.1	Ver.2	App.

Purpose of issue - Preliminary unless indicated
Client Approval ☐ Planning ☐ Tender ☐ Construction ☐ As-built ☐

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Energy for generations

Client: GORT WINDFARMS LTD.

Project: DERRYBRIEN WIND FARM PROJECT

Contract:

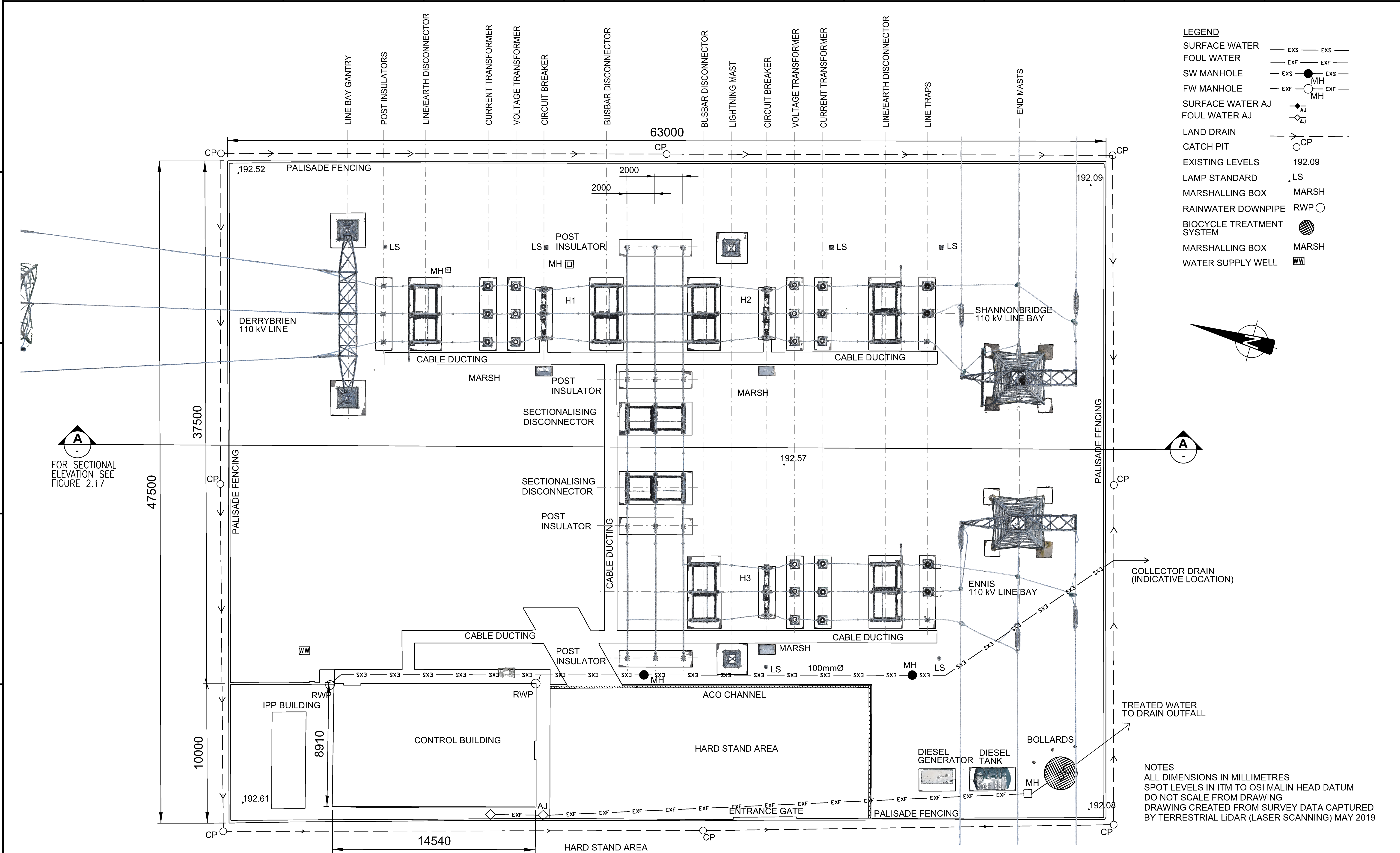
Production Unit: CIVIL & ENVIRONMENTAL ENGINEERING

Drawing Title: FIGURE 11.15
DERRYBRIEN 110 kV SUBSTATION
LAYOUT PLAN

DRAWN	PRODUCED	VERIFIED 1	VERIFIED 2	APPROVED	APPROVAL DATE
P.CARROLL	P.CARROLL	C.DOLAN	H.GRIFFIN	P.KAVANAGH	07/05/2020

CLIENT REF	No. OF SHTS	SIZE	SCALE
Client Ref. No.	-	A3	1:200

Drawing Number: QS-000280-01-D460-012-011-000
SHEET REV



Rev.	Date	Revision Description	Drn.	Prod.	Ver.1	Ver.2	App.

Purpose of issue - Preliminary unless indicated
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Energy for generations

Client: GORT WIND FARMS LTD.

Project: DERRYBRIEN WIND FARM PROJECT

Contract:

Production Unit: CIVIL & ENVIRONMENTAL ENGINEERING

Drawing Title: FIGURE 11.16 AGANNYGAL 110 kV SUBSTATION LAYOUT PLAN

PLANNING

DRAWN	PRODUCED	VERIFIED 1	VERIFIED 2	APPROVED	APPROVAL DATE
P.CARROLL	P.CARROLL	C.DOLAN	H.GRIFFIN	P.KAVANAGH	07/05/2020

CLIENT REF	No. OF SHTS	SIZE	SCALE
Client Ref. No.	-	A3	1:250

Drawing Number: QS-000280-01-D460-012-012-000 (SHEET / REV) to the substation drainage system. Land drains surrounding the substation compound collects surface water runoff which does not drain to ground. All surface water ultimately drains downhill offsite along the edge of the access road constructed to the substation and discharges to an existing drainage channel.

11.3.2.3.4 Water Quality - Wastewater

The welfare facilities in the control building of the Derrybrien 110kV substation consists of one toilet and two sinks. The intermittent presence of maintenance staff at the substation leads to the generation of foul sewage from these facilities. If discharged offsite untreated, there would be a slight impact on local downstream water quality. An Envirocare P6 sewage treatment plant unit caters for the wastewater generated in these facilities. It is regularly serviced under a maintenance contract with Environmental Services.

At Agannygal Substation wastewater is adequately treated by a Biocycle wastewater treatment system before discharge off site.

11.3.2.3.5 Containment Barrages

As discussed in section 11.3.2.2, all the barrages pose no significant risk of acting as miniature reservoirs for floodwaters which could overtop and lead to sudden, larger releases of water downstream. As the barrages are highly permeable structures composed of boulders in which in some cases drainage pipes are provided (Barrages 1 and 2) it is not expected that it could cause a substantial build-up of water. The remaining barrage structures are also stable enough that a relatively sudden build-up of water in a large flood event is not expected to damage the integrity of any barrage itself. As such, from a hydrological perspective, the impact of the remaining barrages on the flow regime is deemed to be **Not Significant**.

The build-up of silt, peat and debris on the upstream side of the remaining barrages causing potential blockages is seen as a non-significant risk. Barrages 1 and 2 have only required a small amount of debris clearance since commissioning, most recently in 2009. Barrages 3 and 4 have not required any clearing out of debris since commissioning and only small amounts of accumulated sediment or debris was evident on the most recent site visits (see Chapter 10 – Soils & Geology) (Plate 11.5). As such, the containment barrages also pose a **Not Significant** flood risk as they are sufficiently wide and porous to convey flood water through them.

11.3.3 Impacts which are occurring

This section considers and assesses the hydrological and hydrogeological impacts associated with the operation of the Wind Farm Project that are still occurring. Surface water generated on the site since construction has continued to drain predominantly as it had under pre-development conditions, discharging to existing established drainage channels through the site. Access tracks and structures are generally located on relatively high areas and on / near local watershed boundaries, away from rivers. There has been no development on the site since the end of construction and activities are confined to operational and maintenance works.

11.3.3.1 Construction

No construction activities have taken place in the Project area since commissioning of the wind farm. No impacts associated with the construction phase addressed in section 11.3.2 continue to affect the hydrological or hydrogeological environment, either because the described impacts are no longer relevant, or mitigation measures have successfully addressed the risks.

11.3.3.2 Operation

11.3.3.2.1 Flood Risk

As discussed in the Flood Risk Assessment (Appendix 11.A), there is no significant increase to date in the risk of flooding arising in the wind farm Project areas during the operational stage. It can be concluded that most of the Project areas are not within floodplains and lie within Flood Zone C (Low risk of flooding) as defined by the guidance document to Planning Authorities in relation to Flood Risk Management. Furthermore, the existing flood risk in the downstream catchment has not to date and is not expected to be increased by any works over the operational life of the wind farm. Several elements of the wind farm infrastructure are vulnerable to pluvial flooding in extreme rainfall events. However, it is judged that the Project satisfies the criteria set out in the Justification as part of “The Planning System and Flood Risk Management – Guidelines for Planning Authorities”.

The wind farm Project is therefore considered to be in overall compliance with the objectives of the above Guidelines. It therefore has not and is not anticipated to give rise to any significant impacts related to flood risk locally or downstream of the site (see Appendix 11.A).

11.3.3.2.2 Drainage Issues

There is no engineered storage or attenuation of surface water runoff provided on site before discharging to receiving watercourses. Runoff water from the gravelled turbine bases and roads is discharged as over the edge drainage distributed over the entire site with limited concentration of wind farm site drainage to single point outfalls. The relevant footprint comprises turbine bases and hardstanding, access tracks, one electrical substation on the wind farm site, OHL route and Agannygal substation. During storm events increased runoff coupled with higher velocities of flow has the potential to increase hydraulic loading, resulting in localised erosion of watercourses and impact on aquatic ecosystems.

The effectiveness of the surface water drains on site has the potential to be reduced due to blockages from peat bank slippages into the drain and from heavy vegetation growth either inside the drain or to its side walls. Inadequate falls in some drains can also result in ponding water. Regular maintenance will continue to be carried out as necessary until the end of operation and decommissioning of the wind farm. Drainage inspections will continue to be carried out monthly and following heavy rainfall or snow events. In addition to this, periodic geotechnical inspections shall identify drainage maintenance issues to be addressed by the wind farm manager.

The risk ratings associated with the wind farm drainage are as discussed in section 11.3.2.3

11.3.3.2.3 Water Quality – Suspended Solids

Water quality impacts potentially arising during the operational phase of the wind farm are considered to be limited to minor low-level siltation or pollution impacts on the minor watercourses within the site. This would give rise to **Not Significant** effects on water quality in the nearest receiving watercourses before dissipating further downstream.

11.3.3.2.4 Water Quality – Hydrocarbons and Cement

Due to the nature of the project there have been and continue to be vehicles periodically on site at any given time of year. The potential effects are limited by the size of the fuel tank of the vehicles using the site. As a result, there is a possibility of occasional accidental emissions in the form of oil, petrol or diesel leaks which could cause **Slight, Temporary** and **Local** contamination of site drainage channels. To date there is no record of any such incidents occurring.

11.3.3.2.5 Water Quality - Wastewater

Foul waste is treated and disposed within Derrybrien 110kV substation by an Envirocare wastewater treatment system. There are generally 4-6 staff on site during the week who use the office associated in the substation control building and so demand for the facilities which generate foul flows is low. Treated water from the substation discharges offsite within subcatchment SC7(a). The Biocycle unit servicing wastewater generated in Agannygal substation has very low demand, catering to a low number of staff on an infrequent basis and the treated effluent is discharged to the surface drainage system. The water quality effect of this is **Neutral** and **Long-term**.

11.3.3.2.6 Suspended Solids - Borrow Pits / Quarries

The locations of Borrow Pit / Quarry no.1, 2 and 3 (approximately 0.46 ha, 0.42 ha and 1.72 ha respectively) are indicated on Figure 11.14 and have not been in use since commissioning. Borrow Pit / Quarry no. 1 and no. 2 were reinstated to the original ground level prior to completion of works on site. Borrow Pit / Quarry no. 2 is noted as occasionally being prone to pooling on its east side. It is not clear whether this is groundwater coming to the surface or ponding rainwater disconnected from the wind farm drainage network (i.e. local pluvial ponding within the depression area of the borrow pit).

Borrow Pit / Quarry no. 3, located to the northern end of the site, has only been partially backfilled back to its original ground level since commissioning. It has maintained a water level below the level of the access road immediately to the north. The relatively high groundwater level, at approximately 2 m below the original surface level, is consistent with ground investigation information discussed in section 11.2.5.2. The level of groundwater in the pit is constant throughout the year at approximately 2 m below the road. In the highly unlikely scenario that the water in the pit were to fill up to the top, a connecting drain and culvert under the wind farm access road has been constructed to convey water away without affecting traffic entering or exiting the site. As a health and safety precaution the area is fenced off to restrict access.

Therefore, the presence of the borrow pits / quarries poses an **Imperceptible** risk either to the surface or subsurface environment for the remainder of the Project life.

11.3.3.2.7 Cutting back of tree re-growth at wind farm

Where trees in previously felled areas grow back, some cutting back of trees (or tree topping) is undertaken. To date only limited tree topping has been carried out. Further cutting back of tree regrowth may be required over the remainder of the operational phase of the wind farm Project. Potential impacts during cutting back of tree re-growth occur mainly from:

- Exposure of soil and subsoils due to vehicle tracking and skidding or forwarding extraction methods resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses.
- Damage to roads resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses.

In order to optimise energy production, it has been necessary to clear-fell some of the maturing forestry adjoining the wind farm site. This was undertaken in 2016, 2017 and 2018 immediately beside the western boundary, south-western and north-western corners of the wind farm. The total area felled came to 0.462 km^2 under felling licence (Ref FL 18197). It should be noted that much of this forestry was already ear-marked by Coillte for commercial felling as it was coming to maturity.

The effects of cutting back tree re-growth are localised and **Brief to Temporary** in nature and are expected to be **Local** in extent and **Slight** over the operational life of the wind farm or during decommissioning.

Relevant mitigation measures for this risk are discussed in section 11.5.2.2 and if properly implemented should reduce the risk to **Imperceptible**.

11.3.3.2.8 Cutting back of tree regrowth on OHL Route

Several watercourses exist within the footprint of the OHL route, the largest being the Owendalulleegh River, approximately 6.0 m wide, which passes beneath the OHL halfway between pole sets 25 and 26, approximately 150 m from both.

Streams and ditches in the vicinity of the OHL have typically been regraded for use as forestry drainage where land use is commercial forestry. It is reported that this commercial forestry was established in the 1960s and 1970s. This is consistent with observations made on site that several areas had been clear felled and replanted prior to the wind farm Project. The ongoing maintenance of the line's corridor requires that maturing trees will be cut, with the first cut carried out in 2019. The felled material is left on the ground reducing the opportunity for ground damage due to timber extraction. The diffuse nature of this work means that impacts in terms of increased suspended solids and nutrient run-off to streams is likely to be low and of short duration. This impact can be described as **Not Significant**, **Local** and **Temporary**.

Relevant mitigation measures for this risk are discussed in section11.5.2.2.

11.3.4 Impacts which are likely to occur

11.3.4.1 Mid 2020 - end of operational phase

As no significant works are planned on site from October 2019 until decommissioning, the impacts and associated mitigation measures associated with routine maintenance (i.e. drainage, cutting back of tree regrowth, etc.) are likely to be no different than those described in section 11.3.3.2.

The only non-routine maintenance works of note that may take place on the wind farm is widening of the narrow turbary road to turbine T45 to provide safe access to the turbines for a large mobile crane. This would involve constructing an additional 2 – 3 m width of floating road directly on the surface of the intact peat on the upslope side of the existing road. This work will not have a perceptible impact on local hydrology.

11.3.4.1.1 Peat failure affecting wind farm drainage

As discussed in Chapter 10 – Soils & Geology, the impacts of site activities during the remainder of the project operation and maintenance phase that could influence the peat with respect to site stability are limited to:

- The increased dead load on the floating roads where they are locally resurfaced or repaired;
- The live load surcharge of the large mobile cranes or heavy low-loader transporters on the floating roads;
- The occasional live load surcharge on the intact peat slopes from low ground-bearing pressure excavators or harvesters carrying out tree-topping or localised repairs on the existing network of drains or cable ducts;
- The additional dead and live load surcharge on the peat along the widened turbary road between Turbines T31 and T45 (if required).

The assessment of stability impacts for this phase of the wind farm Project (2020 to c. 2040) indicates that the probability of occurrence of peat failure precipitating from any expected activities over this period are either Negligible, Low or Very Low. As such, the probability rating of a peat failure leading to the blockage of drainage lines and increasing sediment loading in channels draining from the wind farm is deemed to be **Unlikely,** i.e. it can reasonably be expected not to occur if all mitigation measures are properly implemented. In this case appropriate mitigation measures to be implemented to keep the probability of peat failure low is discussed in detail in Chapter 10.

11.3.4.2 Decommissioning

Decommissioning of the Project would result in the cessation of renewable energy generation at the end of the operational life of the wind farm with the removal of various infrastructural elements. It will involve the removal of the above ground elements of the wind farm and will entail:

- De-energising of the site which will involve initially high voltage (HV) disconnection followed by low voltage (LV) disconnection of turbines;
- Controlled dismantling of turbines (blades, nacelle, and tower) and masts.
- Removal of Derrybrien and Agannygal substations and associated buildings.

- Removal of the OHL poles and mast elements from the OHL corridor for re-use and if necessary, disposal in accordance with the relevant legislation
- Removal of de-energised underground LV cables, electrical control systems and ducts.

The following elements of the wind farm will be left in place after decommissioning:

- The reinforced concrete turbine bases;
- All of the site access tracks including the floating roads on the peat;
- The crane hardstanding areas adjacent to the turbines;
- The hardstanding area for the two substations and control buildings;
- The site drainage network;
- The on-site peat repository/storage areas from construction stage; and
- The borrow pits.

Turbine bases, crane pads and drains are to be left in place. As the vast majority of roads are floating, they can remain in place without the need in principle to maintain associated drainage because they allow for natural infiltration, interflow and saturated groundwater flow. There will be no requirement for additional drainage associated with the decommissioning of the Derrybrien wind farm. Over time the drains will likely fill in and revegetate naturally and become less effective over time. The wind farm site will therefore revert over time to a more natural drainage regime similar to its pre-wind farm Project baseline environment. By the time of decommissioning the groundwater levels on the site will have stabilised at a new equilibrium steady state condition. As the efficiency of the drains reduces in the long term a gradual partial restoration of groundwater levels on the site will occur.

11.3.4.2.1 Turbine Removal

Concerning the hydrological impacts, there is the potential for impact on a number of the receptors as a result of turbine removal operations including accidental release of hydrocarbons associated with increased site traffic. These are expected to have a **Slight Local Temporary one-off Negative** impact on the surface and subsurface water environment.

11.3.4.2.2 Grid Connection Removal

This will involve the dismantling and removal of all superstructures associated with the OHL and Agannygal substation. This includes all building structures, equipment, pole sets, masts and electricity lines. This does not include the removal of access tracks, hardstanding or foundations. Demolition of the control building will be carried out on the hardstand areas with mechanical demolition equipment and hydraulic breakers for the reinforced concrete foundations. There will be no blasting on the site. All demolition waste will be removed from the site.

Impacts associated with building structures, as with turbine removal, are associated with site traffic on the OHL Route which if not properly managed could result in accidental releases of hydrocarbons. These are expected to have a **Slight Local Temporary one-off Negative** impact on the surface and subsurface water environment.

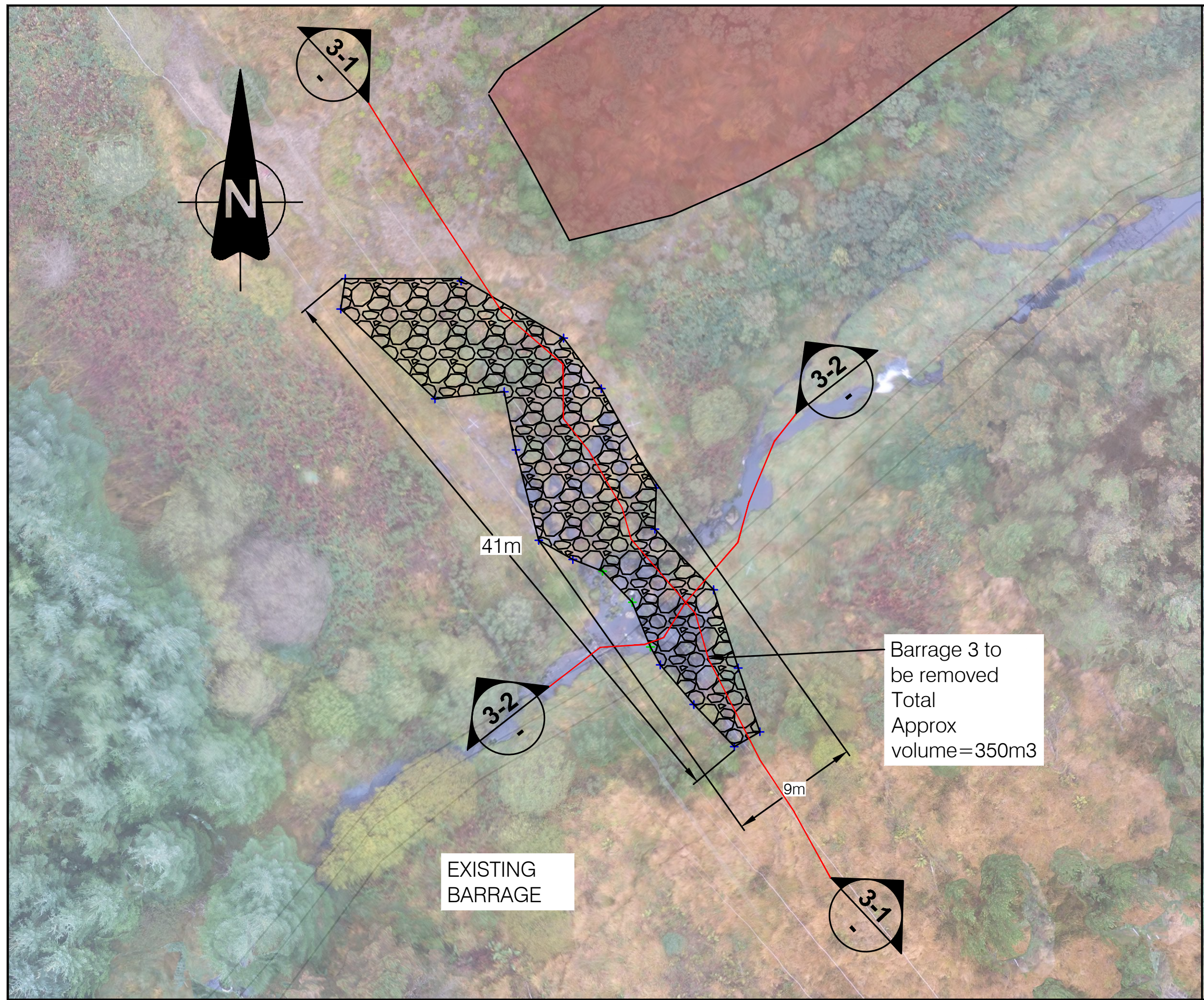
11.3.4.2.3 Containment Barrages

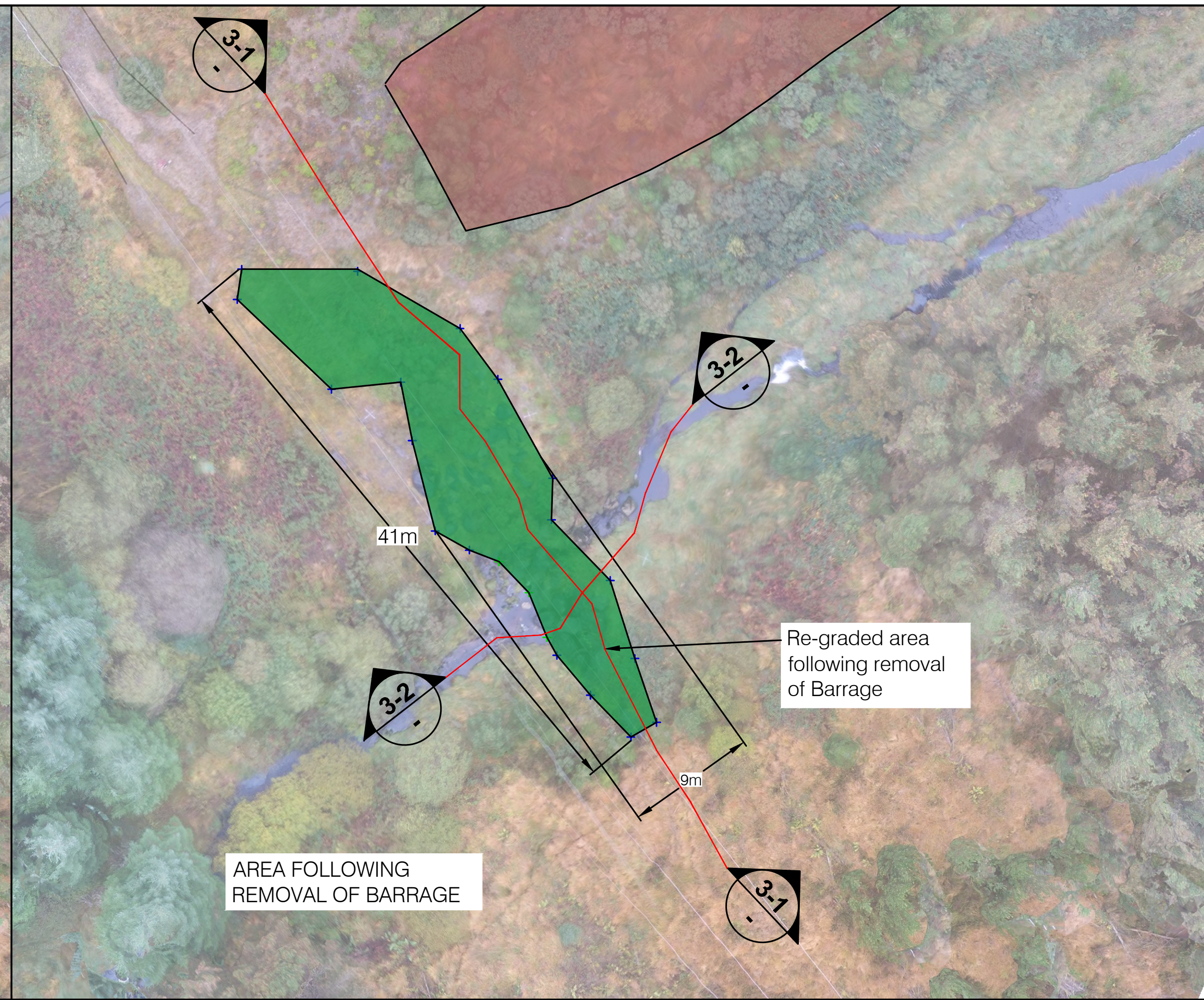
With regard to the off-site features remaining as of 2020, it is planned that Barrages 1 and 2 shall remain in place while Barrages 3 and 4 shall be removed (Figure 11.17 and Figure 11.18). Without appropriate mitigation measures, the removal of the barrages will have a **Slight** one-off **Temporary Negative** impact on the hydrological regime at the subcatchment level.

For each of the barrages to be decommissioned, works shall be undertaken after at least 4-5 days of dry weather and during a period when further dry weather is expected, preferably between the months of May and September inclusive to allow for vegetation growth on the banks ahead of the next winter. In-stream works shall be carried out in accordance with the “Guidelines on Protection of Fisheries during Construction Works in and adjacent to Waters”. Contact shall be made with Inland Fisheries Ireland (IFI) prior to works commencing including agreement of methodology and timing.

The works at each barrage are expected to last no more than one week. Each watercourse shall be blocked upstream of the works area using sand bags and a timber weir and the remaining water shall be over-pumped. The pump will be bunded and located away from the watercourse and a have a silt bag on its outlet. A tight mesh will be fitted on the suction hose before pumping commences. Water will be discharged to vegetation, preferably on the downstream side of the barrage. Where an existing watercourse profile / channel passes through the location of the barrage it is desirable that the natural profile of the watercourse and neighbouring banks are preserved by matching the reclaimed channel section as closely as possible with the upstream and downstream channel sections. However, the barrage locations have a high gradient such that flows following rainfall will be high velocity and may cause significant erosion of the banks. For this reason, care will be taken to ensure the restored banks are gradually sloped back from the channel to the neighbouring banks to mitigate the risk of erosion and collapse of the banks. All elements of the barrage structures will be removed to Borrow Pit / Quarry 3.

Upon completion of these decommissioning works, the weir and sand bags will be removed slowly to prevent a surge in the river. Silt fences will be installed on the stream-side of the banks and the other side spread with grass-seed to encourage re-vegetation. Provided these mitigation measures are put in place during decommissioning the impact on the hydrological regime will be reduced from Slight to **Not Significant**.

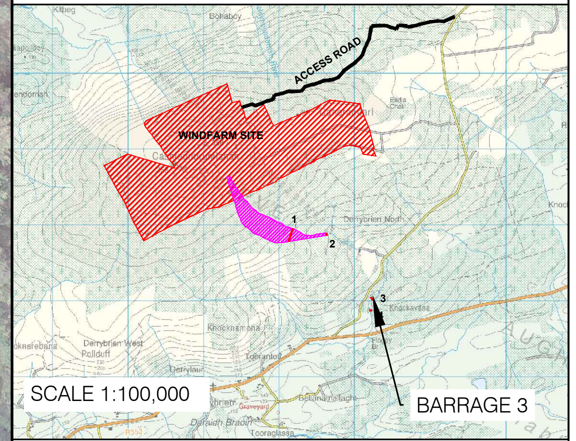




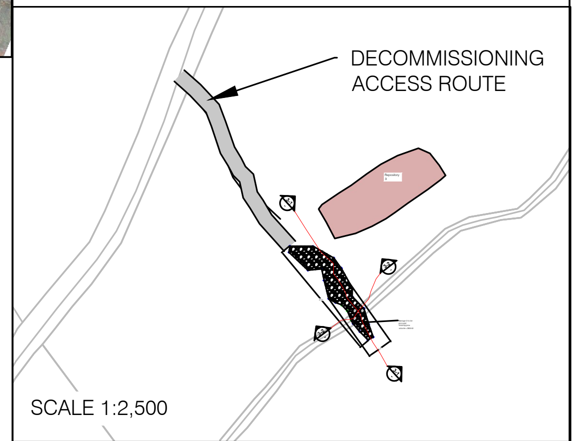
LEGEND

- Stone Barrage
- Re-graded Barrage area
- Re-graded ground level

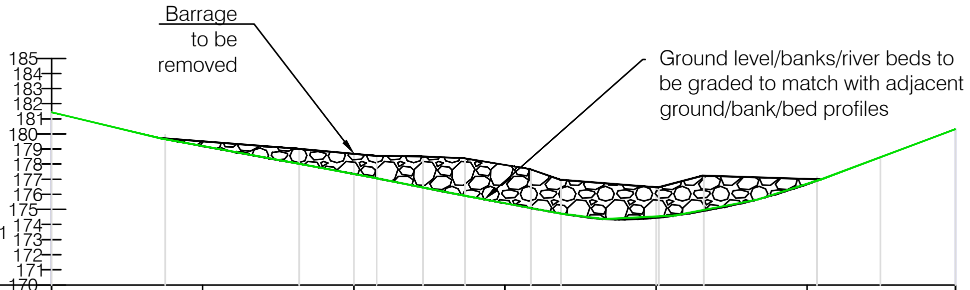
KEY PLAN



DECOMMISSIONING ACCESS ROUTE-BARRAGE 3



BARRAGE 3 SECTION 1
SCALE: 1:500



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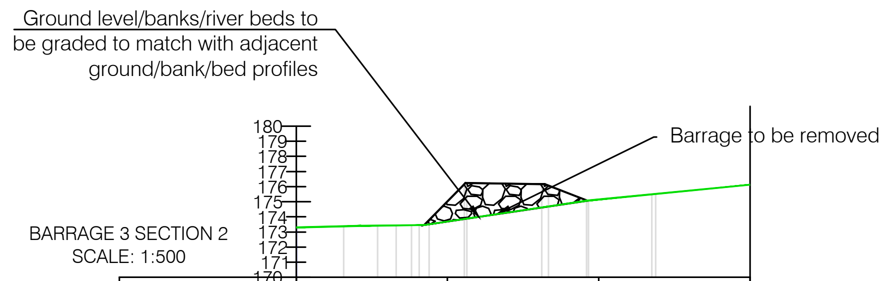
Existing Ground	181.4	179.7	178.7	178.0	176.5	177.2	180.3

BARRAGE 3 SECTION 2
SCALE: 1:500



Chainage	00.000	10.000		20.000	30.000
Existing Ground	173.3	175.0	176.2	175.1	176.1

Decommissioning Plan For Barrage:

1. Reference chapter 11 for details of removal works plan

Rev	Date	Revision description	Drn.	Prod	Ver.	App
0	07.05.20	Issued for substitute consent	LMcM	LMcM	MB	ROD

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Engineering and Major Projects is a division of ESB.

Client: **Gort Windfarms Ltd**

Project: **Derrybrien Wind Farm Project**

Contract:

Drawing title: **Figure 11-17 Barrage 3 Removal**

Production unit: **Civil & Environmental Engineering**

Drawn	Produced	Verified	Approved	Approval date
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Client ref.	No. of sheets	Size	Scale
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Drawing number: QS-000280-01-D460-012-013-000 SHEET REV

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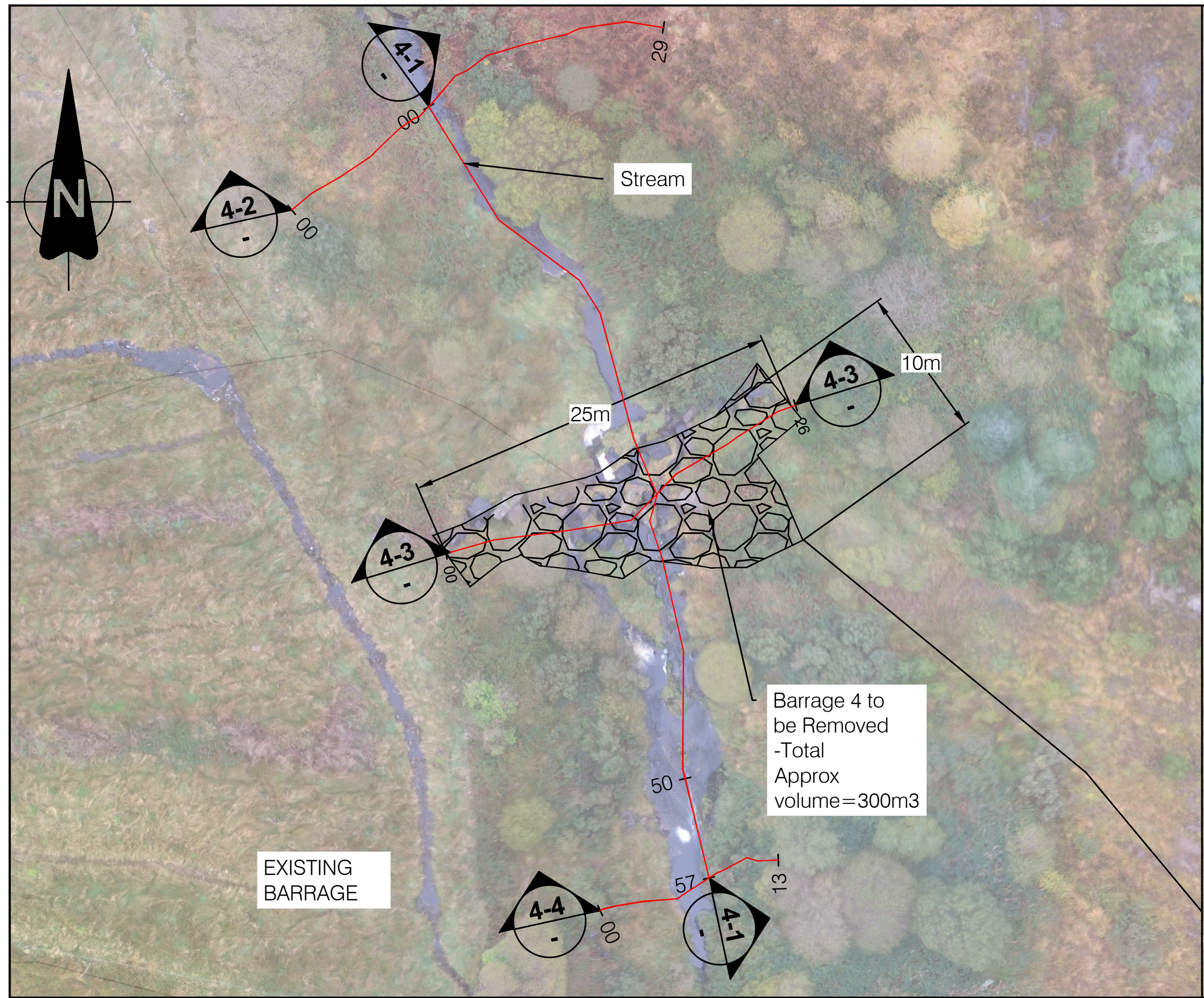
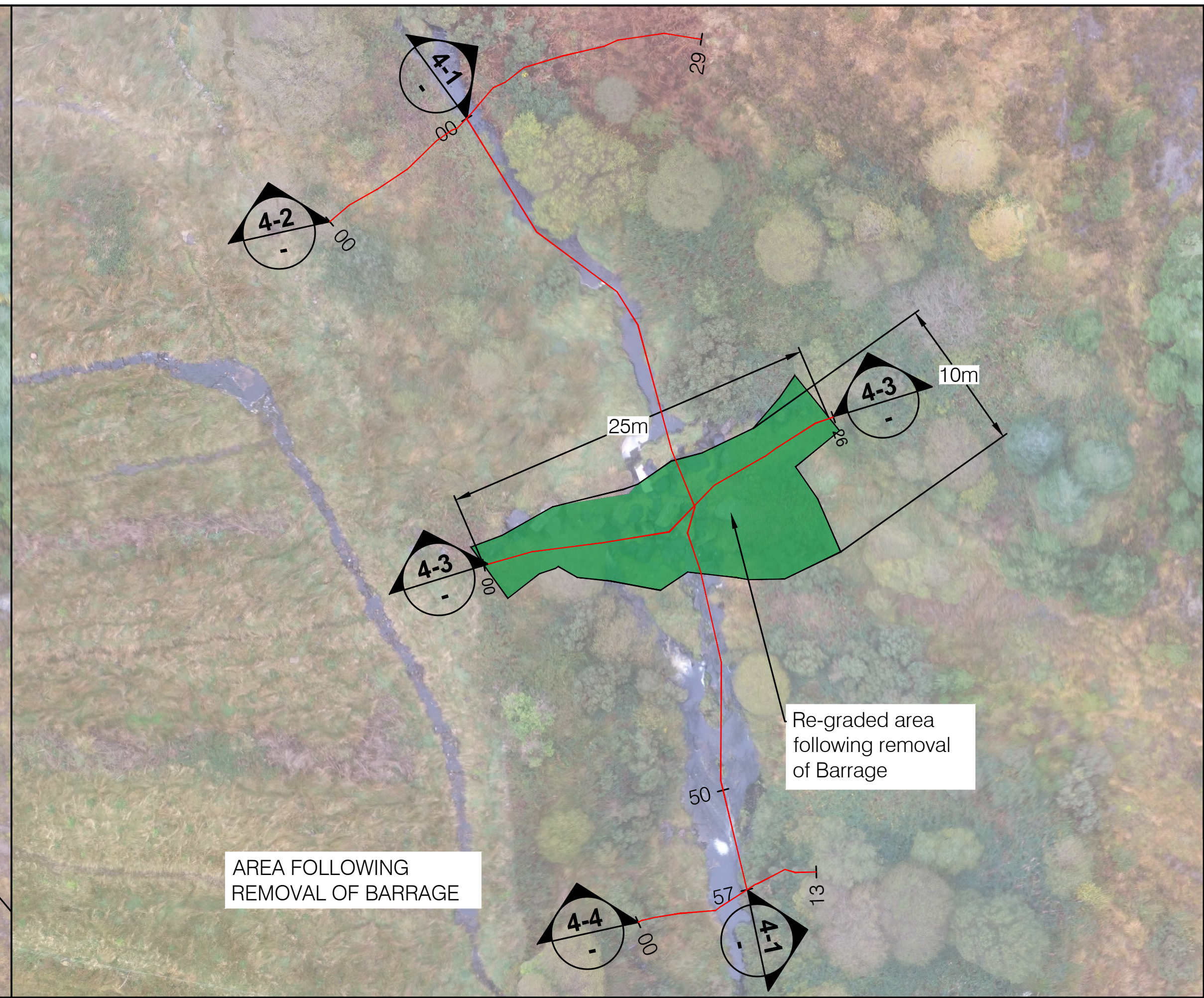
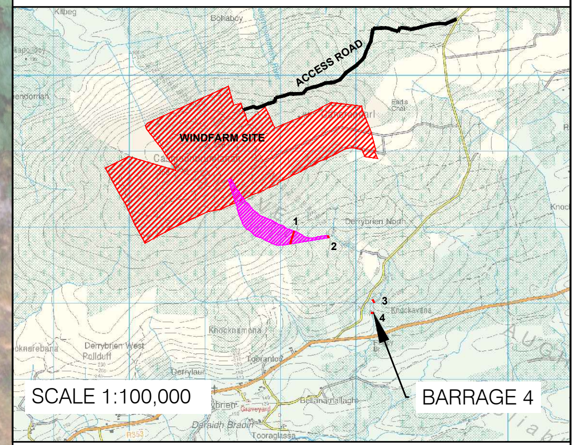




LEGEND

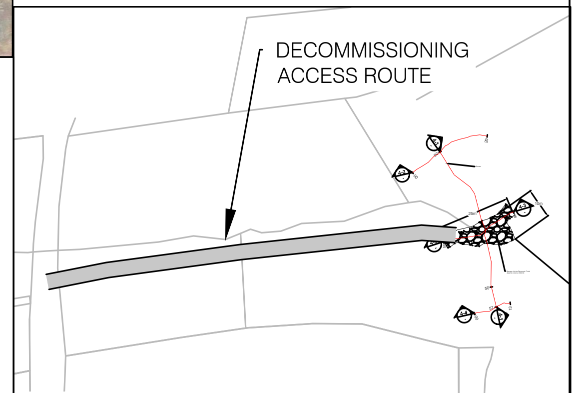
- Stone Barrage
- Re-graded Barrage area
- Re-graded ground level

KEY PLAN



SCALE 1:100,000

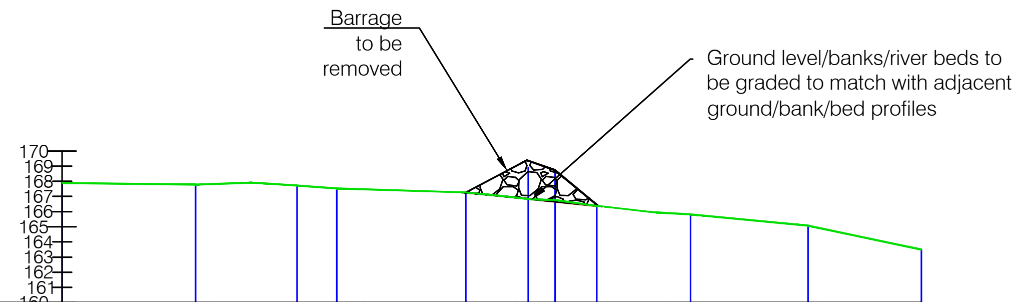
DECOMMISSIONING ACCESS ROUTE-BARRAGE 4



SCALE 1:2,500

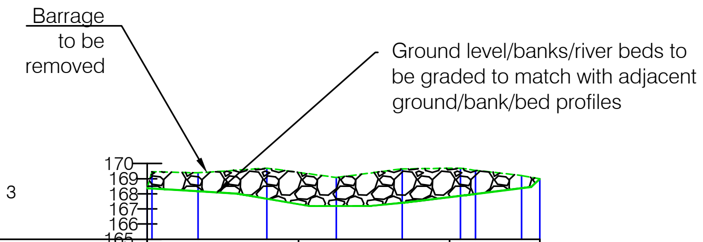
Decommissioning Plan For Barrage:

1. Reference chapter 11 for details of removal works plan



BARRAGE 4 SECTION 1
SCALE: 1:500

Chainage	00.000	10.000	20.000	30.000	40.000	50.000	56.803
Existing Ground	167.9	167.8	167.5	169.0	165.9	164.9	163.5



BARRAGE 4 SECTION 3
SCALE: 1:500

Chainage	00.000	10.000	20.000	25.971
Existing Ground	168.4	169.4	169.7	169.0

Rev	Date	Revision description	Drn.	Prod	Ver.	App
0	07.05.20	Issued for substitute consent	LMcM	LMcM	MB	ROD

Purpose of issue - Preliminary unless indicated

Client Approval ☐ Planning ☒ Tender ☐ Construction ☐ As-Built ☐

Engineering and Major Projects,
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Engineering and Major Projects is a division of ESB.

Energy for generations

Client: Gort Windfarms Ltd

Project: Derrybrien Wind Farm Project

Contract

Drawing title: Figure 11-18 Barrage 4 Removal

Production unit: Civil & Environmental Engineering

Drawn	Produced	Verified	Approved	Approval date
LMcM	LMcM	H.Griffin	P.Kavanagh	07.05.2020

Client ref.	No. of sheets	Size	Scale
	1	A3	1:500

Drawing number: QS-000280-01-D460-012-014-000 (SHEET, REV)

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11.4 Cumulative Impacts

Cumulative impacts can be defined as the additional changes caused by a proposed development in conjunction with other relevant developments. It is similarly defined in the EIA 2017 EPA guidance as –

"The addition of many minor or significant effects, including the effects of other projects, to create larger, more significant effects".

11.4.1 Cumulative impacts which have occurred

The following existing / approved projects and activities were identified for cumulative assessment:

11.4.1.1 Turbary within and immediately adjacent to wind farm site

An area of approximately 67 ha of drained turbary land occupies the eastern part of the wind farm site. Turbary lands also extend immediately beyond the site to the east covering an area of approximately 15 ha. Up until 2012, the extent of turf cutting carried out mechanically is not known but based on observations by wind farm staff on site, turf cutting by hand was carried out on a number of plots, normally in late Spring / early Summer. Since 2012 a contractor has been retained by some plot owners to mechanically cut turf and there has been an increase in the number of plots where mechanical turf cutting has been carried out. The mechanical turf cutting has been carried out using a Difco Bogmiser hopper machine, which cuts 8 sods wide and approximately 72 m in length. Turf cutting using a sausage machine is still being carried out on a single plot.

In April 2020, a peat disturbance was noticed in the turbary area of the wind farm site. The exact date of the original occurrence of the disturbance is unknown. The disturbance was located in the southern portion of Turbary Plot No 160 which is located south of the central turbary access track in an area between turbines T34, T37 and T38. The area of peat disturbed is approximately 0.25 ha. The peat disturbance mass was heavily saturated with water.

Following inspection by geotechnical specialists, it was concluded that no wind farm related activity could have contributed to the peat disturbance and that it was likely to have been caused by a combination of:

- Concentrated groundwater pressures in the peat within the turbary plot
- Undercutting for the drain along the toe of the slope
- Loading due to the more recent use of mechanical harvesting in the peat involving large hoppers

Further details in relation to this incident are provided in Chapter 10-Soils, Geology and Land. The peat disturbance did not give rise to any discharge of materials to watercourses.

Subsequently, remedial drainage works were carried out and in the vicinity of the turbary plot to mitigate the risk of water pressure build up in the peat. The excavation of drains was undertaken by hand. Check dams were provided in the drains of alternating straw bale, stone and impermeable barrier type. Geotechnical risk assessments were carried out in advance of the work.

In light of this recent incident, constraints on turbary activities are being put in place to ensure that there is no risk of further peat instability issues associated with turbary activities going forward. These are detailed in Chapter 10 – Soils & Geology.

11.4.1.2 Wind Farms in Slieve Aughty Mountains

There is a second wind farm (Sonnagh Old Wind Farm) within the Slieve Aughty Mountains to the north of the Derrybrien Wind Farm site which was commissioned a year before Derrybrien Wind Farm in 2004. This wind farm is a small development comprising 9 no. turbines situated on high ground immediately east of Lough Belsrah about 3.4 km north west of the Derrybrien wind farm. 0.013 km^2 (1.3 ha) of the 0.46 km^2 (46 ha) site drains into a tributary to the north of the Boleyneendorrish River. Within this small area, there was no wind farm infrastructure developed. As such, any cumulative impact from a hydrological or hydrogeological perspective is considered imperceptible, particularly given the Boleyneendorrish catchment is 25 km^2 at the point where the relevant tributary meets the main river.

Planning permission was granted to a developer in early 2000s for a wind farm at Keeldeery approximately 3 km to the west of the site. Internal access roads were constructed circa 2007 but the rest of the development was never built out. There was no felling carried out as part of these works. The location of the site at the headwaters of a number of different streams draining to the Owendalulleegh and Boleyneendorrish catchments indicate that impacts in relation to hydrology would have been diffuse and short term. Any cumulative impact from a hydrological or hydrogeological perspective is considered imperceptible . A subsequent application for the site was refused.

11.4.1.3 Thermal Generation

Tynagh 400 MW Power Station in the townland of Derryfrench, County Galway at the site of Tynagh Mines was granted planning permission in 2003 (GCC Reg. Ref. 03/2943). The main construction activity for the Power Station took place in 2004-2006. The plant is over 10 km from Derrybrien wind farm site and is situated in the Shannon WMU.

The Tynagh 220kV grid connection to the ESB Oldstreet to Cashla Line was granted planning permission in 2003 (GCC Reg. Ref. 04/1974). The main construction activity for the Power Station grid connection took place in 2004-2006.

Given that only a small section in the north-eastern corner of the wind farm site (draining to subcatchment SC5) drains to the Shannon WMU, any cumulative impact from a hydrological or hydrogeological perspective is considered imperceptible.

11.4.1.4 Adjacent coniferous forestry plantation

The Slieve Aughty Mountains has some of the largest concentrations of coniferous forest plantation in the country, most of which was originally planted in the 1960s and 1970s.

The extent of forestry compartments has not changed appreciably since prior to project construction with forestry representing over 50% of land usage in the immediate vicinity of the wind farm. Due to its age profile, much of the forestry estate has over the last number of years and will over the next decade require felling. For example, between 2016 and 2018 a total of 2.57 km^2 of forestry was earmarked for felling on Coillte land in the catchments within which Derrybrien Wind Farm is located, similar to the amount felled for the wind farm Project between 2003 and 2005.

The impact of felling on the local hydrological regime(s) is discussed in Appendix 11.A with respect to the felling associated the Derrybrien Wind Farm Project. Across a literature review of peer-reviewed scientific studies, forests are generally found to be associated with reducing peak and low flows. However, the results of studies conducted under realistic forest management procedures have shown that the potential for forest clearance to increase peak and low flows is much less than has often been widely claimed. The OPW (2015) recommend, as an allowance in assessing flood risk, reduction in the time to peak to allow for potential accelerated runoff that may arise as a result of drainage of afforested land. For the mid-range future scenario (MRFS) and high-end future scenario (HEFS) this amounts to a reduction by one-sixth and one-third respectively in the time to peak, e.g. 60-minute time to peak effectively reduced to 50 minutes for MRFS and 40 minutes for HEFS. Conversely, it is recommended to increase the runoff rate by a factor of up to 10% in the HEFS for the temporary period following felling of forestry. Application of a temporary runoff rate factor is considered when assessing the impact of felling in the subcatchments not related to the wind farm Project around the time of construction

There is a degree of uncertainty attached to some of the Coillte data for the period 2000-2006 in terms of felling activity in each of the subcatchments draining from the wind farm site. This is because, although there is data in relation to which forestry block was to be felled in any given year, from time to time felling proceeded either earlier or later than the dates shown on management maps and it has not always been easy to confirm the exact felling year. The following analysis is a combination of hind-cast felling data available from more recent digitised Coillte maps, with the caveats mentioned above, as well as an examination of Google Earth imagery from 2006, 2011, 2015 and 2018 and, in particular, OSI aerials photos from 2000 and 2005.

In the period 2000 to 2005 there was either very limited clear-felling in most of the subcatchments to which substantial portions of the Derrybrien Wind Farm drain or if there was substantial felling, then the wind farm on-site felling in the same subcatchment was quite limited, thereby limiting any potential for cumulative impacts in either scenario.

In SC9, for example, while there was extensive felling within the Coillte forestry blocks between 2003 and 2006 (c. 0.66 km^2) particularly in 2005/2006, during the construction phase of the wind farm only around 0.02 km^2 was felled within the wind farm site that drained to the same subcatchment, so effectively any cumulative impact was likely to have been negligible.

Throughout SC7(c) no off-site Coillte felling took place during the 2000-2005 period, so no cumulative impact would have arisen.

A small amount of Coillte felling did occur in SC7(b) off-site between 2000 and 2005; however, any cumulative impact would have been effectively masked by the 2003 peat slide in the same catchment.

During the same period no off-site felling took place in subcatchment SC7(a), so no cumulative impact would have arisen.

In SC6, although there was extensive Coillte off-site felling, there was virtually none in that portion of the wind farm. Therefore again, effectively no cumulative impact would have occurred.

In SC5 in the Duniry catchment, while there was a significant amount of Coillte off-site felling between 2000-2005, within the same window there was only a tiny portion of felling in the north-east corner of the wind farm, therefore any cumulative impact would have been negligible.

There was no Coillte offsite felling in SC3 and SC4 between 2000 and 2005 and while there was around 19 ha felled in SC2 in the same period, an examination of the OSI aerial photo for 2005 indicates that it occurred at least one year prior to the on-site felling within the same subcatchment, so that any cumulative impact on flood regime would have been not significant to slight locally, persisting for at most one to two years. This effect can be described as a **Slight, Negative** and of **Temporary to Short-term** in duration.

SC1, which is the largest of the subcatchments draining the wind farm registered a large area of off-site felling in the period 2000-2005 including a significant amount that would have coincided with the on-site felling. It is likely therefore that some cumulative effects would have occurred at the time, which would most likely have resulted in an increased runoff rate to the main Boleyneendorrish river for a **Temporary to Short-term** duration, thus having a **Not Significant to Slight** effect on the hydrological regime.

Felling and re-planting of forestry has been and will continue to be a feature of the Slieve Aughty Mountains area and the grant of felling licences have and will continue to need to be considered for each application with the impact on the environment duly considered. Felling licenses issued by the Forestry Service include an obligation on the applicant to ensure that all felling (and planting) operations are carried out in accordance with guidelines in respect to water quality, the environment and the 'Code of Best Forest Practice – Ireland'. The guidelines set out measures based on Sustainable Forest Management principles to cover all situations relating to forestry and water quality.

11.4.1.5 Planting in lieu of felling on wind farm site

On 20th May 2003, Coillte was granted a two-year felling licence by the Forest Service under the Forestry Act 1946, to fell 263 ha of forestry on the wind farm site. In lieu of the clear-felling and non-replanting of 263 ha of forestry on the wind farm site, the Felling Licence (Ref FL 3983) required the licensee, within 1 year from the expiry date of the felling licence, to plant 119.3 ha within identified townlands in Counties Tipperary and Roscommon. The locations where Coillte have advised planting has been carried out are over 50 km and 80 km respectively from the wind farm site and are not physically connected to the Wind Farm Project site.

A full description of the activities around afforestation is provided in the Forestry Service "Code of Best Forest Practice – Ireland (Part 1) (Forestry Service, 2000c). Typically, drainage systems and soil preparation are required to prevent subsurface water rising into and saturating the root zone and waterlogging the soil. By maintaining the water table below the root zone, drainage promotes deep rooting, improves tree anchorage and strengthens the soil.

Given the remoteness of these townlands from the Project areas, it can be assumed that there is no cumulative impact arising with respect to hydrology and hydrogeology.

11.4.1.6 Flood Relief Works at Kinvarra

Temporary flood relief works were undertaken at Kinvarra during the long winter floods of winter 2015-2016. The potential hydrological impacts of the Derrybrien Wind Farm Project are assessed as not extending far enough downstream to impact on flood-prone areas. Therefore, there is no cumulative impact arising with respect to hydrology and hydrogeology.

11.4.1.7 Sand Extraction at Cloghvoley

Planning permission was granted for a sand extraction site (GCC Ref. Ref. 08/1664) located at Cloghvoley to the south-east of the wind farm in May 2008 after the wind farm project was commissioned. On inspection of the planning files there is no cumulative impact arising with respect to hydrology and hydrogeology, there is no indication that there was historic activity that could have coincided with the wind farm Project construction. As such there is no cumulative impact arising with respect to hydrology and hydrogeology.

11.4.1.8 Coillte Quarry

There is a registered quarry just east of the junction between the R353 and the Black Road, to the south-east of the Derrybrien wind farm site; reference number QRY62. This is a quarry that was accepted as being post-1964 but without the benefit of planning. Reasonable assumptions are made on the basis that no information was available from An Bord Pleanála.

Documents in relation to quarry registration were submitted to GCC in April 2005 by Coillte – the site owners. It is a relatively small (1.8 ha) aggregate quarry with an extraction area of 1.3 ha, the aggregate being used for forest road repairs.

The area where the quarry is situated shows no surface drainage channels on OSI 6 inch maps for the area nor is there any indication from aerial photos of the area. The downslope over-ground distance between the quarry and the nearest stream, a tributary of the Owendalulleegh, is just over 500 m through forestry and damp grassland / blanket peat. Given that the material being quarried was predominantly coarse, the likelihood of any suspended solids from the site reaching any of the wind farm drainage streams is considered to have been extremely low. As such, there is believed to be no cumulative impact arising with respect to hydrology. Any cumulative impacts and effects with respect to hydrogeology from the quarry are unknown but would not have been exacerbated by the wind farm Project given the lack of any significant impacts arising from the Project with respect to hydrogeology.

11.4.1.9 Works to Beagh Bridge

The privately owned four-span Beagh Bridge at the outlet of Lough Cutra underwent a structural assessment by ESBI in August 2004. This followed on from the temporary erection of straw filter barriers on the upstream face of the bridge in the aftermath of the peat slide to capture and filter any suspended sediment that may have transported from the landslide area. Evidence of damage and deterioration to two of the three intermediate piers was highlighted although it was deemed by ESBI engineers at the time that the peat slide most likely could not have caused or contributed to this damage. ESBI recommended in their assessment report that all river flow be diverted away from these piers. The recommendations were addressed by the wind farm contractor in January 2005 and left the pier foundations in what was deemed by ESBI as being in better condition than it was prior to the initial assessment.

11.4.2 Cumulative impacts which are occurring

11.4.2.1 Turbary within and outside wind farm site

Cut-over bog where turbary rights occur exist widely within the subcatchments that drain the Derrybrien Wind Farm and to a lesser extent on the OHL route and in the Bleach River catchment containing Agannygal substation. An area of approximately 83 ha of land which was under turbary occupies the eastern part of the wind farm site. Of this approximately 15 ha had been converted to forestry lands having been planted prior to the project development and subsequently felled by Coillte. The remaining circa 67 ha are drained turbary lands. Turbary lands also extend immediately beyond the site to the east covering an area of approximately 15 ha. There were 136 individual turbary plots within or immediately adjacent to the windfarm site, of which 26 were converted to forestry and 22 are partially or fully outside the wind farm site boundary. Individual plot sites range in area between approximately 0.55 ha and 1.10 ha. The turbary rights are understood to be held by a number of local people.

In general, the existence of turbary rights provides no indication of the amount of peat extraction occurring. Indeed, it is estimated in Ireland that only around 10% of turbary owners actively exercise their right to extract peat (Renou-Wilson *et al.,* 2011). Moreover, because it is estimated that more than 80% of peat extracted by rural contractors is privately traded (Fitzgerald, 2006, quoted in Renou-Wilson *et al.,* 2011), it's difficult to know how much is extracted in any given year or in any given area of cut-over bog. In addition, the overall intensity of extraction in any given year is likely to vary due to a range of factors including for example the price of other domestic heating fuels.

Therefore, unlike forestry activity where Coillte and the Department of Forestry keep detailed records of management activities (e.g. clear-felling, and re-planting) which in any case can also be tracked by aerial imagery, there is no co-ordinated record of the intensity or extent of peat extraction in turbary plots. Moreover, depending on the drainage of individually active plots within a larger block of cutover bog, the connectivity of individual plots to surface water drainage and therefore the likelihood or otherwise of peat silt generated during peat extraction reaching rivers and streams is unknown. Furthermore, while the environmental impacts of every aspect of forestry management on surface waters has been researched widely and intensively in Ireland and elsewhere, there is very little research available on the impact of turbary on surface waters in Ireland.

The only research available relates to the industrial scale extraction of peat in large midlands raised bog systems operated by Bord na Móna, much of it done between the 1960s and 1980s. Studies on small catchments with drained blanket peat bogs in the UK have shown that receiving waters are prone to higher suspended solids concentrations as well as greater amounts of fine particulate organic matter in the sediment. In areas where drains have been blocked for several years it was noted that each of these trends toward increased organic matter in sediment was reversed (Ramchunder *et al.,* 2012). These data suggest that if turbary were impacting on the receiving waters around Derrybrien Wind Farm, that we would notice a greater amount of deposited organic particulate matter i.e. peat silt. It is possible that if turbary were ongoing during and before the construction of the wind farm it may have depressed the water quality. Combined with suspended solids generated during the construction phase these conditions may have been reduced water quality at EPA gauges in the vicinity. However, for that to have occurred the solids leaving the site due to both turbary and the construction would have had to have been considerable and bearing in mind that silt traps were placed on all the main outlets drains from the wind farm, this is unlikely to have arisen. It should be noted also that any cumulative impact would likely have dissipated before either of these tributaries (SC6) and SC7(a)) reached the main channel of the Owendalulleegh (see Chapter 8 – Aquatic Ecology).

11.4.2.2 Adjacent coniferous forestry plantations

In the subcatchments draining from the wind farm there is a high percentage of land on which forestry is present. A feature of the areas surrounding the wind farm site is the regularity of felling that takes place of this forestry. For example, between 2016 and 2018 a total of 2.57 km^2 of forestry was earmarked for felling on Coillte land in the catchments within which Derrybrien Wind Farm is located. OPW have advised that felling should be considered as having a potential impact on flood regime downstream both through reduced time to peak and, until new forestry re-grows, an increase in the runoff rates. When reviewing felling license applications, the Forest Service consider the cumulative effect of all forest operations in the catchment, as individual impacts may be small but the combined impact may be significant. The felling programme in the catchment may comprise one or more coupes. As the difficulty of preventing sediment and nutrient losses tends to increase with increasing coupe size, smaller coupes are preferable. The Forest Service currently limits clear-felling to coupes no greater than 25 ha in area. The *Forest Harvesting and the Environment Guidelines* recommend phased felling in a way that minimises cumulative effects as adjoining felling coupes harvested in a short time scale are likely to have a cumulative impact on the environment (Forestry Service, 2000b).

11.4.2.3 Gort Regional Water Supply Scheme

The public water supply for Gort was and continues to be supplied from the Gort Regional Water Supply Scheme which is sourced from the Gort/Cannahowna River. The water treatment plant is located in the townland of Rindifin to the east of Gort. The Derrybrien Wind Farm Project given its scale and remoteness from Rindifin has no perceptible impact on this water supply from a hydrological or hydrogeological perspective. The cumulative impact with regard to water quality is discussed in Chapter 8 – Biodiversity - Aquatic Ecology.

11.4.2.4 Flood Relief Schemes

The Galway Bay South East River Basin Flood Risk Management Plan (FRMP) has included structural measures for communities at significant flood risk identified through the CFRAM Programme. It also includes for ongoing maintenance of existing Flood Relief Schemes such as Gort and those already at the design and construction phase such as in the Gort Lowlands. It should be noted that impacts on local runoff waters from the wind farm project sites are imperceptible by the time they reach the Gort lowlands area at Ballylee, Ballyloughlin, Turlough, Kiltartan area and Lough Coole flood area. (see Appendix 11.A and Appendix 11.B).

11.4.2.5 Local OPW Flood Relief Scheme Gort

In 1997, the OPW completed a local flood relief scheme in Gort to combat potential serious winter flooding events. The potential hydrological impacts of the Derrybrien Wind Farm Project are assessed as not extending far enough downstream to impact on flood-prone areas such as Gort. Therefore, there is no cumulative impact arising with respect to hydrology and hydrogeology.

11.4.2.6 Local Flood Relief Works at Kiltartan

Permanent remedial works were planned and constructed at Kiltartan in 2011-2012 by Galway County Council to combat potential serious winter flooding events. The potential hydrological impacts of the Derrybrien Wind Farm Project are assessed as not extending far enough downstream to impact on flood-prone areas such as Kiltartan. Therefore, there is no cumulative impact arising with respect to hydrology and hydrogeology.

11.4.2.7 M18 Motorway Project

The M18 motorway project was planned and constructed after the Derrybrien Wind Farm Project was developed. Construction of the motorway between Oranmore and Gort as part of the overall Gort to Tuam scheme was carried out between January 2015 and September 2017. This resulted in the N18 being retained as the R458 regional road while the newly constructed M18 became the primary route between Galway and Limerick.

As any hydrology and flooding effects associated with the wind farm are within the vicinity of the wind farm and have no significance downstream as far as areas that have been subject to flooding in the past, there is no potential cumulative impact with this project.

11.4.3 Cumulative impacts which are likely to occur

11.4.3.1 Turbary within and outside the wind farm site

See section 11.4.2.1.

11.4.3.2 Adjacent coniferous forestry plantations

See section 11.4.2.2.

11.4.3.3 Moneypoint – Oldstreet 400 kV Line

The Moneypoint – Oldstreet 400 kV Overhead Line was developed two decades prior to the development of the Derrybrien Wind Farm Project. Planning permission for refurbishment works on the overhead line was granted by Clare County Council (CCC) (Reference 16/1011) in September 2017 and Galway County Council (GCC) (Reference 16/1747) in October 2017. The Derrybrien-Agannygal 110 kV line passes under the 400 kV line at ITM co-ordinates 562119 E, -700626 N. The refurbishment works have no perceptible cumulative impact with respect to hydrology or hydrogeology.

11.4.3.4 Ennis – Shannonbridge 110 kV Line

The Ennis – Shannonbridge 110 kV Line was installed in 1952 with some further structures installed in 1968. Refurbishment of one circuit on this line, Ennis – Agannygal, is scheduled for 2023/2024. The refurbishment works have no perceptible cumulative impact with respect to hydrology or hydrogeology.

11.4.3.5 Proposed Gort Lowlands Flood Relief Scheme

The proposed Gort Lowlands Flood Relief Scheme is examining options of providing flood overflow pathways from several turloughs (Lough Coole to Caherglassaun to Cahermore and an overland spill to the Galway Bay at Dungory Castle at Kinvarra). This is currently at preliminary engineering and feasibility stage and will be the subject to a planning permission stage assuming that a feasible scheme can be achieved. Flood relief solutions for the Gort

Lowlands are being progressed by the OPW and Galway County Council to protect vulnerable properties, farmyards, communities and roads in the Gort Lowlands area. The preferred flood relief option is to reduce turlough levels to identified target levels through engineering overland spill channels between successive turloughs until eventually reaching the sea at Dungory Kinvarra.

While the effect of the wind farm drainage is to increase peak surface water flow rates in the vicinity of the wind farm, this effect diminishes rapidly downstream in the larger river catchments such that by the time flood flows reach Lough Cutra and the Ballylee Thoor floodplain area, the increased runoff rate is not significant in respect to flooding and flood risk. As such, it is understood based on the likely proposals that the flood relief scheme shall have no perceptible cumulative impact with respect to hydrology or hydrogeology.

This matter is discussed in more detail in Appendix 11.A and Appendix 11.B.

There are no further known future proposals for development within or downstream of the study area that could result in cumulative effects on hydrology and hydrogeology.

Correspondingly it is considered that there is no potential for significant effects to result from the continued operation of the Project cumulatively with other known developments.

11.5 Remedial (Mitigation) Measures and Monitoring

Remedial measures are measures undertaken or proposed to be undertaken by the applicant for substitute consent to remedy any significant adverse effects on the environment.

Remedial measures are identified to prevent, reduce or offset likely significant adverse environmental effects. In addition, measures which have the potential to prevent, reduce or offset adverse effects which are not considered significant but where it is considered that such measures are appropriate should also be provided.

11.5.1.1 Remedial Measures & Monitoring for significant effects

11.5.1.2 Drainage diversions

A watercourse draining from the slide area was rerouted around the displaced peat just upstream of the Black Road. The extent of the rerouting is between the downstream end of Barrage 2 and the upstream side of the Black Road Bridge. A small amount of tree felling was required in order to gain access for the diversion drain.

Drainage was re-routed away permanently from entering the slide area by the digging of new drains to divert water via an alternative route down the slope. These new drains linked with existing drains to form the new route for water between the site boundary and the end of the slide area. Where new drainage was constructed in a wooded area, tree felling was carried out to create a corridor of sufficient width to allow an excavator to excavate the drain. Drainage management was generally improved in the slide area of the wind farm through construction of silt traps and clearance of obstructions to release of any visibly trapped water. The exact location of additional silt traps was determined following completion of the drainage system and detailed surveying to choose the optimal locations. The silt traps employed straw bales or graded clean washed stone as a filtration system and were designed with sufficient trapped area to prevent them from being overtopped.

A diversion channel was also excavated immediately upstream of Black Road Bridge around the repository area established to store debris following the peat slide. The original stream and local public road were later re-established.

11.5.1.3 Repairs to In-stream Structures

The peat slide resulted in damage to a number of in-stream structures downstream of the wind farm (Figure 11.13). Repairs were carried out to address structural stability and capacity concerns, thus returning them to their original respective flow capacities. These individual structures are discussed below in order from upstream to downstream of the catchment / reach.

At Black Road Bridge damage was recorded to the bridge parapets following very heavy rain which had remobilised the disturbed peat. Drainage works were carried out in October 2004 followed by cleaning out of peat blockages in co-ordination with Galway County Council. Further cleaning out of excess build-up of peat was carried out in January 2005. In August 2005, further remediation works commenced to aid drainage from the liquid peat mass and restore the pre-existing river bed. Peat that was side cast from the river bed was stored in the adjacent peat repository. Straw bales were used to filter any runoff into the river. Structural repairs consisted of replacing the parapets of the bridge. Upon completion of the works the reinstated river bed flowed downstream of the Black Road Bridge via a silt trap.

At Flaggy Bridge on the R353, parapets and road verges were damaged and required repair after the peat slide, which was observed to cross the bridge on 30th October 2003 following very heavy rain. The parapet was reinstated on 8th November, a little over a week later.

Damage to Unnamed Bridge C by the peat slide necessitated removal of the existing structure and re-construction of the entire bridge span. These works were carried out in February and March 2006. Risks associated with this work included water pollution and damage to local habitats from use of chemicals and concrete and temporary drainage of the river. This was addressed by carrying out the following control measures in accordance with Fisheries Guidance:

i. Maintain original low flow channel width at all times;
ii. Avoid creating shallow or shooting flow;
iii. Do not allow concrete or washings into the water;
iv. Maintain and re-fuel equipment at least 50 m from the water;
v. Prepare and store chemicals at least 50 m from the water;
vi. Runoff from works (if applicable) should be ponded and settled before discharge to water;

Further downstream on the main Owendalulleegh River, stepping stones which had become displaced by the landslide event were replaced.

In all cases described above the in-stream structures were returned close to their pre-existing state with no impact on the overall flow regime locally, upstream or downstream. As such their effect on the hydrological regime is considered in the worst case to be **Slight** for a **Temporary** construction period to **Imperceptible** in the **Long-term**.

11.5.1.4 Containment Barrages

The containment barrages were installed for the purposes of mitigating geotechnical risks following the peat slide; it should be noted that they were not designed to fulfil any hydrological function and also have not done so in practice.

11.5.1.5 Peat Repositories

The peat repositories constructed following the slide have over time stabilised, become grassed and not prone to slippage risk, erosion or the release of soiled peat water and have no effect on the local hydrological regime apart from where drainage was diverted around the repository at Black Road Bridge.

11.5.2 Mitigation Measures for non-significant effects

11.5.2.1 Site Inspections

Following the end of construction phase an inspection and maintenance regime was designed to be followed for the operational life of the wind farm. In accordance with this regime, the site and peat slide areas have been inspected once a year by an experienced geotechnical engineer and a surveyor to monitor the ongoing stability of the site and recommend any necessary works to ensure ongoing stability. The inspections include walkover surveys of site drainage. Recommendations in the reports related to drainage include maintenance to drainage around the base of the wind turbines and to the larger primary drains.

11.5.2.2 Cutting back of tree regrowth

The following activities have and will be carried out during routine drain inspection which is undertaken prior to and following cutting back of the tree regrowth:

- Communication with tree felling operatives in advance to determine whether any areas have been reported where there is unusual waterlogging or bogging of machines;
- Inspection of main drainage ditches and outfalls. During pre-cutting back inspection, the main drainage ditches shall be identified. Ideally, the pre-cutting back inspection shall be carried out during rainfall;
- Following tree topping, all main drains will be inspected to ensure that they are functioning;
- Unblocking of any blocked culverts on drains exiting the site.

11.5.2.3 Programme of cleaning, maintenance and inspection of the site drainage system.

For the operational phase of the wind farm the programme of regular cleaning, maintenance and inspection of the site runoff treatment system will continue to ensure it functions correctly. This will include the inspection, removal and disposal of any collected sediment to licensed disposal / treatment facilities off site.

Prior to any future maintenance work, precautions will need to be taken to ensure the protection of watercourses against silting. Any material or substance which could cause pollution, including silty water, will be prevented from directly entering surface water drains / watercourses by the appropriate use and placement of straw bales, silt fences, cut-off drains and silt traps and temporary sedimentation ponds where appropriate.

Following periodic Geotechnical Inspections, drainage around turbines are prioritised for immediate action due to the potential impact that it could have had on their stability. Where the water level is above the design level due to poor drainage, the additional buoyancy on the pad foundation could result in insufficient resistance to overturning if it occurs during periods of high wind speeds. This has not occurred on the site to date. Nevertheless, the EMP Inspection Reports have noted areas of poor drainage and ponded water at some of the turbines, which needed to be addressed as a priority.

In general, drainage requirements are assessed during the wetter winter months with works scheduled for the drier summer months when there would have been a lower risk of peat instability.

Among the general issues identified and remedial actions recommended were:

- Turbines where there was no drain or insufficient drainage around the pad foundation;
  - Constructing new drains around turbine foundations;
- Areas of ponded surface water;
  - Improving the connection between the drains around the turbines to the site drainage network;
- Drains with insufficient capacity leading to overtopping and erosion of the adjacent access track;
  - Increasing the capacity of the drains by deepening or widening them;
- Drains with insufficient fall;
  - Deepening and re-grading drains;

- Drains blocked due to vegetation growth;
  - Clearing overgrown vegetation;
- Drains blocked due to sidewall collapse or closure in peat;
  - Re-excavating drains and providing additional support to unstable sidewalls;
- Erosion/scouring of drains due to excessive flow velocity;
  - Placing cobble-/boulder-sized rockfill in the drains and realigning drains at junctions where there was excessive erosion;
- Culverts at road and cable crossings blocked due to settlement of drainage pipe;
  - Clearing out the inlet and outlet of these culvert pipes
- Collapsed drainage pipes;
  - Excavating and re-laying the culvert pipes under the roads or cables with rockfill surround supported on the underlying glacial till to prevent further settlement;

The majority of drainage improvement works were carried out within 6 years of completion of the wind farm with a major maintenance programme completed on the site in 2011.

Since 2011, only minor remedial works have been required, indicating that the drainage network has sufficient capacity to handle the anticipated levels of rainfall and surface runoff on the site over the remaining design life of the wind farm. It should be noted in this context that high levels of rainfall occurred on the wind farm site during the exceptional storm events in Ireland (generally affecting the north-west, west, Shannon midland system and southwest) in December 2015, including Storm Desmond and Storm Frank, in which the average monthly rainfall was over 250 – 300% of the Long Term Average for that month of the year.

In April and May 2014 many parts of the floating road system needed to be repaired and upgraded due to wear and tear since commissioning. This included improvement and widening of the existing floating road over culverts at a number of locations (T10, T24, T35, T50 and T66) where the existing road was too narrow and where the side slope down into the drainage channel was too steep. Prior to the work being carried out a suite of siltation control mitigation measures for drains likely to receive silt runoff from sections of the track requiring repairs. The following work was carried out:

- At the culvert adjacent to Turbine T35 the road was widened to provide a minimum 4.5 m road width over the culvert.
- All peat was excavated out from under the widened sections of the roads at the culverts so that the rockfill was supported on the underlying glacial till.
- The existing culvert pipe was extended with a corrugated uPVC drainage pipe so that it protruded 0.5 m out from the new rockfill slope.
- Where the existing culvert was under a floating road it was extended using an oversized pipe to accommodate differential settlement between the two pipes.

While no targeted follow-up assessments were undertaken after these works, the assessment at the time concluded that the mitigation measures would have been sufficient, given the nature of the works and the gently sloping terrain, to prevent any significant downstream impacts on the receiving waters caused by solids runoff.

11.6 Residual Impacts

The mitigation measures outlined in Section 11.5 will continue to be implemented comprehensively, with residual impacts on the surface water or groundwater therefore kept to a minimum. The existing on-site drainage system will remain active and maintained until decommissioning of the wind farm.

The following elements of the wind farm will be left in place at the end of decommissioning –

- The site access tracks and floating roads;
- The turbine foundations and granular crane hardstandings:
- The hardstanding areas for the substation, site compound and anemometers;
- The peat repositories and material sidecast areas; and
- The drainage.

By the end of decommissioning, groundwater levels on the wind farm site will have stabilised at a new equilibrium steady state condition for the drainage network. The drains will be left open and in-service and no further maintenance will be carried out on the drains. Therefore, in the long-term the efficiency of the drains is likely to reduce as they become clogged by vegetation. This will result in a partial gradual restoration of groundwater levels on the site. As discussed in Chapter 10 – Soils & Geology, poor drainage is a recognised contributory risk factor for peat instability. The drainage constructed on site has been assessed as having a **permanent** and **sustained positive impact** on site stability relative to baseline conditions on site in 1998. Therefore, to account for this ongoing risk, bog rehabilitation / restoration intervention measures such as blocking drains, re-wetting the bog and restoring bog hydrology shall not be implemented upon decommissioning of the wind farm.

Residual impacts with respect to hydrology and hydrogeology will take the form mainly of slightly reduced flow rates over time and thus slightly increased erosion which will have an intermittent, imperceptible to slight impact on the quality of small headwater streams in the Boleyneendorrish, Duniry and Owendalulleegh catchments. Downstream major rivers and areas prone to flooding will continue to not be impacted from a hydrological or hydrogeological perspective.

11.7 Conclusions

Based on the assessment undertaken, it can be concluded that the Derrybrien Wind Farm Project has not and is not anticipated to give rise to any significant impacts related to the drainage flow regime and flood risk classification or result in any unacceptable downstream hydrological impacts.

In the post-construction operational life of the wind farm no work has been or is expected to be carried out that would increase the existing low flood risk.

During the post-construction phase of the wind farm, the drainage network has experienced a variety of large storm events ranging from intense short-duration events to long-duration winter floods which saturated the wider area. The drainage network has to date demonstrated sufficient capacity to convey floodwaters without causing excessive flooding of access tracks and turbine bases and not requiring any significant drainage maintenance works.

There was no significant increase in the risk of flooding arising from the wind farm Project in the locality of the wind farm itself given the size of the downstream population and the proportion that could be affected in a flood event. At Agannygal substation, the lack of flow attenuation features and the nature of drainage disposal offsite has had a slight negative impact as it does cause a noticeable change in the character of the environment but does not affect its sensitivity regarding flood risk. On the broader regional scale, any increase in flood risk associated with the Project is deemed imperceptible given the broader extent of the Boleyneendorrish and Owendalulleegh catchments. The Project is therefore in overall compliance with the objectives of the Planning and Flood Risk Management Guidelines. The Derrybrien Wind Farm Project therefore **has not and is not anticipated to give rise to any significant impacts** related to flood risk locally or downstream of the site.

The continued effectiveness of the drainage network is dependent on the continuation of the current inspection and maintenance regime. The periodic inspections to identify any potential issues with maintenance of the wind farm drainage system and implementation of appropriate remedial actions should continue. These routine drainage inspections should continue to be conducted by wind farm operational staff, especially during or in the immediate aftermath of large rain storm events and tree topping activities.

Water quality impacts potentially arising during the operational phase of the wind farm are likely to be limited to minor siltation or pollution incidents as a result of small-scale maintenance and decommissioning works. Such local incidents will not give rise to significant impacts on water quality in downstream receiving streams and rivers. Appropriate precautions have been and will be taken to ensure the protection of watercourses from silting during any maintenance activities.

There are no significant cumulative impacts on drainage and flooding arising from the wind farm in combination with any other projects constructed since commissioning, under construction or in planning.

The operation and future decommissioning of the Derrybrien Wind Farm Project will not give rise to any significant residual hydrogeological and hydrogeological impacts.

All hydrological and hydrogeological impacts and their effects associated with the Derrybrien Wind Farm Project are summarised in Table 11-12.

Impact	**Phase**	**Quality**	**Duration / Frequency**	**Significance pre-mitigation**	**Significance post-mitigation (if any)**	**Extent / Context**
Flood Risk downstream	Construction	Negative	Temporary / Rarely	Not Significant	-	Catchment
Flood Risk onsite	Construction	Negative	Momentary to Brief / Rarely	Slight	-	Subcatchment
Felling of Forestry	Construction	Negative	Temporary to Short-term	Slight to Moderate	-	Local
Suspended Solids - General	Construction	Negative	Brief to Temporary / Frequently	Significant	Not Significant	Local
Hydrocarbons and Cement	Construction	Negative	Brief / Frequently	Slight to Moderate	Not Significant	Local
Wastewater	Construction	Negative	Brief / Frequently	Slight to Moderate	Not Significant	Local
Suspended Solids - Borrow Pits / Quarries	Construction	Negative	Temporary	Imperceptible to Slight	-	Local
Drainage Diversions	Offsite Peat Slide Works	Neutral	Permanent	Imperceptible	-	Subcatchment
Offsite Peat Repositories	Offsite Peat Slide Works	Neutral	Permanent	Imperceptible	-	Subcatchment
Hydromorphology	Offsite Peat Slide Works	Negative	Short-term	Slight to Moderate	-	Catchment
Containment Barrages	Offsite Peat Slide Works	Negative	Momentary to Brief / Rarely	Moderate	Slight	Subcatchment
Downstream Water Quality	Offsite Peat Slide Works	Negative	Short-term / Once	Moderate to Significant to Profound	-	Catchment
Flood risk downstream	Operation	Negative	Temporary / Rarely	Not Significant	-	Catchment
Flood Risk onsite	Operation	Negative	Momentary to Brief / Rarely	Slight	-	Subcatchment
Drainage Issues	Operation	Negative	Brief / Rarely	Slight	Imperceptible	Local
Hydrocarbons	Operation	Neutral	Long-term	-	-	Local
Wastewater	Operation	Neutral	Long-term	-	-	Local
Containment Barrages	Operation	Negative	Momentary to Brief / Rarely	Not Significant	-	Subcatchment

Impact	Phase	Quality	Duration / Frequency	Significance pre-mitigation	Significance post-mitigation (if any)	Extent / Context
Suspended Solids - General	Operation	Negative	Brief / Rarely	Not Significant	-	Local
Hydrocarbons and Cement	Operation	Negative	Brief / Rarely	Slight	-	Local
Wastewater	Operation	Neutral	Long-term	Imperceptible	-	Local
Suspended Solids - Borrow Pits / Quarries	Operation	Neutral	Long-term	Imperceptible	-	Local
Cutting back of tree re-growth at wind farm	Operation	Negative	Brief to Temporary / Occasionally	Slight	Imperceptible	Local
OHL Route tree topping	Operation	Negative	Temporary / Occasionally	Not Significant	Imperceptible	Local
Turbine removal	Decommissioning	Negative	Temporary / Once	Slight	Not Significant	Local
Grid connection removal	Decommissioning	Negative	Temporary / Once	Slight	Not Significant	Local
Containment barrages	Decommissioning	Negative	Temporary / Once	Slight	Not Significant	Subcatchment

Table 11-12 Summary of Hydrological and Hydrogeological Impacts and Effects associated with Wind Farm Project

11.8 References

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11.9 Glossary of Terms

AA – Appropriate Assessment

AAR – Average Annual Rainfall

ADAS - Agricultural Development and Advisory Service

AEP – Annual Exceedance Probability

AGEC - Applied Ground Engineering Consultants

AGL – Advanced Geotechnics Ltd.

BGL – Below Ground Level

CCC – Clare County Council

CFRAMS – Catchment Flood Risk Assessment and Management Studies

DDF – Depth Duration Frequency

DECLG – Department of the Environment, Community and Local Government

DEM – Digital Elevation Model

DEFRA – Department for Environment, Food and Rural Affairs

EC – European Commission

EEA – European Environment Agency

EEC – European Economic Community

ED – Electoral Division

EIA – Environmental Impact Assessment

EIAR – Environmental Impact Assessment Report

EMP – Engineering and Major Projects

EPA – Environmental Protection Agency

ER – Effective Rainfall

ESB – Electricity Supply Board

ESBI – ESB International

EVA – Extreme Value Analysis

EU – European Union

FRA – Flood Risk Assessment

FSU – Flood Studies Update

GCC – Galway County Council

GEV – General Extreme Value

GIS – Geographic Information System

GPA - Guidelines for Planning Authorities

G&WM – Generation & Wholesale Markets

GSI – Geological Survey of Ireland

GT – Generation and Trading

Ha – Hectares

HA – Hydrometric Area

HECRAS - Hydrologic Engineering Center River Analysis System

HEFS – High-End Future Scenario

IH – Institute of Hydrology

IFI – Inland Fisheries Ireland

IPPC – Integrated Pollution Prevention and Control

ITM – Irish Transverse Mercator

LAP – Local Area Plan

LIDAR – Light Detection and Ranging

MIEI – Member of Institute of Engineers Ireland

MRFS – Mid-Range Future Scenario

NHA – National Heritage Area

NRA – National Roads Authority

OHL – Overhead Line

OPW – Office of Public Works

OSI – Ordnance Survey Ireland

PE – Potential Evapotranspiration

PFRA – Preliminary Flood Risk Assessment

PI – Poor Aquifer except for Local zones

QBAR – Mean Annual Flood Flow

QMED – Median Annual Flood Flow

RBD – River Basin District

RBMP – River Basin Management Plan

SAAR – Standard Average Annual Rainfall

SAC – Special Area of Conservation

SC - Subcatchment

SEA – Strategic Environmental Assessment

ShRFB – Shannon Regional Fisheries Board

ST – Silt Trap

TII – Transport Infrastructure Ireland

tp – Time to peak

TRRL – Transport Road Research Laboratory

uPVC - Unplasticised Polyvinyl Chloride

WFD – Water Framework Directive

WMU – Water Management Unit