Chapter 6:

Water

6.1 Introduction

6.1.1 Background & Objectives

Hydro-Environmental Services (HES) was engaged by Pinewoods Wind Ltd to undertake an assessment of the potential impacts of the proposed development on water aspects (hydrology and hydrogeology) of the receiving environment:

The objectives of the assessment are:

- Produce a baseline study of the existing water environment (surface water and groundwater) in the area of the proposed wind farm development;
- Identify likely negative impacts of the proposed development on surface water and groundwater during construction and operational phases of the development;
- Identify mitigation measures to avoid, remediate or reduce significant negative impacts:
- Assess significant residual impacts and cumulative impacts of the proposed development.

6.1.2 Scoping Responses

A number of scoping letters were issued to relevant agencies in relation to the EIS for the proposed development. Details of responses received can be found in Chapter 1 of this EIS.

6.1.3 Relevant Legislation

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

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1995, S.I. No. 352 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001), S.I. No. 30 of 2000, the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/373/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 600 of 2001: Planning and Development Regulations, 2001;
- S.I. No. 94 of 1997: European Communities (Natural Habitats) Regulations, resulting from EU Directives 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and 79/409/EEC on the conservation of wild birds (the Birds Directive);
- S.I. No. 293 of 1988: Quality of Salmon Water Regulations, resulting from EU Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life;
- S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 and S.I. No. 722 of 2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) and provide for implementation of ‘daughter’ Groundwater Directive (2006/118/EC). Since 2000 water management in the EU has been directed by the Water Framework Directive (WFD). The key objectives of the WFD are that all water bodies in member states achieve (or retain) at least ‘good’ status by 2015. Water bodies comprise both surface and groundwater bodies, and the achievement of ‘Good‘ status for these depends also on the achievement of ‘good’ status by dependent ecosystems. Phases of characterisation, risk assessment, monitoring and the design of programmes of measures to achieve the objectives of the WFD have either been

completed or are ongoing. In 2015 it will fully replace a number of existing water related directives, which are successively being repealed, while implementation of other Directives (such as the Habitats Directive 92/43/EEC) will form part of the achievement of implementation of the objectives of the WFD;

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

6.1.4 Relevant Guidance

The following guidance was reviewed in the preparation of this chapter:

- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation on Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Wind Farm Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- Forest Services (Draft) Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures;
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford;
- COFORD (2004): Forest Road Manual – Guidelines for the Design, Construction and Management of Forest Roads;

- Eastern Regional Fisheries Board (not dated): Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites;
- Good Practice During Wind farm Construction (Scottish Natural Heritage, 2010);
- PPG1 – General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works in, near or over Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006.

6.1.5 Methodology

6.1.5.1 Desk Study

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

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Éireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive "WaterMaps" Map Viewer (www.wfdireland.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 18 (Geology of Tipperary). Geological Survey of Ireland (GSI, 1999);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway - Offaly). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland - Groundwater Body Characterisation Reports;
- OPW Indicative Flood Maps (www.floodmaps.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- CFRAM Preliminary Flood Risk Assessment (PFRA) maps (www.cfram.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

6.1.5.2 Site Investigations

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES on 11th, 30th and 31st March 2015. The hydrological walkover survey involved:

- Walkover surveys and hydrological mapping of the proposed site and the surrounding area were undertaken whereby water flow directions and drainage patterns were recorded;

- A preliminary flood risk assessment for the proposed development footprint area;
- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows;
- A total of 3 no. surface water samples were undertaken to determine the baseline water quality of the primary surface waters originating from the proposed site.

6.1.5.3 Impact Assessment Methodology

The sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in **Table 6.1** are then used to assess the potential effect that the proposed development may have on them.

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

Table 6.1: Receptor Sensitivity Criteria (Adapted from www.sepa.org.uk)

6.2 Description of the Existing Environment

6.2.1 Site Description & Topography

The proposed wind farm site is located approximately 8km to the east of Abbeyleix, Co. Laois. The site lies within the townlands of Boleybawn, Knockardugar, Graiguenahown, Ironmills (Kilrush) and Garrintaggart, in Co. Laois and the townland of Crutt in Co. Kilkenny. This area is part of the Castlecomer Plateau, a broad upland area which straddles the boundaries between counties Laois, Carlow and Kilkenny. The site lies on the county boundary between Laois and neighbouring Kilkenny to the south, with the town of Castlecomer around 8km away. It is an upland area with elevations ranging from 250 – 300m AOD (meters above Ordnance Datum). The site consists, in part, of lands owned and operated by Coillte and as such a series of forest tracks and third class roads cross the site. The current land use at the site is predominately agricultural grazing and forestry. The site is drained by several streams which are tributaries of the Owenbeg River.

6.2.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The 30 year annual average rainfall (1981 - 2010) recorded at Abbeyleix, 6.5km northwest of the site, are presented in **Table 6.2**.

Station		*X-Coord*		*Y-Coord*		*Ht (MAOD)*		*Opened*		*Closed*		
Abbeyleix		*248,200*		*186,900*		*164*		*1874*		*N/A*		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
94	67	72	63	63	67	70	87	74	105	91	90	943

Table 6.2: Local Average long-term Rainfall Data (mm)

The closest synoptic station where the average potential evapotranspiration (PE) is recorded is at Kilkenny, approximately 26km south of the site. The long term average PE for this station is 459mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 436mm/yr (which is 0.95 × PE).

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

Effective rainfall (ER) = AAR – AE

= 943mm/yr – 436mm/yr

ER = 507mm/yr

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate 100 - 130mm/year average annual recharge cap is given for the local aquifers. This means that the hydrology of the study area is characterised by relatively high surface water runoff rates and low groundwater recharge rates. Based on a conservative recharge cap of 100mm/year, the annual runoff rate for the site is estimated to be 407mm/yr. The large coverage of poorly draining soil means recharge rates are likely to be towards the lower end of the GSI range and therefore the more conservative recharge cap of 100mm/year is used.

6.2.3 Regional & Local Hydrology

Regionally, the proposed development site itself is located in the Nore River surface water catchment within Hydrometric Area 15 of the South Eastern River Basin District (SERBD). A regional hydrology map is shown as **Figure 6.1.**

In terms of local hydrology the proposed development site is situated within the Owenbeg River and the Dinin River surface water catchments. The Owenbeg River flows in southerly direction approximately 2km west of the site while the Dinin River flows in a southerly direction approximately 6km southeast of the site. A local hydrology map is shown as **Figure 6.2**.

In terms of proposed development, all of the proposed 11 no. turbines are located in the Owenbeg River catchment. A section of access road is located within the Dinin River catchment. Refer to **Table 6.3** below for a summary of proposed infrastructure in relation to local and regional surface water catchments.

6.2.4 Forestry Drainage Background

Within the proposed development site there are numerous manmade drains that are in place predominately to drain the existing forestry plantations. The current internal forestry drainage pattern is influenced by the topography, peat subsoils, layout of the forest plantation and by the existing road network. The forestry plantations, which cover a significant proportion of the site are generally drained by a network of mound drains which typically run perpendicular to the topographic contours of the site and feed into collector drains, which discharge to interceptor drains down-gradient of the plantation (refer to **Plate 6.1** below for existing forestry drainage layout schematic).

Mound drains and ploughed ribbon drains are generally spaced approximately every 15-20m and 2m respectively. Interceptor drains are generally located up-gradient (cut-off drains) and down-gradient of forestry plantations. Interceptor drains are also located up-gradient of existing forestry access roads. Culverts are located on existing access roads at stream and drain crossings and at low points under access roads which drain runoff onto down-gradient forest plantations.

The site drainage surveys, which were undertaken on 11th, 30th and 31st March 2015, were carried out after significant amounts of rainfall and therefore the drains and streams at the site were observed during wet conditions. Every effort was made during the surveys to map the main important drains in the vicinity of the proposed development footprint but due to the dense forestry coverage in some areas it was not feasible to map every single drain. However, it is not necessary to map or have knowledge of every single forestry drain, as the typical standard forestry drainage layout (as shown in **Plate 6.1**) can be applied when designing the wind farm drainage and runoff control measures for the protection of surface water quality. The integration of the existing forestry drains with the proposed wind farm drainage is a key component of the drainage design and the same integration approach (which is outlined further below) will be applied to all forestry drainage and field drainage during the construction and operation of the proposed development.

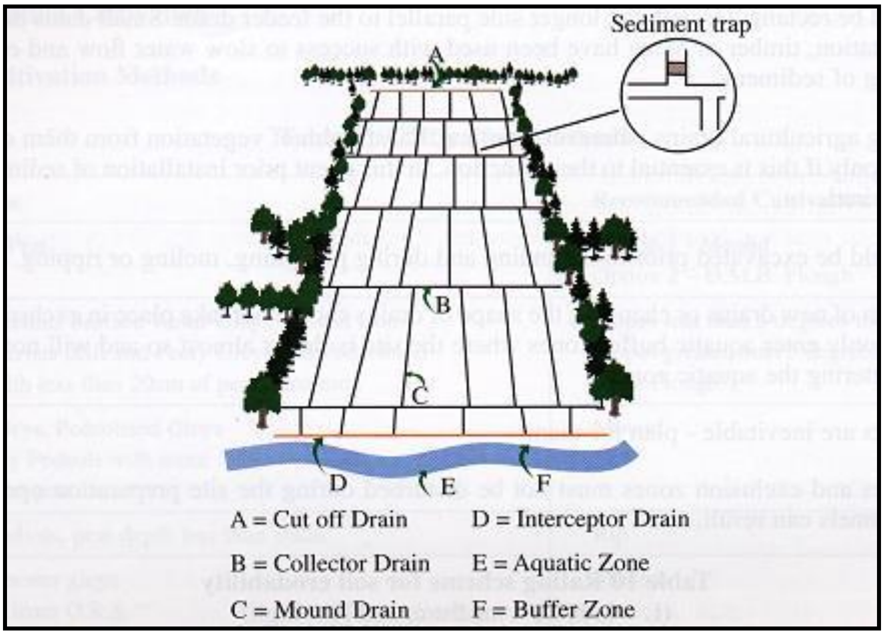


Plate 6.1: Standard Forestry Drainage (Forestry Schemes Manual, Forest Service, August 2004)

6.2.5 Site Drainage

Based on the local topography and the current drainage regime the landholding area can be divided into five sub-catchments. A site drainage map is shown as **Figure 6.3** and a site sub-catchment map is shown **Figure 6.4**.

Sub-catchment 1 includes the north-eastern section of the landholding. The catchment is drained by two unnamed streams; referred to in this report as S2 and S3. Stream S2 rises in a field approximately 200m west/northwest of turbine location T1. Stream S2 then flows in a north-easterly direction for approximately 0.9km prior to merging with stream S3. Stream S3 then flows in a northerly direction along the eastern section of the landholding prior to merging with stream S2. The Owenbeg River exists approximately 500m downstream of the confluence point of the two streams.

Sub-catchment 2 includes the central area of the northern section of the landholding and is drained by one primary stream. Stream S1 emerges in the central area of the site and flows in a northerly direction towards the Owenbeg River. Two new stream crossings over stream S1 will be required to facilitate the development.

Sub-catchment 3 comprises the western slopes of the landholding. This section of landholding drains to several small streams that merge away to the west of the landholding boundary. All these streams flow directly into the Owenbeg River. No streams emerge in the landholding area itself within Sub-catchment 3 and drainage ditches are the primary drainage routes.

Sub-catchment 4 comprises the majority of the southern section of the landholding area. Sub-catchment 4 is drained by one primary stream (S4) which is a tributary of the Ironmills River. The Ironmills River flows in a westerly towards the Owenbeg River.

Sub-catchment 5 comprises a small section on the south-eastern corner of the landholding area. No streams emerge in the landholding area itself within Sub-catchment 5 and drainage ditches are the primary drainage routes towards downstream watercourses that flow into the Dinin River.

A summary of the site sub-catchments and proposed infrastructure is shown in **Table 6.3** below.

Sub-catchment	*Proposed Infrastructure*	*Primary On-site Drainage Features*	*River Catchment*
SC1	Turbines T1, T2, T3 and substation/compound	Streams S2 & S3	Owenbeg
SC2	Turbines T4 & T5	Stream S1	Owenbeg
SC3	Turbine T6, T7, met mast & switching station	Various forestry drains/agricultural land drains	Owenbeg
SC4	Turbines T8, T9, T10 & T11	Stream S4 (i.e. Ironmills River)	Owenbeg
SC5	Existing forestry road for upgrade	Various forestry drains/agricultural land drains	Dinin

Table 6.3: Summary of Site Sub-Catchments & Proposed Infrastructure

6.2.6 Flood Risk Identification

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

No recurring flood incidents within the site or surrounding area were identified from OPW's indicative river and coastal flood map. In addition, no flooding incidences are mapped along the Owenbeg River or the Dinin River immediately downstream of the site.

The PFRA map no. 168 (www.cfram.ie) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (*i.e.* river) and pluvial (*i.e.* rainfall) flood events. The 1 in 100 year fluvial flood zone incorporates notable land area surrounding the Owenbeg River to the north of the site and the Ironmills River to the southwest of the site. There was no 1 in 100 year fluvial flood zones mapped within the site or surrounding area.

There is no identifiable map text on local available historical 6" or 25" mapping for the study area that identify lands that are "prone to flooding".

There are no areas within the site or downstream of it mapped as "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

A key mitigation measure of the proposed development to ensure all surface water runoff is treated (water quality control) and attenuated (water quantity/flood management control), prior to diffuse discharge at pre-existing Greenfield rates. As such, the mechanism by which downstream flooding is prevented and controlled is through avoidance by design. These proposed drainage attenuation measures are outlined in the impact assessment section below.

6.2.7 Surface Water Hydrochemistry

Q-rating status data for EPA monitoring points on the Dinin River are shown on **Table 6.4** below. No Q-rating data was available for Owenbeg River catchment.

The Q-rating for the Dinin River is Good Status with the exception of the station at Doonane Bridge where a Moderate Status is reported.

Water body	*EPA Location Description*	*Easting*	*Northing*	*EPA Q-Rating Status*
Dinin	Br North of Crettyard House	258,820	177,480	Good
Dinin	Doonane Bridge	257,900	177,740	Moderate
Dinin	2km d/s of Massford Bridge	254,260	175,800	Good

Table 6.4: EPA Water Quality Monitoring Q-Rating Values

Field hydrochemistry measurements of electrical conductivity (µS/cm), pH (pH units) and temperature (°C) were taken within surface watercourses across the study area on 11th March 2015. The monitoring was undertaken during a period of wet weather and as a result streams and drains were observed in high flow conditions. The results are listed (along with the surface water feature type) in **Table 6.5** below

Electrical conductivity (EC) values for streams at the site area ranged between 86 and 100µS/cm. This indicates that surface water flow was derived predominantly from rainfall input/runoff during the monitoring period. Measurement in lower-flow conditions (lower water levels in late summer time) may indicate a higher groundwater flow component (i.e. baseflow - typically signified by 'higher' EC values) contributing to discharge in the primary streams. The pH values were generally slightly acidic with some values just exceeding neutral in the larger streams. Slightly acidic pH values of surface waters would be typical of upland areas where acidic gley soils dominate. In addition, the sandstone and shale bedrock (and related till subsoils) which underlie the study area would have slightly acidic groundwater characteristics which would have some effect on surface water chemistry especially during dry periods, when baseflow is likely to be more prevalent.

Location ID	Easting	Northing	EC (µS/cm)	H	p ℃	Drainage Feature
SW1	250,190	179,600	100	0.1	0.0	Stream S4
SW2	251,290	182,340	95	6.9	8.5	Stream S1
SW3	252,110	182,800	86	0.9	0.5	Stream S3
FP1	251,700	181,740	90	2.0	0.5	Stream S2
FP2	251,700	181,740	90	0.2	0.5	Stream S2

Table 6.5: Summary of Surface Water Chemistry Measurements

Surface water samples were taken from watercourses draining the proposed development study area on 11th March 2015. Refer to **Figure 6.3** for sampling locations. Results of the laboratory analysis are shown alongside relevant water quality regulations in **Table 6.6**. In addition, Environmental Objectives Surface Water Regulations (S.I. 272 of 2009) are shown in **Table 6.7**. Original laboratory reports are attached as **Appendix 6.1**.

Parameter	EC DIRECTIVES			Sample ID		
	2006/44/EC		EC DW Regs 2007	SW1	SW2	SW3
	Salmonid	Cyprinid				
Total Suspended Solids (mg/L)	≤ 25 (O)	≤ 25 (O)	-	28	39	14
Ammonia N (mg/L)	≤0.04	≤0.02	0.3	0.036	0.023	0.072
Nitrite NO2 (mg/L)	≤ 0.01	≤ 0.03	0.5	<0.043	0.066	0.046
Ortho-Phosphate – P (mg/L)	-	-	-	0.015	0.031	0.023
Nitrate - NO3 (mg/L)	-	-	50	1.46	1.82	3.19
Phosphorus (mg/L)	-	-		0.063	0.023	0.06
Chloride (mg/L)	-	-	250	12	12.9	13.8
BOD	≤ 3	≤ 6	-	2	<1	2

Table 6.6: Analytical Results of Surface Water Samples (SW1-SW3)

Total suspended solids ranged between 14 and 39 mg/L for samples SW1 to SW3. There was an exceedance of the Freshwater Fish Directive (2006/44/EC) in samples SW1 and SW2 for the Salmonid/Cyprinid limits. As stated above the drainage mapping and sampling was undertaken on a very wet day and the elevated suspended solids are likely due to high turbid flows in the local streams and rivers.

Ammonia N ranged between 0.023 and 0.072 mg/L for samples SW1 to SW3. All samples exceeded the Freshwater Fish Directive (2006/44/EC) in relation to the Cyprinid limit. In relation to the Salmonid limit, there was only one exceedance and that was sample SW3. The exceedances in Ammonia N are not significant (refer to WFD status below) and additional sampling would be required to establish trends. The streams sampled drain both agricultural and forestry lands and these activities will influence local water quality.

Nitrite (NO2) ranged between 0.043 and 0.066 mg/L for samples SW1 to SW3 which exceeded the Freshwater Fish Directive (2006/44/EC) for both Salmonid and Cyprinid limits. Again, additional sampling would be required to establish trends. Agricultural and forestry activities within the catchment will influence local water quality.

In comparison to the Environmental Objectives Surface Water Regulations (S.I. 272 of 2009), Ammonia N in samples SW1 and SW2 were within the High Status threshold while SW3 exceeded both the Good Status and High Status threshold values.

Ortho-phosphate was within the High Status threshold in samples SW1 and SW3 while SW2 was within the Good Status threshold.

BOD exceeded both the High Status and Good Status threshold in samples SW1 and SW3 while SW2 was within the High Status threshold.

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

Table 6.7: Chemical Conditions Supporting Biological Elements*

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

6.2.8 Hydrogeology

The Westphalian sandstones which are mapped to underlie the central section of the subject site are classified by the GSI (www.gsi.ie) as a Locally Important Aquifer, bedrock which is generally moderately productive (Lm).

The Westphalian shales and Namurian sandstones, which underlie the remainder of the subject site, are classified as a Poor Aquifer, having bedrock which is generally unproductive except for local zones (Pl / Pu).

The shales and sandstones that underlie the site generally have an absence of inter-granular permeability, and most groundwater flow is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring 10m thick, and a zone of isolated poorly connected fissuring typically less than 150m.

Groundwater levels in this bedrock type elsewhere have been measured mainly 0-5m below ground level. Groundwater flowpaths are likely to be short (30-300m), with groundwater discharging to nearby streams and small springs. Water strikes deeper than the estimated interconnected fissure zone suggest a component of deep groundwater flow, however shallow groundwater flow is thought to be dominant. Groundwater flow directions are expected to follow topography and therefore groundwater directions within the site are expected to be towards the primary streams within the valleys of the site (GSI, 2004).

Baseflow contribution to streams tends to be low, particularly in summer as the groundwater regime cannot sustain summer baseflows due to low storativity within the aquifer. In winter, low permeabilities will lead to a high water table and potential water logging of soils. Local groundwater flow directions will mimic topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at local streams (GSI, 2004).

6.2.9 Groundwater Vulnerability

The vulnerability rating of the aquifer within the overall landholding ranges between Extreme (E) to Extreme (X) and this reflects the varying depth of local subsoils. An Extreme (X) vulnerability rating is given where bedrock is at or close to the surface. An Extreme (E) vulnerability rating is given where subsoils are present with a maximum thickness of 3 metres. All of the proposed turbines are located in areas mapped as Extreme (E) as determined by the trial pit investigation (refer to Chapter 5).

However, due to the relatively low permeability nature of the shales and sandstones underlying the site, groundwater flowpaths are likely to be short (30 – 300m), with recharge emerging close by at seeps and surface streams. This means there is a low potential for groundwater dispersion and movement within the aquifer, therefore surface water bodies such as drains and streams are more vulnerable than groundwater at this site.

6.2.10 Groundwater Hydrochemistry

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

Based on data from GSI publication Calcareous/Non calcareous classification of bedrock in the Republic of Ireland (WFD,2004), alkalinity for these non-calcareous bedrock type generally ranges from 14 – 400mg/L while electrical conductivity and hardness are reported to have mean values of 446µS/cm and 200mg/L respectively.

6.2.11 Water Framework Directive Water Body Status & Objectives

The South Eastern River Basin District (SERBD) Management Plan was adopted by all local authorities in the SERBD prior to 30th of April 2010, as stipulated in the European Communities (Water Policy) Regulations 2003 (S.I. 722 of 2003 as amended). The SERBD Management Plan (2009 – 2015) objectives, which will be integrated into the design of the proposed wind farm development, include the following:

- Prevent deterioration and maintain a high status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2015;
- Ensure waters in protected areas meet requirements;
- Progressively reduce chemical pollution.

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

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

6.2.12 Groundwater Body Status

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

The Ballingarry GWB (IE_SE_G_009) underlies the western section of the proposed development site and the Castlecomer GWB (IE_SE_G_034) underlies the eastern section of the proposed development site.

All the above mentioned GWBs are assigned ‘Good Status’, which is defined based on the quantitative status and chemical status of the GWB.

6.2.13 Surface Water Body Status

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) in which development is proposed (or immediately upstream of) are shown in **Table 6.8** below. The locations of the SWBs are shown on **Figure 6.2**.

The northern/north-eastern section of the proposed development site is located within the Owenbeg Upper SWB and this water body has been assigned "Moderate" status.

The western/northwestern section of the proposed development site is located within the Owenbeg Mid SWB and this water body has also been assigned "Moderate" status.

The southeastern corner of the proposed development site is located within the Dinin Mid SWB and this water body has been assigned "Moderate" status.

The southern section of the proposed development site is located within the Ironmills SWB and this water body has been assigned "High" status.

Surface Water Bodies (in which development is proposed or downstream of) reported to be either At Risk (1a) or Probably At Risk (1b) from forestry related suspended solid input and eutrophication include the Ironmills SWB and the Owenbeg Upper SWB.

Poor construction and water management practices during the construction phase have the potential to impact on local surface water quality in ways similar to forestry activities as outlined above. Mitigation measures (as detailed below) will ensure that surface runoff from the developed areas of the site will be of a high quality and will therefore not impact on the status of downstream surface water bodies.

Water Body	*General Physico-Chemical Status*	*Overall Ecological Status*	*Overall Status*	*Overall Risk Result*	*Overall Objective*
Dinin Mid	Good	Moderate	Moderate	1a	Restore 2021
Owenbeg Mid	Good	Moderate	Moderate	a	Restore 2021
Ironmills	n/a	High	High	a	Restore 2021
Owenbeg Upper	High	Moderate	Moderate	a	Restore 2021

Table 6.8: Summary WFD Information for Surface Water Bodies

6.2.14 Designated Sites & Habitats

Designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs).The proposed development site is not located within any designated conservation site. Designated sites in proximity to the proposed development study area are show in **Figure 6.5.**

The proposed development site drains to the Owenbeg River and the Dinin River which forms part of the River Barrow and River Nore SAC. The River Nore downstream of the site is also a designated pNHA (*i.e.* River Nore and Abbeyleix Woods Complex).

Designated sites that are not hydrologically connected to the development site but are located in the vicinity include Lisbigney Bog SAC and pNHA (5.5km to the southwest of the site). These designated sites are not hydrologically connected to the proposed wind farm site and therefore there is no potential for impact (*i.e.* there is no surface water runoff or groundwater flow).

6.2.15 Water Resources

There are no groundwater protection zones mapped within the proposed development site or study area. A search of private well locations (wells with an accuracy of 1 – 50m were only considered) in the GSI well database (www.gsi.ie) was also undertaken. No private wells with a mapped accuracy of 1 – 50m are present within 1km of the site.

Due to the fact that the GSI well database is not exhaustive in terms of every well location it is assumed that every private dwelling in the area has a well supply and this impact assessment approach is described further below. This is a very conservative approach as it is unlikely that every private dwelling will have its own supply well.

The private well assessment undertaken below also assumes the groundwater flow direction in the aquifer underlying the site mimics topography, whereby flowpaths will be from topographic high points to lower elevated discharge areas at streams and rivers. Using this conceptual model of groundwater flow, dwellings that are potentially located down-gradient of the proposed development footprint are identified and an impact assessment for these potential well locations is undertaken in the impact assessment section below.

Shown on **Figure 6.6** are the locations of private dwellings in the vicinity of the development study area. Private dwellings are only potentially located down-gradient of turbine location Turbine 11. The potential impact on these wells (if present) is assessed further below. The remainder of the proposed development is not up-gradient of a private dwelling location (refer to footnote below **Table 6.9** further for details relating to the impact assessment approach).

Development Location	*Distance from Closest Private Dwelling (m)*	*Elevation Difference (m)*
Turbine 11	522	65

Table 6.9: Potential Private Wells Down-gradient of the Development Footprint

Note: Distance from closest turbine, compound, borrow pit or substation (i.e. bedrock excavation). Access roads and the grid connection cable trench are not considered a potential risk due to the shallow nature of the works. The distances listed above are from the nearest wind farm infrastructure within the same surface water catchment as the dwelling. Each dwelling is assumed to have an on-site private water well.

6.2.16 Receptor Sensitivity

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

Based on criteria set out in **Table 6.1** above, the Poor Aquifers (*i.e.* Westphalian shales and Namurian sandstones) at the site can be classed as Not Sensitive to pollution while the Locally Important

Aquifers (*i.e.* Westphalian sandstones) can be classed as Sensitive to pollution. The majority of the site is also covered in poorly draining soil which acts as a protective cover to the underlying aquifer. Any contaminants which may be accidently released on-site are more likely to travel to nearby streams within surface runoff.

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

The nearest River Nore Freshwater Pearl Mussel population to the proposed site development is 21.2km downstream via the Owenbeg River. FPM was not recorded in the Owenbeg River during the current assessment. The southern boundary of the site is 14km from the River Nore Freshwater Pearl Mussel population via the Boleybawn Stream/Moneycleare River, where Site 1 was found to be dry during survey work. Freshwater Pearl Mussel can be considered very sensitive to potential impact.

A hydrological constraints map for the development site is shown as **Figure 6.7**. A self-imposed 50m buffer from streams and lakes was applied during the constraints mapping and will be maintained during the construction phase. Apart from the two proposed stream crossings over stream S1 and the proposed stream crossing over stream S4, the proposed development areas are generally away from areas on the site that have been determined to be hydrologically sensitive. Where the development footprint exists within the 50m buffer zone additional mitigation measures will be employed to protect surface water quality. These measures are outlined further below in the chapter.

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

6.2.17 Assessment of Changes in Site Runoff Volumes

The water balance undertaken in this section is for baseline characterisation purposes along with an assessment of potential runoff changes as a result of the proposed development footprint. The rainfall depths presented in this section, which are long term averages, are not used in the design of the sustainable drainage system for the wind farm. As outlined further below a 1 in 100 year 6 hour return period will be used for design purposes.

The water balance calculations are carried out for the month with the highest average recorded rainfall minus evapotranspiration, for the current baseline site conditions (**Table 6.10**). It represents therefore, the long term average wettest monthly scenario in terms of volumes of surface water runoff from the study area pre-development. The surface water runoff co-efficient for the area is estimated to be 80% based on the GSI recharge estimates.

The highest long term average monthly rainfall recorded at Abbeyleix over the period 1981 - 2010 occurred in October, at 105mm. The average monthly evapotranspiration for the synoptic station at Kilkenny over the same period was 16.8mm. The water balance indicates that a conservative estimate of surface water runoff for the site during the highest rainfall month is 270,560m3/month as outlined in **Table 6.11** below.

Water Balance Component	*Depth (m)*
Average October Rainfall (R)	0.105
Average October Potential Evapotranspiration (PE)	0.0168
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.016
Effective Rainfall October (ER = R - AE)	0.09
Recharge co-efficient (20% of ER)	0.018
Runoff (80% of ER)	0.072

Table 6.10: Water Balance and Baseline Runoff Estimates for Wettest Month

Approx. Area (ha)	*Baseline Runoff per month (m3)*	*Baseline Runoff per day (m3)*
380	270,560	8,728

Table 6.11: Baseline Runoff for the Study Area

Site Baseline Runoff/month (m3)	Baseline Runoff/day (m3)	Permanent Development Area (m2)	Permanent Development Area 100% Runoff (m3)	Permanent Development Area 80% Runoff (m3)	Net Increase/month (m3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m3)
270,560	8,728	65,000	5,785	4,628	1,157	37	0.43

Table 6.12: Water Balance and Estimated Development Runoff Volumes

The emplacement of the proposed permanent development footprint, as described in Chapter 2 of the EIS, (assuming emplacement of impermeable materials as a worst case scenario) could result in an average total site increase in surface water runoff of 1,157m3/month from the landholding (**Table 6.12**). This represents a potential increase of 0.43% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the landholding area being developed, the proposed total permanent development footprint being approximately 6.5ha, representing 1.7% of the total landholding area of 380ha. The additional volume in all sub-catchments is relatively low due to the fact that the runoff potential from the site is naturally relatively high (80%). Also, the calculation assumes that all hardstanding areas will be impermeable which will not be the case as access tracks will be constructed of permeable stone aggregate). The increase in runoff from the landholding will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

6.2.18 Development Interaction with the Existing Forestry Drainage Network

In relation to hydrological constraints, a self-imposed buffer zone of 50m has been put in place for on-site streams. Manmade forestry drains or other land drains at the site are not considered a hydrological constraint and therefore no buffering of forestry drains has been undertaken.

The general design approach to wind farm layouts in existing forestry is to utilise and integrate with the existing forestry infrastructure where possible, whether it is existing access roads or the existing forestry drainage network. Utilising the existing infrastructure means that there will be less of a requirement for new construction/excavations which have the potential to impact on downstream watercourses in terms of suspended solid input in runoff (unless managed appropriately). The existing forestry drains have no major ecological or hydrological value, and can be readily integrated into the proposed wind farm drainage scheme using the methods outlined below.

6.2.19 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against impacts on surface water bodies. Two distinct methods will be employed to manage drainage water within the proposed development. The first method involves ‘keeping clean water clean’ by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas. The second method involves collecting any drainage waters from works areas within the site that might carry silt or sediment, and nutrients, to route them towards settlement ponds (or stilling ponds) prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters. During the construction phase all runoff from works areas will be attenuated and treated to a high quality prior to being released. A schematic of the proposed site drainage management is shown as **Plate 6.2** below.

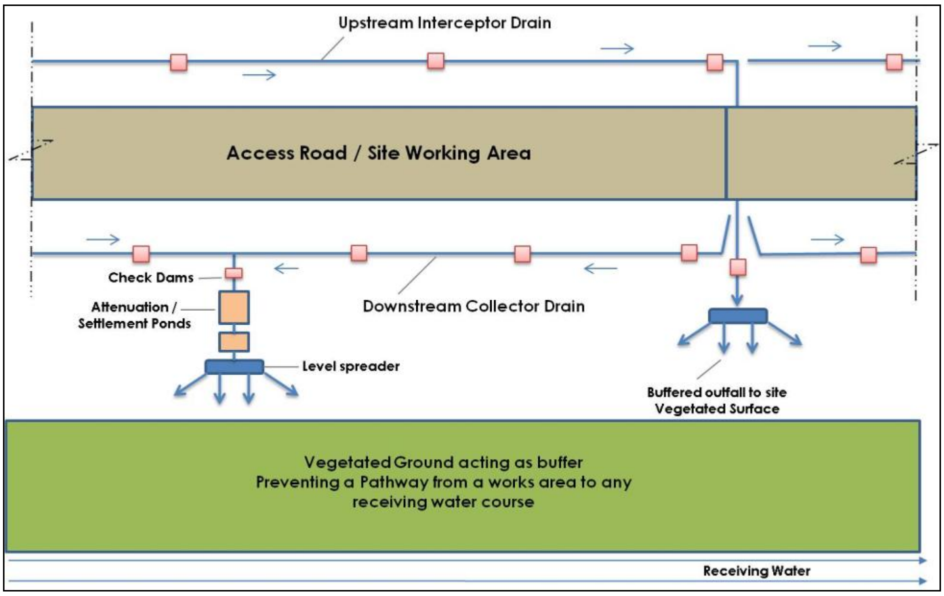
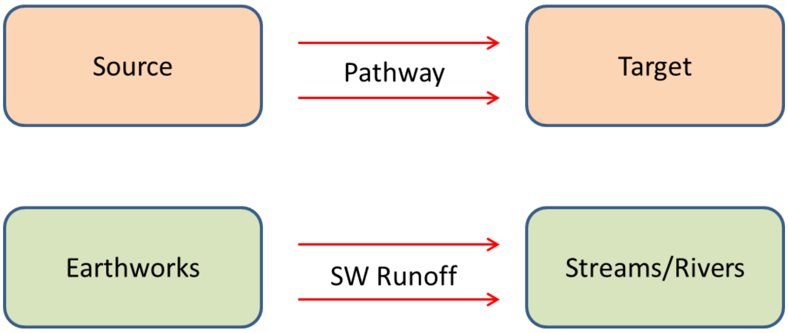


Plate 6.2: Schematic of Proposed Site Drainage Management

6.3 Description of Likely Impacts

6.3.1 Overview

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



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

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

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

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

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

Step 1	Identification and Description of Potential Impact Source This section presents and describes the activity that brings about the potential impact or the potential source of pollution. The significance of effects is briefly described.	
Step 2	Pathway/ Mechanism:	The route by which a potential source of impact can transfer or migrate to an identified receptor. In terms of wind farm developments, surface water and groundwater flows are the primary pathways, or for example, excavation or soil erosion are physical mechanisms by which a potential impact is generated.
Step 3	Receptor:	A receptor is a part of the natural environment which could potentially be impacted upon, *e.g.* human health, plant/animal species, aquatic habitats, soils/geology, water resources, water sources. The potential impact can only arise as a

		result of a source and pathway being present.
Step 4	Pre-mitigation Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impact before mitigation is put in place.
Step 5	Proposed Mitigation Measures:	Control measures that will be put in place to prevent or reduce all identified significant adverse impacts. In relation to wind farm developments, these measures are generally provided in two types: (1) mitigation by avoidance, and (2) mitigation by engineering design.
Step 6	Post Mitigation Residual Impact:	Impact descriptors which describe the magnitude, likelihood, duration and direct or indirect nature of the potential impacts after mitigation is put in place.
Step 7	Significance of Effects:	Describes the likely significant post mitigation effects of the identified potential impact source on the receiving environment.

6.3.2 Construction Phase Potential Impacts

6.3.2.1 Clear Felling of Coniferous Plantation

It is estimated that approximately 6 hectares in total of existing plantation forestry will be felled to allow for development of the proposed wind farm infrastructure. All proposed felling will be undertaken Owenbeg River catchment.

Potential impacts during tree felling 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;
- Entrainment of suspended sediment in watercourses due to vehicle tracking through watercourses;
- Damage to roads resulting in a source of suspended sediment which can become entrained in surface water runoff and enter surface watercourses;
- Release of sediment attached to timber in stacking areas;
- Nutrient release.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters and associated dependant ecosystems.

Pre Mitigation Impact: Indirect, negative, moderate, temporary, high probability impact.

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

Construction phase activities including access road construction, turbine base/hardstanding construction and grid cable trench excavation will require earthworks resulting in removal of vegetation cover and excavation of peat and mineral subsoil where present. Potential sources of sediment laden water include:

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

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

Pathways: Drainage and surface water discharge routes.

Receptors: Down-gradient rivers and dependant ecosystems.

Pre-Mitigation Impact: Indirect, negative, significant, temporary, medium probability impact.

6.3.2.3 Potential Release of Hydrocarbons during Construction and Storage

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

Pathway: Groundwater flow paths and site drainage network.

Receptor: Groundwater and surface water.

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

6.3.2.4 Groundwater and Surface Water Contamination from Wastewater Disposal

Release of effluent from wastewater treatment has the potential to impact on groundwater and surface waters.

Pathway: Groundwater flow paths and site drainage network.

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

Pre mitigation Impact: Indirect, negative, significant, temporary, low probability impact to surface water quality. Indirect, negative, slight, temporary, low probability impact to local groundwater.

6.3.2.5 Release of Cement-Based Products

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

Pathway: Site drainage network.

Receptor: Surface water and peat water hydrochemistry.

Pre-Mitigation Impact: Indirect, negative, moderate, short term, medium probability impact to surface water.

6.3.2.6 Morphological Changes to Surface Watercourses & Drainage Patterns

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

It is proposed that 3 no. new stream crossings will be required to facilitate the wind farm access road. This includes two crossings over stream S1 and one crossing over stream S4.

Pathway: Site drainage network.

Receptor: Surface water flows and stream morphology.

Pre-mitigation Impact: Negative, direct, slight, long term, high probability impact.

6.3.2.7 Potential Impacts on Hydrologically Connected Designated Sites

The proposed development site drains to the Owenbeg River and the Dinin River which forms part of the River Barrow and River Nore SAC. The River Nore downstream of the site is also a designated pNHA (*i.e.* River Nore and Abbeyleix Woods Complex).

Possible effects include water quality impacts which could be significant if mitigation is not put in place.

Pathway: Surface water flow paths.

Receptor: Down-gradient water quality and designated sites.

Pre-Mitigation Impact: Indirect, negative, negligible, temporary, low probability.

6.3.2.8 Potential Impacts on Local Groundwater Well Supplies

Release of contaminants and alterations of groundwater levels within excavations has the potential to impact on groundwater supplies down-gradient of the site. As assessed above no significant impacts on site groundwater levels are anticipated and therefore, no impacts on local groundwater supplies can occur from this impact. Water quality impacts on local wells supplies could potentially occur from contaminants such as hydrocarbons/chemicals etc.

As stated above, private dwellings are potentially located down-gradient of a proposed turbine location Turbine 11. It is assumed that these houses have a private well; however this has not being confirmed. The remainder of the dwelling houses are remote (*i.e.* not located down-gradient of a proposed development area). Details regarding these down-gradient dwellings and their location in relation to proposed wind farm development areas are shown in **Table 6.10** above and on **Figure 6.6**.

Pathway: Groundwater flow paths.

Receptor: Groundwater Supplies.

Pre-Mitigation Impact: Indirect, negative, slight, short term, low probability impact.

Impact Assessment: Private dwelings are potentially down-gradient of a proposed turbine T11. Proposed turbine T11 is approximately 522m up-gadient of the private dwelling and potential well.

However, the risk to this potential well source (and the remaining dwellings which are further away) from potential contaminant release within any excavation at this distance is negligible. Due to the relatively low permeability of this aquifer type and low recharge characteristics, flowpaths are generally short. Maximum flowpaths are estimated to be 30–300m for aquifers in this bedrock type. The flowpath is the distance and direction from the aquifer recharge area to where groundwater is discharged as surface water in rivers, seeps or springs. Therefore, it is unlikely that groundwater flow volumes and direction will be impacted by any activity that is at a distance of greater than 30-300m from a given point in the aquifer. If a flowpath between turbine T11 and the dwelling house did exist, the relatively low permeability would mean that a pollutant would take months to travel this distance as demonstrated below by means of the Darcy mean velocity equation.

$$q = k.i$$

$$v = q/ ne$$

$$T = L / v$$

where:

q	= specific discharge (m/day)
k	= permeability m/day (a value of 0.5m/day for low permeability bedrock is used).
ne	= porosity (a value of 0.025 is used for this bedrock type).
i	=slope of the water table in low permeability rock can be estimated from on topography (a value of 0.12 is used down-gradient of T11 (265mOD - 200mOD)/522m = 0.12).
v	= Darcy velocity (m/day).
L	= Distance (metres).
T	= Time of travel (days)

Based on a groundwater flow velocity of 2.4m/day, the time of travel (ToT) for a potential pollutant to flow from the T11 location to the dwelling house would be in the order of 217 days. During this time any discharge would be assimilated and attenuated by natural groundwater flow, and diluted by rainfall recharge. Also any entrained sediment would be filtered within the low permeability bedrock aquifer. Therefore the risk posed to potential well sources at this distance from potential spills and leaks from excavations is negligible to none.

6.3.2.9 Potential Impacts on Freshwater Pearl Mussel in the River Nore Catchment

The nearest River Nore Freshwater Pearl Mussel population to the proposed site development is 21.2km downstream via the Owenbeg River. FPM were not recorded in the Owenbeg River during the current assessment. The southern boundary of the site is 14km from the River Nore FPM population via the Boleybawn Stream/Moneycleare River, where Site 1 was found to be dry during survey work.

Possible effects relating to poor quality surface water runoff could be significant if mitigation is not put in place.

Pathway: Surface water flow paths.

Receptor: Down-gradient water quality and fresh water pearl mussel sites.

Pre-Mitigation Impact: Indirect, negative, slight, temporary, low probability.

6.3.3 Operational Phase

6.3.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises turbine hardstandings, upgraded access roads, substation and compound. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Impact: Direct, negative, moderate, permanent, moderate probability impact.

Impact Assessment: As determined above there could be a potential increase of 0.43% in the average daily/monthly volume of runoff from the study area in comparison to the baseline pre-development site runoff conditions. This is a very small increase in average runoff and results from a relatively small area of the study area being developed, the proposed total permanent development footprint being approximately 6.5ha, representing 1.7% of the total study area of 380ha.

The increase in runoff from the most development will therefore be negligible. This is even before mitigation measures will be put in place. Therefore, there will be no risk of exacerbated flooding down-gradient of the site.

6.3.4 Decommissioning Phase

The potential hydrological impacts during the decommissioning phase are expected to be similar to the construction phase and therefore mitigation will be the same as the construction phase which is outlined below.

6.4 Mitigation & Monitoring

6.4.1 Construction Phase

6.4.1.1 Clear Felling of Coniferous Plantation

Best practice methods related to water incorporated into the forestry management and mitigation measures have been derived from:

- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations and Water Protection Guidelines;
- Coillte (2009): Methodology for Clear Felling Harvesting Operations;
- Forest Service (Draft): Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures; and,
- Forest Service (2000): Forestry and Water Quality Guidelines. Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.

Mitigation by Avoidance: There is a requirement in the Forest Service Code of Practice and in the FSC Certification Standard for the installation of buffer zones adjacent to aquatic zones at planting stage. Minimum buffer zone widths recommended in the Forest Service (2000) guidance document "*Forestry and Water Quality Guidelines*" are shown in **Table 6.13**.

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

Table 6.13: Minimum Buffer Zone Widths (Forest Service, 2000)

During the wind farm construction phase a self-imposed buffer zone of 50m will be maintained for all streams where possible. These buffer zones are shown on **Figure 6.7**.

With the exception of the proposed stream crossings all proposed tree felling areas are generally located outside of imposed buffer zones. The large distance between proposed felling areas and sensitive aquatic zones means that potential poor quality runoff from felling areas can be adequately managed and attenuated prior to even reaching the aquatic buffer zone and primary drainage routes. Where tree felling is required in the vicinity of streams, the following additional mitigation measures will be employed.

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

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road infrastructure and existing watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;
- Ditches which drain from the proposed area to be felled towards existing surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such ditches to watercourses will occur. Drains and sediment traps will be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (~0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains will include water drops and rock armour, as required, where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited in drains downstream of felling areas. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of in the peat disposal areas. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps. This measure will be reviewed on site during construction;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils, silt traps will be installed at the end of the drainage channels, to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimized and controlled;

- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m watercourse buffer. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works will be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Refuelling of vehicles will normally take place off-site, however, should refuelling or maintenance of machinery be necessary on-site, it will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required;
- Branches, logs or debris will not be allowed to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but care will be taken to avoid removing natural debris deflectors.

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

Drain Inspection and Maintenance: The following items shall be carried out during inspection pre-felling and after:

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

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

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

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

Residual Impact: Indirect, negative, slight, temporary, low probability impact.

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

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

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible. From **Figure 6.7** it can be seen that all of the key proposed development areas are actually significantly away from the delineated buffer zones with the exception of the proposed stream crossings. Additional control measures, which are outlined further on in this section, will be undertaken at these locations).

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

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

Mitigation by Design:

Source controls: Interceptor drains, vee-drains, diversion drains, flume pipes, erosion and velocity control measures such as use of sand bags, oyster bags filled with gravel, filter fabrics, and other similar/equivalent or appropriate systems.

Small working areas, covering stockpiles, weathering off stockpiles, cessation of works in certain areas or other similar/equivalent or appropriate measures.

In-Line controls: Interceptor drains, vee-drains, oversized swales, erosion and velocity control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt bags, silt fences, sedimats, filter fabrics, and collection sumps, temporary sumps/attenuation lagoons, sediment traps, pumping systems, settlement ponds, temporary pumping chambers, or other similar/equivalent or appropriates systems.

Treatment systems: Temporary sumps and attenuation ponds, temporary storage lagoons, sediment traps, and settlement ponds, and proprietary settlement systems such as Siltbuster, and/or other similar/equivalent or appropriate systems.

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

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

- Apart from interceptor drains, which will convey clean runoff water to the downstream drainage system there will be no direct discharge (without treatment for sediment reduction, and attenuation for flow management) of runoff from the proposed wind farm drainage into the existing site drainage network where possible. This will reduce the potential for any increased risk of downstream flooding or sediment transport/erosion;
- Silt traps will be placed in the existing drains upstream of any streams where construction works/tree felling is taking place, and these will be diverted into proposed interceptor drains, or culverted under/across the works area;
- During the operational phase of the wind farm runoff from individual turbine hardstanding areas will be not discharged into the existing drain network but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- Buffered outfalls which will be numerous over the site will promote percolation of drainage waters across vegetation and close to the point at which the additional runoff is generated, rather than direct discharge to the existing drains of the site;
- Drains running parallel to the existing roads requiring widening will be upgraded. Velocity and silt control measures such as check dams, sand bags, oyster bags, straw bales, flow limiters, weirs, baffles, silt fences will be used during the upgrade construction works. Regular buffered outfalls will also be added to these drains to protect downstream surface waters.

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

Silt Fences: Silt fences will be emplaced within drains down-gradient of all construction areas. Silt fences are effective at removing heavy settleable solids. This will act to prevent entry to watercourses of sand and gravel sized sediment, released from excavation of mineral sub-soils of glacial and glacio-fluvial origin, and entrained in surface water runoff. Inspection and maintenance of these structures during construction phase is critical to their functioning to stated purpose. They will remain in place throughout the entire construction phase. Double silt fences will be emplaced within drains down-gradient of all construction areas inside the 50m hydrological buffer zone.

Silt Bags: Silt bags will be used where small to medium volumes of water need to be pumped from excavations. As water is pumped through the bag, most of the sediment is retained by the geotextile fabric allowing filtered water to pass through. Silt bags will be used with natural vegetation filters.

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

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

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

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

Works should be suspended if forecasting suggests any of the following is likely to occur:

- >10 mm/hr (*i.e.* high intensity local rainfall events);
- >25 mm in a 24 hour period (heavy frontal rainfall lasting most of the day); or,
- >half monthly average rainfall in any 7 days.
- Prior to works being suspended the following control measures should be completed:
- Secure all open excavations;
- Provide temporary or emergency drainage to prevent back-up of surface runoff;
- Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Peat and Subsoil Storage Areas: It is proposed that excavated soil will be permanently stored at a pre-designated site close to the temporary compound. Peat will be stored in designated areas based on geotechnical assessment.

During the initial placement of peat and subsoil, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from the storage areas. 'Siltbuster' treatment trains will be employed if previous treatment is not to a high quality.

Drainage from peat storage areas will ultimately be routed to an oversized swale and a number of settlement ponds and a 'Siltbuster' with appropriate storage and settlement designed for a 1 in 100 year 6 hour return period before being discharged to the on-site drains.

Peat/subsoil storage areas will be sealed with a digger bucket and vegetated as soon possible, to reduce sediment entrainment in runoff. Once re-vegetated and stabilised, peat/subsoil storage areas will no longer be a potential source of silt laden runoff. All storage areas will be kept outside of the 50m buffer zone.

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

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

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

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

Residual Impact: Negative, indirect, imperceptible, temporary, low probability impact.

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

6.4.1.3 Potential Release of Hydrocarbons during Construction and Storage

Mitigation by Design:

- On site refuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site, and will be towed around the site by a 4x4 jeep to where machinery is located. The 4x4 jeep will also carry fuel absorbent material and pads in the event of any accidental spillages. The fuel bowser will be parked on a level area in the construction compound when not in use and only designated trained and competent operatives will be authorised to refuel plant on site. Mobile measures such as drip trays and fuel absorbent mats will be used during all refuelling operations;
- Fuels stored on site will be minimised. Any storage areas will be bunded appropriately for the fuel storage volume for the time period of the construction;
- The electrical control building shall be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used shall be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Environmental Management Plan. Spill kits will be available to deal with accidental spillages.

Residual Impact: Indirect, negative, imperceptible, temporary, low probability impact on groundwater and surface water.

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

6.4.1.4 Groundwater and Surface Water Contamination from Wastewater Disposal

Mitigation by Avoidance:

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

Residual Impact: No impact

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

6.4.1.5 Release of Cement-Based Products

Mitigation by Avoidance:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- Where possible, pre-cast elements for culverts and concrete works will be used;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- Where concrete is delivered on site, only the chute need be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be tanked and removed from the site to a suitable, non-polluting, discharge location;
- Use weather forecasting to plan dry days for pouring concrete;
- Ensure pour site is free of standing water, and plastic covers will be ready in case of sudden rainfall event.

Residual Impact: Negative, Indirect, imperceptible, short term, low probability impact.

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

6.4.1.6 Morphological Changes to Surface Watercourses & Drainage Patterns

Mitigation by Design:

- Where possible all proposed new stream crossings will be bottomless culverts and the existing banks will remain undisturbed. No in-stream excavation works are proposed and therefore there will be no impact on the stream at the proposed crossing location;
- Where the proposed grid connection cable route runs adjacent to a proposed access road or road proposed for upgrade, the cable will pass over the culvert within the access road;
- Any guidance/mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings;
- As a further precaution near stream construction work will only be carried out during the period permitted by Inland Fisheries Ireland for in-stream works according to the Eastern Regional Fisheries Board (2004) guidance document "*Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*", that is, May to

September inclusive. This time period coincides with the period of lowest expected rainfall, and therefore minimum runoff rates. This will minimise the risk of entrainment of suspended sediment in surface water runoff, and transport via this pathway to surface watercourses;

- During the near stream construction work double row silt fences will be emplaced immediately down-gradient of the construction area for the duration of the construction phase. There will be no batching or storage of cement allowed in the vicinity of the crossing construction areas;
- All access road river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945). The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent.

Residual Impact: Neutral, direct, negligible, short term, high probability impact.

Significance of Effects: No significant effects on stream morphology or stream water quality are anticipated at crossing locations.

6.4.1.7 Potential Impacts on Hydrologically Connected Designated Sites

The proposed mitigation measures for protection of surface water quality which will include buffer zones and drainage control measures (*i.e.* interceptor drains, swales, settlement ponds) will ensure that the quality of runoff from proposed development areas will remain unchanged.

As stated above, there could potentially be an "*imperceptible, temporary, low probability impact*" on local streams and rivers but this would be very localised and over a very short time period (*i.e.* hours). Therefore, there is reasonable scientific certainty that there will be no significant direct, or indirect impacts on the River Nore SAC/pNHA.

Residual Impact: Reasonable scientific certainty as to the absence of impacts.

Significance of Effects: Reasonable scientific certainty of no significant impacts.

6.4.1.8 Potential Impacts on Local Groundwater Well Supplies

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

Residual Impacts

No residual impacts on groundwater supplies are anticipated either in terms of quality or quantity.

Significance of Effects

No significant impacts on potential groundwater supplies are anticipated.

6.4.1.9 Potential Impacts on Freshwater Pearl Mussel in the River Nore Catchment

Best guidance in relation to protection of freshwater pear mussel (FPM) sites can be obtained from guidance document *Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures (Draft).*

Within catchments that contain FPM and especially populations that are designated (*i.e*. cSAC) particular emphasis is placed upon forestry sites (*i.e.* or proposed wind farm development sites) that lie less than 6km upstream of an identified FPM population. **Table 6.14** shows the screening criteria taken from the FPM requirements guidance document.

Distance from nearest downstream FPM population (Note 1)		*Soil (Note 2)*	*Requirements (see * below)*
PART A within 6km from a FPM site	Site Adjoins Population	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FPM Requirements
	Site contains or adjoins an aquatic zone	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FPM Requirements
	Site does not contain or adjoin an aquatic zone	Erodible	FPM Requirements
		Peaty	FPM Requirements
		Mineral	FS Guidelines*****
PART B greater than 6km from a FPM site		Erodible	FS Guidelines*****
		Peaty	FS Guidelines*****

Table: 6.14: Forest Operations Screening Table (FPM Requirements)

**Note 1: Forestry Services Guidelines apply except in the following situations where the Forestry and FPM Requirements apply.*

- >10% of catchment (Note 3)
- Afforestation >50ha (Note 4)
- Clear felling >25ha (Note 4)

Notes:

1. Distance is measured along the shortest hydrological distance from the nearest point of the site of application to the nearest known FPM population downstream.
2. Soil: Soil types are those as defined in the guidance document.
3. Cumulative Effect: If the application increases the total cumulative area of an operation in a three year period to more than 10% of the FMP catchment, then FPM *Requirements* apply.
4. Area of Individual Operation refers to the area of an individual site (e.g. felling coupe, afforestation site).

The proposed wind farm development is more than 6km upstream of the nearest mapped FPM site and therefore the Forestry Services Guidelines apply as outlined below.

Mitigation measures from best practice Forestry Service Guidelines along with the proposed drainage design (as outlined above in this chapter) will reduce the risk of entrainment of suspended solids and nutrient release in surface watercourses.

Best Practice Mitigation Measures as follows:

- Machine combinations will be chosen which are most suitable for ground conditions at the time of felling, and which will minimise soils disturbance;
- Use of buffer zones for aquatic zones (see **Table 6.14** above);
- Checking and maintenance of roads and culverts will be on-going through any felling operation. No tracking of vehicle through watercourses will occur, as vehicles will use road

infrastructure and watercourse crossing points. Where possible, existing drains will not be disturbed during felling works;

- Drains which drain from the area to be felled towards surface watercourses will be blocked, and temporary silt traps will be constructed. No direct discharge of such drains to watercourses will occur. Drains and sediment traps should be installed during ground preparation. Collector drains will be excavated at an acute angle to the contour (0.3%-3% gradient), to minimise flow velocities. Main drains to take the discharge from collector drains must be provided with water drops and rock armour where there are steep gradients, and should avoid being placed at right angles to the contour;
- Sediment traps will be sited outside of buffer zones and will have no direct outflow into the aquatic zone. Machine access will be maintained to enable the accumulated sediment to be excavated. Sediment will be carefully disposed of away from all aquatic zones. Where possible, all new silt traps will be constructed on even ground and not on sloping ground;
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps;
- All drainage channels will taper out before entering the aquatic buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodible soils silt traps will be installed at the end of the drainage channels to the outside of the buffer zone;
- Drains and silt traps will be maintained throughout all felling works, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are minimised and controlled;
- Brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall;
- Timber will be stacked in dry areas, and outside a local 50m stream buffer zone. Straw bales and check dams to be emplaced on the down gradient side of timber storage/processing sites;
- Works should be carried out during periods of no, or low rainfall, in order to minimise entrainment of exposed sediment in surface water run-off;
- Checking and maintenance of roads and culverts will be on-going through the felling operation;
- Do not refuel or maintain machinery within 50m of an aquatic zone. Dedicated refuelling areas will be used during the felling works; and,
- Do not allow branches, logs or debris to build up in aquatic zones. All such material will be removed when harvesting operations have been completed, but avoid removing natural debris deflectors.

In addition to the Forestry Service Guidelines the protection of surface watercourses during the construction, operational and decommissioning phases of the wind farm will be achieved by a combination of mitigation by avoidance and mitigation by design.

The avoidance of sensitive hydrological features within the site and the proposed drainage system will ensure that the existing quality of surface waters will be maintained and protected. The high level of protection provided to surface water bodies within the catchments of the proposed development will ensure that there will be no impact on freshwater pearl mussel sites, if present, downstream of the proposed development site.

6.4.1.10 Surface Water Quality Monitoring

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

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

- Avoid man-made drains and watercourses without all-year flow;
- Select sampling points upstream and downstream of the works;
- It is advantageous if the upstream location is outside/above the site in order to evaluate the impact of land-uses other than the development works; and,
- Where possible, three downstream locations should be selected: one immediately below the working area, the second at exit from the site boundary, and the third some distance from the second (this allows demonstration of no impact through dilution effect or contamination by other land-uses where impact increases at third downstream location relative to second downstream location).

Residual Impact

No residual impact.

Significance of Effects

No significant residual impacts on the aquatic environment are anticipated.

6.4.2 Operational Phase

6.4.2.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surface with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The footprint comprises turbine hardstandings, upgraded access roads, substation and compound. During storm rainfall events, additional runoff coupled with increased velocity of flow could increase hydraulic loading, resulting in erosion of watercourses and impact on aquatic ecosystems.

Pathway: Site drainage network.

Receptor: Surface waters and dependant ecosystems.

Pre-Mitigation Impact

Direct, negative, moderate, permanent, moderate probability impact.

Mitigation by Design: The operational phase drainage system will be installed and constructed in conjunction with the road and hardstanding construction work as described below:

- Interceptor drains will be installed up-gradient of all proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;
- Swales/road side drains will be used to collect runoff from access roads and turbine hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to settlement ponds for sediment settling;

- On steep sections of access road transverse drains ('grips') will be constructed where appropriate in the surface layer of the road to divert any runoff off the road into swales/road side drains;
- Check dams will be used along sections of access road drains to intercept silts at source. Check dams will be constructed from a 4/40mm non-friable crushed rock;
- Settlement ponds, emplaced downstream of road swale sections and at turbine locations, will buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses; and,
- Settlement ponds will be designed in consideration of the Greenfield runoff rate.

Residual Impact: Negative, direct, negligible, long term, moderate probability impact.

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

6.4.3 Decommissioning Phase

As assessed above for the construction phase, no significant impacts on the hydrological environment are anticipated during the decommissioning phase.

6.4.4 "Do Nothing" Scenario

Current land use practices such as forestry and agriculture will continue. In particular commercial deforestation and reforestation will continue at the site. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas.

6.4.5 "Worst Case" Scenario

Contamination of surface water streams during the construction and operational phases, which in turn could affect the ecology and quality of the downstream water bodies such as the Owenbeg River, Dinin River and Ironmills River. Also, potentially localised groundwater contamination may occur. However, measures will be put in place to prevent this from happening.

6.4.6 Hydrological Cumulative Impacts

A hydrological cumulative impact assessment was undertaken for other wind farm developments and non wind farm projects and plans located within the Owenbeg River catchment. There are no turbines proposed within the Dinin River catchment and the overall access road construction within the catchment is small and therefore no cumulative impacts on the Dinin River catchment was undertaken

The wind farm developments assessed are listed in **Table 6.15** below and are shown on **Figure 6.8**.

In terms of the potential impacts of wind farm developments on downstream surface water bodies, the biggest risk is during the construction phase of the development as this is the phase when earthworks and excavations will be undertaken at the sites.

Catchment Area	*Wind Farm Name*	*Total Turbine No.*	*Potential No. of Turbines in Owenbeg Catchment*
Owenbeg	Cullenagh WF	18	8

Table 6.15: Other Wind Farms in the Owenbeg River Catchment

The total number of turbines that could potentially be operating within the Owenbeg River catchment is 19 (11 from the proposed development and 8 from other wind farms as shown in **Table 6.15** above). The total catchment area of the Owenbeg River is ~94km^2 and therefore this currently equates to one turbine for approximately every ~11.7km^2, which is considered imperceptible in terms of potential cumulative hydrological impacts. When the proposed development is assessed cumulatively with the Cullenagh WF, it equates to one turbine per ~4.95km^2. The potential for impact remains negligible, given the relatively small footprint area of one turbine. Therefore, no significant cumulative hydrological impacts are anticipated from the construction of the proposed wind farm and other wind energy developments in the region.

The proposed grid connection for the proposed development will tie into the permitted 110kV Laois–Kilkenny Grid Reinforcement Project which runs through the north-western section of the site within the Owenbeg River catchment. No hydrological cumulative impacts are expected in-combination with the Laois–Kilkenny Grid Reinforcement Project line and the proposed development, as the former development comprises predominately overhead lines in the vicinity of the development and therefore no significant hydrological impacts are anticipated.

6.5 Conclusion

The hydrological and hydrogeological assessment has shown that the site will be minimally impacted by the proposed development. The residual effects associated with the proposed development will be minimal and hydrological and hydrogeological effects are considered to be of slight significance.

The construction activities and any routine operational activities will be undertaken with full regard to current best practice and guidance. This will reduce the likelihood of abnormal or accidental occurrences, as well as to ensure there are response measures in place throughout the project.

It is anticipated that the proposed mitigation measures will ensure that impacts on the hydrological and hydrogeological regime will be of slight significance. The construction activities and any routine operational activities will be undertaken with full regard for current best practice and guidance. This will reduce the likelihood of abnormal and accidental occurrences, as well as ensure there are response measures in place throughout the project. It is anticipated that the proposed mitigation measures will ensure that impacts on the hydrological and hydrogeological regime will be of slight significance.

Appendix 6.1: Laboratory Reports

ENVIRONMENTAL
LABORATORY SERVICES
Acorn Business Campus
Mahon Industrial Park,
Blackrock,
Cork
Ireland
Tel: +353 21 453 6141
Fax: +353 21 453 6149
Web: www.irishwatertesting.com
email: info@elsltd.com

DETAILED IN SCOPE REG NO.111T

Contact Name	David Broderick	**Report Number**	**83766 - 1**
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	**Sample Number**	83766/001
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	**Received or Collected**	Hand
Fax No	058 44244	**Condition on Receipt**	Good
Customer PO	P1264	**Date of Report**	31/03/2015
Quotation No	QN004036	**Sample Type**	Surface Waters
Customer Ref	Sw1		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.036	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.33	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		1.46	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		<0.013	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		<0.043	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.015	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		12.0	mg/L	INAB	
BOD									
	BOD		EW001	1		2	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		28	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.063	mg/l P	INAB	

Signed : 31/03/2015

Brendan Murray-Deputy Technical Manager

NOTES

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3.OOS=Result which is outside specification highlighted as OOS-A
4.LOQ=Limit of Quantification or lowest value that can be reported
5.ACCRED=Indicates matrix accreditation for the test,a blank field indicates not accredited
6."*" Indicates sub-contract test

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email: info@elsltd.com

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

Contact Name	David Broderick	**Report Number**	**83766 - 1**
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	**Sample Number**	83766/002
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	**Received or Collected**	Hand
Fax No	058 44244	**Condition on Receipt**	Good
Customer PO	P1264	**Date of Report**	31/03/2015
Quotation No	QN004036	**Sample Type**	Surface Waters
Customer Ref	Sw2		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.023	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.41	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		1.82	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		0.020	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		0.066	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.031	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		12.9	mg/L	INAB	
BOD									
	BOD		EW001	1		<1	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		39	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.023	mg/l P	INAB	

Signed : Brendan Murray 31/03/2015

Brendan Murray-Deputy Technical Manager

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email: info@elsltd.com

Contact Name	David Broderick	**Report Number**	**83766 - 1**
Address	Hydro-Environmental Services 22 Lower Main Street, Dungarvan,	**Sample Number**	83766/003
		Date of Receipt	12/03/2015
		Date Started	13/03/2015
Tel No	058 44122	**Received or Collected**	Hand
Fax No	058 44244	**Condition on Receipt**	Good
Customer PO	P1264	**Date of Report**	31/03/2015
Quotation No	QN004036	**Sample Type**	Surface Waters
Customer Ref	Sw3		

CERTIFICATE OF ANALYSIS

TEST	ANALYTE	SUB	METHOD	LOQ	SPEC	RESULT	UNITS	ACCRED.	OOS
Ammonia									
	Ammonia (as N)		EW154M-1	0.0070		0.072	mg/l N	INAB	
AQ2-UP1									
	Nitrate (as N)		EW154M-1	0.12		0.72	mg/l N	INAB	
	Nitrate (as NO3)(Calc)		EW154M-1	0.53		3.19	mg/l NO3	INAB	
	Nitrite (as N)		EW154M-1	0.013		0.014	mg/l N	INAB	
	Nitrite (as NO2)(Calc)		EW154M-1	0.043		0.046	mg/l NO2	INAB	
	Phosphate-Ortho(as P)		EW154M-1	0.009		0.023	mg/l P	INAB	
AQ2-UP2									
	Chloride		EW154M-1	2.6		13.8	mg/L	INAB	
BOD									
	BOD		EW001	1		2	mg/L	INAB	
Suspended Solids									
	Suspended Solids		EW013	5		14	mg/L	INAB	
Total Phosphorus-TP									
	Total Phosphorus-TP		EW146	0.010		0.060	mg/l P	INAB	

Signed : Brendan Murray 31/03/2015

Brendan Murray-Deputy Technical Manager

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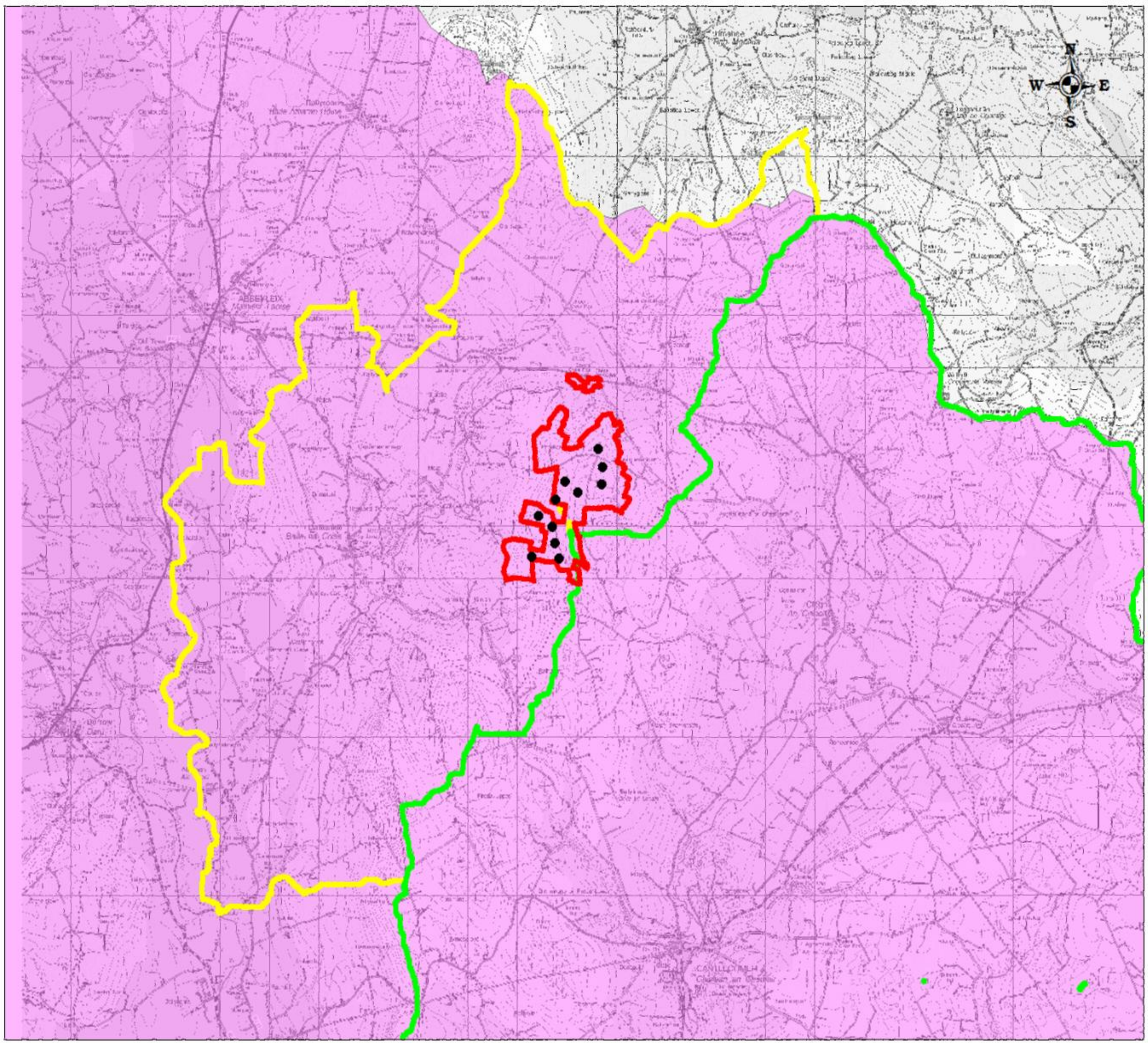
5.ACCRED=Indicates matrix accreditation for the test,a blank field indicates not accredited
6."*" Indicates sub-contract test

Appendix 6.2: Figures



Legend:

- Landholding / Study Area
- Nore River Regional Catchment
- Owenbeg River Catchment
- Dinin River Catchment
- Proposed Turbine location

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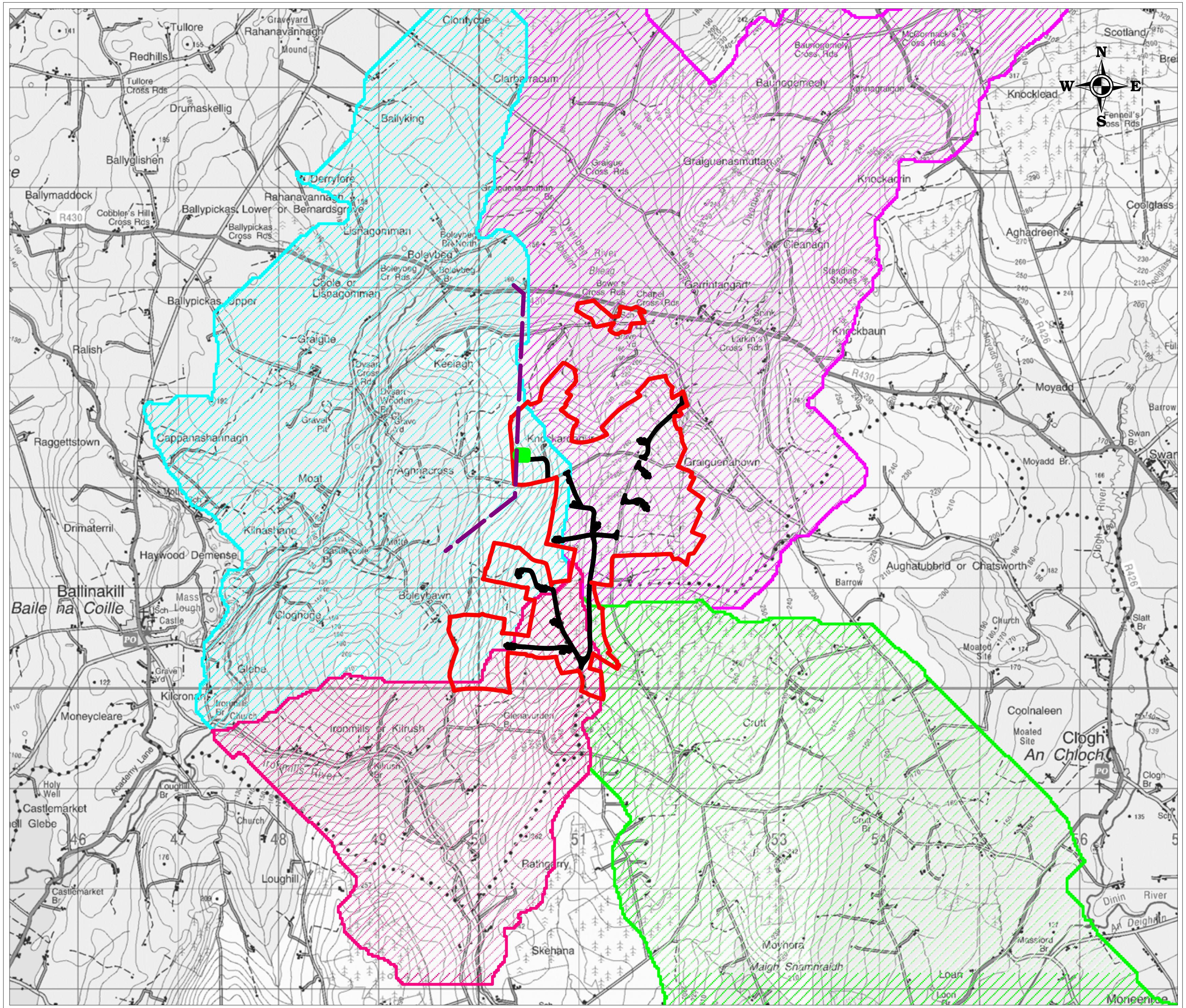
web: www.hydroenvironmental.ie

Title: Regional Hydrology Map
Client: Pinewoods Wind Ltd
Job: Pinewoods WF, Co. Laois
Project No: P1264-0
Figure No: 6.1
Sheet Size: A4
Drawing No: P1264-0-0416-A4-601-00A
Date: - 27/04/2016
Scale: - 1:100,000
Drawn By: GB / Checked By: MG



Legend:

- Landholding / Study Area
- Owenbeg Upper SWB
- Owenbeg Mid SWB
- Ironmills SWB
- Dinin Mid SWB
- Development Footprint
- Grid Connection
- Switching Station

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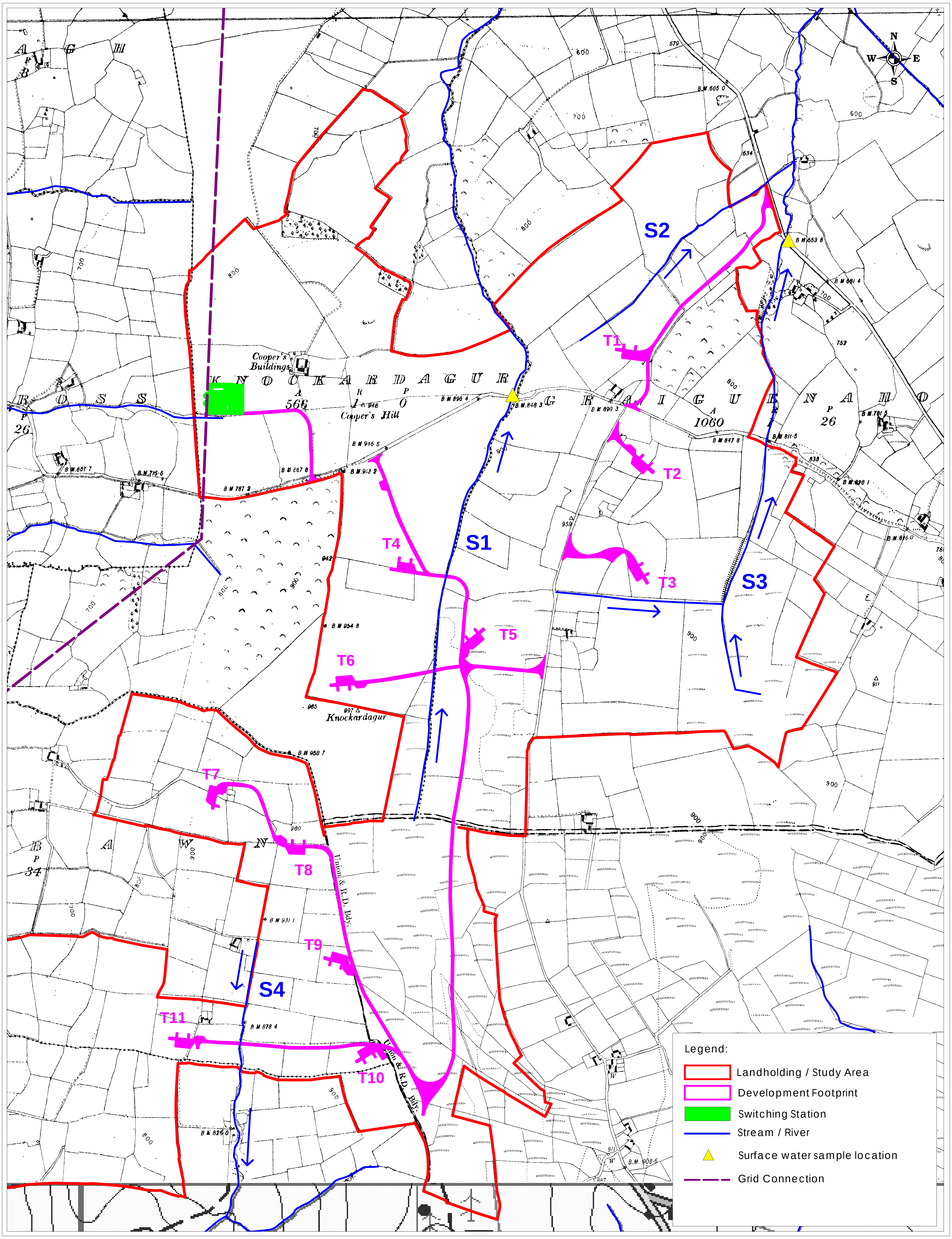
web: www.hydroenvironmental.ie

Title: Local Hydrology Map	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 6.2	
Sheet Size: A4	
Drawing No: P1264-0-0416-A4-602-00A	
Date: - 27/04/2016	
Scale: - 1:50,000	
Drawn By: GB	Checked By: MG



Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-603-00A
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3 / Project No: P1264
Title: Site Drainage Map	Scale: - 1:10000 / Drawn By: DB
Figure No: 6.3	Date: - 27/04/2016 / Checked By: MG

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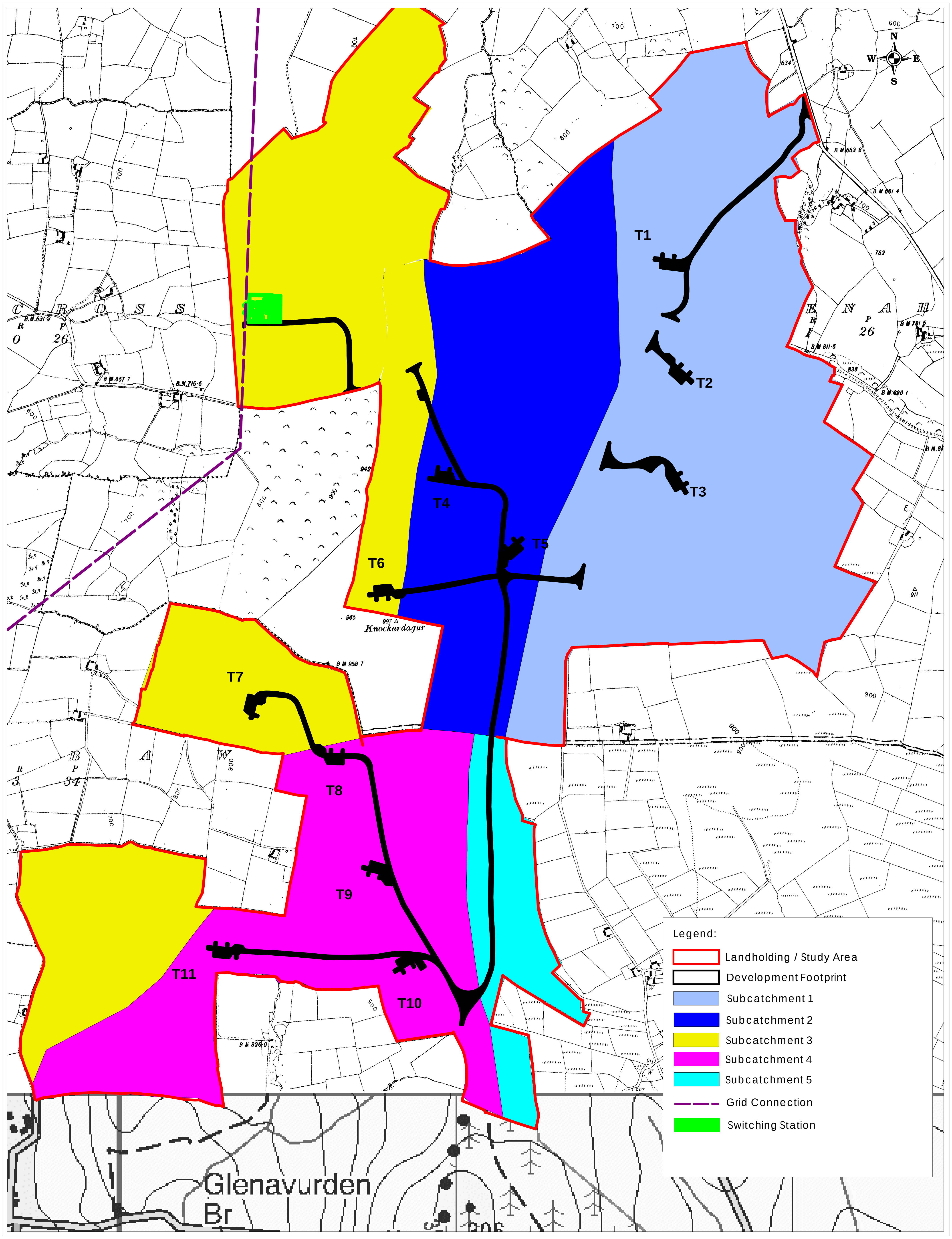

Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-604-00A	
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3	Project No: P1264-0
Title: Site Subcatchment Map	Scale: - 1:10000	Drawn By: DB
Figure No: 6.4	Date: - 27/04/2016	Checked By: MG

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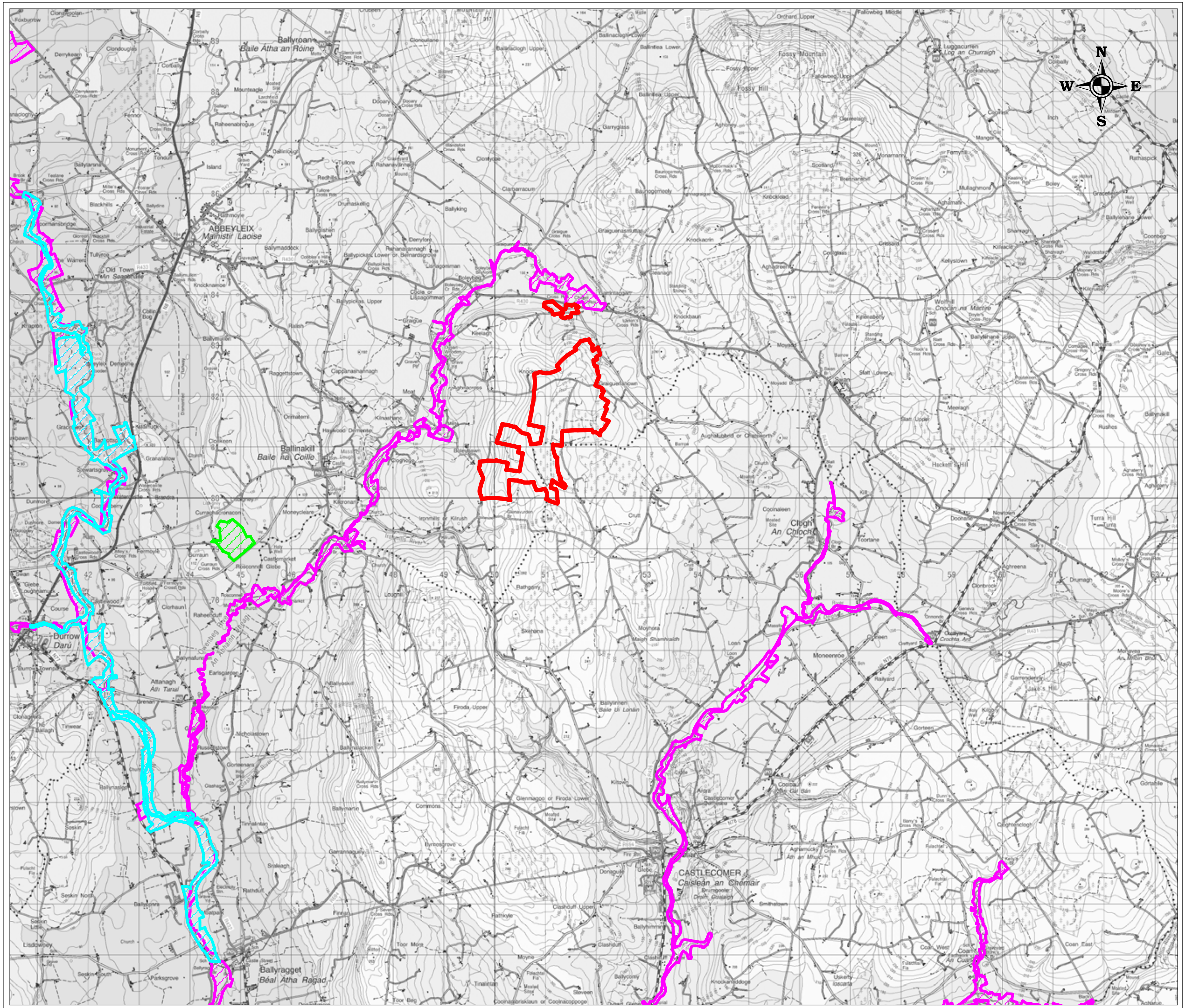

Legend:

- Landholding / Study Area
- River Barrow & River Nore SAC
- River Nore & Abbeyleix Woods Complex pNHA
- Lisbigney Bog SAC & pNHA

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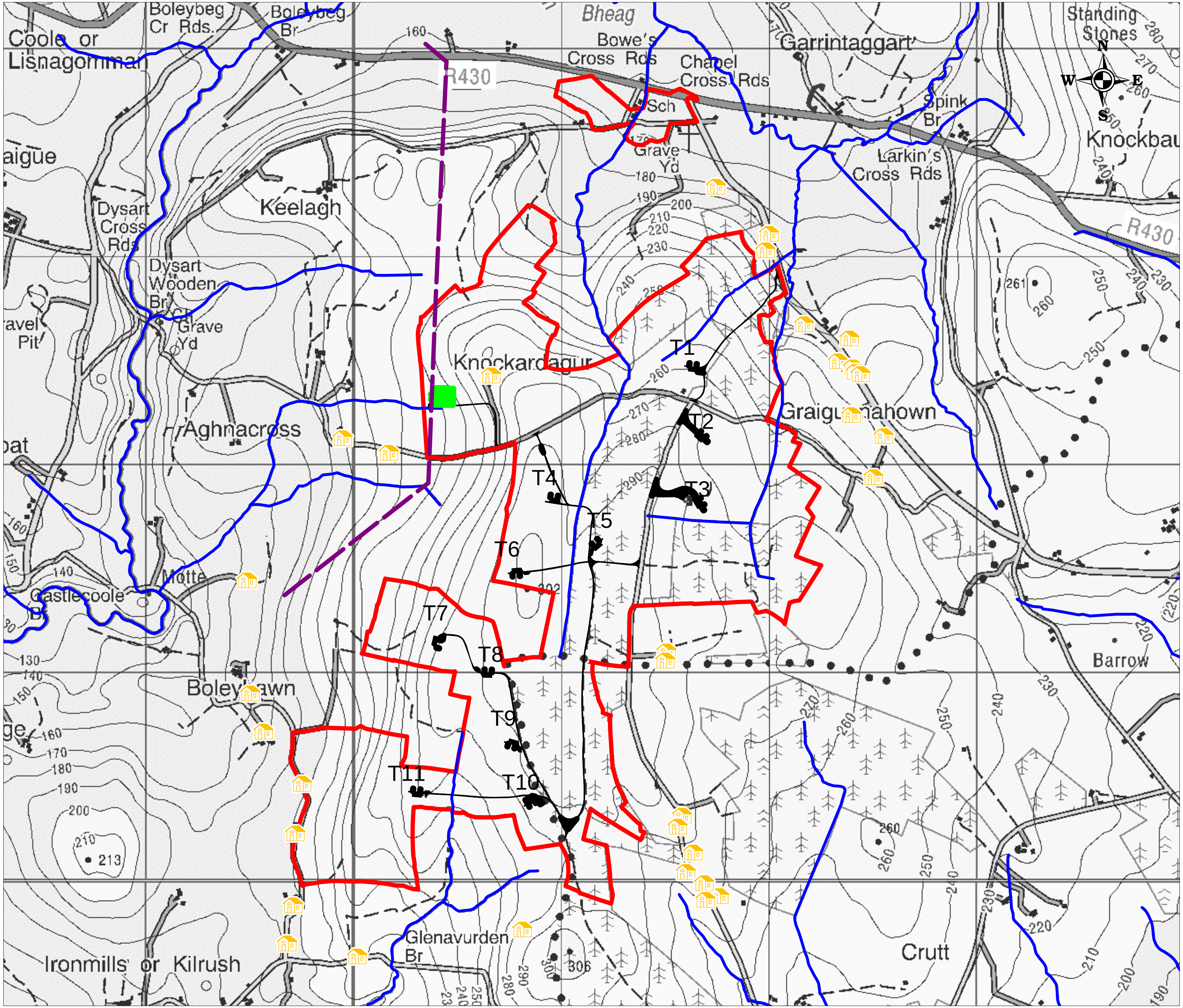
Title: Designated Sites Map	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No:P1264	
Figure No: 6.5	
Sheet Size: A4	
Drawing No:P1264-0-0416-A4-605-00A	
Date: - 27/04/2016	
Scale: - 1:100,000	
Drawn By: GB	Checked By: MG



Legend:

- Landholding / Study Area
- Switching Station
- Private Dwelling Location
- Rivers/Streams

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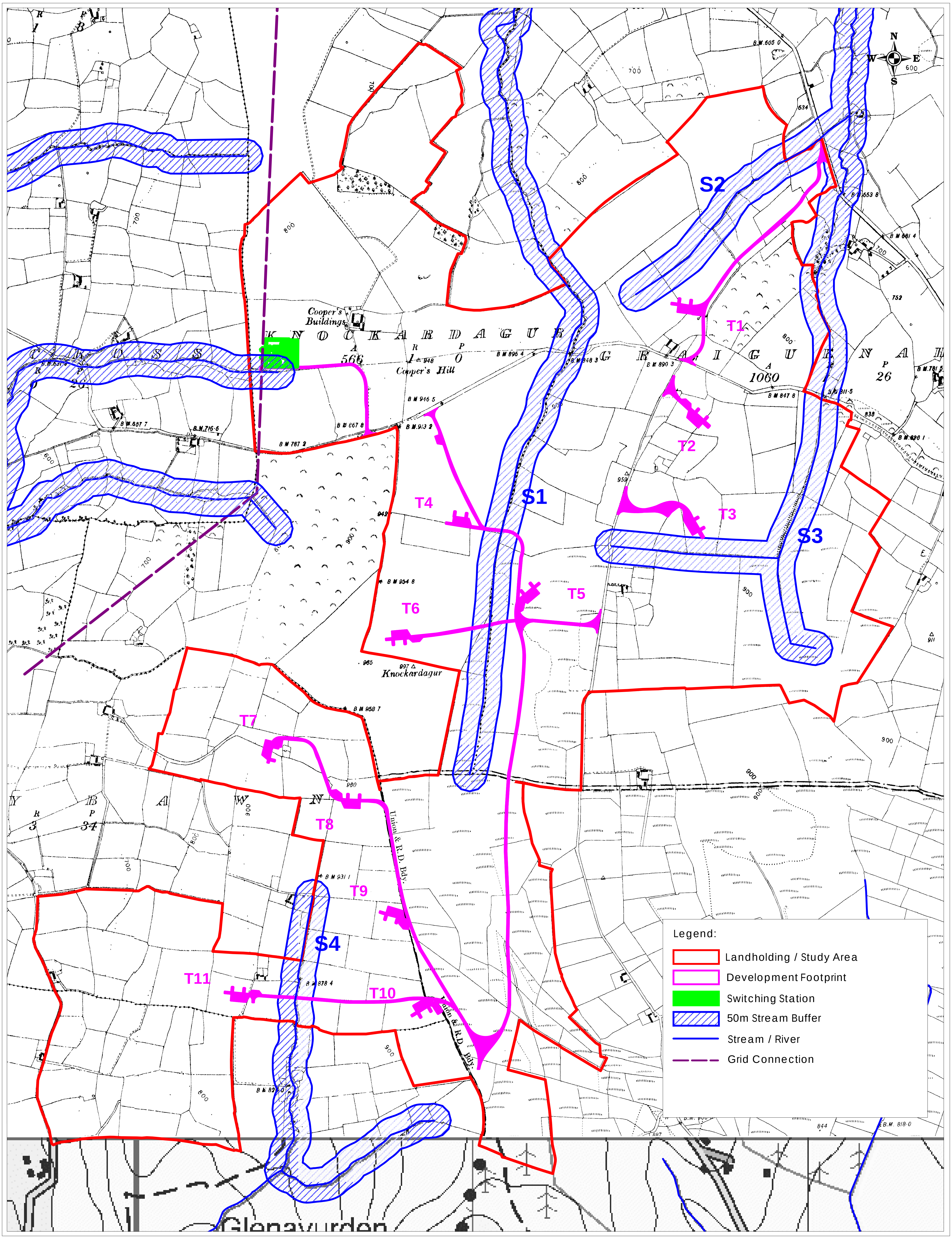
Title: Water Supply Assessment	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 6.6	
Sheet Size: A4	
Drawing No:P1264-0-0416-A4-606-00A	
Date: - 27/04/2016	
Scale: - 1:25,000	
Drawn By: GB	Checked By: MG



Client: Pinewoods Wind Ltd	Drawing No: P1264-0-0416-A3-607-00A
Job: Pinewoods WF Co. Laois / Kilkenny	Sheet Size: A3 / Project No: P1264-0
Title: Hydrological Constraints Map	Scale: - 1:10000 / Drawn By: DB
Figure No: 6.7	Date: - 27/04/2016 / Checked By: MG

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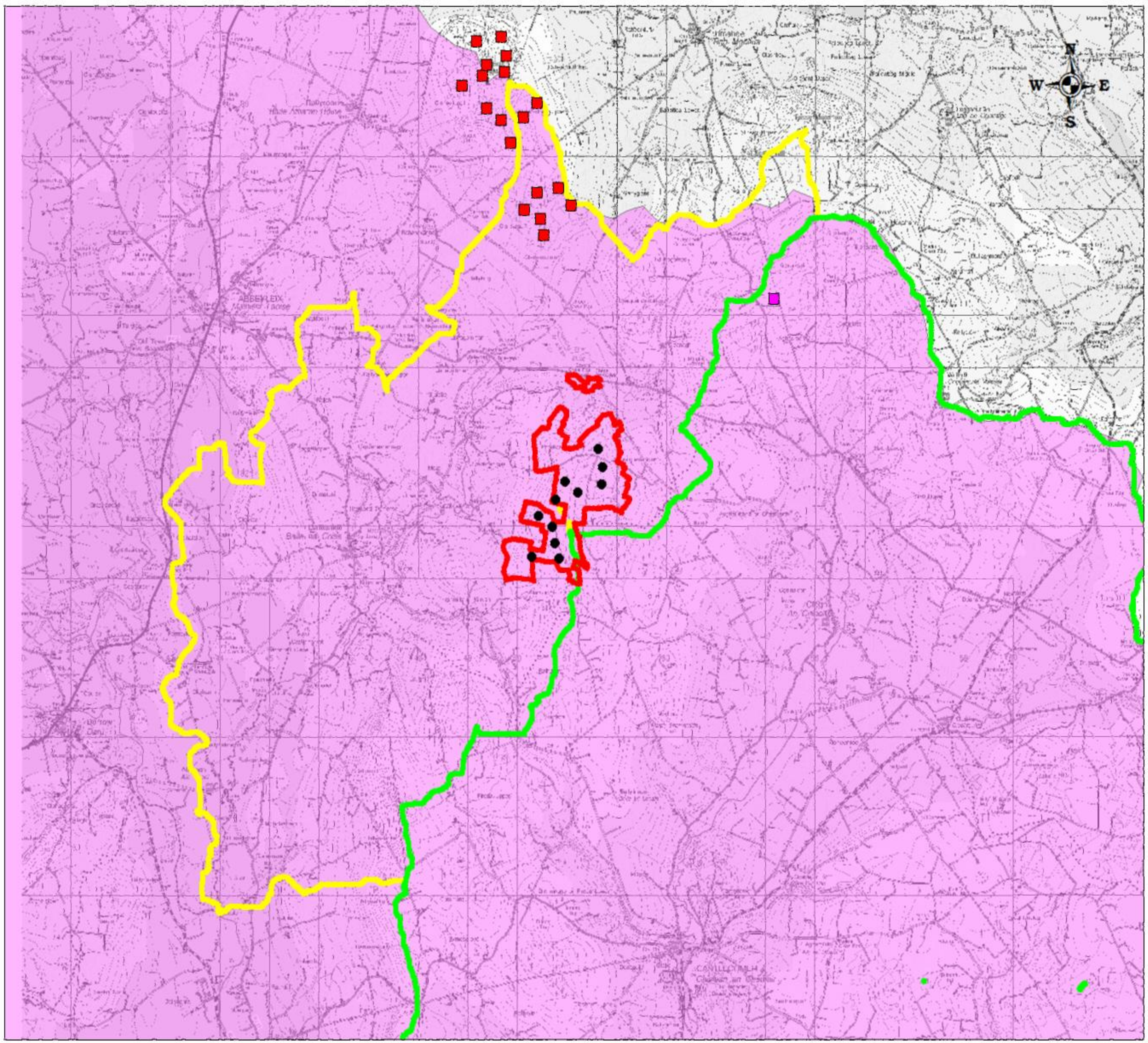

Legend:

- Landholding / Study Area
- Nore River Regional Catchment
- Owenbeg River Catchment
- Dinin River Catchment
- Cullenagh WF
- Knocklead 1 Turbine

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Title: Other Wind Farm Developments	
Client: Pinewoods Wind Ltd	
Job: Pinewoods WF, Co. Laois	
Project No: P1264-0	
Figure No: 6.8	
Sheet Size: A4	
Drawing No: P1264-0-0416-A4-608-00A	
Date: - 27/04/2016	
Scale: - 1:100,000	
Drawn By: GB	Checked By: MG