APPENDIX 2

HYDROLOGICAL ASSESSMENT (CH 9 WATER)

9. WATER

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland (MKO) to carry out an assessment of the potential effects of the Proposed Development on water aspects (hydrology and hydrogeology).

A full description of all elements of the Proposed Development is detailed in Chapter 4 of this EIAR. As detailed in Section 1.1.1 in Chapter 1, for the purposes of this EIAR, the various project components are described and assessed using the following references: 'Proposed Development', 'the Site', 'Wind Farm Site' and 'Grid Connection'. The objectives of the assessment are to:

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

The potential Zone of Impact of the Proposed Development on the water environment is limited within the Water Study Area as defined on Figure 9-1, as these are the regional surface water catchments and groundwater bodies within which the Proposed Development is located.

9.1.2 Statement of Authority

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

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

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

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

Adam Keegan (BSc, MSc) is a hydrogeologist with three years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments.

Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF.

Conor McGettigan (BSc, MSc) is a recently graduated environmental scientist. In recent times Conor has assisted in the preparation of Environmental Impact Assessment Reports (EIARs) for several projects including wind farms and quarries.

9.1.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Section 2.6 of Chapter 2 of the EIAR. Consultation responses relating to the water environment were received from the Geological Survey of Ireland (GSI), the Development Applications Unit (DAU) and Health Service Executive (HSE). Matters raised by Consultees in their responses with respect to the water environment are summarised in Table 9-1 below.

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

Consultee	Description	Addressed in Section
Geological Survey of Ireland (GSI)	• GSI have identified 1 local County Geological Sites (CGS) near the Wind Farm Site; Callighstown-Milltown Esker located close to the eastern boundary of the Wind Farm Site. • GSI have identified 3 no. local County Geological Sites (CGS) near the Grid Connection underground electrical cabling route; Ballyduff Esker, Clonmacnoise Esker and Horseleap Esker. • There are several karst landforms in the vicinity of the underground electrical cabling route including 3 no. karst springs adjacent to the N52 at Durrow, Co. Offaly. • There is 1 no. groundwater abstraction (well) used by the Tullamore Ardan Public Water Supply near the underground electrical cabling route. • Assessment of groundwater characteristics/resources and groundwater protection required. • Assessment of mineral resources and aggregates required.	Geological Heritage Sites are address in Chapter 8, Section 8.3.7. Groundwater assessment addressed in Sections 9.3.8, 9.3.9, 9.3.10, 9.3.13, 9.4.1.3, 9.4.1.4, 9.4.1.5, 9.4.1.6 and 9.4.1.10. Karst Landforms addressed in Section 9.3.7. Water resources (local groundwater wells) addressed in Section 9.3.12. Refer to Chapter 8: Land, Soils and Geology for assessment of aggregate resources.

Consultee	Description	Addressed in Section
Development Applications Unit (DAU)	• Note that any impact on water table levels or groundwater flows may impact on wetland sites some distance away (*i.e* beyond 15km radius). EIAR should assess cumulative impacts with other plans or projects if applicable • A 10m riparian buffer on both banks of a waterway is considered to comprise part of the otter habitat. Therefore, any proposed development should be located at least 10m away from a waterway. • Construction work should not be allowed to impact on water quality and measures should be detailed in the EIAR to prevent sediment and/or fuel runoff from getting into watercourses which could adversely impact on aquatic species.	• Cumulative impact assessment included in Section 9.4.5. • Riparian buffer zone (10m) included within mitigation measures within Section 9.4 • Appropriate mitigation measures relating to sediment/fuel runoff are included within Section 9.4
Environmental Health Service (HSE)	• All drinking water sources, both surface and groundwater shall be identified. Any potential impacts to these drinking water sources shall be assessed	• All drinking water sources identified in Section 9.3.14 with mitigation measures outlined in Section 9.5.2.10

9.1.4 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU.

The requirements of the following legislation are complied with:

- S.I. No. 349/1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84/1994, S.I. No. 101/1996, S.I. No. 351/1998, S.I. No. 93/1999, S.I. No. 450/2000 and S.I. No. 538/2001, S.I. No. 134/2013 and the Minerals Development Act 2017), the Planning and Development Act, and S.I. No. 600/2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/337/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017:

Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);

- Planning and Development Act, 2000, as amended;
- Planning and Development Regulations, 2001 (as amended);
- S.I. No. 296/2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish law;
- S.I. No. 293/1988: European Communities (Quality of Salmonid Waters) Regulations;
- S.I. No. 272/2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy) and S.I. No. 722/2003 European Communities (Water Policy) Regulations which implement EU Water Framework Directive (2000/60/EC) establishing a framework for the Community action in the field of water policy and provide for implementation of 'daughter' Groundwater Directive (2006/118/EC) on the protection of groundwater against pollution and deterioration. Since 2000 water management in the EU has been directed by the Water Framework Directive (2000/60/EC) (as amended by Decision No. 2455/2011/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC; Directive 2013/39/EU; Council Directive 2013/64/EU; and Commission Directive 2014/101/EU ("**WFD**"). The WFD was given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003
(S.I. No. 722/2003);
- S.I. No. 684/2007: Waste Water Discharge (Authorisation) Regulations 2017, 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. 106/2007: European Communities (Drinking Water) Regulations 2007 and S.I. No. 122/2014: European Communities (Drinking Water) Regulations 2014, arising from EU Directive 98/83/EC on the quality of water intended for human consumption (the "Drinking Water Directive") and EU Directive 2000/60/EC;
- S.I. No. 9/2010: European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended by S.I. No. 389/2011; S.I. No. 149/2012; S.I. No. 366/2016; the Radiological Protection (Miscellaneous Provisions) Act 2014; and S.I. No. 366/2016); and,
- S.I. No. 296/2009: The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (as amended by S.I. No. 355/2018)

9.1.5 Relevant Guidance

The Water chapter of the EIAR is carried out in accordance with guidance contained in the following:

- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements;
- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Department of Environment, Heritage and Local Government (DoEHLG); Wind Energy Development Guidelines for Planning Authorities (2006);
- Forestry Commission (2004): Forests and Water Guidelines, Fourth Edition. Publ. Forestry Commission, Edinburgh;
- Coillte (2009): Forest Operations & Water Protection Guidelines;
- 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;
- Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
- Scottish Natural Heritage (2010): Good Practice During Wind Farm Construction;
- SEPA (2014): Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems;
- PPG1 - General Guide to Prevention of Pollution (UK Guidance Note);
- PPG5 – Works or Maintenance in or Near Watercourses (UK Guidance Note);
- CIRIA (Construction Industry Research and Information Association) 2006: Guidance on 'Control of Water Pollution from Linear Construction Projects' (CIRIA Report No. C648, 2006);
- CIRIA 2006: Control of Water Pollution from Construction Sites - Guidance for Consultants and Contractors. CIRIA C532. London, 2006;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

9.1.6 Difficulties Encountered

No difficulties were encountered during the preparation of this EIAR chapter.

9.2 Methodology

9.2.1 Desk Study

A desk study of the Proposed Development site and Water Study Area was 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 of the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway-Offaly); Geological Survey of Ireland (GSI, 1999);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 12 (Geology of Longford-Roscommon); 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);
- National Indicative Flood Mapping (NIFM) maps; and,
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie).

9.2.2 Baseline Monitoring and Site Investigations

A hydrological walkover survey, including detailed drainage mapping, dGPS survey of the Dungolman and Mullenmeehan streams (river bed, bank faces and water levels) and baseline water quality monitoring/sampling, was undertaken by HES over several site visits carried out on 03rd May 2021, 14th May, 07th July and 14th July 2021.

Further site investigations including trial pitting were carried out by HES on 14th July 2021. Additional site visits were also completed within the Wind Farm Site and along the Grid Connection underground electrical cabling route on 18th November 2021, 22nd March 2022 and 01st December 2022.

Hydrological and hydrogeological data used in this assessment includes:

- Walkover surveys and hydrological mapping of the Wind Farm Site, Grid Connection, turbine delivery route, and the surrounding areas were undertaken whereby water flow directions and drainage patterns were recorded;
- A dGPS survey of river channel cross sections (river bed, banks and water level) were taken at 24 no. locations along the Dungolman river and Mullenmeehan stream;
- A Stage 3 Flood Risk Assessment (FRA) for the Wind Farm Site footprint area (refer to Appendix 9-1);
- A total of 8 no. trial pits were completed across the Wind Farm Site;
- PSD analysis of 5 no. subsoil samples taken from 4 no. trial pits and 1 no. exposed face;
- Additional probing at 8 no. locations was completed along the underground electrical cabling route, (refer to Chapter 8);
- 3 no. water level monitoring devices (OTT EcoLog 1000) were installed at 3 no. locations along the Dungolman river and Mullenmeehan stream which monitored water levels between 07th July 2021 – 01st December 2022;

- Field hydrochemistry measurements (electrical conductivity, pH and temperature) were taken to determine the origin and nature of surface water flows at the Wind Farm Site;
- Surface water sampling at 3 no. surface water locations were undertaken to determine the baseline water quality of the primary surface waters originating from the Wind Farm Site;
- Field hydrochemistry measurements and water quality samples were undertaken at 8 no. locations along the Grid Connection underground electrical cabling route; and,
- A WFD Assessment Report has been completed for the Proposed Development (Wind Farm Site and Grid Connection) and is included as Appendix 9-2.

9.2.3 Impact Assessment Methodology

The guideline criteria (EPA, May 2022) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transboundary nature (if applicable). The descriptors used in this environmental impact assessment are those set out in the EPA (2022) Glossary of effects as shown in Chapter 1, Section 1.7.2 of this EIAR.

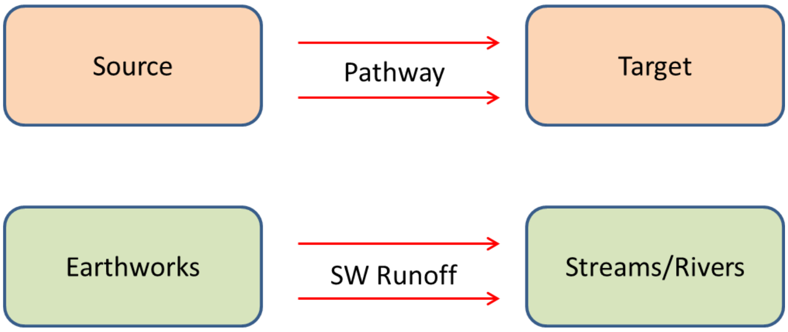
In addition to the above methodology, the sensitivity of the water environment receptors was assessed on completion of the desk study and baseline study. Levels of sensitivity which are defined in Table 9-2 are then used to assess the potential effect that the Proposed Development may have on them.

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

Sensitivity of Receptor	
Not sensitive	Receptor is of low environmental importance (e.g. surface water quality classified by EPA as A3 waters or seriously polluted), fish sporadically present or restricted). Heavily engineered or artificially modified and may dry up during summer months. Environmental equilibrium is stable and is resilient to changes 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

9.2.4 Overview of Impact Assessment Process

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



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

- Environmental Protection Agency (May 2022): Guidelines on the Information to be Contained in Environmental Impact Assessment Reports.

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

In order to provide an understanding of the stepwise impact assessment process applied below (Section 9.4), a summary guide is presented in Table 9-3, which defines the steps (1 to 7) taken in each element of the impact assessment process. The guide also provides definitions and descriptions of the assessment process and shows how the source-pathway-target model, and the EPA impact descriptors are combined.

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

Table 9-3: Impact Assessment Process Steps

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

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Water Chapter of the EIAR.

9.3 Receiving Environment

9.3.1 Site Description and Topography

9.3.1.1 Wind Farm Site

The Wind Farm Site is located approximately 3.5km southwest of Ballymore village and 14km northwest of Athlone (distance from EIAR Site Boundary). The townlands in which the Wind Farm Site is located are listed in Table 1-1 in Chapter 1 of this EIAR.

The Wind Farm Site comprises mainly improved grassland and agricultural pastures separated by hedgerows. A small area of forestry exists in the southwest of the Wind Farm Site. The topography of the Wind Farm Site is undulating with the Wind Farm footprint layout being spread over a series of small hills that range in elevation from 55 to 98m OD (Ordnance Datum), with greatest elevation occurring in the northwest of the Wind Farm Site. The overall slope of the land is towards the east/northeast. The Dungolman River dissects the south of the Wind Farm Site before running along the eastern boundary.

All proposed turbine locations (T1-T9), with the exception of T4, are situated on improved grassland. T4 located in the southwest of the Wind Farm Site is situated in an area of coniferous forestry. The Wind Farm Site access roads are mainly located on improved grassland, but also through a small section of forestry near T4.

The Wind Farm Site measures approximately 949 hectares. The footprint of the Proposed Development measures approximately 8.2 hectares, which represents only 0.9% of the primary EIAR Site Boundary.

9.3.1.2 Grid Connection

The Grid Connection encompasses a 110kV on-site substation and associated temporary construction compound within the Wind Farm Site, including underground 110kV cabling to connect to the national grid at Thornsberry 110kV substation, in the townland of Derrynagall or Ballydaly, near Tullamore, Co. Offaly. The underground electrical cabling route is 31km in length, through the village of Horseleap and bypassing the town of Kilbeggan until its termination point at the Thornsberry 110 kV substation, 2km northeast of Tullamore. The underground electrical cabling route is located primarily within public roads, with elevation ranging between 60-80mOD.

9.3.2 Water Balance

Long term rainfall and evaporation data was sourced from Met Éireann. The long-term average rainfall (1981 - 2010) recorded at Ballymore G.S., 2.2km to the northeast of the Wind Farm Site, are presented in Table 9-4.

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

Station		X-Coord		Y-Coord		Ht (MAOD)		Opened		Closed		Total
Granard		233700		281300		N/A		N/A		N/A		
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
117.4	88.6	98.6	75.1	77.5	79.7	82.4	94	88.6	124.1	109.9	118.8	1154.7

The closest synoptic station[1] where the average potential evapotranspiration (PE) is recorded is at Mullingar, approximately 24km northeast of the Wind Farm Site. The long-term average PE for this station is 445.8mm/year. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the Proposed Development site is estimated as 423.5mm/year (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

= 1,154.7mm/year – 423.5mm/year

ER = 731.2mm/year

Based on groundwater recharge coefficient estimates from the GSI (www.gsi.ie) an estimate of 164.5mm/year average annual recharge is given for till at the Wind Farm Site (recharge coefficient of ~22.5%). While till is mapped over much of the Wind Farm Site, areas in the west are underlain by less permeable subsoils including lacustrine clays This means that the hydrology of the Wind Farm Site is

[1] *A station at which meteorological observations are made for the purposes of synoptic (large spatial scale) analysis*

characterised by high surface water runoff rates and moderate to low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the Wind Farm Site are estimated to be 164.5mm/year and 566.7mm/year (i.e. 731.2mm/year – 164.5mm/year = 566.7mm/year) respectively.

Table 9-5 below presents return period rainfall depths for the area of the Wind Farm Site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 50-year, 100-year). These extreme rainfall depths will be the basis of the Wind Farm Site drainage hydraulic design as described further below.

Table 9-5: Return Period Rainfall Depths for the Wind Farm Site

Duration	10-year Return Period	50-Year Return Period	100-Year Return Period
15 min	14.4	23.7	29.2
1 hour	21.2	33.1	39.9
6 hour	35.0	51.0	59.6
12 hour	42.5	60.2	69.6
24 hour	51.6	71.2	81.3
48 hour	60.4	80.1	90.1

9.3.3 Regional Hydrology

9.3.3.1 Wind Farm Site

On a regional scale, the Wind Farm Site is located in the Inny River surface water sub-catchment, which is in the Upper Shannon catchment within Hydrometric Area 26 of the Irish River Basin District (SIRBD). The Inny River flows to the northwest approximately 8.2km northwest of the Wind Farm Site. The Inny River discharges into Lough Ree approximately 10.6km northwest of the Wind Farm Site. A regional hydrology map is shown as Figure 9-1.

On a more local scale, the Wind Farm Site is located in the Inny River sub-catchment (Inny[Shannon]_SC_090) with the majority of the Wind Farm Site located in the Dungolman WFD river sub basin (Dungolman_030) (refer to Figure 9-2). A small section in the southwest of the Wind Farm Site is mapped in the Dungolman_020 river sub-basin while the northwestern corner of the Wind Farm Site is located in the Inny River (Inny_110) river sub-basin. However, none of the proposed turbines are mapped in the Dungolman_020 or Inny_110 river sub-basins.

As stated above the majority of the Wind Farm Site is located in the Dungolman_030 river sub-basin. The Dungolman River (EPA Code: 26D06) flows to the northeast between T4 and T5. This watercourse then flows along the EIAR Site Boundary to the east of T2 and T3 before veering to the northeast to the east of T1. Drainage in this river sub-basin is directed towards the Dungolman River via several smaller streams and drains. The Dungolman River continues to flow to the north before discharging into the Tang River (EPA Code: 26T02) approximately 5.15km north of the Wind Farm Site. The Tang River continues to flow to the northwest and eventually discharges into the Inny River (EPA Code: 26I01) approximately 8.3km northwest of the Wind Farm Site. The Inny River drains into the eastern side of Lough Ree.

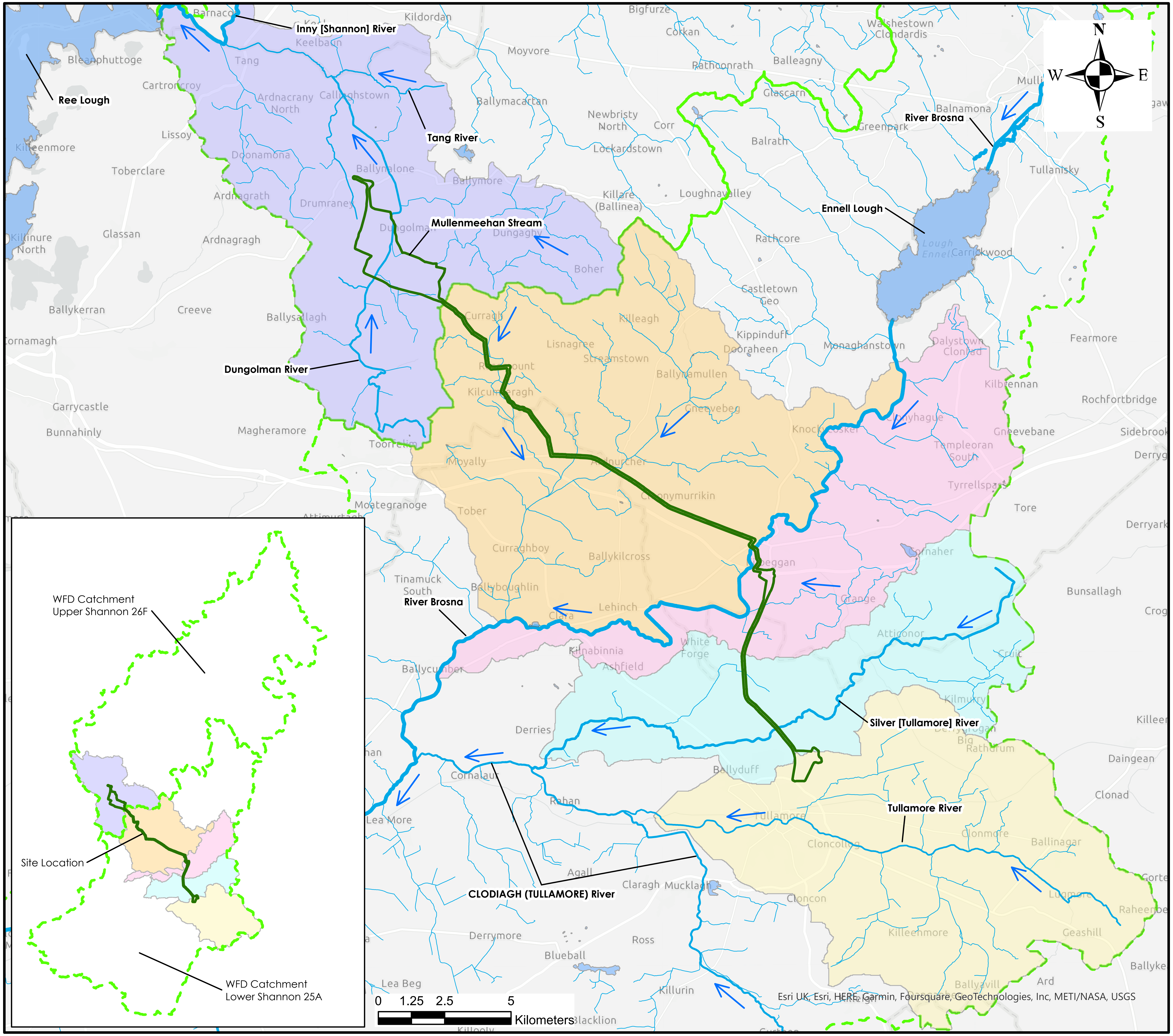
Within the Dungolman_020 River sub-basin, the southwest of the Wind Farm Site drains towards the Dungolman River via the Toorbeg stream (EPA Code: 26T25). Meanwhile within the Inny_110 River sub-basin, the northwest of the Wind Farm Site drains to the northwest via the Ardnacrany south stream (EPA Code: 26A50) which discharges into the Dungolman River approximately 4.3km north of the Wind Farm Site.

9.3.3.2 Grid Connection

The Grid Connection onsite 110kV substation and associated temporary construction compound are located within the Wind Farm Site which is detailed above.

The Grid Connection underground electrical cabling route is located within the Upper Shannon catchment (26) and Lower Shannon catchment (25A) of the Irish River basin district. A Grid Connection hydrology map is shown in Figure 9-3.

The Grid Connection underground electrical cabling route is located within the Inny (Shannon) SC_090, the Brosna_SC_030, Brosna_SC_020, Silver[Tullamore]_SC_010 and Tullamore_SC_010 subcatchments. Apart from the Inny (Shannon) SC_090 subcatchment, all the associated subcatchment rivers flow generally southwest towards the Lower Shannon catchment. The primary watercourse within this Lower Shannon catchment (of the underground electrical cabling route) is the River Brosna. The Silver River and Tullamore River drain into the River Brosna.



Legend

- EIAR Site Boundary
- Watercourses
- Lakes
- WFD Catchments

WFD Subcatchments

- BROSNA_SC_020
- BROSNA_SC_030
- Inny[Shannon]_SC_090
- Silver[Tullamore]_SC_010
- Tullamore_SC_010

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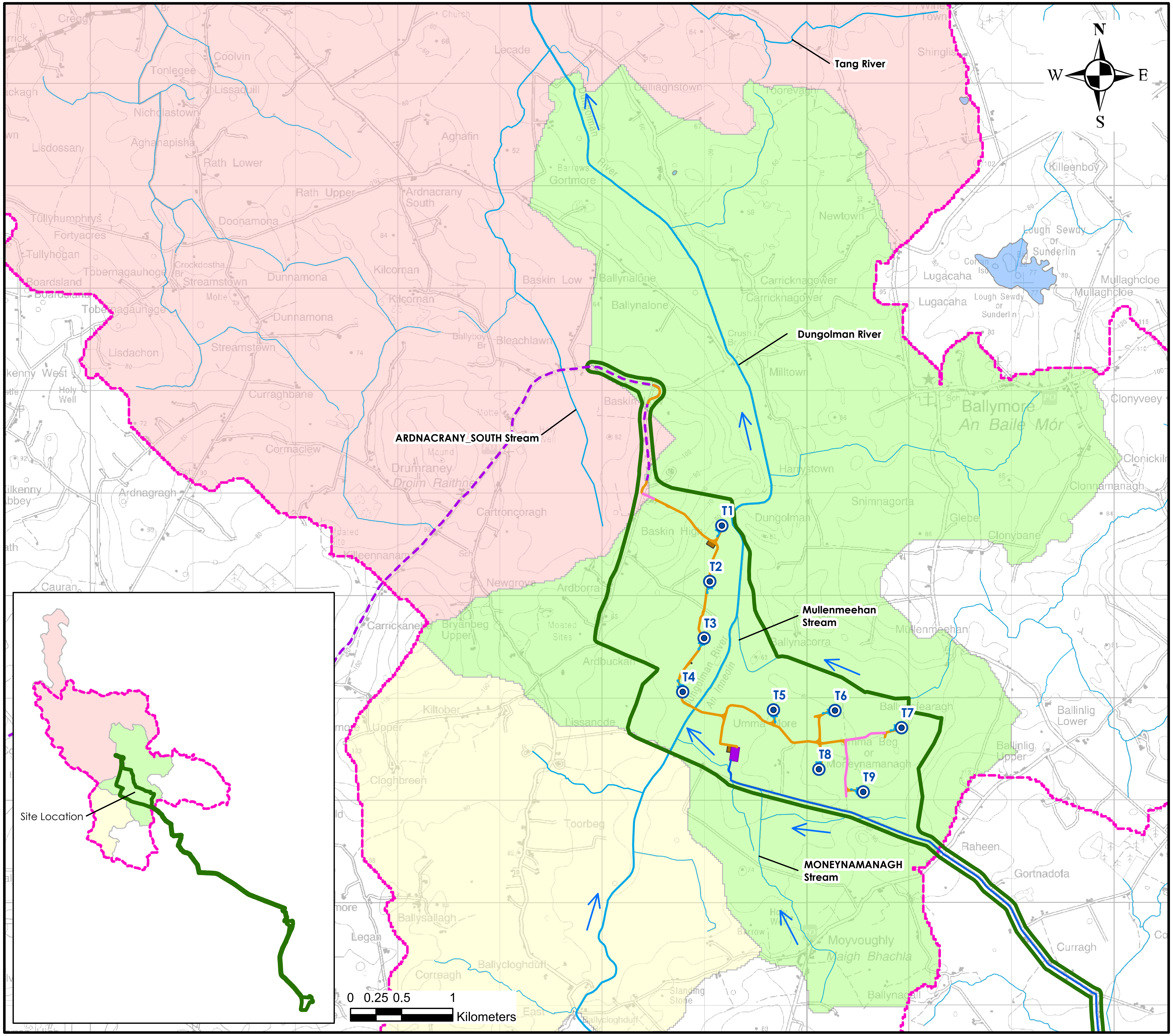
Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Regional Hydrology Map	
Figure No: 9-1	
Drawing No: P1553-0-0123-A3-901-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:135,000	Drawn By: GD
Date: 31/01/2023	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Turbine Hardstands
- Proposed Met Mast Location
- Proposed New Roads
- Proposed Upgrades to Existing Roads
- Proposed Temporary Construction Compounds
- Proposed 110kV Onsite Substation
- Proposed Underground Electrical Cabling Route
- Proposed Turbine Delivery Route
- Watercourses
- Lakes

WFD Subcatchments

- Inny[Shannon]_SC_090

WFD River Sub-Basins

- DUNGOLMAN_020
- DUNGOLMAN_030
- INNY_110

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Client: MKO	
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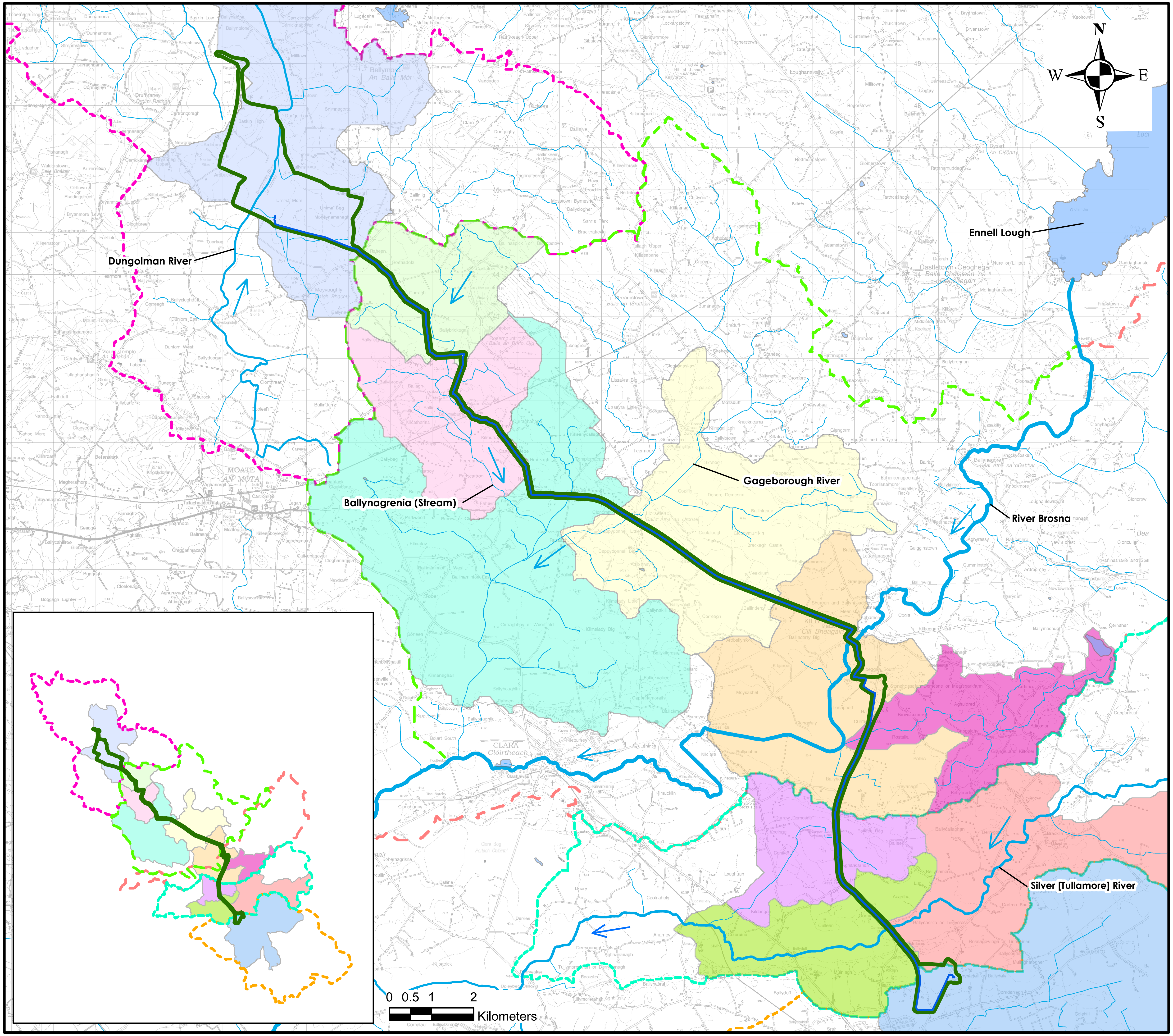
Title: Local Hydrology Map (Wind Farm Site)	
Figure No: 9-2	
Drawing No: P1553-0-0123-A3-902-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:35,000	Drawn By: GD
Date: 31/01/2023	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Underground Electrical Cabling Route
- Watercourses
- Lakes

WFD River Sub-Basins

- BALLYNAGRENIA STREAM_010
- BALLYNAGRENIA STREAM_020
- BROSNA_070
- DUNGOLMAN_030
- DURROW ABBEY STREAM_010
- GAGEBOROUGH_020
- GAGEBOROUGH_030
- SILVER (TULLAMORE)_020
- SILVER (TULLAMORE)_030
- TONAPHORT_010
- TULLAMORE_030

WFD Subcatchments

- BROSNA_SC_020
- BROSNA_SC_030
- Inny[Shannon]_SC_090
- Silver[Tullamore]_SC_010
- Tullamore_SC_010

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Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Local Hydrology Map (Grid Connection)	
Figure No: 9-3	
Drawing No: P1553-0-0123A3-903-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:85,000	Drawn By: GD
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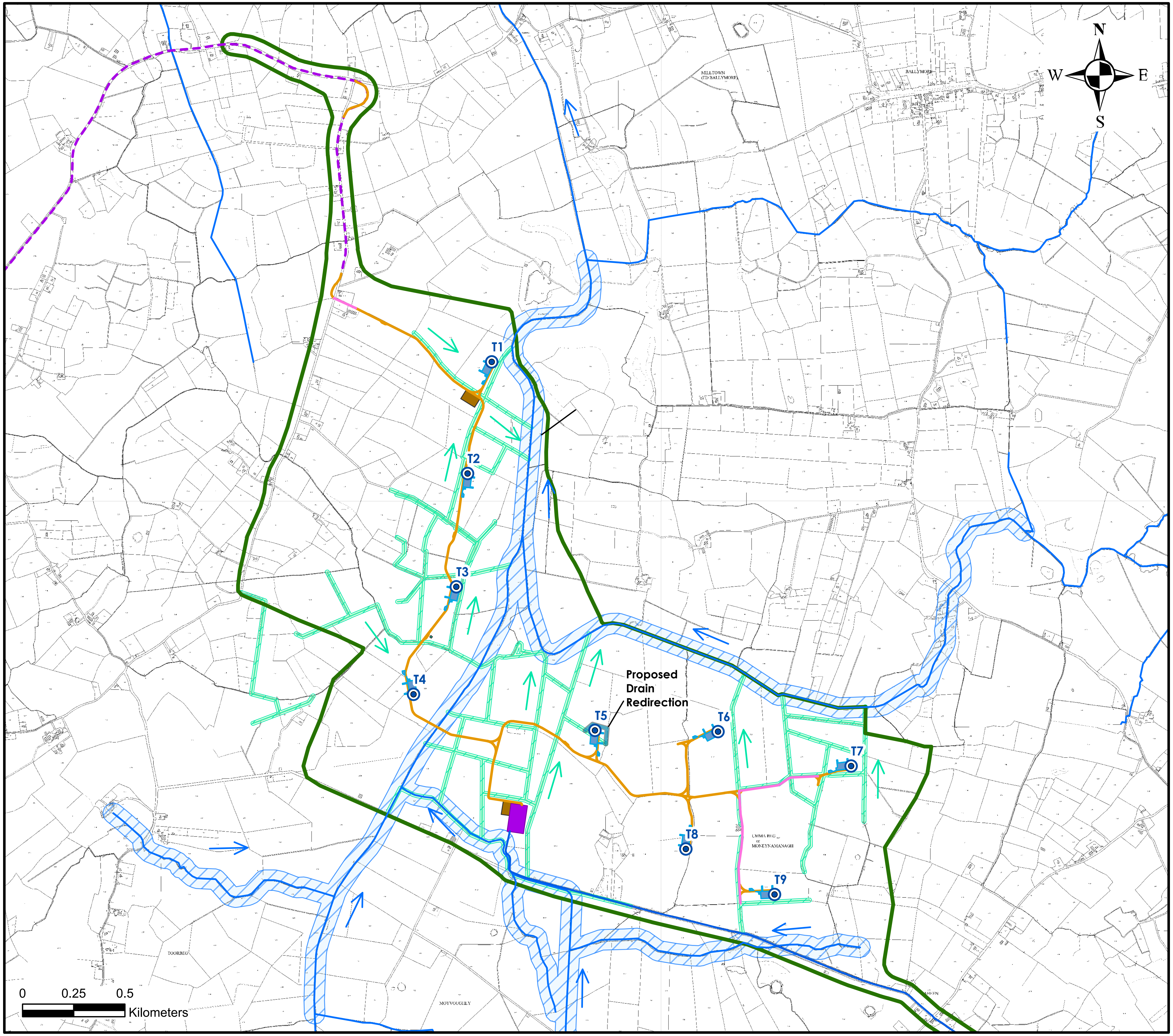
9.3.4 Wind Farm Site Drainage

As discussed above, the majority of the Wind Farm Site is located in the Dungolman_030 River sub-basin, the surface water draining towards the Dungolman River via several smaller streams and agricultural drains. In the southeast of the Wind Farm Site, the Raheen stream (EPA Code: 26R36) flows to the west approximately 150m south of T9. This waterbody discharges into the Moneynamanagh stream (EPA Code: 26M40) 1km southwest of T9 before veering to the northwest and discharging into the Dungolman River 800m southwest of T5. The EPA also map a small stream, the Mullenmeehan stream (EPA Code: 26M12) to flow along the northern EIAR Site Boundary, approximately 300m to the north of T6. The Mullenmeehan stream confluences with the Dungolman River approximately 450m northeast of T3.

The agricultural lands which cover the majority of the Wind Farm Site contain a network of manmade drains which run along the hedgerows and field boundaries and drain into Dungolman River and the Moneynamanagh and Mullenmeehan streams. The west of the Wind Farm Site in the vicinity of T4 consists of forestry with forestry drains discharging into the Dungolman River to the east. A Wind Farm Site drainage map is shown in Figure 9-4.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Turbine Hardstands
- Proposed Met Mast Location
- Proposed New Roads
- Proposed Upgrades to Existing Roads
- Proposed Temporary Construction Compounds
- Proposed 110kV Onsite Substation
- Proposed Underground Electrical Cabling Route
- Proposed Turbine Delivery Route
- Watercourses
- Lakes
- Proposed Drain Redirection
- Drains
- 50m Watercourse Buffer
- 10m Drain Buffer
- Flow Direction

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Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Site Drainage Map (Wind Farm)	
Figure No: 9-4	
Drawing No: P1553-0-0123-A3-904-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:17,500	Drawn By: GD
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9.3.5 Flood Risk Assessment

Wind Farm Site

A Stage III Flood Risk Assessment of the Wind Farm Site has been carried out by HES, the results of which are presented in full in Appendix 9-1 of this EIAR. To identify those areas mapped 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), National Indicative Flood mapping (NIFM) and historical mapping (i.e. 6" and 25" base maps) were consulted.

The OPW (www.floodmaps.ie) show several historic and recurring flood events in the vicinity of the Wind Farm Site. The closest mapped recurring flood event is found approximately 250m southwest of the Wind Farm Site at Kiltober. Here low-lying lands are reported to flood annually following intense rainfall. Similar flood events have been recorded at Tourbeg, Moate, approximately 700m south of the Wind Farm Site. A further flood event is mapped approximately 1km to the north of the Wind Farm Site along the R390 at Ballymore.

The OPW map much of the Wind Farm Site along the Dungolman River and the Mullenmeehan stream to be Benefited Land. Benefited land is land which was drained as part of the Arterial Drainage Scheme. 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.

The PFRA flood maps were queried for potential areas prone to flooding. The maps show that areas in the west and north of the Wind Farm Site are mapped in the 100-year and the Extreme Event fluvial flood zones (Zones A and B respectively) as outlined below. The majority of the Wind Farm Site is however located in Flood Zone C (Low Risk).

The 100-year flood zone is mapped along the Dungolman River within the Wind Farm Site. In the southwest of the Wind Farm Site, the flood zone extends up to 200m from the mapped river course and is mapped ~60m from T4. Further north, T2 is also mapped on the border of the Flood Zone B area, ~300m west of the main river channel. associated with flooding on the Dungolman River while T1 and T3 are located 50m and 180m west of this mapped flood zone respectively.

From the NIFM map of the Wind Farm Site, turbines T1 – T6 are located outside both the Low probability and Medium probability flood zones. Turbine T3 is located within both probability zones.

A detailed Stage III Flood Risk assessment was undertaken, based on the desk study data from the available flood mapping (PFRA/NIFM). This involved a GPS survey of river cross sections and water levels as well as detailed Lidar topographic data for the Wind Farm Site and long-term monitoring of water levels in the Dungolman and Mullenmeehan stream at 3 no. locations.

Flood level modelling for the Dungolman River was undertaken using HEC-RAS open channel flow software. HEC-RAS is a 2-dimensional flow model which can calculate channel water depth/level using parameters such as flood volumes, channel dimensions, slope and friction coefficients (Mannings n number). To investigate the potential for flooding within the Wind Farm Site, modelling of design flood volumes (i.e., 10-year,100-yr and 1000-yr) was undertaken for the river and its flood plain.

The results of the site specific flood modelling are detailed in Appendix 9-1 and are summarised below:

- There is no CFRAM mapping available for the site area.
- The PFRA mapping and NIFM is "broad scale" and based on OSI contour data. Site-specific surveying and flood modelling used in conjunction with Lidar Data is more accurate than these maps (as outlined within the technical guidance on the NIFM mapping in relation to site specific vs regional suitability of the mapping provided on www.floodinfo.ie).

- HES have completed site-specific flood modelling for the Proposed Development infrastructure within the Wind Farm Site identified as being in mapped flood zones (PFRA/NIFM mapping). The results of which are summarised as follows:
  - The assessment show there are no turbines located within mapped flood zones.
  - The onsite substation and temporary access roads are also located outside of the modelled flood zones.
  - The access roads (proposed/upgraded) are located outside of the modelled flood zones apart from 1 no. section (110m) of access road located ~300m west of T5.
  - All proposed wind farm access tracks within modelled flood pluvial zones will have the track surface raised at least 500mm above the 1000-year flood level. No mitigation is required with respect downstream flood risk as they are all outside of the modelled flood zone, apart from a 110m section of access road. There is an existing field drain which will be culverted under the proposed access track. This culvert will provide a drainage outlet for flood water following a significant flood event. This will prevent any damming effect from the proposed access road within this section.
  - Based on the iterative design process, designed around the site-specific flood modelling, any potential upstream and downstream flood impacts associated with the Proposed Development will be unmeasurable/imperceptible. Therefore, there will be no increase in flood risk to people, property, the economy or the environment during extreme flood events.

Grid Connection

The Grid Connection onsite substation and associated temporary construction compound are located within the Wind Farm Site and as such, are addressed in the section above. In addition to the Stage III Flood Risk Assessment for the Wind Farm Site, the potential for flooding along the Grid Connection underground electrical cabling route has also been reviewed.

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

The CFRAM River Flood Extents mapping was reviewed along the length of the underground electrical cabling route. There are no areas along the underground electrical cabling route mapped within the CFRAMS River Flood extent mapping.

The National Indicative Flood Mapping was also reviewed along the length of the underground electrical cabling route. There are sections of the Gaegborogh River near Horseleap which are mapped with flood extents which extend to the road carriageway. Similarly, the Silver River and Tullamore River along the N52 have modelled flood extents which extend onto the road carriageway.

Past Flood events are also recorded and available to view within www.floodinfo.ie/map. There is 1 no. flood event mapped in the townland of Dunard, near Horseleap (Flood ID – 2842). The available information at this location, from Offaly County Council meeting minutes, records that a small stream breaks its banks every ~3 years after heavy rain.

There is also 1 no. location mapped in Kilbeggan (Flood ID-2680), where the River Brosna breaks its banks and floods an existing housing estate, near the underground electrical cabling route.

In summary, there are areas along the underground electrical cabling route which may be prone to flooding, principally along the N52 near the Silver River and the Tullamore River and near the River Brosna. Due to the depth of the underground electrical cabling route, this will have no impact during the operational phase of the Proposed Development. During the construction phase, works along the underground electrical cabling route may have to be postponed following heavy rainfall events which could cause flooding in these areas.

9.3.6 Surface Water Quality

Q-rating status data for EPA monitoring points on the Dungolman River, Mullenmeehan stream and the Inny River are shown on

Table 9-6 below. The Q-Rating is a water quality rating system based on both the habitat and the invertebrate community assessment and is divided into status categories ranging from 0-1 (Poor) to 4-5 (Good/High). Most recent data available (2005 to 2020) show that the
Q-rating for the Dungolman River upstream of the Wind Farm Site at the bridge west of Umma House is of Poor status. Meanwhile, upstream of the Wind Farm Site, the Mullenmeehan stream is reported to be of Moderate status in the latest monitoring round (2020). Downstream of the site the Dungolman and Inny Rivers are both reported as being of Good status. No Q-rating is available for the Moneynamanagh stream located on the south of the Wind Farm Site.

Table 9-6: EPA Water Quality Monitoring Q-Rating Values

Waterbody	EPA Location Description	Year	Easting	Northing	EPA Q-Rating Status
Dungolman_020	Bridge West of Umma House	2020	218,660	245,466	Poor
Mullenmeehan Stream	Bridge near Mullenineehan	2020	221,427	246,572	Moderate
Dungolman_030	Bridge SE of Lecade	2020	217,655	252,059	Good
Inny_110	Red Bridge	2005	211,930	255,015	Good

Field hydrochemistry measurements of unstable parameters, electrical conductivity (µS/cm), dissolved oxygen (mg/L), pH (pH units) and temperature (°C) were taken at various locations in surface watercourses and drainage features at the Wind Farm Site on 06th July 2021, with follow up measurements on 22nd March 2022. The combined results are listed in Table 9-7.

Table 9-7: Field Parameters – Wind Farm Site Summary of Surface Water Chemistry Measurements

Location	Conductivity (µS/cm)	pH	Temp	Dissolved Oxygen (mg/L)
SW1 (06/07/2021)	524	8.15	10.9	10.29
SW2 (06/07/2021)	514	8.03	10.9	9.76
SW3 (06/07/2021)	516	8.04	10.8	10.14
SW1 (22/03/2022)	431.2	8.05	9.6	11.76
SW2 (22/03/2022)	457	7.95	9.9	11.32
SW3 (22/03/2022)	438.2	7.88	9.8	11.6
SW4 (22/03/2022)	204	7.74	11.4	11.77
SW5 (22/03/2022)	477	7.75	11.4	10.31
SW6 (22/03/2022)	463.4	7.83	12	10.62
SW7 (22/03/2022)	494.7	8.01	11.5	11.13
SW8 (22/03/2022)	477.8	7.58	11.2	10.9
SW9 (22/03/2022)	179.6	8.0	10.3	11.5

Location	Conductivity (µS/cm)	pH	Temp	Dissolved Oxygen (mg/L)
SW10 (22/03/2022)	477.0	7.88	11.4	10.92

Surface water hydrochemistry near the Wind Farm Site (SW1-SW3) and along the Grid Connection (SW4-SW10) were taken during site walkover surveys. The locations of these sampling points are shown in Figure 9-5. The electrical conductivity of the surface waters ranged between 179.6 and 516µS/cm. pH ranges between 7.58 – 8.15 indicating a slightly basic water chemistry, while dissolved oxygen ranges between 9.76 – 11.77 mg/L.

Surface water samples were also taken on 06th July 2021, in the main watercourses surrounding the Wind Farm Site (SW1-SW3), with subsequent sampling on 22nd March 2022. Electrical conductivities are within the expected range, varying from 100.3 to 660 µS/cm. The pH is typical of watercourses in the region, ranging between 7.58 and 8.15.

Results of the laboratory analysis from samples taken on 06th July 2021 are shown alongside relevant water quality regulations in Table 9-8 below. Results from follow up sampling on 22nd March 2022 are also shown in Table 9-9. In addition, the European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272/2009) (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy are shown in Table 9-10. Original laboratory reports are included as Appendix 9-3.

Table 9-8: Analytical Results of HES Surface Water Samples (Round 1)

Parameter	EQS	Sample ID		
		SW1 (06/07/21)	SW2 (06/07/21)	SW3 (06/07/21)
Total Suspended Solids (mg/L)	≤25(+)	6	6	7
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	<0.02	0.03	0.14
Nitrite NO_2 (mg/L)		0.05	0.07	0.28
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	<5.0	6.5	<5.0
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10
Total Nitrogen (mg/L)	-	2.7	1.7	1.2
Chloride (mg/L)	≤ 1.3 to ≤ 1.5(*)	13.5	17.3	15.2
BOD		1	1	2

Table 9-9: Analytical Results of HES Surface Water Samples (September & October 2020)

Parameter	EQS	Sample ID									
		SW1 (22/03/22)	SW2 (22/03/22)	SW3 (22/03/22)	SW4 (22/03/22)	SW5 (22/03/22)	SW6 (22/03/2022)	SW7 (22/03/22)	SW8 (22/03/2022)	SW9 (22/03/2022)	SW10 (22/03/2022)
Total Suspended Solids (mg/L)	≤25(+)	<5	<5	<5	11	<5	<5	<5	25	<5	<5
Ammonia (mg/L)	≤0.065 to ≤ 0.04(*)	0.02	0.04	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrite NO_2 (mg/L)		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate – P (mg/L)	≤ 0.035 to ≤0.025(*)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate - NO_3 (mg/L)	-	10.3	12.4	9.5	<0.5	<5.0	11.5	16.7	18.9	6.6	25.3
Phosphorus (mg/L)	-	<0.10	<0.10	<0.10	0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Nitrogen (mg/L)	-	2.6	3.4	3.2	2.1	1.8	1.5	5.6	4.2	1.0	4.6
Chloride (mg/L)	≤ 1.3 to ≤ 1.5(*)	14.2	17.0	16.0	12.5	14.3	12.9	16.8	15.3	18.6	17.5
BOD		1	1	1	2	1	<1	<1	1	1	<1

(+) S.I. No. 293/1988: European Communities (Quality of Salmonid Waters) Regulations
(*) S.I. No. 272 /2009: European Communities Environmental Objectives (Surface Waters) Regulations 2009 (as amended by S.I. No. 296/2009; S.I. No. 386/2015; S.I. No. 327/2012; and S.I. No. 77/2019 and giving effect to Directive 2008/105/EC on environmental quality standards in the field of water policy and Directive 2000/60/EC establishing a framework for Community action in the field of water policy).

Sampling Round 1

Total suspended solids ranged between 6 - 7mg/L which is relatively high, considering the samples were taken in July, when runoff would typically be low, but are below the limits for both Salmonid and Cyprinid waters.

Ammonia-N ranged between <0.02 and 0.14mg/L, the latter of which is above the limits for both Salmonid waters and Cyprinid waters.

BOD was less than 5mg/L in all samples, which is below the limits for Cyprinid waters but potentially exceeds the threshold limit for salmonid waters.

Nitrite ranged between 0.05 – 0.28 mg/L. The results are typically low which is what would be expected for surface waters with little input from intensive agriculture or other anthropogenic factors.

Nitrate ranged between <5.0 and 6.5mg/L which is relatively low and like nitrate, this is what would be expected for surface water with little input from intensive agriculture or other anthropogenic factors.

Sampling Round 2

Total suspended solids are generally <5 mg/L, but reached 11 mg/L and 25 mg/L in SW4 and SW8 respectively. These results are at or below the limits for both Salmonid and Cyprinid waters. The long-term average suspended solids level is likely well below the threshold value of 25 mg/l.

Ammonia-N generally ranged between <0.02 and 0.04mg/L, which is within the “high” status limits for both Salmonid waters and Cyprinid waters of 0.04 mg/l.

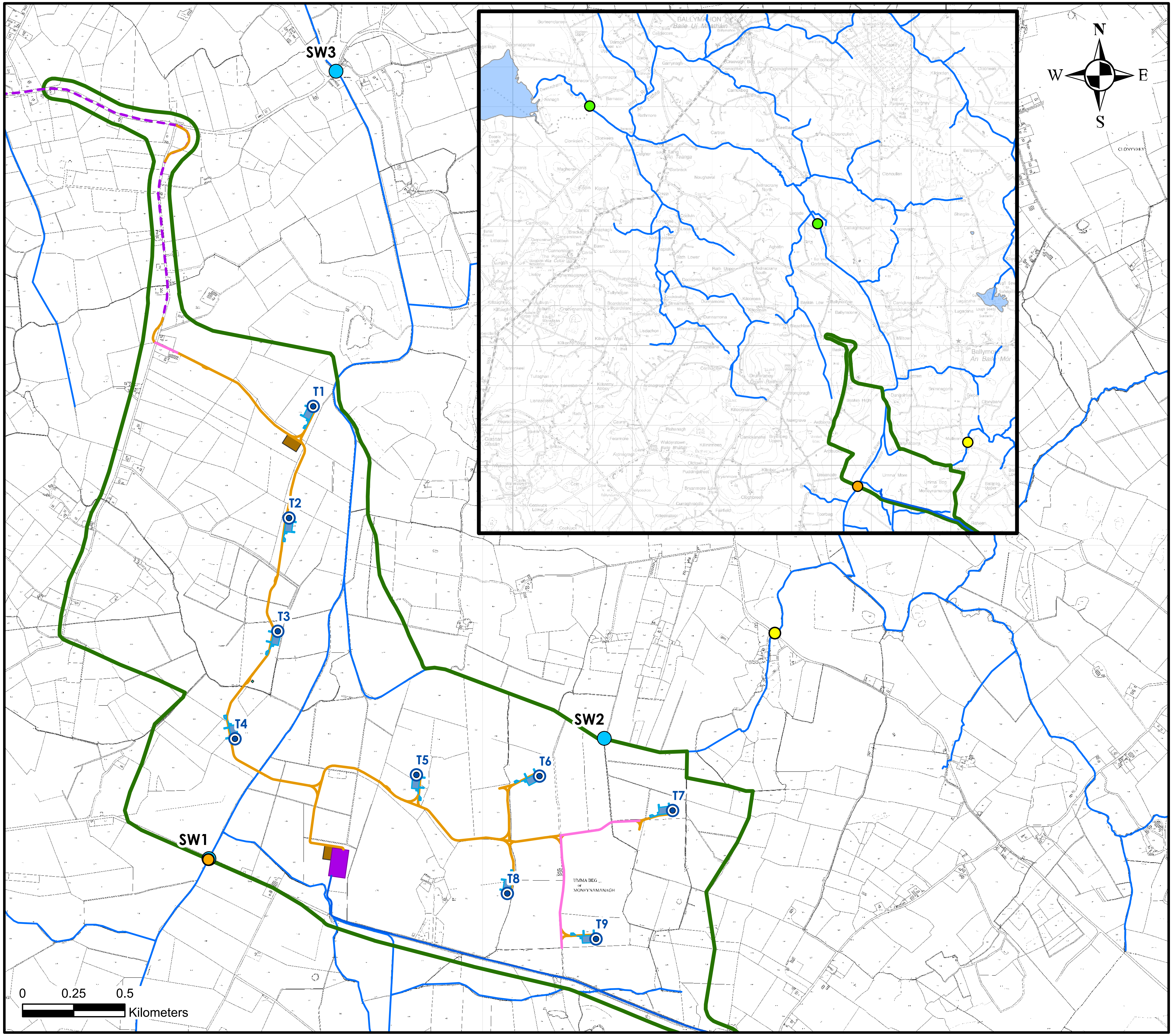
BOD was at or below 1mg/L in 9 of 10 no. samples, which is below the limits for Cyprinid and Salmonid waters. The remaining sample at SW4 measured 2 mg/l.

Nitrate ranged between <0.5 and 25.3mg/L The value of 25.3 mg/L occurred in SW10 and may be related to runoff from local land spreading at the time (March 2022). Orthophosphate was below the detection limit of 0.02 mg/L in all samples.

*Table 9-10: Chemical Conditions Supporting Biological Elements**

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

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



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Turbine Hardstands
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- Proposed New Roads
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- Proposed Temporary Construction Compounds
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- Proposed Underground Electrical Cabling Route
- Proposed Turbine Delivery Route
- Watercourses
- Lakes
- SW Sampling points

River Q-rating

- Good
- Moderate
- Poor

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Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Surface Water Sampling and River Q-Rating Locations Map	
Figure No: 9-5	
Drawing No: P1553-0-0123-A3-905-00A	
Sheet Size: A3	Project No: P1553-0
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9.3.7 Hydrogeology

9.3.7.1 Wind Farm Site

The Geological Survey of Ireland (GSI) classifies the Dinantian Upper Impure Limestones (DUIL) as a Locally Important Aquifer (LI – Bedrock which is generally moderately productive only in local zones). The Wind Farm Site is underlain by the Inny Groundwater Body (GWB).

While no local hydrogeological data is available for this groundwater body, permeability will generally decrease rapidly with depth in this limestone and shale aquifer type. In general, transmissivities will be in the range 2-20m^2/d, with median values occurring towards the lower end of the range (GSI, 2004). The effective thickness of the aquifer is likely to be within 15m of the top of rock, comprising a weathered zone of 5m and a further zone of interconnected fissures of 10m below. Significantly higher permeabilities are likely to be found in fault zones and areas which have undergone structural deformation, which are associated with higher yielding wells. Aquifer storativity will be low in this bedrock unit (GSI, 2004).

Groundwater flow occurs mainly in faults and joints. Most groundwater flow probably occurs in an upper shallow weathered zone. Below this in the deeper zones water-bearing fractures and fissures are less frequent and less well connected. Groundwater in this GWB is generally unconfined. Local groundwater flow is towards the rivers and streams, and flow paths are usually between 30 and three hundred metres in length.

Groundwater within the Wind Farm Site is expected to discharge to the Dungolman River as this will be the dominant hydraulic boundary or discharge zone for groundwater flow in the area. The Wind Farm Site slopes to the east/northeast and groundwater flow will reflect this change in topography.

9.3.7.2 Grid Connection

The Grid Connection is located within several groundwater bodies, which include, from north within the Wind Farm Site to south along the underground electrical cabling route to Thornsberry 110kV substation, the Inny groundwater body (GWB), the Clara GWB, the Gageborogh-Brosna Gravels Group 1 GWB, the Kilbeggan gravels GWB and the Tullamore GWB.

The characteristics of the Inny GWB are as discussed above in Section 9.3.7.1.

The Clara GWB covers an area of 712 km^2 with elevation ranging from 40 – 200mOD. Nearly all the aquifers in this GWB are Locally Important Aquifers which are moderately productive only in local zones (LI).

The Tullamore GWB covers an area of 222 km^2 with elevation ranging between 50-120 mOD. The main aquifer categories are Regionally important karstified aquifer dominated by diffuse flow (Rkd) and Locally important aquifers (LI).

There are no further details on the Gageborogh-Brosna Gravels Group 1 or the Kilbeggan gravels GWB's.

There are 3 no. springs mapped as karst landforms by the GSI, situated along the N52 in the townland of Durrow Demense. These springs discharge into the Durrow Abbey Stream.

9.3.8 Groundwater Hydrochemistry

9.3.8.1 Wind Farm Site

There are no groundwater quality data for the Wind Farm Site and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as effects on groundwater quality are not anticipated.

Based on data from GSI publication Calcareous/Non calcareous classification of bedrock in the Republic of Ireland (WFD, 2004), alkalinity generally ranges from 250 to 350 mg/l (as $CaCO_3$) and hardness ranges from 380 to 450 mg/L (hard to very hard). The underlying formations largely contain calcium bicarbonate type water. Electrical conductivities in these bedrock units are high and will typically range from 650 to 800 μS/cm (GSI, 2003).

9.3.8.2 Grid Connection

There are no groundwater quality data for the underground electrical cabling route and groundwater sampling would generally not be undertaken for this type of development in terms of EIAR reporting, as groundwater quality impacts would not be anticipated. (Surface water sampling is detailed above in Section 9.3.6.)

The differing 5 no. groundwater bodies mean that groundwater hydrochemistry will vary along the underground electrical cabling route.

9.3.9 Groundwater Body Status

9.3.9.1 Wind Farm Site

Local Groundwater Body and Surface water Body status and risk result are available from (www.catchments.ie). The GWB status are shown below in Table 9-11.

The Inny Groundwater Body (GWB: IE_SH_G_110) underlies the Wind Farm Site. It is assigned 'Good Status' under the WFD 2016-2021 (www.wfdireland.ie), this applies to both quantitative status and chemical status. This groundwater body has been deemed to be "Not at risk" and no significant pressures have been identified.

Table 9-11: Groundwater body staus (Wind Farm Site)

SWB Code	Water Body	Overall Status	Risk Status	Pressures
IE_SH_G_110	Inny	Good	Not at risk	N/A

9.3.9.2 Grid Connection

Local Groundwater Body and Surface water Body status and risk results are available from (www.catchments.ie). The GWB status for the Grid Connection are shown below in Table 9-12.

The Inny Groundwater Body (IE_SH_G_110) underlies the Grid Connection onsite substation and associated temporary construction compound which is located in the Wind Farm Site, along with the northern section of the Grid Connection underground electrical cabling route. It is assigned 'Good Status' under the WFD 2016-2021(www.wfdireland.ie), this applies to both quantitative status and chemical status. This groundwater body has been deemed to be “Not at risk” and no significant pressure have been identified.

The Clara GWB (IE_SH_G_240) underlies the underground electrical cabling route. It is assigned ‘Good Status’[2] under the WFD 2016-2021(www.wfdireland.ie), this applies to both quantitative status and chemical status. This groundwater body has been deemed to be “Not at risk” and no significant pressure have been identified.

The Tullamore GWB (IE_SH_G_232) underlies the southern section of the underground electrical cabling route. It is assigned ‘Good Status’ under the WFD 2016-2021(www.wfdireland.ie), this applies to both quantitative status and chemical status. This groundwater body has been deemed to be “Not at risk” and no significant pressure have been identified.

The Kilbeggan Gravels GWB (IE_SH_G_242) is assigned “Good Status’[3] under the WFD 2016-2021 (www.wfdireland.ie), this applies to both quantitative status and chemical status. The risk rating for the GWB is under review.

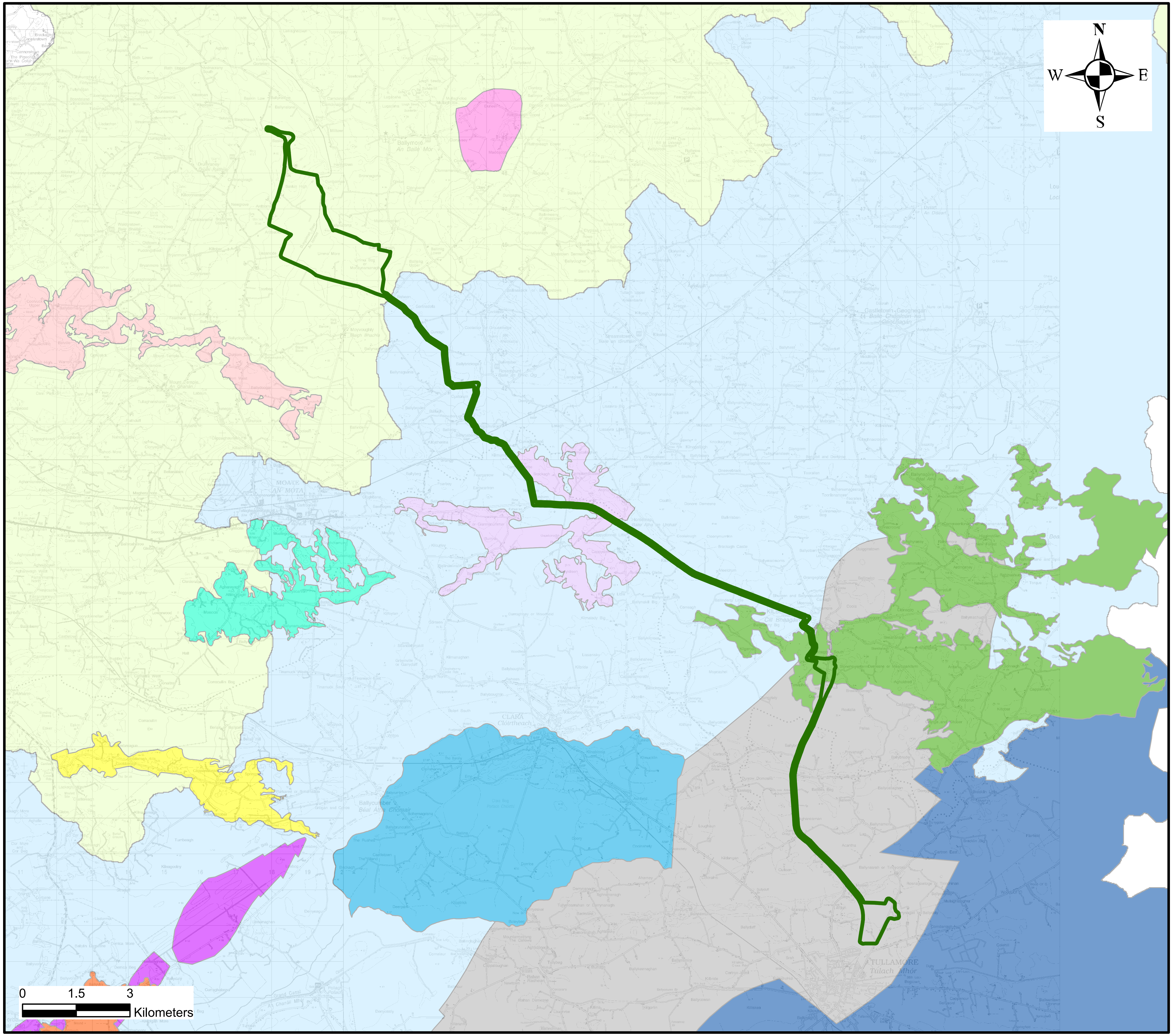
The Gageborogh Gravels Group 1 GWB (IE_SH_G_253) is assigned “Good Status’ under the WFD 2016-2021(www.wfdireland.ie), this applies to both quantitative status and chemical status. The risk rating for the GWB is under review.

Table 9-12: Groundwater body status (Grid Connection)

SWB Code	Water Body	Overall Status	Risk Status	Pressures
IE_SH_G_110	Inny	Good	Not at risk	None defined
IE_SH_G_240	Tullamore	Good	Not at risk	None defined
IE_SH_G_232	Clara	Good	Not at risk	None defined
IE_SH_G_242	Kilbeggan Gravels	Good	Under review	Under Review
IE_SH_G_253	Gageborogh Gravels (Group 1)	Good	Under review	Under review

A groundwater body map is shown in Figure 9-6.

[2] *‘Status’ means the condition of the water in the waterbody. It is defined by its chemical status and its ecological status, whichever is worse. Waters are ranked in one of 5 classes: High, Good, Moderate, Poor and Bad (WFD, 2010).*
[3] *‘Status’ means the condition of the water in the waterbody. It is defined by its chemical status and its ecological status, whichever is worse. Waters are ranked in one of 5 classes: High, Good, Moderate, Poor and Bad (WFD, 2010).*



Legend

- EIAR Site Boundary

WFD Groundwater Bodies

- Athlone Gravels
- Boor Gravels
- Clara
- Ferbane
- Funshinagh
- GWDTE-Ballymore Fen & Mire (SAC002313)
- GWDTE-Clara Bog (SAC000572)
- Gageborogh-Brosna Gravels Group 1
- Gageborogh-Brosna Gravels Group 2
- Gageborogh-Brosna Gravels Group 3
- Geashill
- Inny
- Kilbeggan Gravels
- Tullamore

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Client: MKO

Job: Umma More Renewable Energy Development

Title: WFD Groundwater Bodies Map

Figure No: 9-6

Drawing No: P1553-0-0123-A3-906-00A

Sheet Size: A3	Project No: P1553-0
Scale: 1:100,000	Drawn By: GD
Date: 31/01/2023	Checked By: MG

9.3.10 Surface Water Body Status

9.3.10.1 Wind Farm Site

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) in which the Wind Farm Site is located immediately upstream or downstream of are shown in Table 9-13 below.

The surface water quality status (2016-2021) for the Dungolman River (IE_SH_26D060200) is Poor, while the Mullenmeehan stream (IE_SH_26M120080) upstream of the Wind Farm Site is classified as Moderate with a risk result of "Not at risk". In the vicinity of the Wind Farm Site the Dungolman River (IE_SH_26D060400) has been assigned Poor status with this waterbody deemed to be "At risk" and under significant pressure from urban wastewater. Further downstream the Inny River (IE_SH_26I011400) is assigned a Moderate status but is deemed to be under significant pressure from agricultural activities in the surrounding catchment. Meanwhile Lough Ree (IE_SH_26_750a) achieved Good status and is deemed to be "Not at risk".

Table 9-13: Summary WFD Information for Surface Waterbodies

SWB Code	Water Body	Overall Status	Risk Status	Pressures
IE_SH_26D060200	Dungolman_020	Poor	Not at risk	None defined
IE_SH_26M120080	Mullenmeehanstream_010	Good	Not at risk	None defined
IE_SH_26D060400	Dungolman_030	Poor	At Risk	Urban Wastewater
IE_SH_26I011400	Inny_110	Unassigned	Under review	Agriculture
IE_SH_26_750a	Lough Ree	Good	Not at risk	None defined

9.3.10.2 Grid Connection

A summary of the WFD status and risk result of Surface Water Bodies (SWBs) along the Grid Connection are shown in Table 9-14 below.

The surface water quality status (2016-2021) for the Ballynagrenia_010 and 020 waterbodies are Poor and Good respectively. Ballynagrenia_010 is identified as being "At Risk" from agricultural pressure, while Ballynagrenia_020 is "Not at Risk" from any external pressures.

Further south along the underground electrical cabling route, the Gageborogh_020 and Gageborogh_030 water bodies both achieved "Good" status during the WFD 2016-2021. Both waterbodies are classified as "At Risk" from agricultural pressures.

The Brosna_070 waterbody achieved Good status and is "Not at Risk". The Tonaphort_010 is assigned a Moderate status, but is not assigned a risk rating. The Durrow Abbey Stream_010 achieved Poor status and is considered "At Risk" from forestry and agricultural pressures.
Finally, the Silver (Tullamore)_020 waterbody achieved "Good" status and is considered "Not at risk".

Table 9-14: Summary WFD Information for Surface Waterbodies

SWB Code	Water Body	Overall Status	Risk Status	Pressures
IE_SH_25B160400	Ballynagrenia_010	Moderate	At Risk	Agriculture
IE_SH_25B160600	Ballynagrenia_020	Good	Not at risk	None defined
IE_SH_25G010500	Gageborogh_030	Good	At Risk	Agriculture
IE_SH_25G010300	Gageborogh_020	Good	At Risk	Agriculture
IE_SH_25B090450	Brosna_070	Good	Not At Risk	None defined
IE_SH_25T450930	Tonaphort_010	Unassigned	Under review	Under review
IE_SH_25D120200	Durrow Abbey Stream_010	Moderate	At Risk	Forestry, Peat workings and agriculture
IE_SH_25S030100	Silver(Tullamore)_020	Good	Under Review	Under review

9.3.11 Designated Sites and Habitats

9.3.11.1 Wind Farm Site

In the Republic of Ireland, designated sites include proposed Natural Heritage Areas (pNHAs), Natural Heritage Areas (NHAs), Special Areas of Conservation (SAC) and Special Protection Areas (SPA's). The Wind Farm Site is not located within any designated site. A designated site map for the area is shown as Figure 9-7.

Designated sites within 15km of the proposed Wind Farm Site include:

- Ballynagrenia and Ballinderry Bog NHA (Site Code: 000674), approximately 2km to the south;
- Lough Sewdy pNHA (Site Code: 000689), approximately 3.2km to the northeast;
- Ballymore Fen SAC (Site Code: 002313), approximately 4.8km to the northeast;
- Ballynagarbry pNHA (Site Code: 001717), approximately 5.2 km to the south;
- Carn Park Bog SAC and pNHA (Site Code: 000676), approximately 6.3km to the southwest;
- Waterstown Lake pNHA (Site Code: 001732), approximately 7.2km to the west;
- Crosswood Bog SAC and pNHA (Site Code: 002337), approximately 9.7km to the southwest; and,
- Lough Ree SAC, SPA and pNHA (Site Code: 000440), approximately 10.5km to the northwest;

Ballynagrenia and Ballinderry Bog NHA and the Ballynagarby pNHA are located to the south of the Wind Farm Site, however these designated sites are located upstream of the Wind Farm Site and therefore are not hydraulically connected (downgradient) to the Wind Farm Site, therefore we have excluded those sites from further impact assessment analysis.

Lough Sewdy pNHA is located ~3.2km northeast of the Wind Farm Site. This waterbody is mapped within the Inny(Shannon)_SC_070 sub-catchment and is not hydraulically connected to the Wind Farm Site due to the topographic boundary between these two subcatchments. The lake is not hydraulically connected to the Wind Farm Site, therefore it is excluded from further assessment.

The Ballymore Fen SAC is situated ~5.2km south of the Wind Farm Site on the south-eastern boundary of the Inny(Shannon)_SC_090 subcatchment. The majority of the fen is mapped in the adjoining Inny(Shannon)_SC_070 subcatchment. The location of the fen on the boundary of these two subcatchments, indicates its hydraulic nature, in that it is located on slightly higher ground and drains down towards the rivers in the lower subcatchments. It is therefore hydraulically upgradient of the Wind Farm Site and is excluded from further assessment.

The Carn Park Bog SAC and pNHA is located 6.3km southwest of the Wind Farm Site. The bog is located within the Breensford_SC_010 subcatchment which drains north towards the Inny River. The bog is located in a separate subcatchment to the Wind Farm Site at the upper reaches of a well defined basin. There is no hydrological connection between the Carn Park Bog SAC and pNHA and the Wind Farm Site, therefore it is excluded from further assessment.

The Waterstown Lake pNHA is located 7.2km west of the Wind Farm Site. The Waterstown Lake is also situated in the Inny(Shannon)_070 subcatchment, slightly downgradient of the Carn Park Bog SAC and pNHA. Again, as it is located within a separate subcatchment to the Wind Farm Site, it is excluded from further assessment.

The Crosswood Bog SAC and pNHA is located 9.7km southwest of the Wind Farm Site. The bog is located within the Shannon(Lower)_SC_010 subcatchment. This is significantly distal to the Wind Farm Site and the Inny(Shannon)_SC_090 subcatchment in which the Wind Farm Site is located. The

Crosswood Bog SAC and pNHA is hydraulically isolated from the Wind Farm Site and as such is not carried further in the assessment.

Lough Ree SAC, SPA and pNHA is located approximately 10km northwest and downstream of the Wind Farm Site. This designated site is hydrologically linked with the Wind Farm Site via the Dungolman and Inny Rivers. Refer to Section 6.5.1.1.1 in Chapter 6 of the EIAR: Biodiversity regarding the Lough Ree SAC, SPA and pNHA and the Qualifying Interests/ Special Conservation Interests for which the European site has been designated. Please also refer to the Natura Impact Statement (NIS) prepared for the Proposed Development, which further considers the Lough Ree SAC, SPA and pNHA.

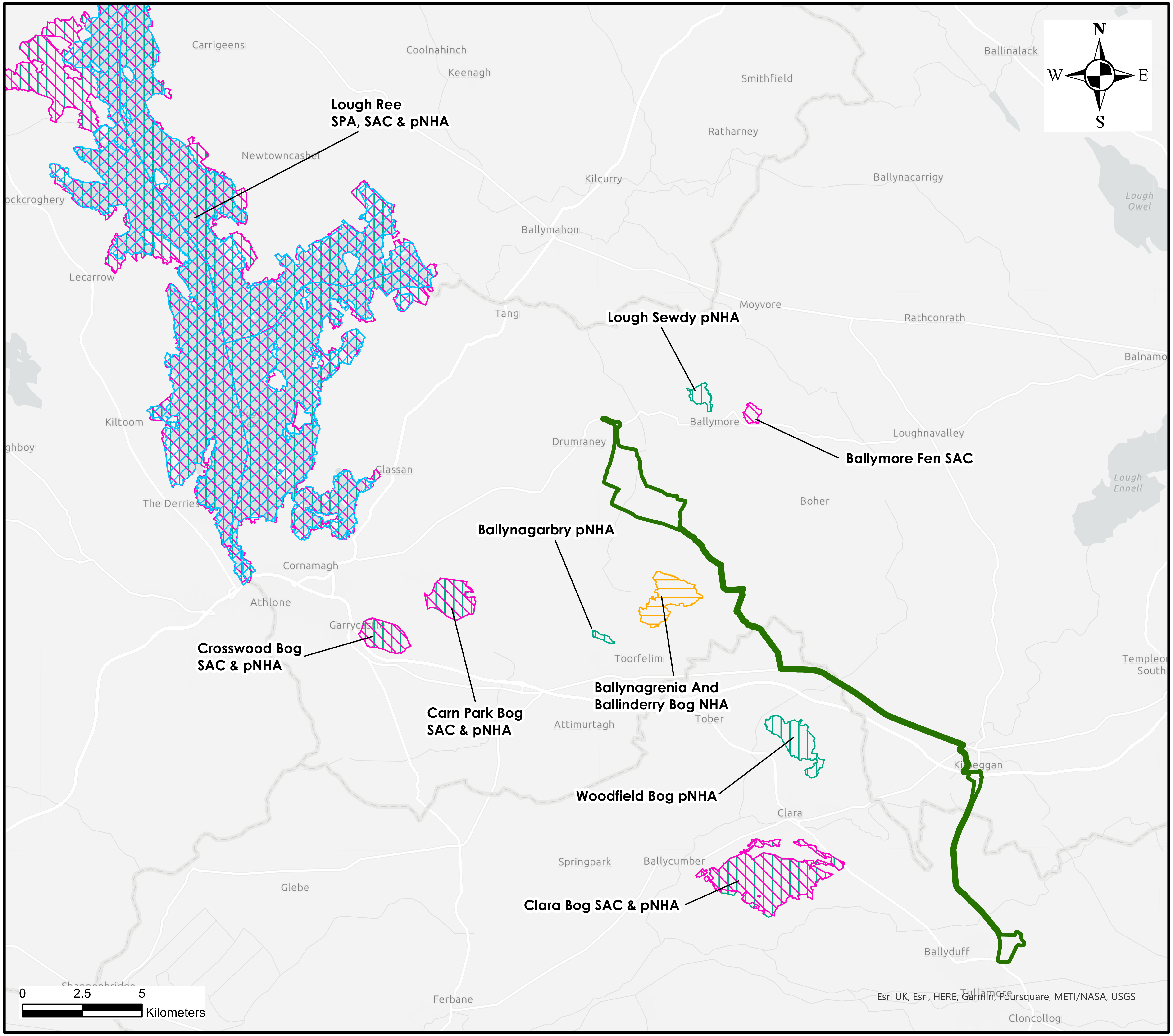
The majority of these designated sites are located hydraulically upgradient of the Wind Farm Site or in separate sub-catchments as the Wind Farm Site. Therefore, these sites are not hydrologically linked to the Wind Farm Site and are not subject to further analysis. Only one designated site is carried forward for further assessment, and this is Lough Ree SAC, SPA and pNHA (Site Code: 000440), approximately 10.5km to the northwest of the Wind Farm Site.

9.3.11.2 Grid Connection

The Grid Connection onsite substation and associated temporary construction compound are located within the Wind Farm Site and as such, are addressed in the section above. There are no designated sites mapped along the Grid Connection underground electrical cabling route. The nearest designated site is the Clara Bog SAC and pNHA, situated ~4km west of the underground electrical cabling route at its closest point. The Clara Bog SAC is a raised bog situated at an elevation of ~60mOD and is hydraulically upgradient of the Brosna and Silver Rivers. The streams and rivers which are crossed along the underground electrical cabling route south of Horseleap, drain towards the Silver River and ultimately the River Brosna. As the bog is situated upgradient of the Brosna and Silver rivers, there is no hydraulic connection between the Clara Bog SAC/pNHA and the underground electrical cabling route.

The Woodfield Bog pNHA is situated approximately 1km south of the underground electrical cabling route, south of the village of Horseleap. This pNHA site is located near Kilamady hill, on an elevated site which is significantly above the Gageborough river and the underground electrical cabling route. It is therefore not hydraulically connected with the underground electrical cabling route.

The River Shannon Callows SAC and Middle Shannon Callows SPA are situated ~38km downgradient of surface watercourses along the proposed underground electrical cabling route. Despite their significant separation distance, the designated sites are screened in, due to their hydrological connection with stream along the underground electrical cabling route. Refer to Section 6.5.1.1.1 in Chapter 6 of the EIAR: Biodiversity regarding the River Shannon Callows SAC and Middle Shannon Callows SPA and the Qualifying Interests/ Special Conservation Interests for which the European sites has been designated. Please also refer to the Natura Impact Statement (NIS) prepared for the Proposed Development, which further considers the River Shannon Callows SAC and Middle Shannon Callows SPA.



Legend

- EIAR Site Boundary
- SPA
- SAC
- pNHA
- NHA

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Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Designated Sites Map	
Figure No: 9-7	
Drawing No: P1553-0-0123-A3-907-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:150,000	Drawn By: GD
Date: 31/01/2023	Checked By: MG

9.3.12 Water Resources

9.3.12.1 Wind Farm Site

There are no mapped public or group water scheme groundwater protection zones in the Wind Farm Site. The closest mapped Group Scheme is the Tubber Scheme, located approximately 4.2km south of the Wind Farm Site and in the Clara Ground Waterbody. This protection zone is therefore not of any significance for the Proposed Development.

A search of private well locations (accuracy of 1 – 50m only) was undertaken using the GSI well database (www.gsi.ie). There are no wells with an accuracy of 1 – 50m mapped in the Wind Farm Site. There is one well (2023NEW016), mapped ~200m outside the northern boundary of the Wind Farm Site. This well (GSI Name: 2023NEW029) has agricultural and domestic uses and a poor yield class of 10.9m^3/day. The GSI also map several wells in the vicinity of the southwest of the Wind Farm Site. These boreholes (GSI name: 2023NEW032 and 2023NEW033) also have poor yield classes and domestic and agricultural uses.

A map of nearby wells is included as Figure 9-8.

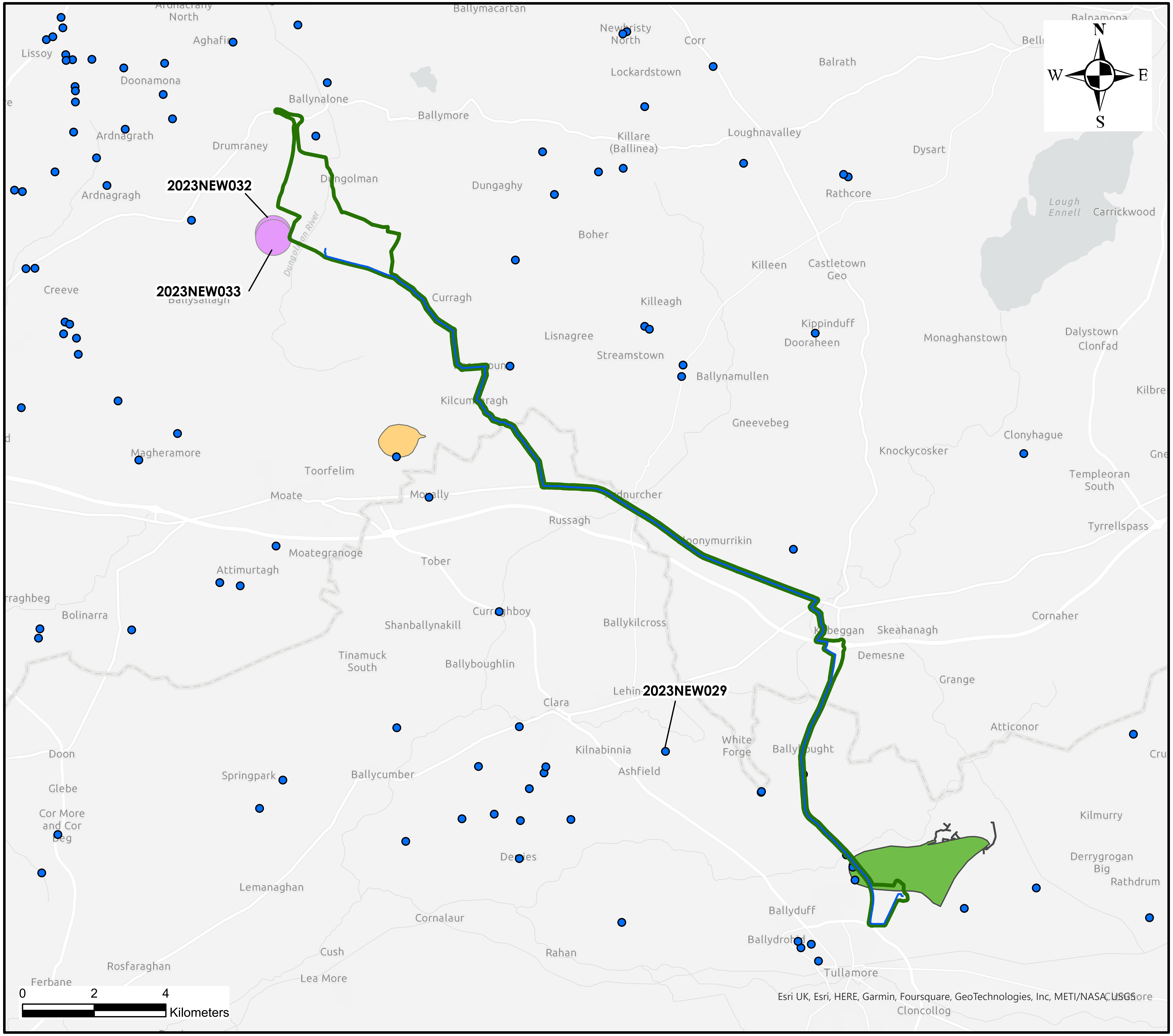
An assessment of potential effects to local groundwater wells is completed in Section 9.5.2.10 below.

9.3.12.2 Grid Connection

The Grid Connection onsite substation and associated temporary construction compound are located within the Wind Farm Site and as such, are addressed in the section above. A search of private well locations (accuracy of 1 – 50m only) was undertaken using the GSI well database (www.gsi.ie). There are 3 no. wells mapped along the Grid Connection underground electrical cabling route, within the EIAR Site Boundary.

There is 1 no. PWS source protection area mapped at the southern end of the underground electrical cabling route, near the Thornsbury 110kV substation. There are 2 no. boreholes (PW1 & PW2) used by the Tullamore Ardan PWS which are located ~50m east of the N52 and the underground electrical cabling route. The water strikes recorded in PW1 occurred between 72-103 mbgl, while the water strike in PW2 was recorded at 35mbgl. PW1 is a grout sealed borehole, while there is no grout seal noted on the construction log of PW2.

A Source Protection Report for the Ardan PWS has been prepared by the GSI. The underground electrical cabling route travels along the N52, a 1.03km section of the underground electrical cabling route is situated within the Source Protection Zone for the Ardan PWS. This is assessed in Section 9.5.2.10 below.



Legend

- EIAR Site Boundary
- Proposed Underground Electrical Cabling Route
- GSI Mapped Wells (accuracy <50m)
- GSI Mapped wells (500m - 1km accuracy)

Public Supply Source Protection Area

- SI-Inner Protection Area (TULLAMORE ARDAN PWS)

Group Scheme Preliminary Source Protection Areas

- Tubber

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Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Nearby GW Wells Map	
Figure No: 9-8	
Drawing No: P1553-0-0123-A3-908-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:100,000	Drawn By: GD
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9.3.14 Receptor Sensitivity

Due to the nature of wind farm developments, being mostly near surface construction activities, effects on groundwater are negligible and surface water is the main sensitive receptor assessed during impact assessments. The primary risk to groundwater at the Wind Farm Site and the Grid Connection would be from cementitious materials, hydrocarbon spillage and leakages during construction works. These are common potential risks on all construction sites (such as road works and industrial sites), which can be addressed by way of mitigation. All potential contamination sources are to be carefully managed at the Wind Farm Site and Grid Connection during the construction and operational phases of the Proposed Development and mitigation measures are proposed below to deal with these potential risks.

Based on criteria set out in Table 9-2 above, the Locally Important Aquifer can be classed as Sensitive to pollution. The majority of the Wind Farm Site however is subsoils which have moderate to poor recharge coefficients and are in turn is underlain by lake sediments and silty/clayey glacial deposits and these layers act as a protective cover to the underlying bedrock aquifer. However, due to the geological and hydrological regime at the Wind Farm Site, 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 control measures are outlined below to avoid this occurring and to ensure protection of all downstream receiving waters. These mitigation and control measures will also be utilised during works for the Grid Connection where applicable, also noting that the Grid Connection underground electrical cabling works are shallow and transient in nature and the works will mainly be completed within an existing road carriageway.

Mitigation measures will ensure that surface runoff from the developed areas of the Wind Farm Site and Grid Connection 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 Wind Farm Site will mimic the existing drainage regime thereby avoiding changes to flow volumes leaving the Wind Farm Site.

9.3.15 Development Interaction with the Drainage Network of the Wind Farm Site

The general design approach to wind farm layouts in existing forestry/agricultural land is to utilise and integrate new drainage with the existing drainage infrastructure where possible.

9.3.16 Proposed Drainage Management

Runoff control and drainage management are key elements in terms of mitigation against effects on surface water bodies. Two distinct methods will be employed to manage drainage water within the Wind Farm Site. 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 Wind Farm 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 (i.e. dirty water) will be attenuated and treated to a high quality prior to being released. The drawings for the proposed drainage management system is included as Appendix 9-4.

9.4 Characteristics of the Proposed Development

The Proposed Development is defined in Section 4.1 of Chapter 4. The main characteristics of the Proposed Development that could impact on water and hydrogeology are:

- Establishment of the temporary construction compound, which will involve minor regrading of soil/subsoil and the emplacement of the construction compound. Welfare facilities will be provided at the temporary construction compounds. Wastewater effluent will be collected in a wastewater holding tank and periodically emptied by a licenced contractor.
- Construction of the site access tracks will use the excavate and replace technique. This will involve the use of aggregate, imported from local quarries where required. Construction of these access tracks has the potential to impact on surface water quality.
- Construction of the crane hardstand areas and turbine assemblage areas will utilise ground bearing foundations. Construction of these areas has the potential to impact on surface water quality.
- Settlement ponds where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning.
- Construction of the onsite substation will be completed with a ground bearing foundation. Welfare facilities will be provided at the substation. Construction of the onsite substation and associated parking area has the potential to impact on surface water quality.
- Grey water will be supplied by rainwater harvesting and water tankered to site where required. Bottled water will be used for potable supply.
- Construction of the turbine foundations, which will require large volumes of concrete (approximately 700m^3 per turbine foundation plus approximately 50m^3 of lean-mix concrete for the blinding layer), placing demand on local concrete batching plants / quarries. Concrete could impact on surface water and groundwater quality.
- Cabling between turbine locations and the onsite substation will involve the excavation of a shallow trench (approximately 1.2m deep), placement of ducting and backfilling with aggregate, lean-mix concrete, and excavated material, as appropriate (depending on the location of the cable trench). These works have the potential to impact on surface water quality.
- Underground electrical cabling between the onsite substation and the Thornsberry 110 kV Substation will involve the excavation of a trench predominantly within the public road, placement of ducting and backfilling with lean-mix concrete and compacted engineered fill. These works have the potential to impact on surface water quality.
- Junction Accommodation and Public Road Works, including:
    - Location 1 – M6 Junction 10 left slip / N55 junction in Athlone
    - Location 2 – N55 / R916 Cornamaddy Roundabout
    - Location 3 – N55 / R390 Junction in Athlone
    - Location 4 – Bend on R390 at Coolteen
    - Location 5 – Bends on R390 at Beechlawn
    - Location 6 – R390 / L5363 Junction
    - Location 7 – Access junction on L5363
- Tree felling and replanting. 1 no. turbine is located in commercial forestry (T4) which will require felling, and replanting of forestry at alternative replacement lands. While this work will be done with Forestry Service licences and approvals, the works could result in soil/subsoils erosion.

9.5 Likely Significant Effects and Associated Mitigation Measures

9.5.1 Do Nothing Scenario

If the Proposed Development were not to proceed, coniferous plantation and agriculture will continue to function and may be extended to occupy a larger portion of the land. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with coniferous plantation is likely to occur. Surface water drainage carried out in areas of forestry will continue to function and may be extended in some areas. The opportunity to capture the available renewable energy resource would be lost.

9.5.2 Construction Phase Likely Significant Effects and Mitigation Measures

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

Construction phase activities including access road construction, construction compound, turbine base/hardstanding construction, cabling trenching within the Wind Farm Site, and Grid Connection onsite substation construction, construction compound and underground electrical cabling route cable trench excavation will require earthworks resulting in removal of vegetation cover and excavation/landscaping of small volumes of soil and mineral subsoil where present. The soil and subsoil removed will be accommodated within identified spoil management areas within the Wind Farm Site or transported to a local licenced facility. The spoil management areas will be situated outside of all mapped flood zones and drainage buffer zones. Potential sources of sediment laden water include:

- Drainage and seepage water resulting from site infrastructure excavation;
- Stockpiled excavated material providing a point source of exposed sediment;
- Construction of the underground electrical cabling 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. Potential effects are significant if not mitigated against.

Pathways: Drainage and surface water discharge routes.

Receptors:

Wind Farm Site: Down-gradient rivers (Dungolman River, Inny River, Moneynamanagh stream and Mullenmeehan stream) and dependent ecosystems. Lough Ree is also located downstream of the Wind Farm Site and is hydrologically linked to the Wind Farm Site via the Dungolman and Inny Rivers.

Grid Connection: Down-gradient surface watercourses

Pre-Mitigation Potential Effects: Indirect, negative, significant, temporary, unlikely impact.

Proposed Mitigation Measures:

Wind Farm Site

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). From Figure 9-4 it can be seen that all of the key development components within the Wind Farm Site are located significantly away from the delineated 50m watercourse buffer zones with the exception of the upgrading of the existing watercourse crossing, new drain crossing and upgrades to existing site tracks. Spoil management areas for removed soil/subsoil will be localised to spoil management areas outside of these buffer zones and will be designed and constructed with the minimal amount of surface area exposed. In these spoil management areas, the vegetative top-soil layer will be removed and re-instated or reseeded directly after construction, allowing for re-vegetation which will mitigate against erosion. Additional control measures, which are outlined further on in this section, will be undertaken at the proposed watercourse and drain crossing locations.

It should be noted that an extensive network of agricultural and forestry drains already exists, and these will be integrated and enhanced as required and used within the Wind Farm Site drainage system. The integration of the existing drainage network and the Wind Farm Site 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 Wind Farm Site 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;
- Buffered outfalls which will be numerous over the Wind Farm Site which 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 Wind Farm Site; and,
- 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.

Grid Connection

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above.

More than 95% of the underground electrical cabling connection route is >50m from any nearby watercourse, sections within 50m of the route are confined to existing watercourse crossings at bridges. It is proposed to limit any works in any areas located within 50m of any watercourse/waterbody including the stockpiling of excavated soils and subsoils.

There are a total of 34 no. watercourse crossings along the underground electrical cabling connection route, as shown in Figure 4-29 of Chapter 4. There are 11 no. river/stream crossings (watercourses mapped by EPA), with the remaining crossings being classified as culverts. All the crossings are existing bridges and culverts along the public road.

No in-stream works are required at any of these crossings, however due to the proximity of the streams to the construction work at the crossing locations, there is a potential for surface water quality impacts during trench excavation work. Mitigation measures are outlined below.

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

The 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; and,
- Avoid the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone;

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 hydrological buffer zones.

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 Proposed Development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of soil/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

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

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

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

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

Works will be suspended if forecasting suggests any of the following is likely to occur, or if on-site monitoring indicates any of the following has occurred:

- >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, and after, works being suspended the following control measures will be undertaken:
    - All open excavations will be secured and sealed off;
    - Provide temporary or emergency drainage to prevent back-up of surface runoff; and,
    - Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Spoil Management Areas:
It is proposed that excavated soil will be used for landscaping where required.

During the initial construction of roads, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from works areas.

Where applicable, the vegetative top-soil layer of the spoil management areas will be rolled back to facilitate placement of excavated spoil up to a maximum height of 1.0 metres, following which the vegetative-top soils layer will be reinstated. Where reinstatement is not possible, spoil management areas will be sealed with a digger bucket and seeded as soon possible to reduce sediment entrainment in runoff.

Management of Runoff from underground electrical cabling route and existing and proposed access roads:
Where construction is undertaken along sections of the underground electrical cabling connection route, proposed access road or existing roads requiring upgrade, the drainage management infrastructure (as outlined above) will be in place to manage and control runoff from the trench excavation area. Where the internal electrical cable trench is to be constructed off-road (within the Wind Farm Site) or for the Grid Connection underground electrical cabling route along public roads, surface water control measures such as silt fences will be employed when work is required within hydrological buffer zones.

Timing of Site Construction Works:
Construction of the Wind Farm 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).

Post-Mitigation Residual Effect The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be - Negative, indirect, imperceptible, temporary, unlikely effect on the water environment within the Wind Farm Site (Dungolman River, Inny River, Moneynamanagh stream and Mullenmeehan stream) and along the underground electrical cabling route

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

9.5.2.2 Construction Phase Tree Felling

As part of the Proposed Development, tree felling will be required within and around the Proposed Development footprint to allow for the construction of the turbine bases, access roads underground cabling, and the other ancillary infrastructure.

Further details on tree felling required within and around development footprint on the Wind Farm Site is detailed in Chapter 6 of this EIAR. A small section of the Wind Farm Site is located on commercial forestry, namely Turbine no. 4 and its associated infrastructure. A total of 6.4 hectares of commercial forestry will be permanently felled within and around Turbine No. 4 and its associated infrastructure, along with existing treeline boundaries as detailed in Chapter 6, Section 6.6.3.1.2. Keyhole felling to facilitate groundworks will be undertaken during the construction phase. Any further felling (related to turbulence) will be carried out during the construction phase of the Proposed Development.

The commercial forestry felling activities required as part of the Proposed Development will be the subject of a Felling Licence application to the Forest Service, in accordance with the Forestry Act 2014 and the Forestry Regulations 2017 (SI 191/2017) and as per the Forest Service's policy on granting felling licenses for wind farm developments.

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; and,
- Nutrient release.

Pathways: Drainage and surface water discharge routes.

Receptors: Surface waters and associated dependent ecosystems (Dungolman River, Inny River, Moneynamanagh stream and Mullenmeehan stream).

Pre-Mitigation Potential Effect: Indirect, negative, moderate, temporary, unlikely effect.

Proposed Mitigation Measures:

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

- Department of Agricultural, Food and the Marine (2019): Standards for Felling and Reforestation;
- 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 9-15.

Table 9-15: Minimum Buffer Zone Widths (Forest Service, 2000)

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

During the Wind Farm Site construction phase a buffer zone of 50m will be maintained for all streams and rivers where possible, and a 10m buffer will be applied to main drains.

All proposed tree felling areas are 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;
- 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 spoil management 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 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;
- Any diesel or fuel oils stored at the temporary site compounds will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,
- 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, create attenuation, 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 near 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; and,
- 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 will 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 passes, 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); and,
- The above sampling strategy will be undertaken for all on-site sub-catchments streams where tree felling is proposed.

Also, daily surface water monitoring forms (for visual inspections and field chemistry measurements) will also be utilised at every works site near any watercourse. These will be taken daily and kept on site for record and inspection.

Post-Mitigation Residual Effects: Forestry works are completed in accordance with guideline standards that all aim to protect surface water quality and aquatic habitats. With the application of the mitigation outlined above, the residual effect is considered to be: Indirect, negative, slight, temporary, unlikely effect.

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

9.5.2.3 Excavation Dewatering and Potential Impacts on Surface Water Quality

Wind Farm Site

Groundwater seepages may occur in turbine base excavations, particularly those on lower elevations *i.e* T1-T4 and this will create additional volumes of water to be treated by the drainage management system.

Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted at the site and therefore pollution issues are not anticipated in this respect.

Grid Connection

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above. Some minor groundwater/surface water seepages will likely occur in trench excavations and substation foundation excavations and this will create additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments. No contaminated land was noted along the underground electrical cabling route therefore pollution issues are not anticipated.

Pathway: Overland flow and site drainage network.

Receptor: Surface water bodies downgradient of Wind Farm Site (Dungolman River, Inny River, Moneynamanagh stream and Mullenmeehan stream) and water bodies downgradient of underground electrical cabling route (as listed above in Section 9-12 and Section 9-30).

Pre-Mitigation Potential Effect: Indirect, negative, significant, temporary, unlikely effect on surface water quality.

Proposed Mitigation Measures (By Design)
Management of excavation seepage and subsequent treatment prior to discharge into the drainage network will be undertaken as follows:

- Appropriate interceptor drainage, to prevent upslope surface runoff from entering excavations will be put in place;
- If required, pumping of excavation inflows will prevent build up of water in the excavation;
- The interceptor drainage will be discharged to the Site constructed drainage system or onto natural vegetated surfaces and not directly to surface waters;
- The pumped water volumes will be discharged via volume and sediment attenuation ponds adjacent to excavation areas, or via specialist treatment systems such as a Siltbuster unit;
- There will be no direct discharge to surface watercourses, and therefore no risk of hydraulic loading or contamination will occur; and,
- Daily monitoring of excavations by a suitably qualified person will occur during the construction phase. If high levels of seepage inflow occur, excavation work should immediately be stopped and a geotechnical assessment undertaken.

Post-Mitigation Residual Effects: The potential for the release of suspended solids to watercourse receptors is a risk to water quality and the aquatic quality of the receptor. Proven and effective measures to mitigate the risk of releases of sediment have been proposed above and will break the pathway between the potential sources and the receptor. The residual effect is considered to be - Negative, indirect, imperceptible, short term, unlikely impact on local surface water bodies.

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

9.5.2.4 Potential Release of Hydrocarbons

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 flowpaths and site drainage network.

Receptor: Groundwater and surface water at the Wind Farm site and Grid Connection.

Pre-Mitigation Potential Effect:

Indirect, negative, slight, short term, unlikely effect on local groundwater quality.

Indirect, negative, significant, short term, unlikely effect on surface water quality.

Proposed Mitigation Measures (by Design):

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off Site (Wind Farm Site and Grid Connection), 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 temporary 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;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse;
- Fuels stored on site will be minimised;
- Any diesel or fuel oils stored at the temporary construction compound will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within the Construction and Environmental Management Plan (Appendix 4-2). Spill kits will be available to deal with accidental spillages.

Post-Mitigation Residual Effects: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be – Negative, indirect, imperceptible, short term, unlikely effect on surface water quality and groundwater quality.

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

9.5.2.5 Groundwater and Surface Water Contamination from Wastewater Disposal

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

Pathway: Groundwater flowpaths and Grid Connection /Wind Farm Site drainage network.

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

Pre mitigation Potential Effect:

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

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

Proposed Mitigation Measures (By Avoidance)

- The temporary construction compound adjacent to the onsite substation located within the Wind Farm Site will be used for the construction of the northern section of the underground electrical cabling route;
- Port-a-loos with an integrated waste holding tank will be used at the temporary construction compounds, maintained by the providing contractor, and removed from Wind Farm Site on completion of the construction works;
- Mobile welfare units will be used during the construction of the underground electrical cabling route, particularly towards the south of the route;
- Water supply for the Wind Farm Site office and other sanitation will be brought to the Wind Farm Site and removed after use from the Wind Farm Site to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the Wind Farm Site, or discharged to the Wind Farm Site.

Post-Mitigation Residual Effects: The release of wastewater at the Wind Farm Site and along the Grid Connection underground electrical cabling route can pose a risk to down gradient groundwater wells, groundwater quality and surface water quality. Proven and effective methods to mitigate against these potential impacts have been outlined above which will break the potential pathways between any source and receptor. The residual effect is considered to be - No residual effect.

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

9.5.2.6 Release of Cement-Based Products

Concrete and other cement-based products are highly alkaline and corrosive and can have significant negative 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 $\geq 6 \leq 9$ is set in S.I. No. 293 of 1988 Quality of Salmonid Water Regulations, with artificial variations not in excess of $\pm$ 0.5 of a pH unit. Entry of cement based products into the site drainage system, into surface water runoff, and hence to surface watercourses or directly into watercourses represents a risk to the aquatic environment. Batching of wet concrete at the Wind Farm Site/ Grid Connection and washing out of transport and placement machinery are the activities most likely to generate a risk of cement based pollution. Placed concrete in turbine bases and foundations can have minor local impacts on groundwater quality over time. However, due to limited surface area of exposed concrete, the anoxic conditions below ground, and the high rate of dilution from the wider groundwater system relative to the small volumes of groundwater that would come in contact with the concrete, the potential for impacts are low.

Pathway: Site drainage network, groundwater flow.

Receptor: Surface water and groundwater chemistry.

Pre-Mitigation Potential Effect:

Indirect, negative, moderate, short term, unlikely impact on surface waters such as the Dungolman River, Inny River, Moneynamanagh stream and Mullenmeehan stream.

Indirect, negative, imperceptible, long term, unlikely impact on local groundwater quality.

Proposed Mitigation Measures
Mitigation by Avoidance:

- No batching of wet-cement products will occur on the Wind Farm Site/along the underground electrical cabling route works or near other ancillary construction activities. 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 will need to be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be directed into a dedicated concrete wash out pit. Decommissioning of this pit will occur at the end of the construction phase and water and solids will be tanked and removed from the site to a suitable, non-polluting, discharge location;
- All concrete will be paced in shuttering and will not be in contact with soils or groundwater until after it has set;
- Use weather forecasting to plan dry days for pouring concrete; and,
- Ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

No mitigation required for potential groundwater impacts as these are imperceptible at the outset.

Post-Mitigation Residual Effects: The potential for the release of cement-based products or cement truck wash water to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases cement-based products or cement truck wash water have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be - Negative, Indirect, imperceptible, short term, unlikely effect on surface water, Indirect, negative, imperceptible, long term, unlikely effect on local groundwater quality.

Significance of Effects: No significant effects on surface water or groundwater quality will occur.

9.5.2.7 Morphological Changes to Surface Watercourses and Drainage Patterns

Diversion, culverting, road and underground electrical cabling route 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 interfere with water quality and flows during the construction phase.

The following watercourse crossings are proposed as part of the Proposed Development:

- 1 no. watercourse crossings will be constructed across the Dungolman river within the Wind Farm site.
- Minor culverts within existing artificial (field) drains across the site will be required at 11 no. locations across the proposed Wind Farm Site. These crossing are further described in Section 4.6.4 of Chapter 4 and included in Figures 4-30 to 4-33.
- Along the underground cable route there are 34 no. watercourse crossings along the existing road carriage. 11 of these 34 no. crossings are mapped as EPA watercourses. The remaining 23 are smaller unmapped drains.

Section 4.7.7 in Chapter 4 of this EIAR details the water crossing locations along the proposed Grid Connection underground electrical cabling route, and describes the proposed crossing construction methodology. Additional details are presented below.

Pathway: Site drainage network.

Receptor: Surface water flows and stream morphology (Surface watercourses along the underground electrical cabling route, Dungolman River and minor field drains).

Pre-Mitigation Potential Impact: Negative, direct, slight, long term, high probability effect on surface watercourses near the watercourse crossings.

Proposed Mitigation Measures (By Design):

Wind Farm Site:

- 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;
- Within the Wind Farm Site where the site underground cabling runs adjacent to a proposed access road or an existing access road proposed for upgrade, the cable will pass over the culvert (where one exists or is proposed) within the access road;
- Within the Wind Farm Site, where a proposed access road crosses an existing field drain, the crossing will include a suitably sized piped at the correct invert level to maintain the existing flow regime and prevent ponding.
- Any guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings. A 10m buffer is applied to main drains to allow for future OPW maintenance;
- Works will be completed in accordance with the requirements of "*Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters";* and,
- All new 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.

Grid Connection:

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above.

With respect to the Grid Connection underground electrical cabling route watercourse crossings, 4 construction crossing methods are proposed that will avoid in-stream works and these include:

- **Option A:** Where adequate cover exists above a culvert, the standard aforementioned trench arrangement will be used where the cable ducts pass over a culvert without any contact with the existing culvert or water course. The cable trench will pass over the culvert in a standard trench. Where no crossing currently exists, the cable will pass over the watercourse in a bottomless box culvert or pre-cast concrete slab in a standard trefoil arrangement. Where required existing culvert crossings will be extended using appropriately sized corripipe.
- **Option B:** Where the culvert consists of a socketed concrete or sealed plastic pipe and sufficient depth is not available over the crossing, a trench will be excavated beneath the culvert and cable ducts will be installed in the standard formation 300mm below the existing pipe.
- **Option C:** Where cable ducts are to be installed over an existing culvert and sufficient cover cannot be achieved, the ducts will be laid in a much shallower trench, the depth of which will be determined by the cover available at the culvert crossing location. The ducts within the shallow formation trench will be encased in 6mm thick steel galvanized plates and backfilled with 35N concrete. Where sufficient deck cover is not available to fully accommodate the required ducts, it may be necessary to locally raise the pavement level. Any addition of a new pavement will be tied back into the existing road pavement at grade.
- **Option D:** Directional Drilling (DD) is a method of drilling under obstacles such as bridges, culverts, railways, water courses, etc. in order to install cable ducts under the obstacle. This method is employed where installing the ducts using standard installation methods is not possible. The DD method of duct installation will be carried out using Vermeer D36 x 50 Directional Drill (approximately 22 tonnes), or similar plant, for the directional drilling at watercourse/culvert crossings. During the drilling process, a mixture of a natural, inert and fully biodegradable drilling fluid such as Clear Bore™ and water is pumped through the centre of the drill rods to the reamer head and is forced in to void and enables the annulus which has been created to support the surrounding subsoil and thus prevent collapse of the reamed length.

Mitigation Measures relating to the use of a mixture of a natural, inert and fully biodegradable drilling fluid such as Clear Bore™ and water for directional drilling include:

- The area around the Clear Bore™ batching, pumping and recycling plants will be bunded using terram and sandbags in order to contain any spillages;
- One or more lines of silt fences will be placed between the works area and adjacent rivers and streams on both banks;
- Accidental spillage of fluids will be cleaned up immediately and transported off site for disposal at a licensed facility; and,
- Adequately sized skips will be used for temporary storage of drilling arisings during directional drilling works. This will ensure containment of drilling arisings and drilling flush.

Post-Mitigation Residual Effects: With the application of the best practice mitigation outlined above, and through compliance with the Section 50 consenting process, the residual effect is considered to be - Neutral, direct, negligible, short term, unlikely effect on stream flows, stream morphology and surface water quality.

Significance of Effects: For the reasons outlined above, no significant effects on stream morphology or stream water quality will occur at crossing locations.

9.5.2.8 Potential Effects on Hydrologically Connected Designated Sites

Possible effects include water quality impacts which could be significant if mitigation is not put in place. Dewatering of construction sites, such as within the Wind Farm Site can also effect nearby designated sites, however this will not be undertaken as part of the Proposed Development. The implementation of piling construction methods also eliminates the requirement for dewatering. The turbine foundation may be formed using piling methods or on competent strata (i.e bedrock or subsoil of sufficient load bearing capacity).

Wind Farm Site

Lough Ree SAC/SPA/pNHA is situated hydraulically downgradient of the Wind Farm Site. Lough Ree is fed by the Inny River, which is in turn fed by the Dungolman River as one of its tributaries. The remaining designated sites, namely Ballynagrenia and Ballinderry Bog NHA, Lough Sewdy pNHA, Ballymore Fen SAC, Ballynagarbry pNHA, Carn Park Bog SAC and pNHA, Waterstown Lake pNHA, Woodfield Bog pNHA and Crosswood Bog SAC and pNHA are all hydraulically upgradient of the Wind Farm Site, and are therefore hydraulically disconnected from the Wind Farm Site.

Grid Connection

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above. The Grid Connection underground electrical cabling route passes within existing public roads close to Ballynagrenia and Ballinderry Bog NHA, Woodfield Bog pNHA, Clara Bog SAC and Ballyduff Wood pNHA. However all these designated sites/proposed designated sites are located hydraulically upgradient of the underground electrical cabling route, therefore there is no hydraulic connection between these sites and the underground electrical cabling route. The River Shannon Callows SAC and Middle Shannon Callows SPA are situated ~20km downgradient of surface watercourses along the proposed underground electrical cabling route. Surface water mitigation measures employed during the construction of the underground electrical cabling route will ensure there are no effects on these designated sites.

Pathway: Surface water and shallow groundwater flowpaths.

Receptor:

Wind Farm Site- Down-gradient water quality and designated sites (Lough Ree SAC).

Grid Connection underground electrical cabling route – (River Shannon Callows SAC and Middle Shannon Callows SPA).

Pre-Mitigation Potential Effect: Indirect, negative, negligible, temporary, unlikely effect.

Impact Assessment and Proposed Mitigation Measures

Wind Farm Site:

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 Wind Farm Site areas will be very high.

As stated in Section 9.5.2.1 above, there could potentially be a “negative, temporary, unlikely effect” on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect effects on downstream designated sites (Lough Ree SAC/SPA/pNHA) distant from the Wind Farm Site will not occur.

Grid Connection:

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above.

As the designated sites mentioned above are hydraulically upgradient of the Grid Connection underground electrical cabling route, there is no surface water pathway between the underground electrical cabling route and the named designated sites.

Nonetheless, the River Shannon Callows SAC and Middle Shannon Callows SPA are situated ~20km downgradient of surface watercourses near the underground electrical cabling connection route. This is a significant separation distance between the proposed works and the downgradient receptor. Mitigation measures to protect surface watercourses will be put in place during works along the underground electrical cabling route. The proposed mitigation measures which will include drainage control measures, sediment control measures and mitigation measures related to spills/chemical releases will ensure that the quality of runoff from along the underground electrical cabling route during construction will be good. The closest point of intersection between the underground electrical cabling route and a designated site is near the northeast corner of Ballynagrenia and Ballinderry Bog NHA where the underground electrical cabling route passes along the N52, 1.2km east of the bog. Due to the shallow nature of the trench (~1.2m) and the location of the underground electrical cabling route hydraulically downgradient of the Ballynagrenia and Ballinderry Bog NHA, there will be no hydrological impact on the designated site.

As stated in Section 9.5.2.1 above, there could potentially be an "imperceptible, short term, likely impact" on local streams and rivers but this would be very localised and over a very short time period (i.e. hours). Therefore, significant direct, or indirect impacts on the SACs, SPAs, NHAs, and pNHAs will not occur.

The hydrological regime locally will not be affected by the Proposed Development works and so the regime of the SACs, SPAs, NHA and pNHAs will not be affected.

- No significant dewatering is proposed during construction. Any pumping required will be temporary and at a very shallow depth. The turbine foundation may be formed using piling methods or on competent strata (i.e bedrock or subsoil of sufficient load bearing capacity).
- All building and trenching works are proposed at or very near existing ground levels with minimal ground disturbance proposed.
- No deep foundations are required or are proposed. As such there will be no interruption or blocking of shallow or deep groundwater pathways below the Site.

Post-Mitigation Residual Effects: For the reasons outlined above, and in conjunction with the implementation of the mitigation measures, no hydrological or hydrogeological effects on designated sites will occur.

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

9.5.2.9 Potential Effects on Groundwater and Surface Water due to Temporary Junction Works

Minor haul route works are required at 7 no. locations listed below, however all proposed road works are small-scale and localised, they include:

- Location 1 – M6 Junction 10 left slip/N55 junction in Athlone
- Location 2 – N55/R916 Cornamaddy Roundabout

- Location 3 – N55/R390 Junction in Athlone
- Location 4 – Bend on R390 at Coolteen
- Location 5 – Bends on R390 at Beechlawn
- Location 6 – R390/L5363 Junction
- Location 7 – Access Junction on L5363

Due to the shallow nature of the temporary junction works effects on groundwater flows and levels will not occur, however there is a potential for effects on groundwater quality from fuels and other chemicals during the construction phase. Mitigation measures are outlined below.

Pathway: Surface water and groundwater flow paths.

Receptor: Down-gradient water quality.

Pre-Mitigation Potential Effect: Indirect, negative, slight, temporary, unlikely effect on surface water quality.
Indirect, negative, slight, temporary, unlikely effect on groundwater quality.

Proposed Mitigation Measures
The following mitigation measures are proposed:

Mitigation by Avoidance:

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

The purpose of the constraint zone is to:

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

General Best Practice Pollution Prevention Measures will also include:

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

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

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser, as described in Section 9.5.2.4. No maintenance of construction vehicles or plant will take place along the temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

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

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

9.5.2.10 Potential Effects on Local Groundwater Wells (Wind Farm Site and Grid Connection)

As stated in Section 9.3.7.1 above, the groundwater flow in the mineral soil deposits (silts, sands and gravels) beneath Wind Farm Site will discharge into the local surface waterbody network, i.e. the Dungolman River, and groundwater flow in the north of the Wind Farm Site will discharge to the Mullenmeehan stream, which ultimately discharge into the Dungolman River at their confluence. Therefore within the Wind Farm Site groundwater flows towards the local watercourses, and therefore the potential for any of the proposed wind farm works to effect any local water well is minimal (as all local wells are upstream of the wind farm footprint).

Temporary dewatering of turbine bases during construction has the potential to impact on local groundwater levels. Due to the nature of the quaternary sediments at the Wind Farm Site, detailed during the trial pit excavations (refer to Chapter 8), it is expected that dewatering will not be required, or will be very limited in extent.

<u>Wind Farm Site</u>
As outlined in Section 9.3.12.1, there are no public or group groundwater scheme protection zones mapped near the Wind Farm Site. There are no mapped wells situated within the Wind Farm Site, however there are several wells mapped nearby by the GSI, with varying location accuracies.

All mapped GSI wells, and any unmapped wells, are situated hydrologically upgradient of the Wind Farm Site. From a surface water perspective they drain towards the Dungolman River, but are situated further upgradient than the Wind Farm Site. The groundwater regime at the Wind Farm Site will reflect this, with groundwater hydraulic gradients in the direction of the Dungolman River (away from mapped and unmapped wells).

<u>Grid Connection</u>

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above.

The Ardan PWS boreholes are situated 50m east of the N52. The Grid Connection underground electrical cabling route passes along the N52 in this area, within a 1.03km section of the road which is situated within the Tullamore Ardan PWS Source Protection Area.

No groundwater level effects will occur from the construction of the Grid Connection underground electrical cabling trench due to the shallow nature of the excavation (i.e. ~1.2m), the excavation of the trench within the road carriageway and the unsaturated nature of the subsoil/bedrock to be excavated. The static water level in the Ardan PWS boreholes ranges between 11.78mbTOC and 14.11mbTOC from dip data within the Source Protection Report[4]. These static water levels are >10m below the invert of the underground electrical cabling route channel along the road carriageway, and at that depth the grid connection works cannot cause any impact.

Pathway: Groundwater flow paths.

Receptor: Down-gradient domestic and public groundwater wells (mapped GSI wells listed in Section 9.3.12, and any unmapped wells, and also including the Tullamore Ardan PWS).

Pre-Mitigation Potential Impact: Indirect, negative, slight, temporary, unlikely effect on groundwater quality and quantity.

Proposed Mitigation Measures
Mitigation measures to protect and ensure the quantity and quality of groundwater during the construction phase of the Proposed Development has been outlined in Sections 9.5.2.4, 9.5.2.5, 9.5.2.6 and 9.5.2.9. These broadly include:

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

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser, as described in Section 9.5.2.4. No maintenance of construction vehicles or plant will take place along the temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

Mitigation measures related to the use and storage of concrete products:

- No batching of wet-cement products will occur on site/along the Grid Connection underground electrical cabling route works. 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; and,
- Where concrete is delivered on-site, only the chute will need to be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be directed into a dedicated concrete wash out pit. Decommissioning of this pit will occur at the end of the construction phase and water and solids will be tanked and removed from the site to a suitable, non-polluting, discharge location.

Mitigation measures related to potential impacts from wastewater disposal:

- The Grid Connection temporary construction compound located within the Wind Farm Site will be used for the construction of the Grid Connection underground electrical cabling route along the northern section of the route (i.e near the Wind Farm Site);
- Welfare cabins and port-a-loos will be used during the construction of the underground electrical cabling route, particularly towards the south of the route;

[4] *GSI (2014): Establishment of Groundwater Source Protection Zones -Tullamore Water Supply Scheme: Ardan Boreholes*

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

Post-Mitigation Residual Effect: The construction of the turbine bases, the potential for dewatering during construction and other elements of the construction process as outlined above have the potential to negatively impact on local groundwater wells, both private and public. Proven and effective measures to mitigate the risk from fuels/oils, concrete products and wastewater have been proposed. The residual effect is considered to be - Indirect, negative, imperceptible, temporary, unlikely effect on local groundwater wells.

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

9.5.2.11 Assessment of Potential Health Effects

Wind Farm Site

Potential health effects are associated with negative impacts on public and private water supplies and potential flooding. There are no mapped public or group water scheme groundwater protection zones in the area of the Wind Farm Site. Notwithstanding this, the proposed site design and mitigation measures ensures that the potential for impacts on the water environment will not be significant.

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues. A detailed Stage III Flood Risk Assessment has been caried out for the proposed Wind Farm Site, summarised in Section 9.3.5. This Flood Risk Assessment, combined with the assessment of changes in permeable surfaces (Section 9.5.3.1) demonstrates that the risk of the Wind Farm Site works contributing to downstream flooding is insignificant. On-site (construction phase) drainage control measures will ensure no downstream increase in local flood risk.

Grid Connection

Potential health effects from the Grid Connection underground electrical cabling route are associated with negative impacts (i.e. contamination) on public and private water supplies and potential alteration of flooding risks. An assessment of potential impacts on private and public water supplies is completed at Section 9.3.12, and no significant effects will occur. Therefore, no health effects are likely to occur.

Flooding of property can cause inundation with contaminated flood water. Flood waters can carry waterborne disease and contamination/effluent. Exposure to such flood waters can cause temporary health issues. The Flood Risk Identification (undertaken at Section 9.3.5) has also shown that the risk of the Grid Connection works contributing to downstream flooding is also very low, as the works footprint is small, the works are for the most part along existing roads, and the duration of the works is short. On-site (construction phase) drainage control measures along the Grid Connection underground electrical cabling route will ensure no downstream increase in local flood risk.

9.5.2.12 Assessment of Potential Impacts on WFD Objectives

WFD status for Groundwater Bodies and Surface Water Bodies are defined within Sections 9.3.9 and 9.3.10. The Groundwater Bodies within the Wind Farm Site and Grid Connection are all assigned "Good" Status. The Surface Water Bodies within the Wind Farm Site and Grid Connection have an assigned status ranging from "Good" to "Poor" with 2 no. SWB's listed with Undefined statuses.

Changes in surface water or groundwater flow regimes and water quality has the potential to impact on the objectives and status of the associated Groundwater Bodies and Surface Water Bodies.

A detailed WFD Assessment Report has been completed in combination with this EIAR chapter (9) and is included within Appendix 9-2.

Pathway: Groundwater flowpaths and Surface Water Flowpaths within the Wind Farm Site and Grid Connection.

Receptor: WFD Groundwater Bodies and Surface Water Bodies.

Pre-mitigation Potential Effect:
Indirect, negative, moderate, temporary, unlikely effect on Surface Water Bodies.
Indirect, negative, slight, temporary, unlikely effect on Groundwater Bodies.

Proposed Mitigation Measures (By Avoidance)

- Mitigation measures relating to surface water drainage regimes and water quality protection have been detailed within Sections 9.5.2.1to 9.5.2.9;
- Similarly, concise mitigation measures relating to the protection of groundwater quality, quantity and the groundwater flow regime have been detailed within Sections 0, 9.5.2.4, 9.5.2.5, 9.5.2.6, 9.5.2.8 and 9.5.2.9 above.

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

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

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

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

9.5.3 Operational Phase Likely Significant Effects and Mitigation Measures

9.5.3.1 Progressive Replacement of Natural Surface with Lower Permeability Surfaces

Progressive replacement of the vegetated surfaces 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 9 no. turbine bases and hardstanding, new and upgraded access roads, site entrance, met mast, temporary construction compounds and the 110kV onsite substation. 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.

The emplacement of the permanent development footprint within the Wind Farm Site, assuming emplacement of impermeable materials as a worst-case scenario, could result in an average total site increase in surface water runoff of 2,392m^3/month at the Wind Farm Site (Table 9-19). This represents a potential increase of 0.29 % in the average daily/monthly volume of runoff from the Wind Farm Site 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 site being developed, the proposed total permanent development footprint being approximately 8.2ha, representing ~0.84 % of the EIAR Site Boundary area of 949ha.

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 permanent development footprint within the Wind Farm Site. 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 Site. A 1 in 10 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 9-16 - Table 9-18). It represents therefore, the long term average wettest monthly scenario in terms of volumes of surface water runoff from the Wind Farm Site pre-wind farm development. The recharge co-efficient for the Wind Farm Site is estimated to be 22.5% based on the predominant till coverage.

The highest long term average monthly rainfall recorded at Ballymore occurs in October, at 124.1mm. This is a monthly average for the period 1981-2010. The average monthly evapotranspiration for the synoptic station at Mullingar over the same period in October was 16.2mm. The water balance indicates that a conservative estimate of surface water runoff for the Wind Farm Site during the highest rainfall month is 805,794m^3/month or 26,859m^3/day.

Table 9-16: Water Balance and Baseline Runoff Estimates for Wettest Month (October)

Water Balance Component	Depth (m)
Average October Rainfall (R)	0.124
Average October Potential Evapotranspiration (PE)	0.0162
Average October Actual Evapotranspiration (AE = PE x 0.95)	0.0154
Effective Rainfall (ER = R - AE)	0.1086
Recharge (22.5% of ER)	0.0244
Runoff (77.5% of ER)	0.0842

Table 9-17: Baseline Runoff for the Wind Farm Site

Approx. Area (ha)	Baseline Runoff per month (m^3)	Baseline Runoff per day (m^3)
949	805,794	26,859

Table 9-18: Wind Farm Site Baseline Site Runoff V Development Runoff

Development Type	Site Baseline Runoff/month (m^3)	Baseline Runoff/day (m^3)	Permanent Hardstanding Area (m^2)	Hardstanding Area 100% Runoff (m^3)	Hardstanding Area 77. 5% Runoff (m^3)	Net Increase/month (m^3)	Net Increase/day (m3)	% Increase from Baseline Conditions (m^3)
Wind Farm	805,794	26,859	98,025	10, 645	8,253	2,392	79.73	0.29

The additional volume is low due to the fact that the runoff potential from the Wind Farm Site is naturally high (77.5%). 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 permanent development footprint within the Wind Farm Site 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 Wind Farm Site.

The Grid Connection onsite substation and temporary construction compound are located within the Wind Farm Site and as such, are discussed above.

The Grid Connection underground electrical cabling route will not result in the emplacement of lower permeability surfaces as all excavations will be within the existing road hardstanding. The tarmac/harstanding will be excavated to facilitate the laying of the electrical cabling and will be reinstated with a new road surface with equivalent permeability. In this way, there will be no net change in permeability along the underground electrical cabling route.

Pathway: Site drainage network, Grid Connection underground electrical cabling route (road) drainage network.

Receptor: Surface waters and dependent ecosystems.

Pre-Mitigation Potential Effect: Direct, negative, moderate, permanent, unlikely effect on downstream surface water bodies (River Inny, Ballynagrenia river, Gageborogh river, River Brosna, Silver river).

Effects Assessment

As determined in Table 9-17 above there could be a potential increase in runoff of 0.29 % in the average daily/monthly volume of runoff from the Wind Farm Site in comparison to the baseline pre-development Wind Farm 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 8.2ha, representing 0.84% of the total EIAR Site Boundary area of 949ha.

The increase in runoff from the Proposed 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 Wind Farm Site or Grid Connection underground electrical cabling route.

Proposed Mitigation Measures

Mitigation by Design:

The operational phase drainage system will be in place from the construction stage. Drainage from the operational site will comprise:

- Runoff from individual turbine hardstanding areas will not be discharged into the existing drain network, but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- Interceptor drains will be installed up-gradient of all proposed infrastructure within the Wind Farm Site 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 Wind Farm 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.

Post-Mitigation Residual Effects: With the implementation of the Wind Farm Site drainage measures as outlined above, and based on the post-mitigation assessment of runoff, it is considered that the residual effect will be - Negative, imperceptible, indirect, long-term, unlikely effect on all downstream surface water bodies.

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

9.5.3.2 Potential Release of Hydrocarbons

Accidental spillage during refuelling of operational 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 flowpaths and site drainage network.

Receptor: Groundwater and surface water at the Wind Farm Site and Grid Connection.

Pre-Mitigation Potential Effect:

Indirect, negative, slight, short term, unlikely effect on local groundwater quality.

Indirect, negative, significant, short term, unlikely effect on surface water quality.

Proposed Mitigation Measures (by Design):

- Onsite re-fuelling of machinery will not be carried out during the operational phase of the development. All plant/machinery will be refuelled offsite;
- Fuels stored on site will be minimised and any diesel or fuel oils stored on-site will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- The electrical control building at the Wind Farm Site will 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;
- Any plant used during the operational phase of the proposed development will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillages.

Post-Mitigation Residual Effects: The potential for the release of hydrocarbons to groundwater and watercourse receptors is a risk to surface water and groundwater quality, and also the aquatic quality of the surface water receptors. Proven and effective measures to mitigate the risk of releases of hydrocarbons have been proposed above and will break the pathway between the potential source and each receptor. The residual effect is considered to be – Negative, indirect, imperceptible, short term, unlikely effect on surface water quality and groundwater quality.

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

9.5.3.3 Assessment of Impacts on WFD Objectives

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

9.5.4 Decommissioning Phase Likely Significant Effects and Mitigation Measures

The wind turbines proposed as part of the Wind Farm Site are expected to have a lifespan of approximately 30 years. Following the end of their useful life, the equipment may be replaced with a new technology, subject to planning permission being obtained, or the Wind Farm Site may be decommissioned fully.

Upon decommissioning of the Wind Farm Site, the wind turbines will be disassembled in reverse order to how they were erected. The turbines will be disassembled with a similar model of crane that was used for their erection. The turbine will likely be removed from Site using the same transport methodology adopted for delivery to Site initially. The turbine materials will be transferred to a suitable recycling or recovery facility.

The underground electrical cabling connecting the turbines to the on-site substation will be removed from the cable ducts. The cabling will be pulled from the cable ducts using a mechanical winch which will extract the cable and re-roll it on to a cable drum. This will be undertaken at the original cable jointing pits which will be excavated using a mechanical excavator and will be fully re-instated once the cables are removed. The cable ducting will be left in-situ as it is considered the most environmentally prudent option, avoiding unnecessary excavation and soil disturbance. The cable materials will be transferred to a suitable recycling or recovery facility.

All above ground turbine components would be separated and removed off-site for recycling. Turbine foundations would remain in place underground and would be covered with earth and reseeded as appropriate. Leaving the turbine foundations in-situ is considered a more environmentally prudent option, as to remove that volume of reinforced concrete from the ground could result in unnecessary environment emissions such as silt laden run-off entering the receiving watercourses), erosion, dust, noise, traffic and an increased possibility of contamination of the local water table.

Site roadways could be in use for purposes other than the operation of the Proposed Development by the time the decommissioning of the Wind Farm Site is to be considered, and therefore it may be more appropriate to leave the Site roads in situ for future use. It is envisaged that the roads will provide a useful means of extracting the commercial forestry crop which exists on the Site, and as agricultural roads. If it were to be confirmed that the roads were not required in the future for any other useful purpose, they could be reinstated where required (left in place, covered over with soil/subsoil).

Removal of this infrastructure would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increased sedimentation (if turbine foundations, access tracks and hardstandings are being reinstated there is a risk of silt laden run-off entering the receiving watercourses), erosion, dust, noise, traffic and an increased possibility of contamination of the local water table.

The Grid Connection underground electrical cabling route and onsite substation will remain in place as it will be under the ownership of the ESB. There are no impacts associated with this.

A Decommissioning Plan has been prepared (Appendix 4-6) the detail of which will be agreed with the local authority prior to any decommissioning. The Decommissioning Plan will be updated prior to the end of the operational period in line with decommissioning methodologies that may exist at the time and will agreed with the competent authority at that time. The potential for effects during the decommissioning phase of the Proposed Development has been fully assessed in the EIAR.

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

9.5.5 Cumulative Impacts

Construction Phase

A detailed cumulative assessment has been carried out for all planning applications (granted and awaiting decisions) within a combined river sub-basin zone within the vicinity of the Wind Farm Site defined in Section 2.7 of this EIAR and within Appendix 2-3. This combined sub basin area encompasses the area of the Inny[Shannon]_SC_090 subcatchment. There will be no potential for cumulative impacts beyond Inny[Shannon]_SC_090 due to increases in flow volume (as the catchment area increases) and increasing distance from the Proposed Development. A further assessment has been completed within a 2km buffer zone of the turbine locations and within a 200m buffer zone of the proposed underground electrical cabling route. Due to the narrow nature of the underground electrical cabling connection trench (~0.6m wide), a 200m buffer zone is an appropriate scale when considering potential cumulative effects on the water environment.

A total of 422 planning applications have been identified within the sub-basin zone. More than 95% of these applications are for new dwellings or renovations of existing dwellings, as well as for the erection of farm buildings. The other non-dwelling/farm related planning applications include 1 no. planning applications for a replacement of a 15m telecommunications pole with a 21m telecommunications pole (PL 21656) near Ballymore and an above ground water storage reservoir (3150m^3) is also included in the assessment (PL 187011). The planning applications have been reviewed based on their type, scale and proximity to the proposed Wind Farm Site. Based on the scale of the works, their proximity to the Proposed Development and the temporal period of likely works, no cumulative effects will occur as a result of the Proposed Development.

A desk study of planning applications within 200m of the underground electrical cabling route was undertaken. 81 no. planning applications were identified during this study. Again, the majority of applications relate to the construction or renovation/extension of domestic dwellings, which will not generate potential cumulative effects due to their scale.

3 no. solar farms were identified within Offaly/Westmeath situated within 200m of the proposed underground electrical cabling route. These include a 10 year permission for a solar farm on lands adjacent to the N52 near the townland of Gormagh (PL 22387), a 10 year permission for a solar farm at Dawn Meats near Kilbeggan (PL 22350) and a 10 year planning permission for the construction of a solar farm in the townland of Derries, Co. Offaly, of which the approved underground electrical cable is situated within 200m of the underground electrical cabling route of the Proposed Development. As the construction of the underground electrical cabling connection will be a relatively short construction project, which will be broken up into sections of ~100 to 150m works length (meaning that only ~100m of open trench will exist at any one time during the construction), the potential for cumulative effects with these nearby energy developments are not significant from a hydrological/hydrogeological perspective. It is also likely that the construction phases of these projects will not overlap with the construction phase of the Proposed Development, within the buffer zone. The construction of the underground electrical cabling connection route for the Proposed Development would be subject to a Road Opening License, as would any other similar nearby grid connection works. The timing of these works would therefore be controlled by the road opening licensing process and would not overlap.

Operational Phase

During the operational phase of the Proposed Development, the main sources of potential environmental effects will not exist. There will be no exposed excavations and spoil management areas will not be in operation. There will be no sources of sediment to reach watercourses. There will be no use of cementitious materials. Fuels/oil will be kept to a minimum at the site. Any oils for turbine maintenance will be stored within bunded areas.

The underground electrical cabling route will be backfilled at the end of the construction phase and will remain in-situ during the operational phase. No maintenance of the electrical cabling is envisaged, however any minor maintenance will be completed from inspection points along the route.

During the operational phase of the Proposed Development, there will be no cumulative effects with other planned projects (as listed in Appendix 2-3) within the sub-basin catchment zone or along the underground electrical cabling route (200m buffer).

Decommissioning

During the decommissioning phase, the potential cumulative effects are similar to the construction phase, but to a lesser degree with less ground disturbance. Please note that the Grid Connection onsite 110kV substation and underground electrical cabling route will remain in-situ and will not be decommissioned. There would be increased trafficking and an increased risk of disturbance to underlying soils at the Wind Farm Site, during the decommissioning phase. Any potential effects would be likely to be less than during the construction stage as the drainage swales would be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site would be bunded. In the event of decommissioning of the Wind Farm Site, the proposed access tracks may be used in the decommissioning process.

During the decommissioning phase, there will be no cumulative effects within the sub-basin zone or within the 200m buffer of the underground electrical connection cabling route.

The hydrological impact assessment undertaken above in this chapter outlines that significant effects will not occur during the construction, operational and decommissioning works.

No significant cumulative effects on the hydrology and hydrogeology environment will occur as a result of the proposed development within the Wind Farm Site and the associated underground electrical cabling route.

APPENDIX 9-1

FLOOD RISK ASSESSMENT

HYDRO ENVIRONMENTAL SERVICES

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UMMA MORE RENEWABLE ENERGY DEVELOPMENT, CO. WESTMEATH

STAGE III FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:
Umma More Ltd

Prepared by:
Hydro-Environmental Services

DOCUMENT INFORMATION

Document Title:	**UMMA MORE RENEWABLE ENERGY DEVELOPMENT, CO. WESTMEATH Stage III FLOOD RISK ASSESSMENT**
Issue Date:	**5th December 2022**
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Project Reporting History:	**P1553-0**
Current Revision No:	**P1553-0_FRA_Final_Rev F2**
Author(s):	**ADAM KEEGAN DAVID BRODERICK MICHAEL GILL**
Signed:	**Michael Gill B.A., B.A.I., M.Sc., MIEI Managing Director – Hydro-Environmental Services**

Disclaimer:
This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the reference agreed with the client, and in line with instructions and information provided by the client, and incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. The report contains information from sources and data which we believe to be reliable, but we have not confirmed that reliability and make no representation as to their accuracy or completeness. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. The flood risk assessment undertaken as part of this study is site-specific and the report findings cannot be applied to other sites outside of the survey area which is defined by the site boundary. This report is confidential to the client, and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

TABLE OF CONTENTS

FIGURES (Attached)

FIGURES IN TEXT

TABLES IN TEXT

APPENDICES

1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by Umma More Limited to undertake a Stage III Flood Risk Assessment (FRA) for the proposed Umma More Renewable Energy Development southwest of Ballymore, Co. Westmeath. A study area location map is shown below as **Figure A.**

The FRA was undertaken at the design stage in order to further understand the extents of potential flooding at the proposed Wind Farm Site and to inform the siting of turbines and associated infrastructure within the Wind Farm Site. The initial scoping stage of the project had highlighted areas within the proposed Wind Farm Site which were mapped within the PFRA Flood risk zones.

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

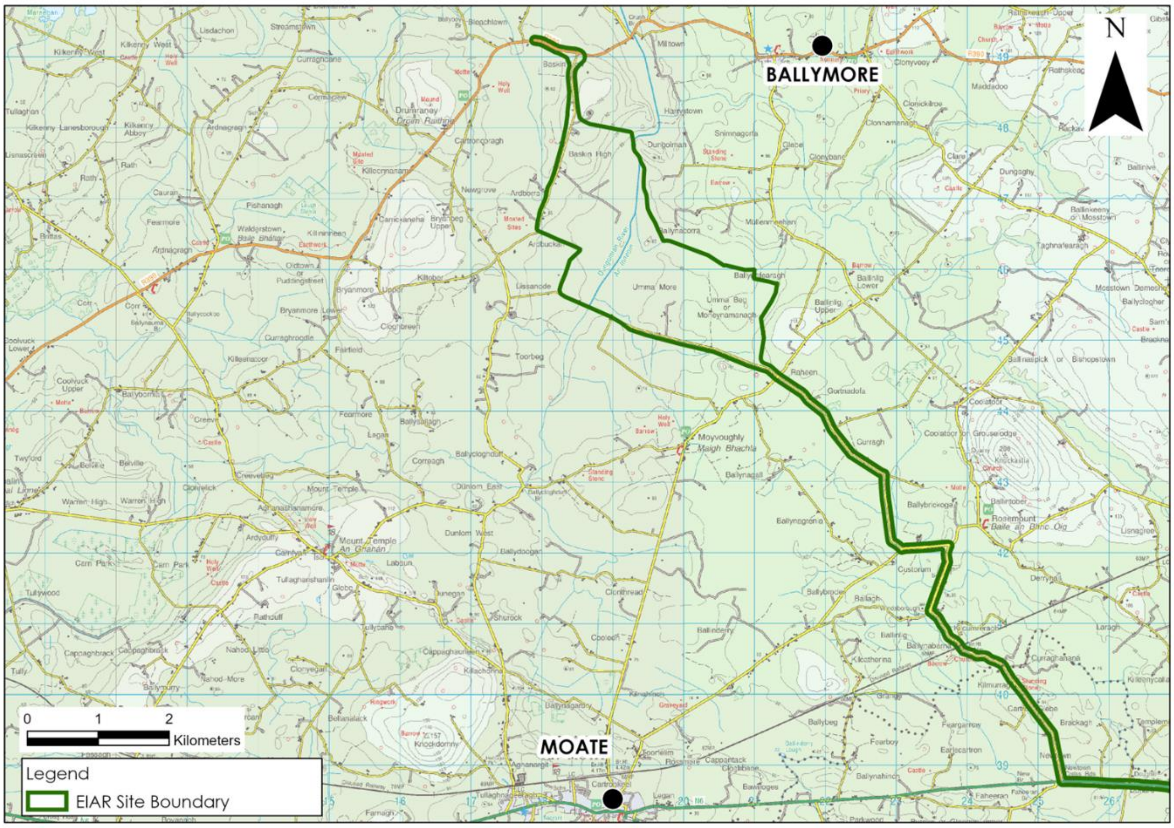


Figure A: Site Location Map

1.2 STATEMENT OF EXPERIENCE

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

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

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

David Broderick (BSc, MSc) is a Hydrogeologist with 13 years environmental consultancy experience in Ireland. David has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. David has significant experience in surface water drainage issues, SUDs design and flood risk assessment.

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

1.3 REPORT LAYOUT & METHODOLOGY

This FRA report is structured as follows:

- Section 2 describes the proposed site setting and details of the Proposed Development;
- Section 3 outlines the hydrological and geological characteristics of the local surface water catchment in the vicinity of the Wind Farm Site;
- Section 4 deals with an initial flood risk identification undertaken for the Proposed Development based on desk studies and walkover surveys;
- Section 5 deals with a detailed site-specific flood risk assessment (FRA) which includes flood level modelling;
- Section 6 provides commentary in relation to the County Westmeath Development Plans and Justification Test; and,
- Section 7 presents the FRA report conclusions.

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

- OPW Flood Studies Update (FSU) Web Portal;
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA hydrology maps;
- Preliminary Flood Risk Assessment Maps (PFRA);
- National Indicative Fluvial Mapping (released early 2022)
- CFRAM mapping;
- Westmeath County Development Plan 2021 – 2027;
- Site Walkovers (conducted on 14th May, 20th June, 30th June and 14th July 2021); and,
- Watercourse topographic surveys and flow monitoring completed between 14th May and 20th June 2021.

- Hydrological (stage) monitoring at 3 no. locations along the Dungolman and Mullenmeehan watercourses

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting of the Wind Farm Site along with a description of the Proposed Development.

2.2 SITE LOCATION AND TOPOGRAPHY

The Wind Farm Site is located approximately 3.5km southwest of the village of Ballymore and approximately 14km northwest of Athlone, Co. Westmeath. The total Wind Farm Site is approximately 487 Ha.

The Wind Farm Site comprises mainly improved grassland and agricultural pastures separated by hedgerows and drainage ditches. A small area of forestry exists in the southwest of the Wind Farm Site. The topography of the Wind Farm Site is slightly undulating. The majority of Wind Farm Site is situated between 55-70 mOD with a relatively flat plain across the centre of the Wind Farm Site near the Dungolman River. Towards the northwest and southeast of the Wind Farm Site the topography steepens to ~100mOD. The Dungolman River bisects the centre of the Wind Farm Site before running along the eastern boundary of the northern section of the Wind Farm Site.

All proposed turbine locations (T1-T9), with the exception of T4, are situated on improved grassland. T4 is located in the southwest of the Wind Farm Site, in an area of coniferous forestry. The Wind Farm Site access roads are mainly located on improved grassland, but also through forestry near T4.

A study area location map is shown as **Figure A** above.

2.3 PROPOSED DEVELOPMENT DETAILS

The Proposed Development comprises of 9 No. wind turbines, access roads, temporary construction compounds, meteorological mast, underground cabling, a 110kV onsite substation and associated underground 110kV cabling connecting to the existing Thornsberry 110kV substation, spoil management, junction accommodation works, tree felling, site drainage and all ancillary works and apparatus. Rock for construction will be sourced off-site. The full description of the Proposed Development is provided in Chapter 4 of the EIAR.

There will also be a requirement for 1 no. new watercourse crossing across the Dungolman river as well as potential new/improved crossings/culverts at the streams/drains that are intersected by the proposed access track alignments at 11 no. locations.

A proposed Wind Farm Site layout map is shown as Figure B below.

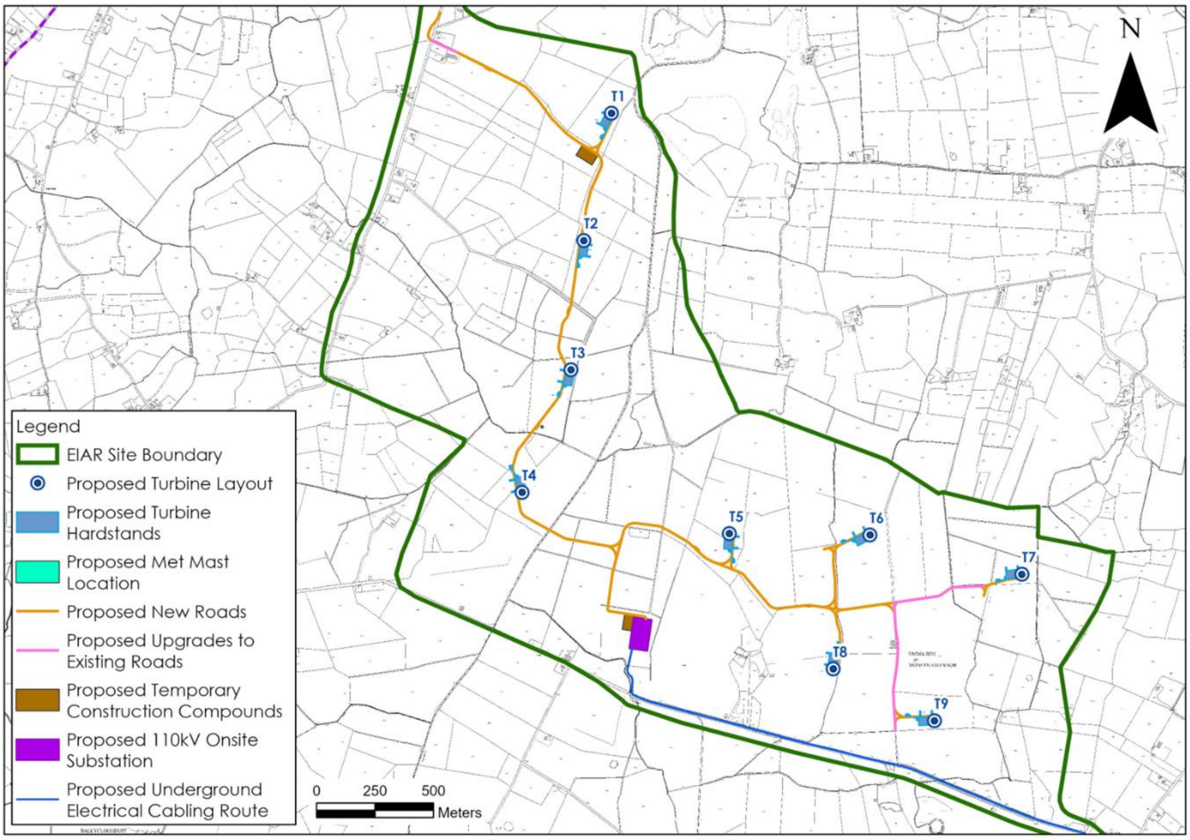


Figure B: Proposed Wind Farm Site Layout Map

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the Wind Farm Site.

3.2 BASELINE HYDROLOGY

3.2.1 Regional and Local Hydrology

On a regional scale, the Wind Farm Site is located in the Inny River surface water sub-catchment, which is in the Upper Shannon catchment within Hydrometric Area 26 of the Shannon International River Basin District (SIRBD). The Inny River flows to the northwest approximately 8.2km northwest of the Wind Farm Site. The Inny River discharges into Lough Ree approximately 10.6km northwest of the Wind Farm Site.

On a more local scale, the Wind Farm Site is located in the Inny River sub-catchment (Inny[Shannon]_SC_090) with the majority of the Wind Farm Site located in the Dungolman WFD river sub basin (Dungolman_030) (refer to **Figure C**). A small section in the southwest of the Wind Farm Site is mapped in the Dungolman_020 river sub-basin while the northwestern corner of the Wind Farm Site is located in the Inny River (Inny_110) river sub-basin. However, none of the proposed turbines are mapped in the Dungolman_020 or Inny_110 river sub-basins. A local hydrology map is shown as **Figure C**.

As stated above the majority of the Wind Farm Site is located in the Dungolman_030 river sub-basin. The Dungolman River (EPA Code: 26D06) flows to the northeast between T4 and T5. This watercourse then flows along the EIAR Site boundary to the east of T2 and T3 before veering to the northeast to the east of T1. Drainage in this river sub-basin flows towards the Dungolman River via several smaller streams and drains. In the southeast of the study area, the Raheen stream (EPA Code: 26R36) flows to the west approximately 150m south of T9. This waterbody discharges into the Moneynamanagh stream (EPA Code: 26M40) 1km southwest of T9 before turning northwest and discharging into the Dungolman River 800m southwest of T5. During site visits there was very little flow in the Raheen stream (1-2l/s), with no flow observed in the area of the stream directly south of the proposed T9 (this area is elevated at the upper reaches of the stream).

The EPA also map a watercourse, the Mullenmeehan stream (EPA Code: 26M12) which flows west along the northern EIAR Site Boundary, approximately 300m to the north of T6. The Mullenmeehan stream reaches a confluence with the Dungolman River approximately 450m northeast of T3. Although referred to as a stream by the EPA, flows in the Mullenmeehan stream were measured at >200 l/s during site visits. The Dungolman River flows north before discharging into the Tang River (EPA Code: 26T02) approximately 5.15km north of the Wind Farm Site. The Tang River continues to flow to the northwest and eventually discharges into the Inny River (EPA Code: 26I01) approximately 8.3km northwest of the Wind Farm Site.

The agricultural lands which cover the majority of the Wind Farm Site contain a network of drains which run along the hedgerows and field boundaries and discharge into Dungolman River and the Moneynamanagh and Mullenmeehan streams. There was very little observable flow in these drains during the site visits. The west of the Wind Farm Site in the vicinity of T4 consists of forestry with smaller forestry drains discharging into the Dungolman River to the east.

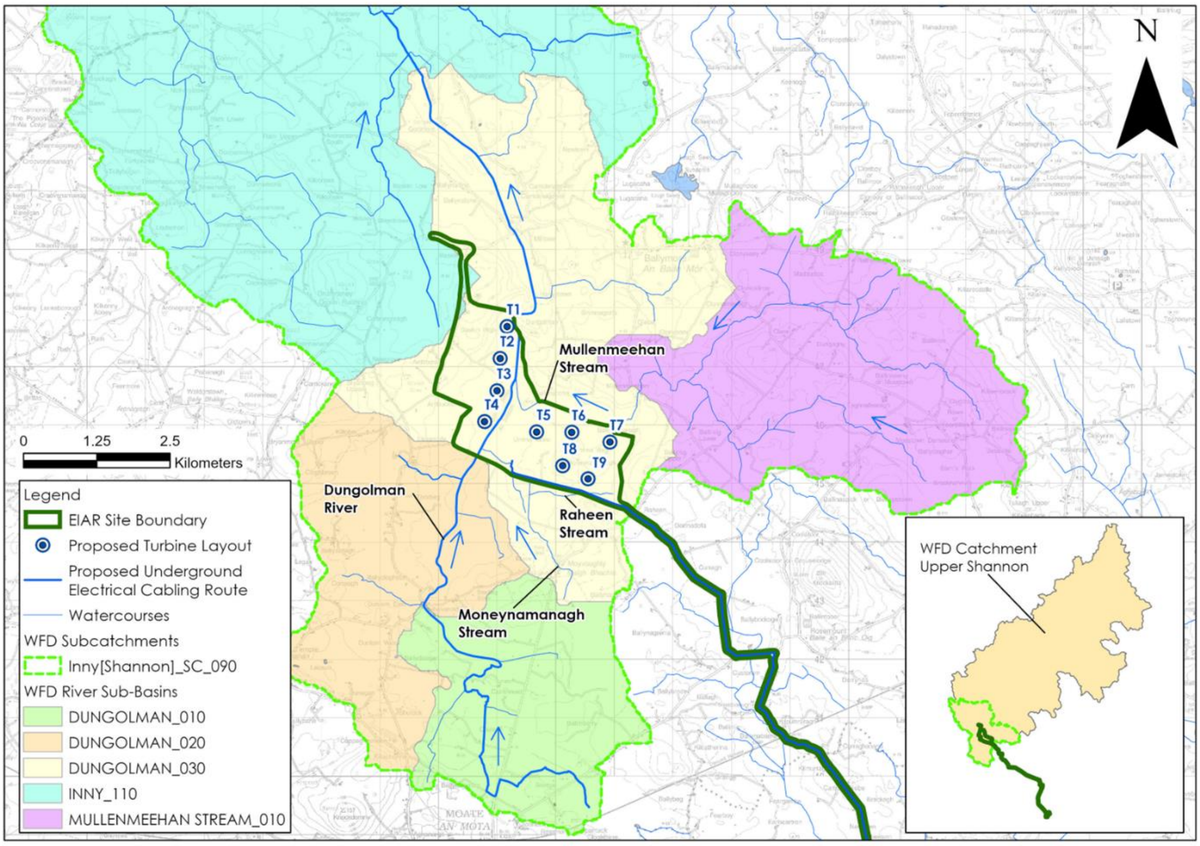


Figure C: Local Hydrology Map

3.2.2 Rainfall and Evaporation

The SAAR (Standard Average Annual Rainfall) recorded at Ballymore G.S., approximately 2.2km northeast of the Wind Farm Site, is 1,154.7mm (www.met.ie). The average potential evapotranspiration (PE) at Mullingar, approximately 24km northeast of the Wind Farm Site, is 445.8m/year (www.met.ie). The actual evapotranspiration ("AE") is calculated to be 423.5mm (95% PE). Using the above figures the effective rainfall ("ER")[1] for the area is calculated to be (ER = SAAR – AE) 731.2mm/year.

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 22.5% recharge is taken for the Wind Farm Site as an overall average. This value is for "Till derived from limestones" with a "High" vulnerability rating. Some areas in the west of the Wind Farm Site are mapped to be underlain by "Fen Peat" (although Fen Peat was not identified within the walkover surveys). Areas underlain by Fen peat will experience lower recharge rates (5%). The value of 22.5% recharge was chosen to reflect the dominance of till across the site and the high drainage density. This means that the hydrology of the Wind Farm Site is characterised by high surface water runoff rates and moderate to low groundwater recharge rates. Therefore, conservative annual recharge and runoff rates for the Wind Farm Site are estimated to be 164.5mm/year and 566.7mm/year (*i.e.* 731.2mm/year – 164.5mm/year = 566.7mm/year) respectively.

Table A below presents return period rainfall depths for the area of the Wind Farm Site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 5-year, 30-year, 100-year).

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

Table A: Rainfall return period depths for Wind Farm Site

	Return Period (Years)			
Duration	1	5	30	100
5 mins	3.9	6.9	12.4	17.8
15 mins	6.4	11.3	20.3	29.2
1 hour	10.3	17.1	28.9	39.9
6 hours	19.0	29.2	45.4	59.6
12 hours	24.1	35.9	54.1	69.6
24 hours	30.6	44.2	64.4	81.3
2 days	38.2	52.7	73.4	90.1

3.3 GEOLOGY

Based on the GSI/Teagasc soils mapping (www.gsi.ie) the Wind Farm Site is mainly underlain by poorly drained mineral soils (AminPD) and to a lesser extent deep well drained mineral (AminDW).

GSI subsoils mapping (www.gsi.ie) show that limestonetills are the dominant subsoil type in the area of the Wind Farm Site. Trial pit investigations show that the subsoils generally comprise silty SAND and silty gravelly SAND with occasional CLAYS encountered.

Based on the GSI bedrock mapping (www.gsi.ie), the Wind Farm Site is mapped to be underlain by Lucan Formation Limestone, with some Waulsortian Limestone mapped towards the southeast corner.

3.4 DESIGNATED SITES & HABITATS

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

The only downstream designated sites that are hydrologically connected to the Wind Farm Site are Lough Ree SAC/SPA. The Dungolman river discharges to the Tang River, which discharges to the Inny river, which eventually reaches Lough Ree approximately 14km downstream of the Wind Farm Site.

Other nearby designated sites include Ballynagrenia and Ballinderry Bog NHA, which is situated 2.5km south of the Wind Farm Site. This bog is situated at the headwaters of the Dungolman River and as such is hydraulically upgradient of the Wind Farm Site.

4. FLOOD RISK IDENTIFICATION

4.1 INTRODUCTION

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

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

A Stage 2 assessment has been completed as part of the EIAR for the Proposed Development, and involves the confirmation of sources of flooding, appraising the adequacy of existing information and determining what surveys and modelling approach may be required for further assessment.

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

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

Further to this, a Stage 3 FRA is a detailed flood risk assessment which assesses flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

4.2 SOILS MAPS – FLUVIAL MAPS

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

Based on the EPA soil map for the area, large areas of the Wind Farm Site are mapped as river alluvium. Extensive alluvium deposits are associated with the Dungolman River in the west, the Raheen and Moneynamanagh stream in the south and the Mullenmeehan stream in the north of the Wind Farm Site. The following turbines are mapped on alluvium: T4 in the west and T5, T6, T7 in the northeast. In addition, lands adjacent to T9 and T8 are mapped as river alluvium.

4.3 HISTORICAL MAPPING

There is no text on local available historical 6" or 25" mapping for the proposed Wind Farm Site that identify areas that are "*prone to flooding*" within the Wind Farm Site.

4.4 OPW NATIONAL FLOOD HAZARD MAPPING

The OPW National Flood Hazard Maps records the occurrence of several historic and recurring flood instances in the vicinity of the Site. However, no flood instances are located within the Site boundaries (refer to **Figure D** below)

The OPW (www.floodmaps.ie) show several historic and recurring flood events in the vicinity of the Wind Farm Site. The closest mapped recurring flood event is found approximately 250m southwest of Wind Farm Site at Kiltober. Here low-lying lands are reported to flood annually following intense rainfall. Similar flood events have been recorded at Tourbeg, Moate, approximately 700m south of the Wind Farm Site. A further flood event is mapped approximately 1km to the north of the Wind Farm study area along the R390 at Ballymore. The Kilbeggan area engineer notes that "*localised low lying area floods after heavy rains every year and that the road is liable to flood*".

The OPW map much of the Wind Farm Site along the Dungolman River and the Mullenmeehan stream to be Benefited Land. Benefited land is land which was drained as part of the Arterial Drainage Scheme. Furthermore, the primary watercourses at the Wind Farm Site including the Dungolman River, Mullenmeehan stream and the Moneynamanagh stream are recorded as channels for arterial drainage schemes. The secondary field drains and ditches are not mapped within the arterial drainage scheme.

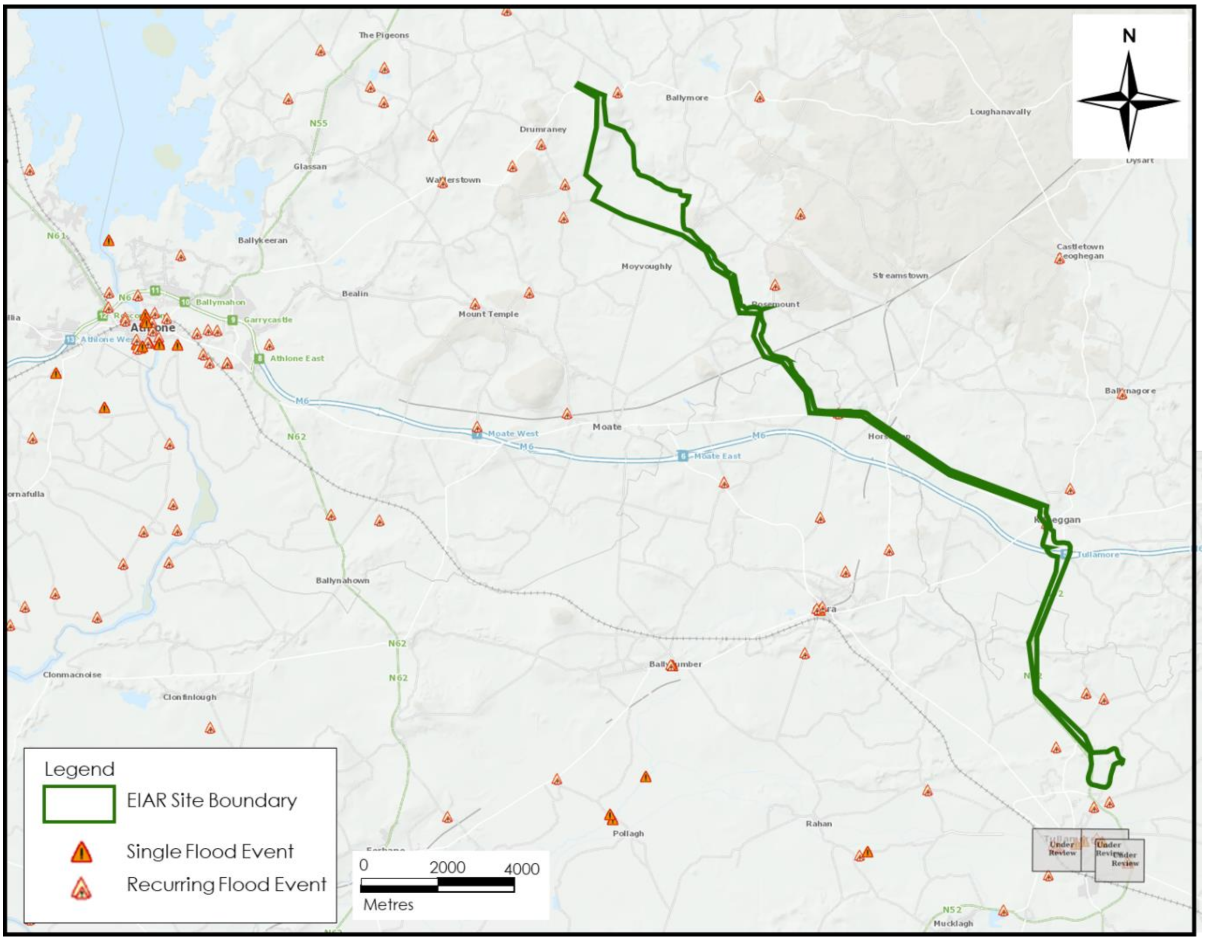


Figure D: OPW Indicative Floods Map (Source: www.floods.ie)

4.5 CFRAM MAPS – FLUVIAL AND COASTAL FLOODING

Where complete the Catchment Flood Risk Assessment and Management (CFRAM)[2] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the Preliminary Flood Risk Assessment Maps (PFRA) maps. However, CFRAM mapping is not currently available for the area of the proposed Wind Farm Site.

Indicative flood maps (NIFM) have been produced for all watercourses that are on the EPA watercourse layers 'WATER_RivNetRoutes' and 'WFD_LakeSegment', and have a catchment area greater than 5km^2, and for which flood maps were not produced under the National CFRAM Programme. The NIFM mapping is detailed further in **Section 4.7**.

4.6 PRELIMINARY FLOOD RISK ASSESSMENT MAPS – FLUVIAL AND PLUVIAL FLOODING

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

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

The PFRA flood maps were therefore queried for potential areas prone to flooding. The maps show that areas in the west and north of the Wind Farm Site are mapped in the 100-year and the Extreme Event fluvial flood zones (Zones A and B respectively) as outlined below. The majority of the Wind Farm Site is however located in Flood Zone C (Low Risk).

The 100-year flood zone is mapped along the Dungolman River within the Wind Farm Site. In the southwest of the Wind Farm Site, the flood zone extends up to 200m from the mapped river course and is mapped in the area of T4. Further north, T2 is also mapped on the border of the Flood Zone B area, ~300m west of the main river channel, while T1 and T3 are located 50m and 180m west of this mapped flood zone respectively.

The 100-year flood zone along the Mullenmeehan stream in the northeast of the Wind Farm Site does not extend as far south as any of the proposed turbine locations. The topography is slightly steeper away from the river bank along this stream. There are no fluvial flood zones located in the southeast of the Wind Farm Site.

The general blocky shape of the PFRA map is due to the coarse scale nature of the topography data used to create the map. Typically, 2m contours are used to create these maps. In zones where the topography only varies by 1-2m over large areas of lands, the extents of the flood zones can be overestimated.

The GSI Historical 2015/2016 surface water flood map[3] shows fluvial and pluvial floods during the winter 2015/2016 flood event. This map does not show any flooding within the Wind Farm Site, with only small-localised areas of flooding in the surrounding lands.

The flood zones indicated on the PFRA mapping are shown on **Figure E** below.

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

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

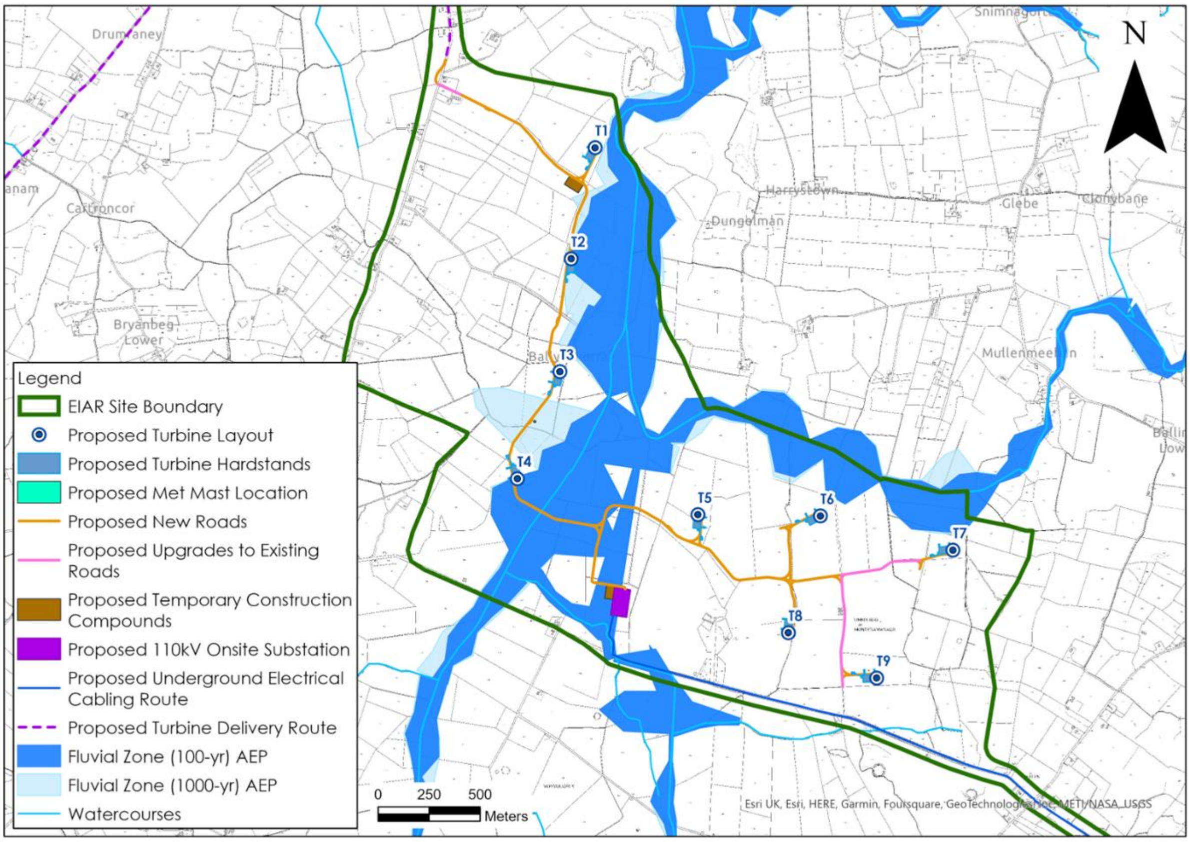


Figure E: PFRA Flood Zone Mapping

4.7 NATIONAL INDICATIVE FLUVIAL MAPPING

The National Indicative Fluvial Flood maps for the Wind Farm Site were released in early 2022. These maps supercede the older PFRA maps, and are carried out in areas where the more detailed CFRAM mapping has not been undertaken. The online flood mapping database, Floodinfo.ie[4] states;

The National Indicative Fluvial Maps provide an indication of areas that may flood, during a flood of an estimated probability of occurring. As detailed in the Technical Data, a number of assumptions have been made in order to produce a dataset suitable for national level flood risk assessments.

The National Indicative Fluvial Maps are not the best achievable representation of flood extents and they are not as accurate as the Flood Maps produced under the National Catchment Flood Risk Assessment and Management (CFRAM) Programme.

The maps should not be used to assess the flood risk associated with individual properties or point locations, or to replace a detailed site-specific flood risk assessment.

From the NIFM map of the site, turbines T1 – T9 are located outside both the Low probability and Medium probability flood zones. Turbine T3 is located within both probability zones, however both the low probability and medium probability flood zones are mapped with unusual areas along the western side of the Dungolman river. Turbine T3 is located within a mapped flood zone which is separated from the river channel by ~250m of land not mapped

[4] https://www.floodinfo.ie/map/nifm_user_guidance_notes/

within the flood zone (presumably interpreted as higher ground). The mapped flood zone creates islands of higher ground nearer the river channel, particularly along the western side of the channel with areas of mapped flood zones further west of these "islands".

In reality, these areas of high ground do not exist from site walkover data and from Lidar data sourced for the more detailed flood modelling outlined in **Section 5.3**. It is assumed that the NIFM modelling is using coarser topographic data, which is interpreting areas of high and low ground based on contour data, which is not detailed enough for a site-specific assessment.

The flood zones indicated on the NIFM mapping are shown on **Figure F** below.

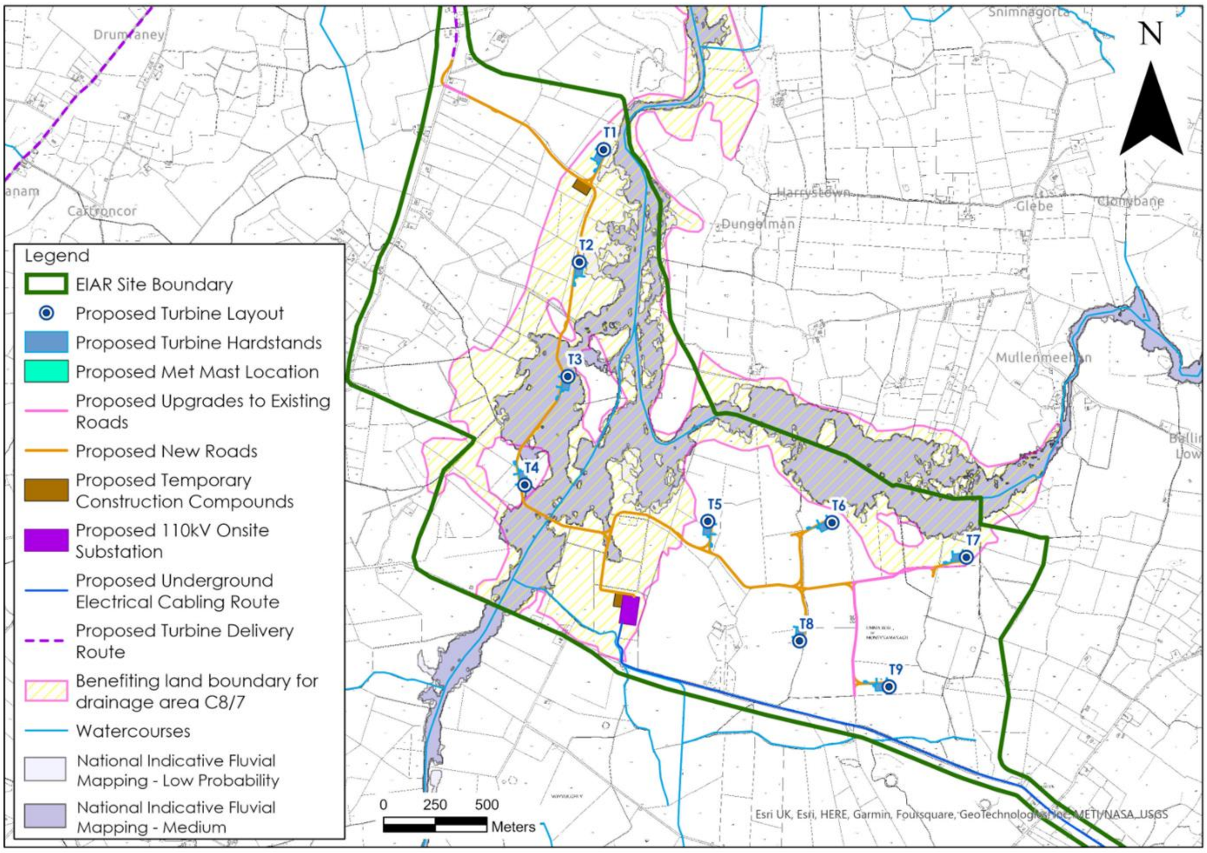


Figure F: National Indicative Flood Mapping

4.8 WATER LEVEL MONITORING

Water level monitoring was undertaken at 3 no. locations along the Dungolman and Mullenmeehan stream between July 2021 and December 2022. Water levels in these rivers were recorded using in-situ OTT EcoLog 1000 loggers recording at 30 minute intervals. These water levels were then normalised to mOD, following a topographic (dGPS) survey of the water level at the logger locations. SW1 is located at the southern end of the Wind Farm Site, ~ 475m southwest of the proposed onsite substation. SW2 is located at a small bridge along the Mullenmeehan stream, ~400m northeast of turbine T6, while SW3 is located 1.2km north of the site on a bridge which crosses the Dungolman river. The water levels are shown below in **Figure G**.

Water levels at SW1(Dungolman river) at the southern end of the Wind Farm Site range between 54.7 – 56.4 mOD, while water levels at SW2 (Mullenmeehan stream) range between

53.7 – 55.5 mOD. Further downstream at SW3 (Dungolman river), water levels range between 51 – 52.3 mOD. The water levels were recorded to compare with the modelled flood elevations (**Section 5.3**). The water levels at SW2 are approximately near the centre of the Wind Farm Site and are the most representative of water levels near the Proposed Development infrastructure.

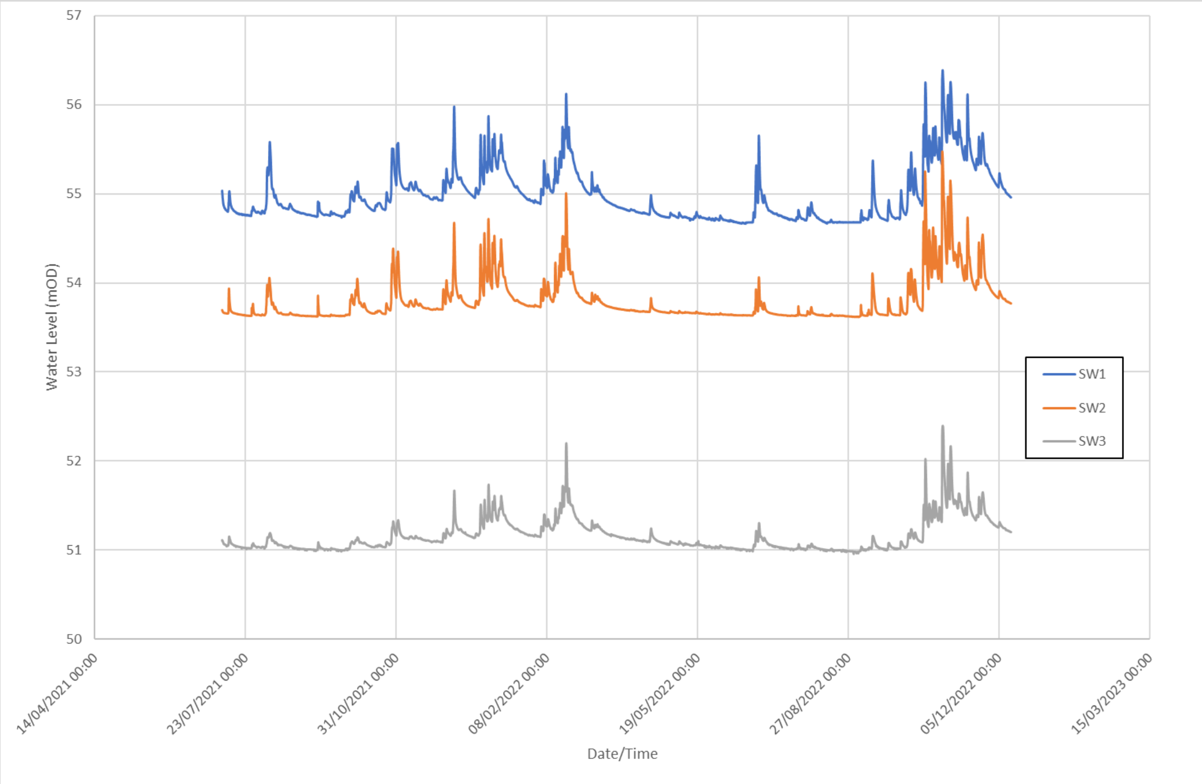


Figure G: Water Levels (moD) at 3 no. monitoring locations (Dungolman and Mullenmeehan stream)

4.9 SUMMARY – FLOOD RISK IDENTIFICATION

Based on the information gained through the flood identification process, it would appear that sections of the Wind Farm Site are susceptible to fluvial flooding. While the majority of the Wind Farm Site is mapped in Flood Zone C, PFRA mapping shows areas of the Wind Farm Site adjacent to the Dungolman River and Mullenmeehan stream as Flood Zone A. Turbines T2 and T4 are located on the edges of the mapped PFRA flood zones, along with sections of existing roads and proposed new roads. NIFM mapping of the Wind Farm Site shows that turbine T3 is located within the Low probability and Medium probability flood zone.

This is discussed further in **Section 4.4** below where a site-specific flood risk assessment is carried out to further assess the risk of potential flooding at the Wind Farm Site.

4.10 INITIAL FLOOD RISK ASSESSMENT SURVEY

4.10.1 Site Survey

An initial walkover of the Wind Farm Site was undertaken on 14th May 2021, and a subsequent survey was undertaken on 20th June 2021. During both site visits the lands, specifically the areas identified from the PFRA and OSI base mapping (discussed above), were surveyed for any signs or anecdotal evidence of flooding. The local landowners were also consulted in relation to historical flooding on their lands, of which there were no notable instances of anecdotal flooding within the Wind Farm Site.

A walkover survey of the Wind Farm Site, particularly along the banks of the Mullenmeehan stream, identified ~1-1.5m deep drains which flow north discharging to the stream. These drains are emplaced along most field boundaries. The majority of the drains at the site are oriented in a north-south direction and discharge to the Mullenmeehan stream, before reaching the Dungolman River. There was typically no/low flow rates in these drains during site visits, with the largest drains discharging ~1L/s.

Soil samples taken from trial pitting, carried out on 30th June 2021 encountered CLAY within some trial pits, particularly at TP-1.2 and TP-2 which generally impedes drainage. Elsewhere, SANDS and gravelly SANDS were typically encountered which may be alluvial deposits, although the thickness is considerable, and a glacial origin is also likely.

4.10.2 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the Proposed Development can be described using the Source – Pathway – Receptor Model ("S-P-R"). The primary potential source of flooding in this area, and the one with most consequence for the Proposed Development, is fluvial with minor pluvial flooding. The primary potential pathway would be fluvial overbank flooding of the main river channel (Dungolman River) which flows through the Wind Farm Site, during significant rainfall events. The potential receptors in the area are infrastructure and land as outlined below.

4.10.3 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process, the sources of flood risk for the Proposed Development are outlined and assessed in **Table B**.

Table B: Initial S-P-R Assessment of Flood Sources for the proposed development

Source	Pathway	Receptor	Comment
Tidal	Not applicable.	Land and infrastructure.	The proposed site is >90km from the coast and there is no risk of coastal flooding.
Fluvial	Overbank flooding	Land and infrastructure.	Based on the PFRA mapping areas of the proposed infrastructure, there are 2 no. areas located inside a mapped fluvial flood Zone: 1: Proposed road and river crossing near **T5** extending to and including areas of the proposed **T4** hardstand are located within Flood Zone A and B. 2: Proposed Turbine T2 and the sections of proposed road north and south of the turbine are mapped within Flood Zone B.
Pluvial	Ponding of rainwater on the route right of way.	Land and infrastructure.	No pluvial flooding is mapped within the site boundary
Surface water	Surface ponding/ Overflow.	Land and infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels.	Land and infrastructure.	Based on local hydrogeological regime and PFRA mapping, there is no apparent risk from groundwater flooding.

5. DETAILED FLOOD RISK ASSESSMENT

5.1 INTRODUCTION

In order to carry out a Stage III level site-specific FRA for the Wind Farm Site and to assess the capacity and design flood levels of the Dungolman River and flood plain, a detailed topographic survey of the Dungolman River channel was undertaken as part of this site-specific assessment along with use of Lidar data to determine ground elevations for the wider site and flood plain area. The river channel survey is described in **Section 5.1** below. This combined topographic data was used to create a river channel/flood plain 2-dimensional flow model for the section of Dungolman River channel and valley within the Wind Farm Site.

Flood level modelling for the Dungolman River was undertaken using *HEC-RAS*™[5] open channel flow software. *HEC-RAS* is a 2-dimensional flow model which can calculate channel water depth/level using parameters such as flood volumes, channel dimensions, slope and friction coefficients (Mannings *n* number). To investigate the potential for flooding within the Wind Farm Site, modelling of design flood volumes (*i.e.,* 10-year,100-yr and 1000-yr) was undertaken for the river and its flood plain.

Apart from the PFRA and the more recent NIFM, no direct CFRAM flood studies or modelling have been completed for the Dungolman River catchment itself, and therefore the OPW FSU Web Portal was used to calculate the Q_{med} (flow) for the river at the Wind Farm Site.

The design flood event growth factors applied in the River Shannon CFRAM study[6] were used to calculate the 10 -year, 100-year and 1000-year design flood flows in the Dungolman River (Q_{med} x Growth Factor x Climate Change). A potential increase in flow of 20% was applied to account for future climate change scenarios. The design flood flows for the Dungolman River and contributing streams are shown in **Table C** below.

Table C: Design Flood Flows

Channel	Qmed (m^3/s)	10-yr Design Flood Flow (m^3/s)*	100-yr Design Flood Flow (m^3/s)*	1000-yr Design Flood Flow (m^3/s)*
Dungolman River (Upstream of site)	3.82	6.7	9.3	11.9
Southern Tributary	1	1.75	2.43	3.12
Northern Tributary	5.25	9.2	12.8	16.38
Total (Downstream of site)	10.07	17.64	24.53	31.42

+ Growth factors of 1.46, 2.03 and 2.6 were used to estimate the 10-year, 100-year and 1000-year design floods. Includes 20% increase for climate change

For the stretch of the Dungolman River at the location of the Wind Farm Site in the flood model, a friction coefficient (Mannings *n* number) of 0.07 was used to reflect the weedy and slow moving nature of the channel and for the surrounding lands a coefficient of 0.035 was used for grassland (short grass) and 0.1 for forestry (dense forestry).

The slope of the Dungolman River channel as it flows through the Wind Farm Site was determined from the topographic survey and this is calculated to be 0.00049 upstream of the site and 0.0004 downstream of the Wind Farm Site.

[5] *HEC-RAS – Hydrologic Engineering Centre – River Analysis System*
6 Shannon Catchment-based Flood Risk Assessment and Management Study – Hydrology Report Unit of Management 25/26 (OPW/Jacobs, 2016.)

5.2 SITE SURVEY

A total of 14 no. open channel cross-sections of the Dungolman River were taken in the vicinity of the Wind Farm Site between 14th May and 20th June 2021.

Cross-sections were taken from the southern Wind Farm Site boundary, near the unnamed road which runs between the townlands of Raheen and Lissanode, to the northern Wind Farm Site boundary just west of the existing sand and gravel quarry.

The survey cross-sections were extended across the floodplain and study area using Lidar data

The locations of the cross-sections are shown on **Figure H – Figure J** below. Cross-sections elevation data (in HEC-RAS format) are attached as **Appendix I.**

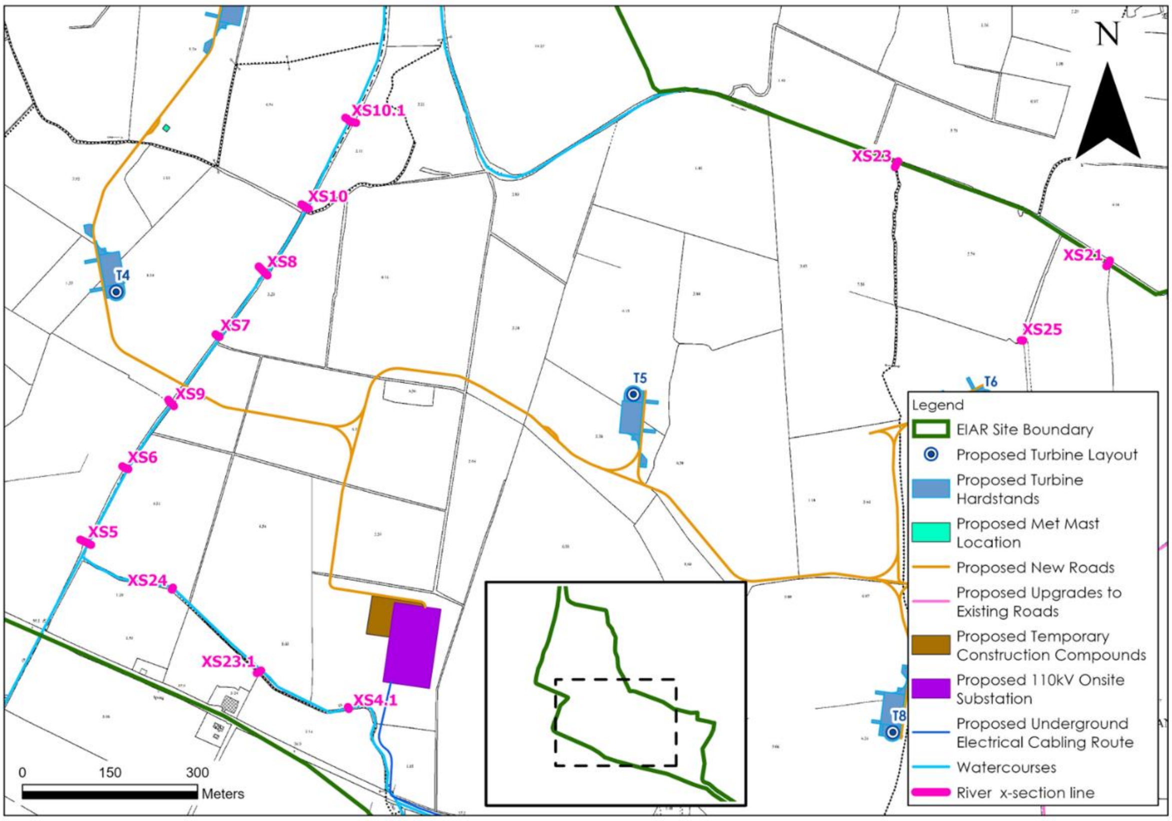


Figure H: Southern site Channel Cross-Sections

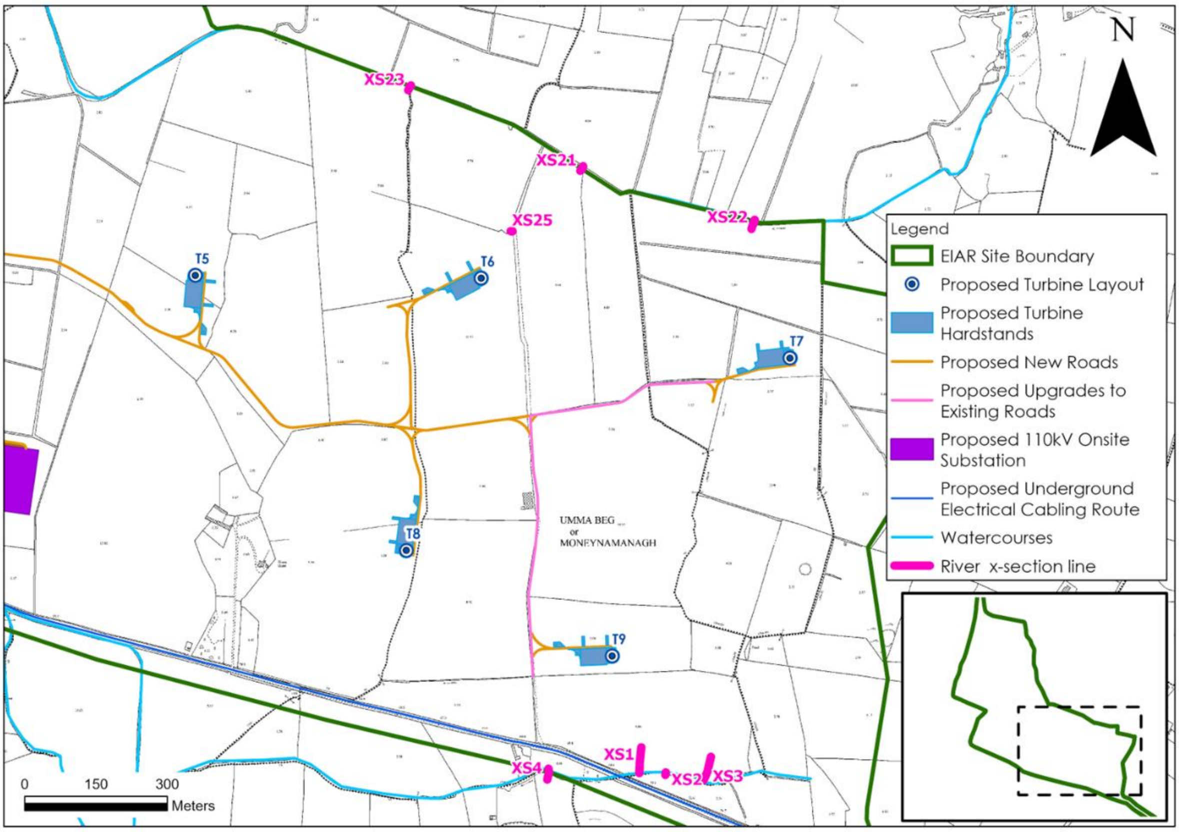


Figure I: Central/Eastern Site area cross sections

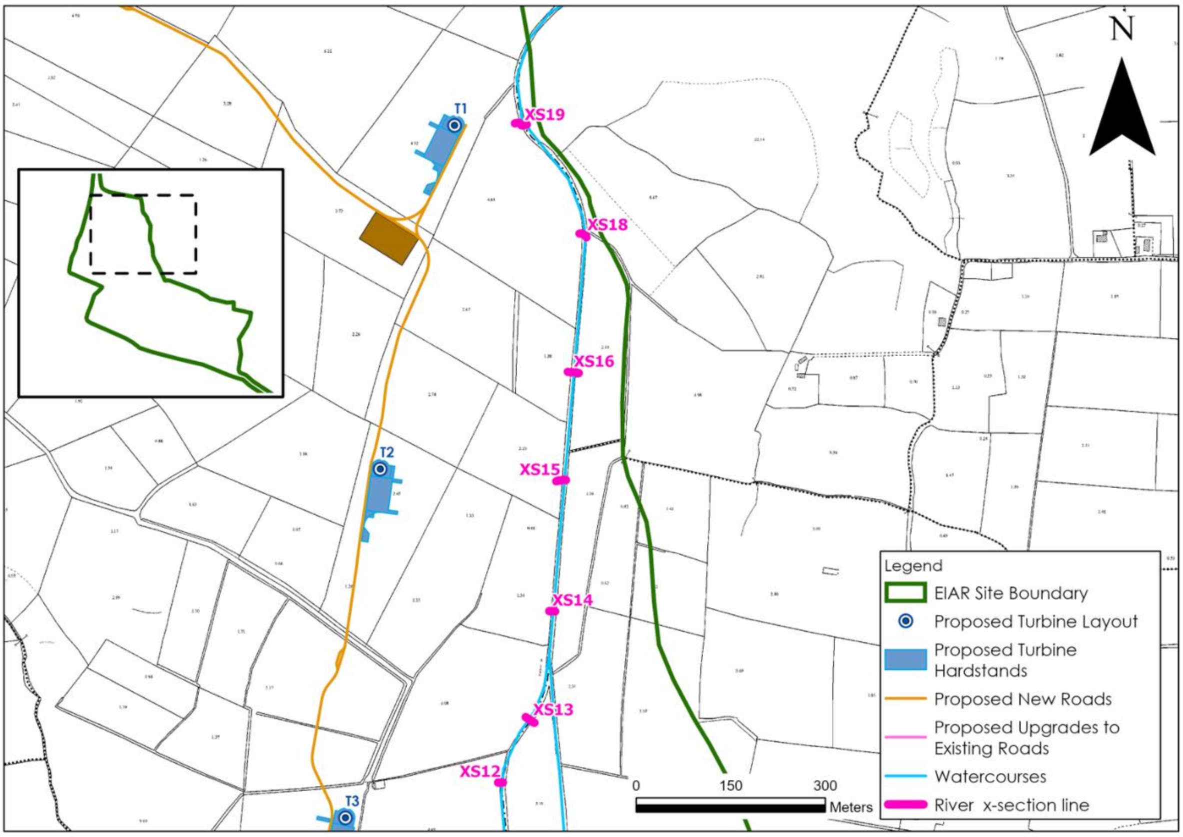


Figure J: Northern Site area cross sections

5.3 FLOOD MODELLING

Prior to modelling the design flood flows, the flow in the Dungolman River and Mullenmeehan on the day of the topographic survey was run to assess the accuracy of the model. There are no historical flood flows with known water levels available for flood flow calibration. The flow in the main Dungolman River channel on 20th June 2021 was measured to be 0.33m^3/s upstream of the site and 0.54m^3/s downstream.

The modelled water levels for measured flows on 20th June 2021 are shown in **Table D** below. There is good correlation between measured and modelled water levels at the model cross-sections. The overall model average difference between the measured and modelled level is 0.132m which is generally within acceptable tolerances according to HEC-RAS guidance[7] (i.e. <0.150m).

Table D: Comparison of Measured and Modelled Levels on 20/06/2021

Cross-section	Measured Level (m OD)	Modelled Level (m OD)	Difference (m)
1	53.091	52.87	0.221
2	53.168	52.95	0.218
3	53.168	53.01	0.158
4	53.159	53.04	0.119
5	53.342	53.13	0.212
6	53.551	53.35	0.201
7	53.576	53.43	0.146
9	53.695	53.72	-0.025
10	54.026	53.89	0.136
11	54.231	54.09	0.141
12	54.264	54.13	0.134
13	54.203	54.16	0.043
14	54.222	54.21	0.012

The CFRAM design flood flows were then modelled and the results are shown in **Table E** below. The primary areas of concern were along the main channel, between X5 and X19, as the PFRA mapping identified these areas as being potentially flood prone. These areas are low lying and they coincide with the proposed locations of a number of turbines and site access roads. The proposed infrastructure towards the east of the site, particularly T6 and T7 are significantly above any modelled flood levels. These turbines are at elevations of 60-61mOD based on available Lidar data, ~5-6m above the maximum modelled flood elevations.

HEC-RAS model output tables for the design flood modelling are attached as **Appendix II.**

7 HEC RAS River Analysis System – User's Manual (February 2016)

Table E: Modelled River Flood Levels in the Dungolman River

Cross-section	10-year Flood Level (m OD)	100-year Flood Level (m OD)	1000-year Flood Level (m OD)
1	55.1	55.38	55.66
2	55.24	55.52	55.78
3	55.53	55.77	55.93
4	55.6	55.81	55.96
5	55.64	55.84	55.98
6	55.67	55.86	56
7	55.68	55.86	56
8	55.72	55.88	56.01
9	55.74	55.89	56.02
10	55.78	55.91	56.02
11	55.81	55.93	56.04
12	55.84	55.95	56.04
13	55.92	56.07	56.21
14	55.99	56.16	56.31

The modelled flood level for the 100-year flow (1% AEP) (Flood zone A) for the Wind Farm Site ranges between 56.16 mOD at the southern upstream section of the Wind Farm Site, to 55.38 mOD at the northern downstream section near the existing sand and gravel quarry. During the modelled flood conditions a slope of 0.03% is calculated between the northern and southern sections.

The modelled flood level for the 1000-year flow (0.1% AEP) (Flood zone B) ranges between 56.31 mOD at the southern upstream section of the Wind Farm Site, to 55.66 mOD at the northern downstream section near the existing sand and gravel quarry. This modelled 1000-yr flood level is ~0.3m higher than the modelled 100-year flood level.

5.4 SUMMARY- DETAILED FLOOD RISK ASSESSMENT

Using the modelled flood levels (100-year (1% AEP) and 1000-year (0.1% AEP) flood levels) along with the Wind Farm Site topography and Lidar data, a site-specific flood zone map for the Wind Farm Site was created and this is attached as **Figure 1**.

Based on the information gained through the flood modelling, the areas of the Wind Farm Site at risk of flooding with regard the proposed development are outlined and assessed in **Table F**.

Through an iterative process of flood modelling and the design of the infrastructure locations around the modelled flood zones, the layout of the Wind Farm Site has been optimized. The only remaining infrastructure within a modelled flood zone is a small section (~110m) of access track between T4 and T5. This can be mitigated by building up the road within this section above the modelled flood elevation (100 year – 55.86 mOD, 1000 year – 56 mOD).

Table F:Summary of Flood Risk Based on Site Specific Flood Modelling

Source	Pathway	Receptor	Desk Study Data	Site Specific Modelling Data
Tidal	Not applicable.	Land and infrastructure.	The Wind Farm Site is >90km from the coast and there is no risk of coastal flooding.	No modelling completed on tidal flooding as not applicable given the distance involved.
Fluvial	Overbank flooding	Land and infrastructure.	Based on the detailed flood risk assessment and site-specific flood zone map: 1: Proposed road and river crossing near **T5**, as well as the turbine hardstand area at T5 are located within Flood Zone A and B. 2: Proposed Turbine **T2** and the sections of proposed road north and south of the turbine are mapped within Flood Zone A and B.	All turbines (T1-T9) located outside of modelled 100 year and 1000 year flood zones. Iterative process of site layout design and flood modelling, only 1 no. section of access road (110m) between T4 and T5 is mapped within the 100 year and 1000 year flood zones. The temporary site compounds, spoil management areas and substation are not located within modelled flood zones.
Pluvial	Ponding of rainwater on the route right of way.	Land and infrastructure.	No pluvial flooding is mapped within the site boundary	No pluvial modelling completed due to a review of the desk study data and the soils/subsoils information from the trial pitting (generally permeable sands)
Surface water	Surface ponding/ Overflow.	Land and infrastructure	Same as above (pluvial).	No surface water modelling completed due to a review of the desk study data and the soils/subsoils information from the trial pitting (generally permeable sands)

Groundwater	Rising groundwater levels.	Land and infrastructure.	No risk from groundwater flooding.	No modelling completed – no risk from groundwater flooding on this site.

Proposed turbines T1 – T9 are located outside of the modelled flood zones. The proposed onsite substation and temporary construction compounds are also mapped outside of the modelled flood zones. The only area of the Wind Farm Site which is mapped within the modelled flood zones is a small section of access road (110m) located ~300m west of turbine T5. As mentioned above, this can be mitigated by building up the finished access road level above the modelled flood level.

6. PLANNING POLICY AND JUSTIFICATION TEST

6.1 PLANNING POLICY AND THE WESTMEATH COUNTY DEVELOPMENT PLAN

The following policies are defined in the Westmeath CDP 2021-2027 (**Table G**) in respect of flooding, and we have outlined in the column to the right how these policies are provided for within the Proposed Development design:

Table G: Westmeath County Development Plan Objectives/Policies and Project Responses

No.	Policy	Development Design Response
CPO 10.96	Implement and comply fully with the recommendations of the Strategic Flood Risk Assessment prepared as part of the Westmeath County Development Plan 2021-2027.	This FRA is consistent with the requirements of the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" and is in line with the recommendations of the SFRA prepared as part of the Westmeath County Development Plan 2021-2027.
CPO 10.97	Have regard to the Guidelines for Planning Authorities on the Planning System and Flood Risk Management (DoEHLG/OPW 2009) and Circular PL2/2014, through the use of the sequential approach and application of the Justification Tests in Development Management.	This FRA is consistent with the requirements of the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" A Justification Test (JT) for the Proposed Development is undertaken in Section 6.2 below.
CPO 10.98	Ensure that a flood risk assessment is carried out for any development proposal, within 200m of a watercourse and at risk of flooding, in accordance with the Planning System and Flood Risk Management (DoEHLG/OPW 2009). This assessment shall be appropriate to the scale and nature of risk to the potential development.	Included to the scale and nature of the Proposed Development.
CPO 10.99	Support the implementation of recommendations in the CFRAM Programme to ensure that flood risk management policies and infrastructure are progressively implemented.	This FRA is in line with the management policies outlined in the objective.
CPO 10.100	Support the implementation of recommendations in the Flood Risk Management Plans (FRMP's), including planned investment measures for managing and reducing flood risk.	N/A
CPO 10.101	Consult with the OPW in relation to proposed developments in the vicinity of drainage channels and rivers for which the OPW are responsible, and to retain a strip on either side of such channels where required, to facilitate maintenance access thereto.	OPW mapping has been consulted and access to either side of managed channels will be maintained
CPO 10.102	Assist the OPW in developing catchment-based Flood Risk Management Plans for rivers in County Westmeath and have regard to their provisions/recommendations.	No plan in place currently for the Wind Farm Site
CPO 10.103	Protect and enhance the County's floodplains and wetlands as 'green infrastructure' which	No alteration of hydromorphology is recommended within this report

	provides space for storage and conveyance of floodwater, enabling flood risk to be more effectively managed and reducing the need to provide flood defenses in the future, subject to normal planning and environmental criteria.	or within the overall development plan for the Proposed Development.
CPO 10.104	Protect the integrity of any formal (OPW or Westmeath County Council) flood risk management infrastructure, thereby ensuring that any new development does not negatively impact any existing defense infrastructure or compromise any proposed new infrastructure.	No existing defences at the Wind Farm Site. OPW access to arterial drainage areas will be maintained as outlined above.
CPO 10.105	Ensure that where flood risk management works take place that the natural and cultural heritage, rivers, streams and watercourses are protected and enhanced.	No flood risk management works *i.e* flood barriers, recommended.
CPO 10.106	Ensure each flood risk management activity is examined to determine actions required to embed and provide for effective climate change adaptation as set out in the OPW Climate Change Sectoral Adaptation Plan Flood Risk Management applicable at the time.	No flood risk management activity recommended.
CPO 10.107	Consult, where necessary, with Inland Fisheries Ireland, the National Parks and Wildlife Service and other relevant agencies in the provision of flood alleviation measures in the County.	N/A

6.2 REQUIREMENT FOR A JUSTIFICATION TEST

The matrix of vulnerability versus flood zone to illustrate appropriate development that are required to meet the Justification Test[8] is shown in **Table H** below.

The Proposed Development is considered to be a 'Highly Vulnerable Development' due to the nature of the turbine infrastructure and the onsite substation.

The majority of the Wind Farm Site is situated within Flood Zone C, however a proposed section of access road between T4 and T5 (110m) is located within the modelled extents of Flood Zone A and B therefore a justification is required for this area. A justification test for this layout is presented as illustrated below.

Table H: Matrix of Vulnerability versus Flood Zone

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

Note: Taken from Table 3.2 (DoEHLG, 2009)

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

Bold: *Applies to this project.*

Box 5.1 of "The Planning System and Flood Risk Management Guidelines" (PSFRM Guidelines) outlines the criteria required to complete the "Justification Test".

Table I: Format of Justification Test for Development Management

Box 5.1 Justification Test for Development Management (to be submitted by the applicant)
When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied: 1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines. 2. The proposal has been subject to an appropriate flood risk assessment that demonstrates: i. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk; ii. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible; iii. The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and iv. The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes. The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

Note: *this table has been adapted from Box 5.1 of "The Planning System and Flood Risk Management Guidelines", (2009).*

Referring to Point 1 and Points 2 (i) to (iv) inclusive:

The section of the access tracks located in the mapped flood zones (110m) are located within the Wind Farm Site, providing access between the Proposed Development turbines and ancillary infrastructure. The closest third-party sensitive receptor to the section of the access tracks located in the mapped flood zones is approximately 578 metres. During the site selection process, one of the criteria considered was the identification of an area that can maintain an appropriate set-back from third-party sensitive receptors. Having reviewed the settlement patterns in the vicinity, along with a number of other criteria, the Wind Farm Site was identified as a suitable location for the provision of a renewable energy development of the scale proposed.

1. The Proposed Development has been the subject of a flood risk assessment (this report) and the following has been determined:

   i. Due to the relatively small footprint of the Proposed Development and the only portion of the Proposed Development within a modelled flood zone being a 110m section of access track, the Proposed Development is predicted to have an unmeasurable/imperceptible impact on flood water levels downstream of the Wind Farm Site. No increase in downstream flood risk is anticipated.
   ii. The design of the Wind Farm Site has undergone an iterative process following the flood modelling, moving proposed turbines and all other site infrastructure (aside from the 110m road section) outside of the modelled flood zones. These measures will mitigate against any potential disruption to the natural hydrology of the Wind Farm Site. No increase in flood risk to people, property, the economy or the environment during extreme flood events as a result of the

Proposed Development is predicted due to the appropriate design measures which will result in unmeasurable/imperceptible upstream and downstream effects;

iii. Detailed flood level and flow modelling have been undertaken to assess the effects of locating some sections of access tracks within fluvial flood zones whereby both the upstream and downstream impacts has been determined to be unmeasurable/imperceptible. Further mitigation is deemed not necessary; and,

iv. The Proposed Development is compatible with the wider planning objectives of the area, including the provision of wind energy developments at appropriate locations and the proper planning and sustainable development of the area.

7. FRA CONCLUSIONS

7.1 CONCLUSIONS

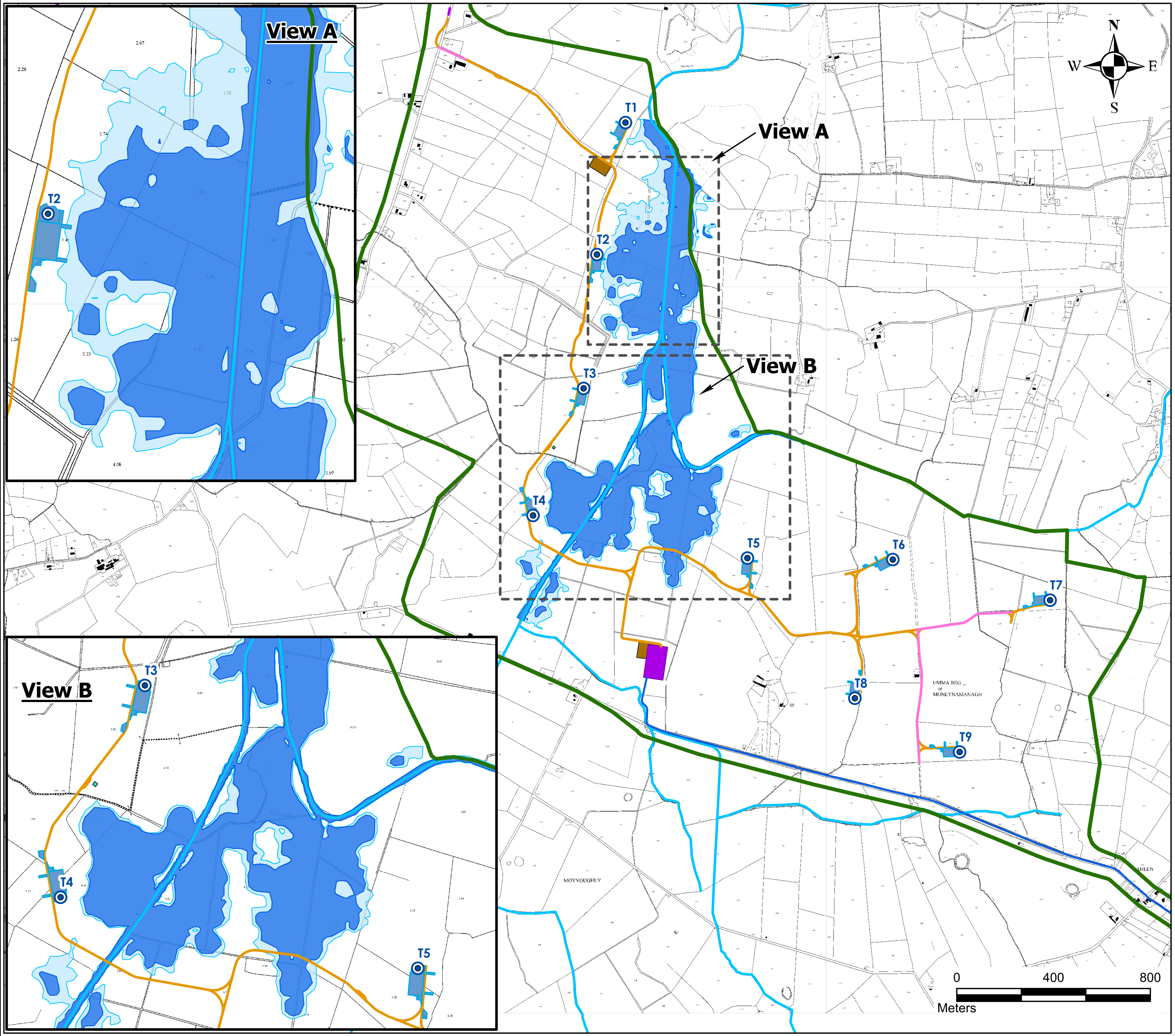
- There is no CFRAM mapping available for the Wind Farm Site area;
- The PFRA mapping and NIFM flood mapping is available for the Wind Farm Site.
- They are "broad scale" and based on OSI contour data. Some of the Proposed Development is located within flood zones indicated by the PFRA and NIFM mapping;
- HES have completed site-specific flood modelling for the Proposed Development areas identified as being in mapped flood zones (PFRA/NIFM mapping):
  - The assessment in **Section 5.2** and **5.3** above show there are no turbines located within modelled flood zones;
  - The substation and Wind Farm Site underground electrical cabling connection are also located outside of the modelled flood zones;
  - The access roads (proposed/upgraded) are located outside of the modelled flood zones apart from 1 no. section (110m) of access road located ~300m west of T5;
- There is therefore, 1 no. section of 110m of access road which remains within a modelled flood zone. In order to mitigate this flood risk, all proposed Wind Farm Site access tracks within the modelled flood pluvial zones will have the track surface raised at least 500mm above the 1000-year flood level. There is an existing field drain which will be culverted under the proposed access track. This culvert will provide a drainage outlet for flood water following a significant flood event. This will prevent any damming effect from the proposed access road within this section during significant flooding events.
- Based on the iterative design process, designed around the site specific flood modelling, any potential upstream and downstream flood impacts associated with the proposed development will be unmeasurable/imperceptible; and,
- Therefore, there will be no increase in flood risk to people, property, the economy or the environment during extreme flood events.

* *

8. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
DOEHLG	2009	The Planning System and Flood Risk Management.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.
OPW	2011	Preliminary Flood Risk Assessment Maps
Westmeath County Council	2021	Westmeath County Development Plan 2021-2027

FIGURES



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Turbine Hardstands
- Proposed Met Mast Location
- Proposed New Roads
- Proposed Upgrades to Existing Roads
- Proposed Temporary Construction Compounds
- Proposed 110kV Onsite Substation
- Proposed Underground Electrical Cabling Route
- Watercourses
- 100-Year AEP Flood Area
- 1000-Year AEP Flood Area

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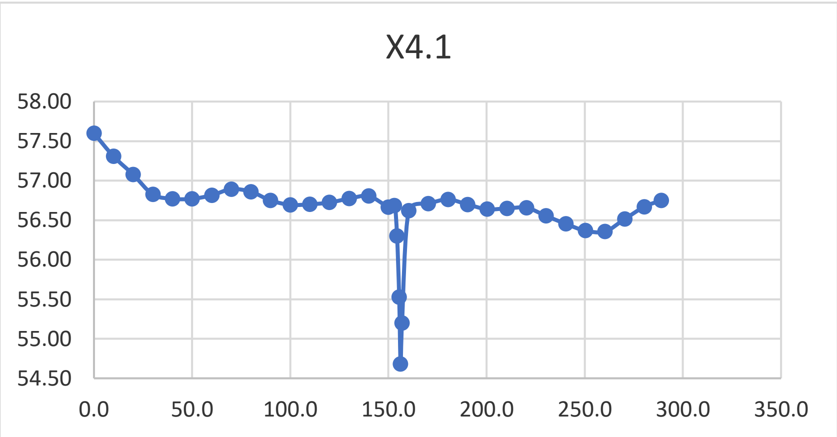
Client: MKO	
Job: Umma More Renewable Energy Development	
Title: Flood Risk Map	
Figure No: FR01	
Drawing No: P1553-0-0123-A3-FR1-00A	
Sheet Size: A3	Project No: P1553-0
Scale: 1:15,000	Drawn By: GD
Date: 31/01/2023	Checked By: MG

APPENDIX I: DUNGOLMAN RIVER CHANNEL SURVEY

X Section 4

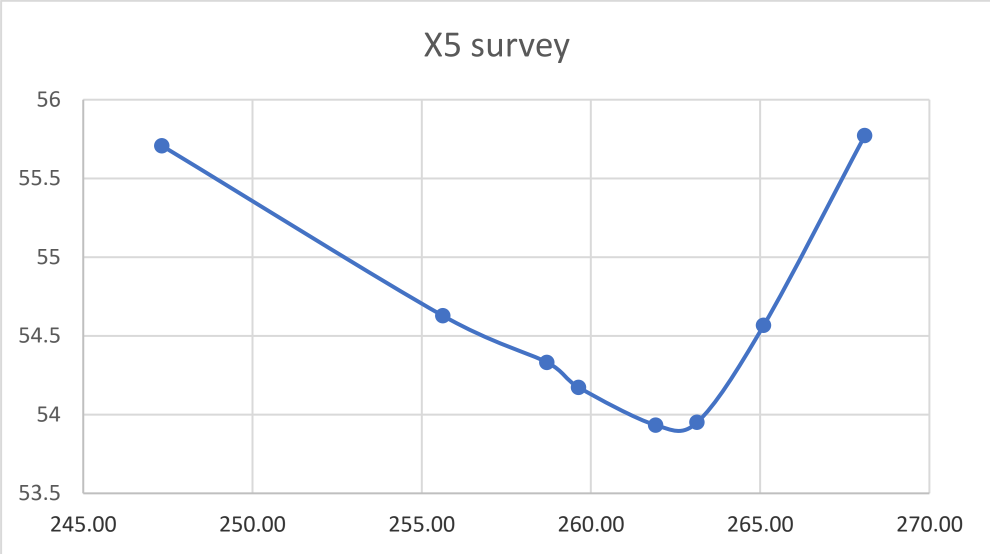
Id		E	N	Elevation	Distance	WL
	1	219245.6	245198.9	57.60	0.0	
	2	219241.9	245208.2	57.31	10.0	
	3	219238.3	245217.5	57.08	20.0	
	4	219234.7	245226.9	56.83	30.0	
	5	219231	245236.2	56.77	40.0	
	6	219227.4	245245.5	56.77	50.0	
	7	219223.7	245254.8	56.82	60.0	
	8	219220.1	245264.1	56.89	70.0	
	9	219216.5	245273.4	56.86	80.0	
	10	219212.8	245282.7	56.75	90.0	
	11	219209.2	245292.1	56.69	100.0	
	12	219205.6	245301.4	56.70	110.0	
	13	219201.9	245310.7	56.72	120.0	
	14	219198.3	245320	56.77	130.0	
	15	219194.7	245329.3	56.80	140.0	
	16	219191	245338.6	56.67	150.0	
x4.1		619133.8	745368.3	56.68	153.1	55.016
x4.2		619134.5	745367.2	56.30	154.4	55.016
x4.3		619135	745366.3	55.53	155.5	55.016
x4.4		619135.5	745365.7	54.68	156.2	55.016
x4.5		619135.5	745365	55.20	156.9	55.016
	1	219187.2	245347.4	56.62	160.4	
	2	219187.3	245357.4	56.71	170.4	
	3	219187.3	245367.4	56.76	180.4	
	4	219187.3	245377.4	56.70	190.4	
	5	219187.4	245387.4	56.64	200.4	
	6	219187.4	245397.4	56.65	210.4	
	7	219187.5	245407.4	56.66	220.4	
	8	219187.5	245417.4	56.55	230.4	
	9	219187.5	245427.4	56.45	240.4	
	10	219187.6	245437.4	56.37	250.4	
	11	219187.6	245447.4	56.36	260.4	
	12	219187.6	245457.4	56.51	270.4	
	13	219187.7	245467.4	56.67	280.4	
	14	219187.7	245476.1	56.75	289.1	



X Section 5

Id	E	N	Elevation	Distance	WL
1	218507.6	245736.3	60.551	0	
2	218516.7	245732.1	60.201	10	
3	218525.7	245727.9	59.847	20	
4	218534.8	245723.7	59.389	30	
5	218543.9	245719.5	58.97	40	
6	218553	245715.4	58.44	50	
7	218562.1	245711.2	57.997	60	
8	218571.2	245707	57.887	70	
9	218580.2	245702.8	57.824	80	
10	218589.3	245698.6	57.808	90	
11	218598.4	245694.4	57.827	100	
12	218607.5	245690.3	57.838	110	
13	218616.6	245686.1	57.836	120	
14	218625.7	245681.9	57.849	130	
15	218634.7	245677.7	57.851	140	
16	218643.8	245673.5	57.762	150	
17	218652.9	245669.3	57.682	160	
18	218662	245665.2	57.628	170	
19	218671.1	245661	57.524	180	
20	218680.2	245656.8	57.344	190	
21	218689.2	245652.6	57.225	200	
22	218698.3	245648.4	57.167	210	
23	218707.4	245644.2	57.038	220	
24	218716.5	245640.1	56.795	230	
25	218725.6	245635.9	56.251	240	
26	218728.9	245634.3	56.091	243.66	
5.1	618675	745655	55.708	247.32	54.222
5.2	618683	745652	54.628	255.63	54.222
5.3	618686	745651	54.332	258.70	54.222
5.4	618687	745650	54.173	259.64	54.222
5.5	618689	745649	53.933	261.92	54.222
5.6	618690	745648	53.951	263.14	54.222
5.7	618691	745647	54.567	265.11	54.222
5.8	618694	745646	55.772	268.09	54.222
1	218756.5	245621.1	56.199	278.09	
2	218765.6	245616.9	56.207	288.09	
3	218774.6	245612.6	56.279	298.09	
4	218783.7	245608.4	56.33	308.09	
5	218792.7	245604.1	56.323	318.09	
6	218801.8	245599.9	56.298	328.09	
7	218810.9	245595.6	56.308	338.09	
8	218819.9	245591.4	56.29	348.09	
9	218829	245587.1	56.301	358.09	
10	218838	245582.9	56.385	368.09	
11	218847.1	245578.6	56.484	378.09	
12	218856.1	245574.4	56.594	388.09	
13	218865.2	245570.1	56.672	398.09	
14	218874.2	245565.9	56.764	408.09	
15	218883.3	245561.6	56.786	418.09	

Id	E	N	Elevation	Distance 0
16	218892.3	245557.4	56.765	428.09
17	218901.4	245553.1	56.524	438.09
18	218910.4	245548.8	56.387	448.09
19	218919.5	245544.6	56.357	458.09
20	218928.5	245540.3	56.52	468.09
21	218937.6	245536.1	56.762	478.09
22	218946.6	245531.8	56.989	488.09
23	218955.7	245527.6	57.152	498.09
24	218964.7	245523.3	57.258	508.09
25	218973.8	245519.1	57.242	518.09
26	218982.8	245514.8	57.012	528.09
27	218991.9	245510.6	56.811	538.09
28	219000.9	245506.3	56.717	548.09
29	219010	245502.1	56.611	558.09
30	219019	245497.8	56.539	568.09
31	219028.1	245493.6	56.529	578.09
32	219037.2	245489.3	56.491	588.09
33	219046.2	245485.1	56.447	598.09
34	219055.3	245480.8	56.398	608.09
35	219064.3	245476.6	56.4	618.09
36	219073.4	245472.3	56.434	628.09
37	219082.4	245468.1	56.491	638.09
38	219091.5	245463.8	56.496	648.09
39	219100.5	245459.6	56.443	658.09
40	219109.6	245455.3	56.341	668.09
41	219118.6	245451.1	56.216	678.09
42	219127.7	245446.8	56.159	688.09
43	219136.7	245442.6	56.259	698.09
44	219145.8	245438.3	56.375	708.09
45	219154.8	245434.1	56.398	718.09
46	219163.9	245429.8	56.349	728.09
47	219172.9	245425.6	56.395	738.09
48	219182	245421.3	56.493	748.09
49	219191	245417.1	56.539	758.09
50	219200.1	245412.8	56.545	768.09
51	219209.1	245408.6	56.58	778.09
52	219218.2	245404.3	56.581	788.09
53	219227.2	245400.1	56.589	798.09
54	219236.3	245395.8	56.692	808.09
55	219245.3	245391.6	56.82	818.09
56	219254.4	245387.3	56.911	828.09
57	219263.5	245383.1	57.017	838.09
58	219272.5	245378.8	57.217	848.09
59	219281.6	245374.6	57.482	858.09
60	219290.6	245370.3	57.611	868.09
61	219299.7	245366.1	57.608	878.09
62	219308.7	245361.8	57.673	888.09
63	219309.3	245361.5	57.68	888.72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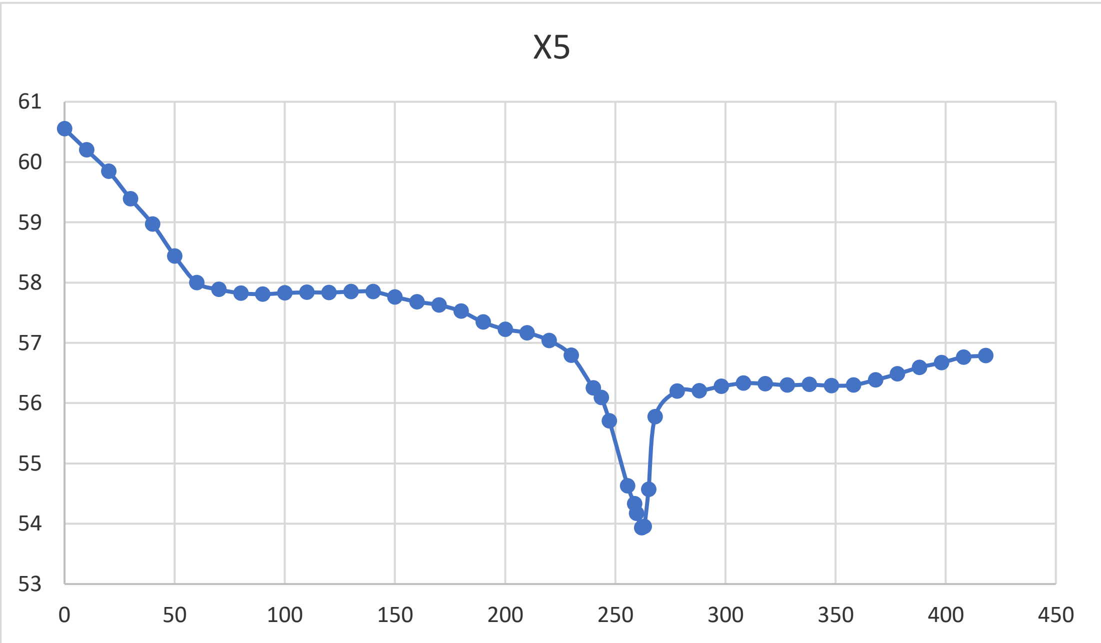
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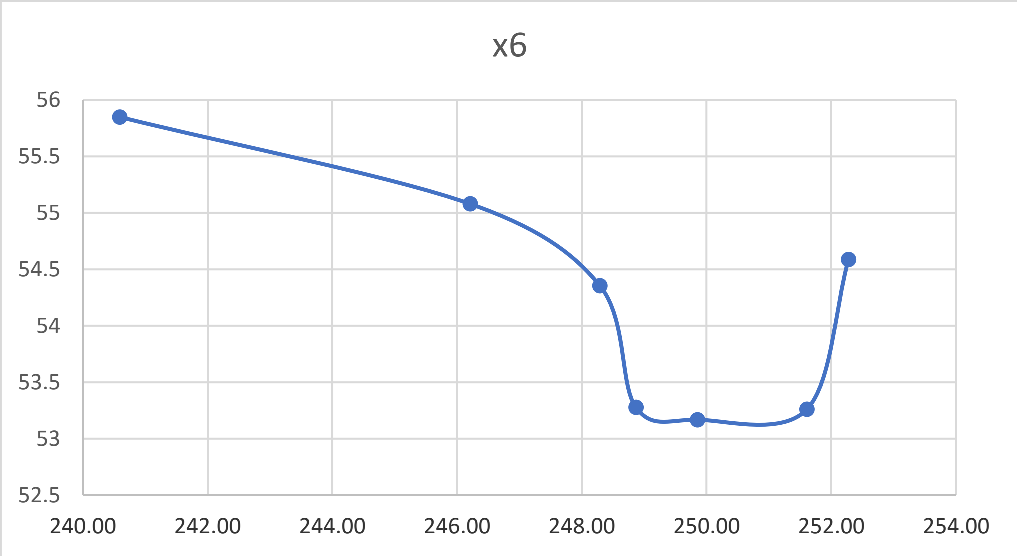
X Section 6

Id	E	N	Elevation	Distance	WL
1	218581.4	245858.8	59.483	0	
2	218590.6	245854.7	59.176	10	
3	218599.7	245850.6	58.862	20	
4	218608.8	245846.5	58.546	30	
5	218617.9	245842.4	58.229	40	
6	218627	245838.3	57.88	50	
7	218636.2	245834.2	57.454	60	
8	218645.3	245830.1	57.068	70	
9	218654.4	245826	56.765	80	
10	218663.5	245821.9	56.58	90	
11	218672.6	245817.8	56.5	100	
12	218681.8	245813.7	56.487	110	
13	218690.9	245809.6	56.463	120	
14	218700	245805.5	56.435	130	
15	218709.1	245801.3	56.419	140	
16	218718.2	245797.2	56.405	150	
17	218727.4	245793.1	56.401	160	
18	218736.5	245789	56.453	170	
19	218745.6	245784.9	56.507	180	
20	218754.7	245780.8	56.413	190	
21	218763.8	245776.7	56.289	200	
22	218773	245772.6	56.262	210	
23	218782.1	245768.5	56.265	220	
24	218791.2	245764.4	56.209	230	
25	218800.3	245760.3	56.145	240	
6.1	618747	745781	55.848	240.59	54.203
6.2	618752	745778	55.079	246.21	54.203
6.3	618754	745778	54.354	248.29	54.203
6.4	618755	745777	53.278	248.87	54.203
6.5	618756	745777	53.168	249.86	54.203
6.6	618757	745776	53.26	251.61	54.203
6.7	618758	745776	54.588	252.28	54.203
1	218820.1	245750.6	56.156	262.28	
2	218829.1	245746.2	56.247	272.28	
3	218838.1	245741.8	56.107	282.28	
4	218847	245737.4	56.051	292.28	
5	218856	245732.9	56.095	302.28	
6	218865	245728.5	56.137	312.28	
7	218873.9	245724.1	56.162	322.28	
8	218882.9	245719.7	56.161	332.28	
9	218891.9	245715.3	56.182	342.28	
10	218900.9	245710.8	56.245	352.28	
11	218909.8	245706.4	56.331	362.28	
12	218918.8	245702	56.424	372.28	
13	218927.8	245697.6	56.497	382.28	
14	218936.7	245693.1	56.487	392.28	
15	218945.7	245688.7	56.487	402.28	
16	218954.7	245684.3	56.54	412.28	
17	218963.6	245679.9	56.63	422.28	

Id	E	N	Elevation	Distance 0
18	218972.6	245675.5	56.78	432.28
19	218981.6	245671	56.939	442.28
20	218990.5	245666.6	56.969	452.28
21	218999.5	245662.2	56.904	462.28
22	219008.5	245657.8	56.821	472.28
23	219017.5	245653.3	56.795	482.28
24	219026.4	245648.9	56.755	492.28
25	219035.4	245644.5	56.617	502.28
26	219044.4	245640.1	56.587	512.28
27	219053.3	245635.7	56.7	522.28
28	219062.3	245631.2	56.835	532.28
29	219071.3	245626.8	56.934	542.28
30	219080.2	245622.4	56.973	552.28
31	219089.2	245618	56.879	562.28
32	219098.2	245613.5	56.687	572.28
33	219107.2	245609.1	56.578	582.28
34	219116.1	245604.7	56.607	592.28
35	219125.1	245600.3	56.609	602.28
36	219134.1	245595.9	56.558	612.28
37	219143	245591.4	56.518	622.28
38	219152	245587	56.48	632.28
39	219161	245582.6	56.42	642.28
40	219169.9	245578.2	56.385	652.28
41	219178.9	245573.7	56.372	662.28
42	219187.9	245569.3	56.353	672.28
43	219196.8	245564.9	56.363	682.28
44	219205.8	245560.5	56.391	692.28
45	219214.8	245556	56.383	702.28
46	219223.8	245551.6	56.41	712.28
47	219232.7	245547.2	56.341	722.28
48	219241.7	245542.8	56.252	732.28
49	219250.7	245538.4	56.256	742.28
50	219259.6	245533.9	56.281	752.28
51	219268.6	245529.5	56.307	762.28
52	219277.6	245525.1	56.322	772.28
53	219286.5	245520.7	56.32	782.28
54	219295.5	245516.2	56.292	792.28
55	219304.5	245511.8	56.283	802.28
56	219313.4	245507.4	56.348	812.28
57	219322.4	245503	56.458	822.28
58	219331.4	245498.6	56.64	832.28
59	219340.4	245494.1	56.866	842.28
60	219349.3	245489.7	57.076	852.28
61	219358.3	245485.3	57.242	862.28
62	219367.3	245480.9	57.454	872.28
63	219376.2	245476.4	57.718	882.28
64	219385.2	245472	57.946	892.28
65	219394.2	245467.6	58.101	902.28
66	219403.1	245463.2	58.278	912.28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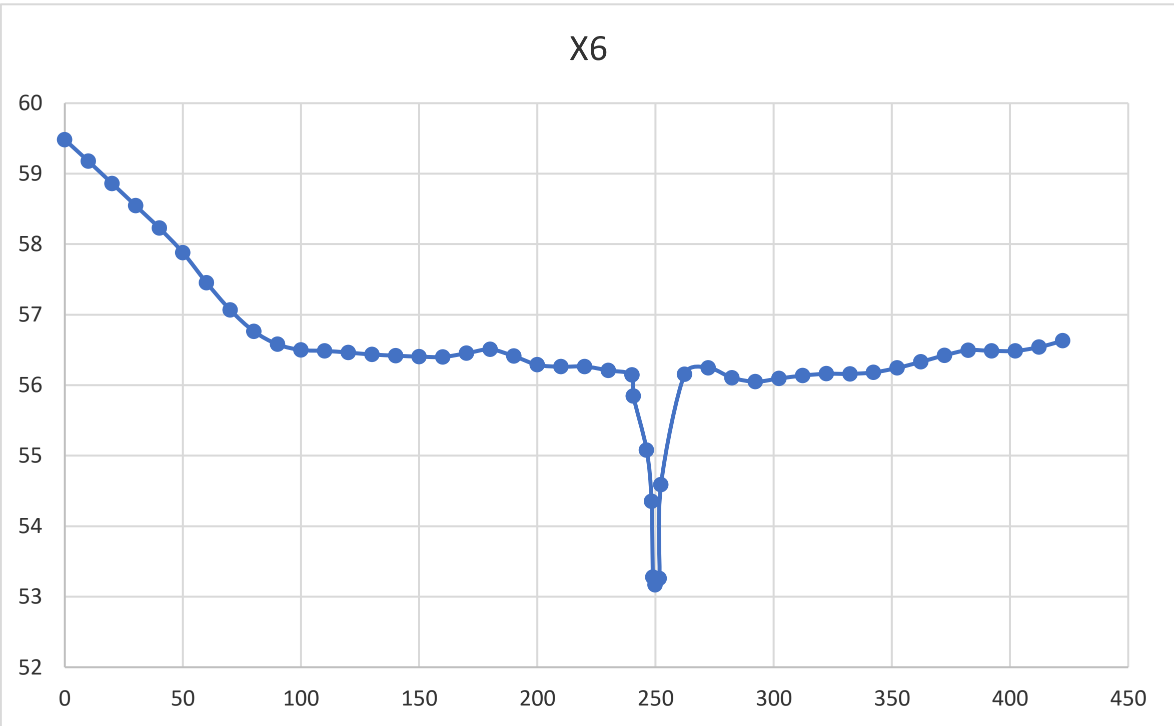
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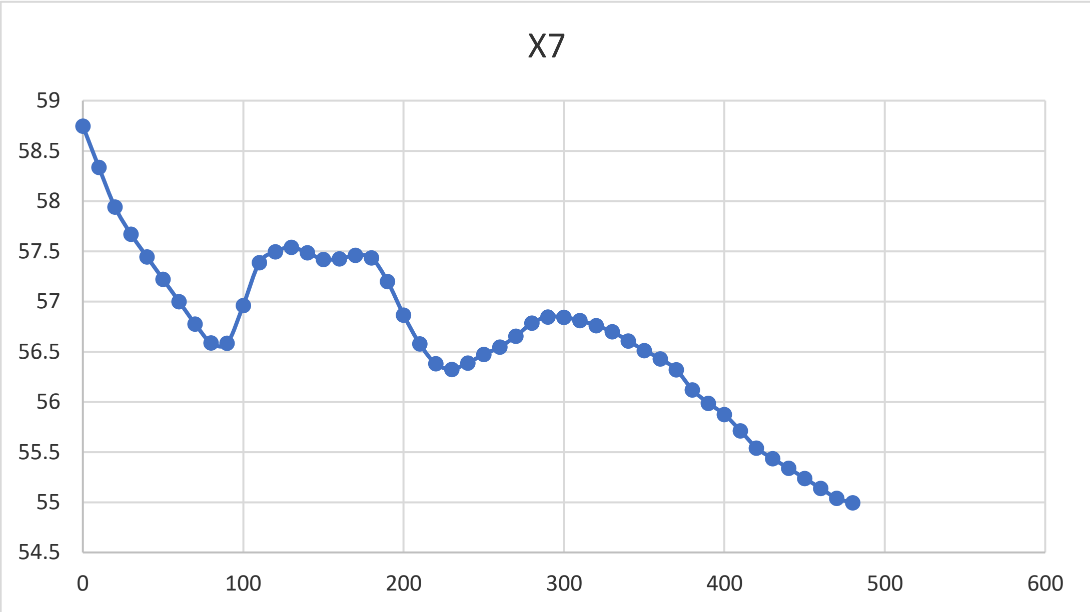
X Section 7

Id	E	N	Elevation	Distance	WL
1	218504	246231.7	58.748	0	
2	218512.8	246227	58.336	10	
3	218521.6	246222.2	57.941	20	
4	218530.4	246217.5	57.67	30	
5	218539.2	246212.8	57.444	40	
6	218548	246208	57.221	50	
7	218556.8	246203.3	56.999	60	
8	218565.6	246198.6	56.776	70	
9	218574.4	246193.8	56.587	80	
10	218583.3	246189.1	56.585	90	
11	218592.1	246184.4	56.961	100	
12	218600.9	246179.6	57.386	110	
13	218609.7	246174.9	57.497	120	
14	218618.5	246170.2	57.54	130	
15	218627.3	246165.4	57.485	140	
16	218636.1	246160.7	57.418	150	
17	218644.9	246156	57.426	160	
18	218653.7	246151.2	57.459	170	
19	218662.5	246146.5	57.434	180	
20	218671.3	246141.8	57.198	190	
21	218680.1	246137	56.865	200	
22	218689	246132.3	56.578	210	
23	218697.8	246127.5	56.38	220	
24	218706.6	246122.8	56.325	230	
25	218715.4	246118.1	56.388	240	
26	218724.2	246113.3	56.473	250	
27	218733	246108.6	56.546	260	
28	218741.8	246103.9	56.655	270	
29	218750.6	246099.1	56.784	280	
30	218759.4	246094.4	56.847	290	
31	218768.2	246089.7	56.843	300	
32	218777	246084.9	56.81	310	
33	218785.9	246080.2	56.76	320	
34	218794.7	246075.5	56.699	330	
35	218803.5	246070.7	56.608	340	
36	218812.3	246066	56.512	350	
37	218821.1	246061.3	56.43	360	
38	218829.9	246056.5	56.32	370	
39	218838.7	246051.8	56.121	380	
40	218847.5	246047.1	55.987	390	
41	218856.3	246042.3	55.874	400	
42	218865.1	246037.6	55.712	410	
43	218873.9	246032.9	55.541	420	
44	218882.7	246028.1	55.435	430	
45	218891.6	246023.4	55.339	440	
46	218900.4	246018.7	55.239	450	
47	218909.2	246013.9	55.139	460	
48	218918	246009.2	55.039	470	
49	218926.8	246004.5	54.995	480	

Id	E	N	Elevation	Distance	WL
50	218935.6	245999.7	55.167	490	
51	218944.4	245995	55.443	500	
52	218953.2	245990.2	55.723	510	
7.1	618907	746007	55.829	518.41	54.231
7.2	618911	746004	55.119	522.98	54.231
7.3	618912	746003	54.402	525.00	54.231
7.4	618913	746003	53.791	526.22	54.231
7.5	618914	746003	53.208	527.31	54.231
2	218976.6	245977.6	55.557	537.31	
3	218985.6	245973.1	55.689	547.31	
4	218994.5	245968.7	55.669	557.31	
5	219003.5	245964.3	55.743	567.31	
6	219012.5	245959.9	55.783	577.31	
7	219021.4	245955.4	55.801	587.31	
8	219030.4	245951	55.761	597.31	
9	219039.4	245946.6	55.708	607.31	
10	219048.3	245942.1	55.687	617.31	
11	219057.3	245937.7	55.7	627.31	
12	219066.3	245933.3	55.777	637.31	
13	219075.2	245928.8	55.896	647.31	
14	219084.2	245924.4	56.077	657.31	
15	219093.2	245920	56.354	667.31	
16	219102.1	245915.6	56.59	677.31	
17	219111.1	245911.1	56.661	687.31	
18	219120.1	245906.7	56.586	697.31	
19	219129	245902.3	56.554	707.31	
20	219138	245897.8	56.527	717.31	
21	219147	245893.4	56.473	727.31	
22	219155.9	245889	56.421	737.31	
23	219164.9	245884.6	56.357	747.31	
24	219173.9	245880.1	56.309	757.31	
25	219182.8	245875.7	56.102	767.31	
26	219191.8	245871.3	56.008	777.31	
27	219200.8	245866.8	56.092	787.31	
28	219209.7	245862.4	56.197	797.31	
29	219218.7	245858	56.33	807.31	
30	219227.7	245853.5	56.454	817.31	
31	219236.6	245849.1	56.571	827.31	
32	219245.6	245844.7	56.66	837.31	
33	219254.6	245840.3	56.666	847.31	
34	219263.5	245835.8	56.635	857.31	
35	219272.5	245831.4	56.554	867.31	
36	219281.5	245827	56.491	877.31	
37	219290.4	245822.5	56.411	887.31	
38	219299.4	245818.1	56.317	897.31	
39	219308.4	245813.7	56.241	907.31	
40	219317.3	245809.3	56.283	917.31	
41	219326.3	245804.8	56.281	927.31	
42	219335.3	245800.4	56.138	937.31	

43	219344.2	245796	56.008	947.31
44	219353.2	245791.5	55.903	957.31
45	219362.2	245787.1	55.821	967.31
46	219371.1	245782.7	55.762	977.31
47	219380.1	245778.2	55.825	987.31
48	219389.1	245773.8	55.961	997.31
49	219398	245769.4	56.048	1007.31
50	219407	245765	56.118	1017.31
51	219415.9	245760.5	56.191	1027.31
52	219424.9	245756.1	56.248	1037.31
53	219433.9	245751.7	56.358	1047.31
54	219442.8	245747.2	56.497	1057.31
55	219451.8	245742.8	56.675	1067.31
56	219460.8	245738.4	56.865	1077.31
57	219469.7	245734	57.033	1087.31
58	219478.7	245729.5	57.236	1097.31
59	219487.7	245725.1	57.449	1107.31
60	219496.6	245720.7	57.649	1117.31
61	219505.6	245716.2	57.799	1127.31
62	219514.6	245711.8	57.858	1137.31
63	219523.5	245707.4	57.867	1147.31
64	219532.5	245703	57.86	1157.31
65	219541.5	245698.5	57.85	1167.31
66	219545.3	245696.6	57.842	1171.56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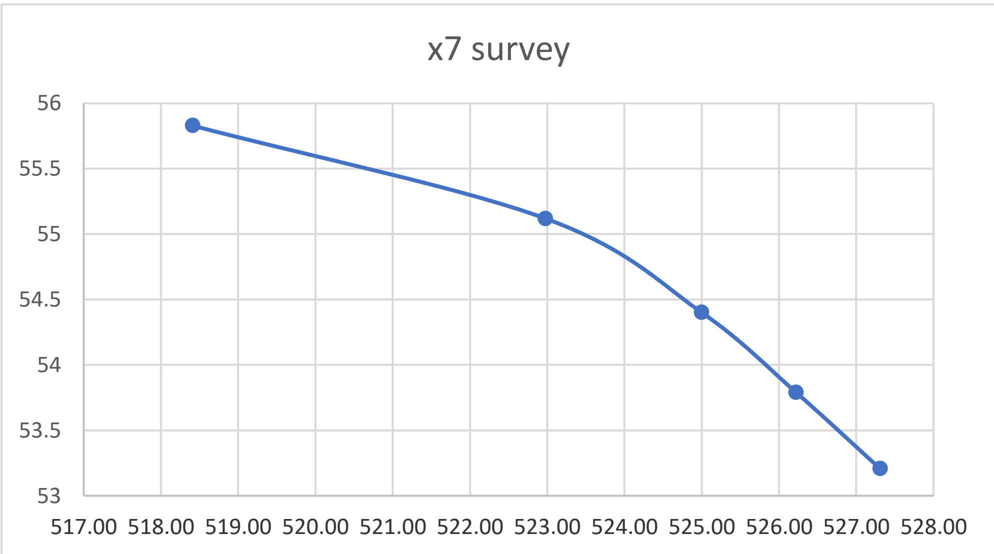
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X Section 8

Id	E	N	Elevation	Distance	WL
1	218473.3	246348.8	59.157	0	
2	218482.5	246344.8	59.141	10	
3	218491.7	246340.8	58.839	20	
4	218500.8	246336.7	58.392	30	
5	218510	246332.7	58.075	40	
6	218519.1	246328.7	57.835	50	
7	218528.3	246324.7	57.619	60	
8	218537.4	246320.7	57.44	70	
9	218546.6	246316.6	57.411	80	
10	218555.8	246312.6	57.4	90	
11	218564.9	246308.6	57.316	100	
12	218574.1	246304.6	57.215	110	
13	218583.2	246300.6	57.152	120	
14	218592.4	246296.5	57.139	130	
15	218601.5	246292.5	57.128	140	
16	218610.7	246288.5	57.102	150	
17	218619.9	246284.5	57.069	160	
18	218629	246280.5	57.064	170	
19	218638.2	246276.4	57.053	180	
20	218647.3	246272.4	57.05	190	
21	218656.5	246268.4	57.067	200	
22	218665.6	246264.4	57.032	210	
23	218674.8	246260.4	56.93	220	
24	218683.9	246256.3	56.926	230	
25	218693.1	246252.3	56.967	240	
26	218702.3	246248.3	56.98	250	
27	218711.4	246244.3	57.015	260	
28	218720.6	246240.3	57.183	270	
29	218729.7	246236.2	57.228	280	
30	218738.9	246232.2	57.089	290	
31	218748	246228.2	56.967	300	
32	218757.2	246224.2	56.778	310	
33	218766.4	246220.2	56.603	320	
34	218775.5	246216.1	56.587	330	
35	218784.7	246212.1	56.612	340	
36	218793.8	246208.1	56.575	350	
37	218803	246204.1	56.482	360	
38	218812.1	246200	56.857	370	
39	218821.3	246196	56.561	380	
40	218830.5	246192	56.674	390	
41	218839.6	246188	56.68	400	
42	218848.8	246184	56.579	410	
43	218857.9	246179.9	56.342	420	
44	218867.1	246175.9	55.979	430	
45	218876.2	246171.9	55.72	440	
46	218885.4	246167.9	55.621	450	
47	218894.6	246163.9	55.61	460	
48	218903.7	246159.8	55.609	470	
49	218912.9	246155.8	55.613	480	

Id	E	N	Elevation	Distance	WL
50	218922	246151.8	55.648	490	
51	218931.2	246147.8	55.355	500	
52	218940.3	246143.8	55.232	510	
53	218949.5	246139.7	55.4	520	
54	218958.6	246135.7	55.492	530	
55	218967.8	246131.7	55.5	540	
56	218977	246127.7	55.519	550	
57	218986.1	246123.7	55.56	560	
58	218995.3	246119.6	55.595	570	
59	219004.4	246115.6	55.677	580	
60	219013.6	246111.6	55.813	590	
61	219022.7	246107.6	55.947	600	
62	219031.9	246103.6	56.099	610	
8.1	618981	746123	56.501	612.90	54.026
8.2	618990	746114	54.522	625.17	54.026
8.3	618991	746113	54.119	627.14	54.026
8.4	618991	746113	53.693	627.57	54.026
8.5	618992	746112	53.708	628.66	54.026
8.6	618993	746111	53.866	629.83	54.026
8.7	618994	746110	54.549	631.36	54.026
8.8	618996	746108	55.849	634.44	54.026
2	219058.6	246082.9	56.221	644.44	
3	219067.7	246078.7	56.118	654.44	
4	219076.8	246074.6	55.92	664.44	
5	219085.9	246070.4	55.77	674.44	
6	219095	246066.2	55.746	684.44	
7	219104.1	246062.1	55.774	694.44	
8	219113.2	246057.9	55.793	704.44	
9	219122.3	246053.8	55.791	714.44	
10	219131.4	246049.6	55.778	724.44	
11	219140.5	246045.4	55.771	734.44	
12	219149.6	246041.3	55.746	744.44	
13	219158.7	246037.1	55.699	754.44	
14	219167.7	246032.9	55.72	764.44	
15	219176.8	246028.8	55.835	774.44	
16	219185.9	246024.6	55.932	784.44	
17	219195	246020.4	55.986	794.44	
18	219204.1	246016.3	56.033	804.44	
19	219213.2	246012.1	56.1	814.44	
20	219222.3	246007.9	56.179	824.44	
21	219231.4	246003.8	56.221	834.44	
22	219240.5	245999.6	56.229	844.44	
23	219249.6	245995.5	56.213	854.44	
24	219258.7	245991.3	56.168	864.44	
25	219267.8	245987.1	56.12	874.44	
26	219276.9	245983	56.093	884.44	
27	219285.9	245978.8	55.965	894.44	
28	219295	245974.6	55.879	904.44	
29	219304.1	245970.5	55.88	914.44	

Id	E	N	Elevation	Distance	WL
30	219313.2	245966.3	55.864	924.44	
31	219322.3	245962.1	55.82	934.44	
32	219331.4	245958	55.786	944.44	
33	219340.5	245953.8	55.771	954.44	
34	219349.6	245949.7	55.776	964.44	
35	219358.7	245945.5	55.804	974.44	
36	219367.8	245941.3	55.823	984.44	
37	219376.9	245937.2	55.816	994.44	
38	219386	245933	55.802	1004.44	
39	219395	245928.8	55.755	1014.44	
40	219404.1	245924.7	55.735	1024.44	
41	219413.2	245920.5	55.811	1034.44	
42	219422.3	245916.3	55.852	1044.44	
43	219431.4	245912.2	55.902	1054.44	
44	219440.5	245908	56.021	1064.44	
45	219449.6	245903.8	56.165	1074.44	
46	219458.7	245899.7	56.327	1084.44	
47	219467.8	245895.5	56.41	1094.44	
48	219476.9	245891.4	56.398	1104.44	
49	219486	245887.2	56.371	1114.44	
50	219495.1	245883	56.306	1124.44	
51	219504.2	245878.9	56.336	1134.44	
52	219513.2	245874.7	56.513	1144.44	
53	219522.3	245870.5	56.706	1154.44	
54	219531.4	245866.4	56.812	1164.44	
55	219540.5	245862.2	56.894	1174.44	
56	219549.6	245858	57.019	1184.44	
57	219558.7	245853.9	57.185	1194.44	
58	219567.8	245849.7	57.383	1204.44	
59	219576.9	245845.6	57.628	1214.44	
60	219586	245841.4	57.805	1224.44	
61	219595.1	245837.2	57.866	1234.44	
62	219604.2	245833.1	58.073	1244.44	
63	219613.3	245828.9	58.186	1254.44	
64	219622.4	245824.7	58.285	1264.44	
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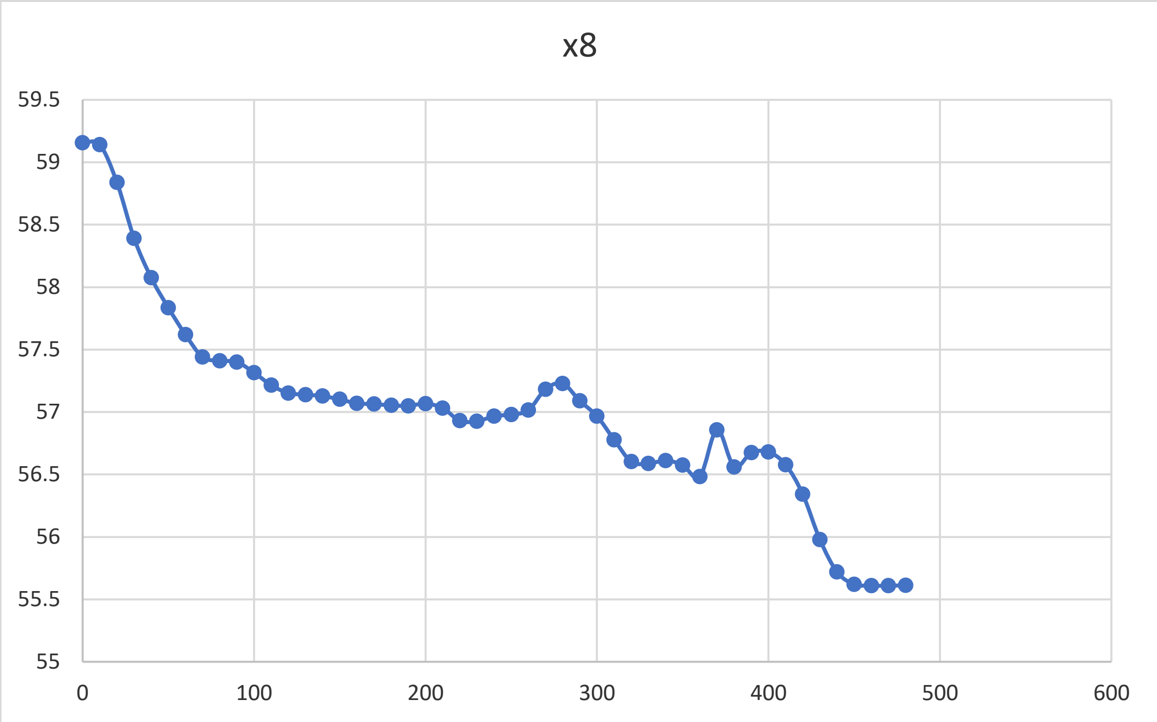
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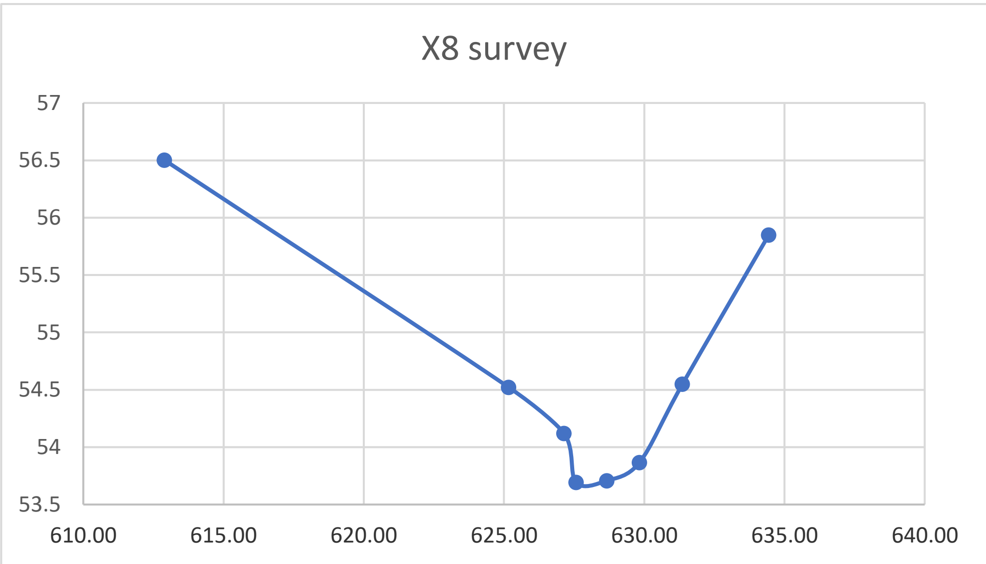
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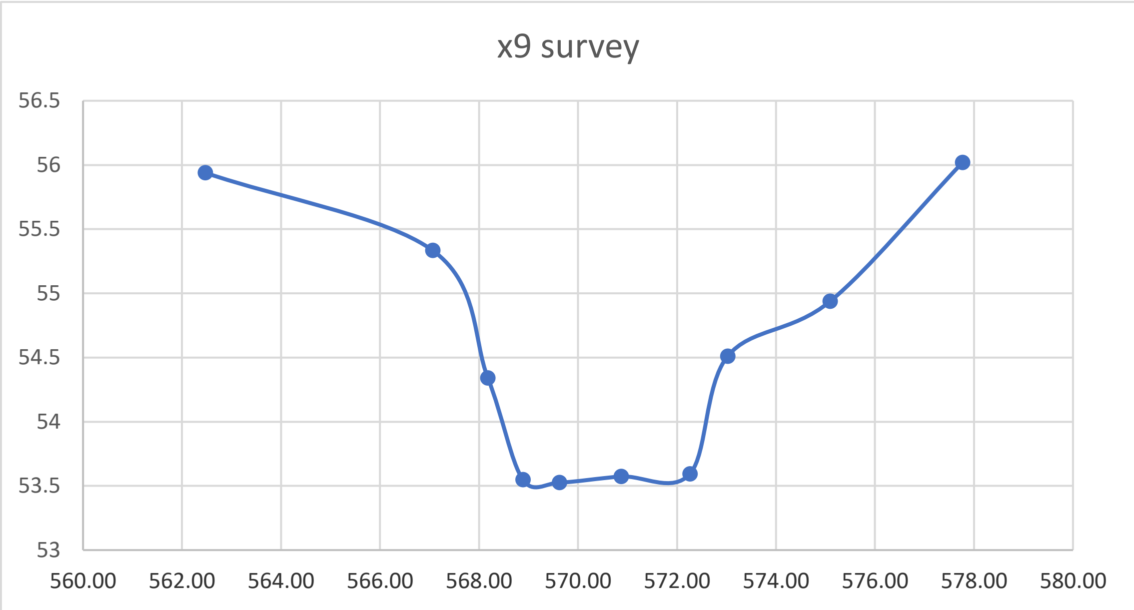
X Section 9

Id	E	N	Elevation	Distance	WL
1	218391.9	246154.2	58.935	0	
2	218400.6	246149.2	58.932	10	
3	218409.3	246144.2	58.864	20	
4	218418	246139.3	58.898	30	
5	218426.6	246134.3	59	40	
6	218435.3	246129.3	59.083	50	
7	218444	246124.3	59.168	60	
8	218452.6	246119.3	59.231	70	
9	218461.3	246114.4	59.195	80	
10	218470	246109.4	59.151	90	
11	218478.7	246104.4	59.018	100	
12	218487.3	246099.4	58.808	110	
13	218496	246094.4	58.54	120	
14	218504.7	246089.5	58.277	130	
15	218513.3	246084.5	58.054	140	
16	218522	246079.5	57.852	150	
17	218530.7	246074.5	57.664	160	
18	218539.4	246069.5	57.513	170	
19	218548	246064.5	57.562	180	
20	218556.7	246059.6	57.589	190	
21	218565.4	246054.6	57.549	200	
22	218574	246049.6	57.426	210	
23	218582.7	246044.6	57.295	220	
24	218591.4	246039.6	57.193	230	
25	218600.1	246034.7	57.117	240	
26	218608.7	246029.7	57.086	250	
27	218617.4	246024.7	56.958	260	
28	218626.1	246019.7	56.803	270	
29	218634.7	246014.7	56.784	280	
30	218643.4	246009.8	56.896	290	
31	218652.1	246004.8	57.001	300	
32	218660.8	245999.8	56.958	310	
33	218669.4	245994.8	56.877	320	
34	218678.1	245989.8	56.794	330	
35	218686.8	245984.9	56.825	340	
36	218695.5	245979.9	56.893	350	
37	218704.1	245974.9	56.781	360	
38	218712.8	245969.9	56.689	370	
39	218721.5	245964.9	56.533	380	
40	218730.1	245960	56.493	390	
41	218738.8	245955	56.521	400	
42	218747.5	245950	56.653	410	
43	218756.2	245945	56.67	420	
44	218764.8	245940	56.56	430	
45	218773.5	245935	56.39	440	
46	218782.2	245930.1	56.337	450	
47	218790.8	245925.1	56.304	460	
48	218799.5	245920.1	56.264	470	
49	218808.2	245915.1	56.162	480	

Id	E	N	Elevation	Distance	WL	
50	218816.9	245910.1	56.126	490		
51	218825.5	245905.2	56.178	500		
52	218834.2	245900.2	56.32	510		
53	218842.9	245895.2	56.488	520		
54	218851.5	245890.2	56.575	530		
55	218860.2	245885.2	56.52	540		
56	218868.9	245880.3	56.274	550		
57	218877.6	245875.3	56.189	560		
9.1	618826	745895	55.939	562.47	54.264	
9.2	618829	745891	55.334	567.06	54.264	Top of bank west
9.3	618829	745890	54.341	568.18	54.264	
9.4	618830	745890	53.549	568.89	54.264	
9.5	618831	745890	53.526	569.63	54.264	
9.6	618832	745889	53.573	570.87	54.264	
9.7	618832	745888	53.594	572.26	54.264	
9.8	618833	745888	54.51	573.02	54.264	
9.9	618834	745886	54.938	575.09	54.264	Top of bank east
9.10	618836	745884	56.018	577.77	54.264	
1	218897.8	245858.1	56.358	587.77		
2	218906.5	245853	56.221	597.77		
3	218915.1	245848	56.31	607.77		
4	218923.8	245843	56.452	617.77		
5	218932.4	245838	56.609	627.77		
6	218941.1	245833	56.677	637.77		
7	218949.8	245828	56.63	647.77		
8	218958.4	245823	56.582	657.77		
9	218967.1	245817.9	56.547	667.77		
10	218975.7	245812.9	56.52	677.77		
11	218984.4	245807.9	56.484	687.77		
12	218993	245802.9	56.461	697.77		
13	219001.7	245797.9	56.465	707.77		
14	219010.3	245792.9	56.505	717.77		
15	219019	245787.9	56.627	727.77		
16	219027.6	245782.8	56.736	737.77		
17	219036.3	245777.8	56.733	747.77		
18	219044.9	245772.8	56.583	757.77		
19	219053.6	245767.8	56.485	767.77		
20	219062.2	245762.8	56.54	777.77		
21	219070.9	245757.8	56.675	787.77		
22	219079.5	245752.8	56.703	797.77		
23	219088.2	245747.7	56.628	807.77		
24	219096.8	245742.7	56.492	817.77		
25	219105.5	245737.7	56.397	827.77		
26	219114.1	245732.7	56.242	837.77		
27	219122.8	245727.7	56.111	847.77		
28	219131.5	245722.7	56.122	857.77		
29	219140.1	245717.7	56.225	867.77		
30	219148.8	245712.6	56.353	877.77		
31	219157.4	245707.6	56.48	887.77		

Id	E	N	Elevation	Distance	WL
32	219166.1	245702.6	56.581	897.77	
33	219174.7	245697.6	56.534	907.77	
34	219183.4	245692.6	56.494	917.77	
35	219192	245687.6	56.514	927.77	
36	219200.7	245682.6	56.577	937.77	
37	219209.3	245677.5	56.694	947.77	
38	219218	245672.5	56.843	957.77	
39	219226.6	245667.5	56.899	967.77	
40	219235.3	245662.5	56.747	977.77	
41	219243.9	245657.5	56.547	987.77	
42	219252.6	245652.5	56.371	997.77	
43	219261.2	245647.5	56.197	1007.77	
44	219269.9	245642.4	56.137	1017.77	
45	219278.5	245637.4	56.182	1027.77	
46	219287.2	245632.4	56.213	1037.77	
47	219295.8	245627.4	56.212	1047.77	
48	219304.5	245622.4	56.226	1057.77	
49	219313.2	245617.4	56.23	1067.77	
50	219321.8	245612.4	56.183	1077.77	
51	219330.5	245607.3	56.128	1087.77	
52	219339.1	245602.3	56.105	1097.77	
53	219347.8	245597.3	56.179	1107.77	
54	219356.4	245592.3	56.444	1117.77	
55	219365.1	245587.3	56.741	1127.77	
56	219373.7	245582.3	56.923	1137.77	
57	219382.4	245577.3	57.085	1147.77	
58	219391	245572.2	57.244	1157.77	
59	219399.7	245567.2	57.427	1167.77	
60	219408.3	245562.2	57.62	1177.77	
61	219417	245557.2	57.783	1187.77	
62	219425.6	245552.2	57.861	1197.77	
63	219434.3	245547.2	57.972	1207.77	
64	219442.9	245542.2	58.139	1217.77	
65	219451.6	245537.1	58.327	1227.77	
66	219460.2	245532.1	58.486	1237.77	
67	219468.9	245527.1	58.679	1247.77	
68	219477.5	245522.1	58.928	1257.77	
69	219486.2	245517.1	59.181	1267.77	
70	219491.1	245514.3	59.331	1273.40	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X Section 10.1

Id	E	N	Elevation	Distance	WL
1	218584.9	246633.2	57.433	0	
2	218593.9	246629	57.097	10	
3	218603	246624.8	56.762	20	
4	218612	246620.5	56.564	30	
5	218621.1	246616.3	56.474	40	
6	218630.2	246612.1	56.384	50	
7	218639.2	246607.8	56.34	60	
8	218648.3	246603.6	56.323	70	
9	218657.3	246599.4	56.321	80	
10	218666.4	246595.1	56.327	90	
11	218675.5	246590.9	56.342	100	
12	218684.5	246586.7	56.35	110	
13	218693.6	246582.4	56.359	120	
14	218702.6	246578.2	56.384	130	
15	218711.7	246574	56.418	140	
16	218720.8	246569.7	56.442	150	
17	218729.8	246565.5	56.414	160	
18	218738.9	246561.3	56.341	170	
19	218747.9	246557	56.297	180	
20	218757	246552.8	56.32	190	
21	218766.1	246548.6	56.314	200	
22	218775.1	246544.3	56.222	210	
23	218784.2	246540.1	56.119	220	
24	218793.3	246535.9	56.09	230	
25	218802.3	246531.6	56.203	240	
26	218811.4	246527.4	56.337	250	
27	218820.4	246523.2	56.385	260	
28	218829.5	246518.9	56.231	270	
29	218838.6	246514.7	56.013	280	
30	218847.6	246510.5	55.863	290	
31	218856.7	246506.2	55.827	300	
32	218865.7	246502	55.81	310	
33	218874.8	246497.8	55.811	320	
34	218883.9	246493.6	55.826	330	
35	218892.9	246489.3	55.871	340	
36	218902	246485.1	55.918	350	
37	218911	246480.9	55.916	360	
38	218920.1	246476.6	55.814	370	
39	218929.2	246472.4	55.679	380	
40	218938.2	246468.2	55.739	390	
41	218947.3	246463.9	55.807	400	
42	218956.3	246459.7	55.806	410	
43	218965.4	246455.5	55.818	420	
44	218974.5	246451.2	55.81	430	
45	218983.5	246447	55.772	440	
46	218992.6	246442.8	55.695	450	
47	219001.6	246438.5	55.614	460	
48	219010.7	246434.3	55.581	470	
49	219019.8	246430.1	55.584	480	

Id	E	N	Elevation	Distance	WL
50	219028.8	246425.8	55.622	490	
51	219037.9	246421.6	55.693	500	
52	219046.9	246417.4	55.78	510	
53	219056	246413.1	55.879	520	
54	219065.1	246408.9	56.033	530	
55	219074.1	246404.7	56.328	540	
56	219083.2	246400.4	56.609	550	
57	219092.3	246396.2	56.759	560	
58	219101.3	246392	56.888	570	
59	219110.4	246387.7	57.11	580	
60	219119.4	246383.5	57.504	590	
61	219128.5	246379.3	58.198	600	
62	219137.6	246375	58.677	610	
63	219146.6	246370.8	58.129	620	
64	219155.7	246366.6	57.265	630	
65	219164.7	246362.3	56.554	640	
66	219173.8	246358.1	56.205	650	
10.1	619129	746378	55.241	650.32	53.625
10.2	619135	746375	54.726	656.93	53.625
10.4	619136	746373	53.275	657.59	53.625
10.5	619137	746224	52.958	658.59	53.625
10.6	619137	746372	53.098	659.94	53.625
10.7	619138	746372	53.422	660.67	53.625
10.8	619140	746371	54.182	661.79	53.625
10.9	619148	746370	55.242	663.91	53.625
68	219191.9	246349.7	55.67	671.87	
69	219201	246345.4	56.093	681.87	
70	219210	246341.2	56.089	691.87	
71	219219.1	246337	55.898	701.87	
72	219228.2	246332.7	55.875	711.87	
73	219237.2	246328.5	55.815	721.87	
74	219246.3	246324.3	55.707	731.87	
75	219255.3	246320	55.551	741.87	
76	219264.4	246315.8	55.369	751.87	
77	219273.5	246311.6	55.317	761.87	
78	219282.5	246307.3	55.323	771.87	
79	219291.6	246303.1	55.311	781.87	
80	219300.6	246298.9	55.293	791.87	
81	219309.7	246294.6	55.409	801.87	
82	219318.8	246290.4	55.636	811.87	
83	219327.8	246286.2	55.783	821.87	
84	219336.9	246281.9	55.802	831.87	
85	219346	246277.7	55.78	841.87	
86	219355	246273.5	55.67	851.87	
87	219364.1	246269.2	55.583	861.87	
88	219373.1	246265	55.5	871.87	
89	219382.2	246260.8	55.436	881.87	
90	219391.3	246256.5	55.475	891.87	
91	219400.3	246252.3	55.573	901.87	

Id	E	N	Elevation	Distance	WL
92	219409.4	246248.1	55.66	911.87	
93	219418.4	246243.8	55.637	921.87	
94	219427.5	246239.6	55.603	931.87	
95	219436.6	246235.4	55.635	941.87	
96	219445.6	246231.1	56.067	951.87	
97	219454.7	246226.9	55.816	961.87	
98	219463.7	246222.7	55.663	971.87	
99	219472.8	246218.5	55.653	981.87	
100	219481.9	246214.2	55.689	991.87	
101	219490.9	246210	55.751	1001.87	
102	219500	246205.8	55.785	1011.87	
103	219509	246201.5	55.739	1021.87	
104	219518.1	246197.3	55.708	1031.87	
105	219527.2	246193.1	55.763	1041.87	
106	219536.2	246188.8	55.861	1051.87	
107	219545.3	246184.6	55.995	1061.87	
108	219554.3	246180.4	56.106	1071.87	
109	219563.4	246176.1	56.245	1081.87	
110	219572.5	246171.9	56.502	1091.87	
111	219581.5	246167.7	56.795	1101.87	
112	219590.6	246163.4	57.028	1111.87	
113	219599.6	246159.2	57.171	1121.87	
114	219608.7	246155	57.302	1131.87	
115	219617.8	246150.7	57.426	1141.87	
116	219626.8	246146.5	57.583	1151.87	
117	219635.9	246142.3	57.787	1161.87	
118	219643.9	246138.5	57.923	1170.74	

X Section 10

Id	E	N	Elevation	Distance	WL
1	218384.5	246594.2	58.953	0	
2	218393.3	246589.5	58.558	10	
3	218402.2	246584.8	58.322	20	
4	218411	246580.1	58.315	30	
5	218419.8	246575.4	58.452	40	
6	218428.6	246570.7	58.659	50	
7	218437.5	246566	58.695	60	
8	218446.3	246561.3	58.309	70	
9	218455.1	246556.6	57.839	80	
10	218463.9	246551.9	57.383	90	
11	218472.8	246547.2	57.044	100	
12	218481.6	246542.5	56.932	110	
13	218490.4	246537.8	56.949	120	
14	218499.2	246533.1	56.996	130	
15	218508.1	246528.4	57.055	140	
16	218516.9	246523.7	57.077	150	
17	218525.7	246519	57.085	160	
18	218534.6	246514.3	57.091	170	
19	218543.4	246509.6	57.087	180	
20	218552.2	246504.9	57.086	190	
21	218561	246500.2	57.021	200	
22	218569.9	246495.5	56.959	210	
23	218578.7	246490.8	56.89	220	
24	218587.5	246486.1	56.828	230	
25	218596.3	246481.4	56.766	240	
26	218605.2	246476.7	56.673	250	
27	218614	246472	56.559	260	
28	218622.8	246467.3	56.451	270	
29	218631.6	246462.6	56.316	280	
30	218640.5	246457.9	56.216	290	
31	218649.3	246453.2	56.226	300	
32	218658.1	246448.5	56.327	310	
33	218666.9	246443.8	56.387	320	
34	218675.8	246439.1	56.386	330	
35	218684.6	246434.4	56.368	340	
36	218693.4	246429.7	56.253	350	
37	218702.3	246425	56.118	360	
38	218711.1	246420.3	56.092	370	
39	218719.9	246415.6	56.044	380	
40	218728.7	246410.9	55.996	390	
41	218737.6	246406.2	55.983	400	
42	218746.4	246401.5	55.988	410	
43	218755.2	246396.8	55.957	420	
44	218764	246392.1	55.921	430	
45	218772.9	246387.4	55.919	440	
46	218781.7	246382.7	55.927	450	
47	218790.5	246378	55.9	460	
48	218799.3	246373.3	55.872	470	
49	218808.2	246368.6	55.866	480	

Id	E	N	Elevation	Distance	WL	
50	218817	246363.9	55.904	490		
51	218825.8	246359.2	55.863	500		
52	218834.7	246354.5	55.806	510		
53	218843.5	246349.8	55.801	520		
54	218852.3	246345.1	55.893	530		
55	218861.1	246340.4	56.011	540		
56	218870	246335.7	56.069	550		
57	218878.8	246330.9	56.118	560		
58	218887.6	246326.2	56.119	570		
59	218896.4	246321.5	56.099	580		
60	218905.3	246316.8	56.164	590		
61	218914.1	246312.1	56.191	600		
62	218922.9	246307.4	56.207	610		
63	218931.7	246302.7	56.196	620		
64	218940.6	246298	56.168	630		
65	218949.4	246293.3	56.15	640		
66	218958.2	246288.6	56.207	650		
67	218967	246283.9	56.231	660		
68	218975.9	246279.2	56.176	670		
69	218984.7	246274.5	56.149	680		
70	218993.5	246269.8	56.209	690		
71	219002.4	246265.1	56.324	700		
72	219011.2	246260.4	56.467	710		
73	219020	246255.7	56.572	720		
74	219028.8	246251	56.575	730		
75	219037.7	246246.3	56.369	740		
76	219046.5	246241.6	56.108	750		
77	219055.3	246236.9	55.916	760		
78	219064.1	246232.2	55.775	770		
79	219073	246227.5	55.653	780		
80	219081.8	246222.8	55.482	790		
81	219090.6	246218.1	55.298	800		
82	219099.4	246213.4	55.183	810		
10.1	619054	746230	55.305	819.41	53.695	
10.2	619060	746227	54.844	826.02	53.695	Top of bank west
10.3	619061	746224	53.677	828.71	53.695	
10.4	619061	746224	53.318	829.37	53.695	
10.5	619062	746224	53.011	830.37	53.695	
10.6	619063	746223	53.138	831.72	53.695	
10.7	619064	746223	53.479	832.45	53.695	
10.8	619065	746223	54.289	833.58	53.695	
10.9	619067	746222	55.316	835.69	53.695	top of bank east
2	219129.3	246196.8	55.717	845.69		
3	219138.2	246192.2	55.678	855.69		
4	219147.1	246187.7	55.698	865.69		
5	219156	246183.1	55.791	875.69		
6	219164.9	246178.6	55.758	885.69		
7	219173.8	246174	55.686	895.69		
8	219182.7	246169.5	55.713	905.69		

Id	E	N	Elevation	Distance	WL
9	219191.6	246164.9	55.914	915.69	
10	219200.5	246160.4	56.16	925.69	
11	219209.4	246155.8	56.257	935.69	
12	219218.4	246151.3	56.319	945.69	
13	219227.3	246146.7	56.319	955.69	
14	219236.2	246142.2	56.158	965.69	
15	219245.1	246137.6	56.059	975.69	
16	219254	246133.1	55.994	985.69	
17	219262.9	246128.5	55.901	995.69	
18	219271.8	246124	55.766	1005.69	
19	219280.7	246119.4	55.653	1015.69	
20	219289.6	246114.9	55.633	1025.69	
21	219298.5	246110.3	55.66	1035.69	
22	219307.4	246105.8	55.721	1045.69	
23	219316.3	246101.2	55.834	1055.69	
24	219325.2	246096.7	55.921	1065.69	
25	219334.1	246092.1	55.916	1075.69	
26	219343	246087.6	55.837	1085.69	
27	219351.9	246083	55.695	1095.69	
28	219360.8	246078.5	55.601	1105.69	
29	219369.8	246073.9	55.578	1115.69	
30	219378.7	246069.4	55.568	1125.69	
31	219387.6	246064.8	55.572	1135.69	
32	219396.5	246060.3	55.66	1145.69	
33	219405.4	246055.7	55.61	1155.69	
34	219414.3	246051.2	55.53	1165.69	
35	219423.2	246046.6	55.621	1175.69	
36	219432.1	246042.1	55.705	1185.69	
37	219441	246037.5	55.774	1195.69	
38	219449.9	246033	55.795	1205.69	
39	219458.8	246028.4	55.8	1215.69	
40	219467.7	246023.9	55.802	1225.69	
41	219476.6	246019.3	55.812	1235.69	
42	219485.5	246014.8	55.831	1245.69	
43	219494.4	246010.2	55.851	1255.69	
44	219503.3	246005.7	55.882	1265.69	
45	219512.2	246001.1	55.883	1275.69	
46	219521.2	245996.6	55.862	1285.69	
47	219530.1	245992	55.911	1295.69	
48	219539	245987.5	55.97	1305.69	
49	219547.9	245983	56.12	1315.69	
50	219556.8	245978.4	56.221	1325.69	
51	219565.7	245973.9	56.188	1335.69	
52	219574.6	245969.3	56.224	1345.69	
53	219583.5	245964.8	56.274	1355.69	
54	219592.4	245960.2	56.428	1365.69	
55	219601.3	245955.7	56.637	1375.69	
56	219610.2	245951.1	56.898	1385.69	
57	219619.1	245946.6	57.102	1395.69	

Id	E	N	Elevation	Distance	WL
59	219636.9	245937.5	57.373	1415.69	
60	219645.8	245932.9	57.492	1425.69	
61	219654.7	245928.4	57.647	1435.69	
62	219663.6	245923.8	57.82	1445.69	
63	219672.6	245919.3	57.969	1455.69	
64	219681.5	245914.7	58.087	1465.69	
65	219690.4	245910.2	58.206	1475.69	
66	219699.3	245905.6	58.327	1485.69	
67	219708.2	245901.1	58.436	1495.69	
68	219717.1	245896.5	58.527	1505.69	
69	219726	245892	58.655	1515.69	
70	219734.9	245887.4	58.924	1525.69	
71	219736.4	245886.7	58.976	1527.34	

X Section 12

Id	E	N	Elevation	Distance	WL
1	218511.8	246678.5	58.464	0	
2	218521.8	246678	58.183	10	
3	218531.8	246677.4	57.557	20	
4	218541.7	246676.9	57.237	30	
5	218551.7	246676.4	57.15	40	
6	218561.7	246675.9	57.126	50	
7	218571.7	246675.4	57.095	60	
8	218581.7	246674.8	57.039	70	
9	218591.7	246674.3	56.989	80	
10	218601.7	246673.8	56.928	90	
11	218611.6	246673.3	56.834	100	
12	218621.6	246672.7	56.741	110	
13	218631.6	246672.2	56.657	120	
14	218641.6	246671.7	56.595	130	
15	218651.6	246671.2	56.499	140	
16	218661.6	246670.6	56.425	150	
17	218671.6	246670.1	56.397	160	
18	218681.6	246669.6	56.39	170	
19	218691.5	246669.1	56.363	180	
20	218701.5	246668.5	56.369	190	
21	218711.5	246668	56.479	200	
22	218721.5	246667.5	56.513	210	
23	218731.5	246667	56.346	220	
24	218741.5	246666.4	56.29	230	
25	218751.5	246665.9	56.316	240	
26	218761.4	246665.4	56.222	250	
27	218771.4	246664.9	56.153	260	
28	218781.4	246664.3	56.145	270	
29	218791.4	246663.8	56.123	280	
30	218801.4	246663.3	56.1	290	
31	218811.4	246662.8	56.203	300	
32	218821.4	246662.2	56.3	310	
33	218831.4	246661.7	56.266	320	
34	218841.3	246661.2	56.186	330	
35	218851.3	246660.7	56.112	340	
36	218861.3	246660.1	56.089	350	
37	218871.3	246659.6	56.106	360	
38	218881.3	246659.1	56.145	370	
39	218891.3	246658.6	56.157	380	
40	218901.3	246658	56.1	390	
41	218911.2	246657.5	56.023	400	
42	218921.2	246657	55.964	410	
43	218931.2	246656.5	55.999	420	
44	218941.2	246656	56.086	430	
45	218951.2	246655.4	56.109	440	
46	218961.2	246654.9	56.089	450	
47	218971.2	246654.4	56.064	460	
48	218981.2	246653.9	56.083	470	
49	218991.1	246653.3	56.136	480	

Id	E	N	Elevation	Distance	WL
50	219001.1	246652.8	56.179	490	
51	219011.1	246652.3	56.194	500	
52	219021.1	246651.8	56.176	510	
53	219031.1	246651.2	56.208	520	
54	219041.1	246650.7	56.302	530	
55	219051.1	246650.2	56.462	540	
56	219061	246649.7	56.657	550	
57	219071	246649.1	56.64	560	
58	219081	246648.6	56.463	570	
59	219091	246648.1	56.395	580	
60	219101	246647.6	56.403	590	
61	219111	246647	56.389	600	
62	219121	246646.5	56.344	610	
63	219131	246646	56.323	620	
64	219140.9	246645.5	56.353	630	
65	219150.9	246644.9	56.216	640	
66	219160.9	246644.4	55.994	650	
67	219170.9	246643.9	55.897	660	
68	219180.9	246643.4	55.844	670	
69	219190.9	246642.8	55.778	680	
70	219200.9	246642.3	55.727	690	
71	219210.8	246641.8	55.692	700	
72	219220.8	246641.3	55.685	710	
73	219230.8	246640.7	55.73	720	
74	219240.8	246640.2	55.71	730	
12.1	619188	746661	55.602	730.61	53.576
12.2	619191	746661	55.16	733.53	53.576
12.3	619192	746661	54.38	734.63	53.576
12.4	619193	746661	53.692	735.96	53.576
12.5	619193	746661	52.983	736.27	53.576
12.6	619195	746661	52.695	737.58	53.576
12.7	619196	746661	53.152	738.55	53.576
2	219259.1	246640.1	55.405	748.55	
3	219269.1	246639.9	55.571	758.55	
4	219279.1	246639.8	55.646	768.55	
5	219289.1	246639.6	55.711	778.55	
6	219299.1	246639.5	55.665	788.55	
7	219309.1	246639.3	55.616	798.55	
8	219319.1	246639.1	55.661	808.55	
9	219329.1	246639	56.331	818.55	
10	219339.1	246638.8	54.745	828.55	
11	219349.1	246638.7	55.388	838.55	
12	219359.1	246638.5	55.773	848.55	
13	219369.1	246638.4	55.663	858.55	
14	219379.1	246638.2	55.637	868.55	
15	219389.1	246638	55.634	878.55	
16	219399.1	246637.9	55.622	888.55	
17	219409.1	246637.7	55.607	898.55	
18	219419.1	246637.6	55.633	908.55	

Id	E	N	Elevation	Distance	WL
19	219429.1	246637.4	55.616	918.55	
20	219439.1	246637.3	55.552	928.55	
21	219449.1	246637.1	55.662	938.55	
22	219459.1	246637	56.006	948.55	
23	219469.1	246636.8	56.439	958.55	
24	219479.1	246636.6	56.913	968.55	
25	219489.1	246636.5	57.14	978.55	
26	219499.1	246636.3	57.195	988.55	
27	219509.1	246636.2	57.287	998.55	
28	219519.1	246636	57.425	1008.55	
29	219529.1	246635.9	57.587	1018.55	
30	219539.1	246635.7	57.816	1028.55	
31	219549.1	246635.5	58.153	1038.55	
32	219559.1	246635.4	58.472	1048.55	
33	219567.5	246635.3	58.53	1056.95	

X Section 13

Id	E	N	Elevation	Distance	WL
1	218718.4	247019.6	60.159	0	
2	218727.4	247015.2	59.928	10	
3	218736.3	247010.8	59.826	20	
4	218745.3	247006.5	59.704	30	
5	218754.3	247002.1	59.596	40	
6	218763.3	246997.7	59.494	50	
7	218772.3	246993.4	59.392	60	
8	218781.3	246989	59.355	70	
9	218790.3	246984.6	59.148	80	
10	218799.3	246980.2	58.827	90	
11	218808.3	246975.9	58.593	100	
12	218817.3	246971.5	58.469	110	
13	218826.3	246967.1	58.313	120	
14	218835.3	246962.7	58.117	130	
15	218844.3	246958.4	57.949	140	
16	218853.3	246954	57.911	150	
17	218862.3	246949.6	57.946	160	
18	218871.2	246945.2	57.854	170	
19	218880.2	246940.9	57.772	180	
20	218889.2	246936.5	57.685	190	
21	218898.2	246932.1	57.386	200	
22	218907.2	246927.7	57.267	210	
23	218916.2	246923.4	57.479	220	
24	218925.2	246919	57.663	230	
25	218934.2	246914.6	57.745	240	
26	218943.2	246910.3	57.817	250	
27	218952.2	246905.9	57.796	260	
28	218961.2	246901.5	57.654	270	
29	218970.2	246897.1	57.693	280	
30	218979.2	246892.8	57.805	290	
31	218988.2	246888.4	57.679	300	
32	218997.2	246884	57.309	310	
33	219006.1	246879.6	56.993	320	
34	219015.1	246875.3	56.759	330	
35	219024.1	246870.9	56.555	340	
36	219033.1	246866.5	56.422	350	
37	219042.1	246862.1	56.341	360	
38	219051.1	246857.8	56.236	370	
39	219060.1	246853.4	56.085	380	
40	219069.1	246849	56.014	390	
41	219078.1	246844.6	56.01	400	
42	219087.1	246840.3	55.933	410	
43	219096.1	246835.9	55.83	420	
44	219105.1	246831.5	55.726	430	
45	219114.1	246827.2	55.767	440	
46	219123.1	246822.8	55.85	450	
47	219132.1	246818.4	55.92	460	
48	219141	246814	56.067	470	
49	219150	246809.7	56.171	480	

Id	E	N	Elevation	Distance	WL	
50	219159	246805.3	56.23	490		
51	219168	246800.9	56.204	500		
52	219177	246796.5	56.083	510		
53	219186	246792.2	55.958	520		
54	219195	246787.8	55.95	530		
55	219204	246783.4	55.996	540		
56	219213	246779	56.042	550		
57	219222	246774.7	56.069	560		
58	219231	246770.3	56.177	570		
59	219240	246765.9	56.386	580		
60	219249	246761.5	56.412	590		
61	219258	246757.2	56.326	600		
62	219267	246752.8	56.249	610		
63	219275.9	246748.4	56.13	620		
64	219284.9	246744.1	55.799	630		
x13-1	619232	746765	55.615	630.32	53.551	
x13-2	619234	746763	55.541	633.43	53.551	
x13-3	619236	746762	55.381	635.14	53.551	top of bank west
x13-4	619237	746761	54.372	636.88	53.551	
x13-5	619237	746761	54.356	637.03	53.551	
x13-6	619239	746760	53.603	638.84	53.551	
x13-7	619240	746759	52.719	640.34	53.551	
x13-8	619241	746759	52.718	641.12	53.551	
x13-9	619242	746758	52.835	642.08	53.551	
x13-10	619242	746758	53.197	642.87	53.551	
x13-12	619242	746758	53.525	643.04	53.551	
x13-13	619243	746757	54.135	643.76	53.551	
x13-14	619244	746757	55.287	645.19	53.551	top of bank east
x13-15	619246	746756	55.392	647.04	53.551	
2	219308.4	246731.4	55.762	657.04		
3	219317.7	246727.8	55.619	667.04		
4	219327.1	246724.3	54.831	677.04		
5	219336.4	246720.7	54.467	687.04		
6	219345.8	246717.2	55.441	697.04		
7	219355.1	246713.7	55.518	707.04		
8	219364.5	246710.1	55.495	717.04		
9	219373.8	246706.6	55.512	727.04		
10	219383.2	246703	55.518	737.04		
11	219392.5	246699.5	55.518	747.04		
12	219401.9	246695.9	55.465	757.04		
13	219411.2	246692.4	55.458	767.04		
14	219420.6	246688.8	55.486	777.04		
15	219429.9	246685.3	55.486	787.04		
16	219439.3	246681.7	55.481	797.04		
17	219448.6	246678.2	55.564	807.04		
18	219458	246674.6	55.714	817.04		
19	219467.3	246671.1	55.874	827.04		
20	219476.7	246667.5	56.322	837.04		
21	219486	246664	56.758	847.04		

Id	E	N	Elevation	Distance	WL
22	219495.4	246660.4	56.969	857.04	
23	219504.7	246656.9	57.061	867.04	
24	219514.1	246653.3	57.124	877.04	
25	219523.4	246649.8	57.213	887.04	
26	219532.8	246646.2	57.416	897.04	
27	219542.1	246642.7	57.692	907.04	
28	219551.5	246639.1	58.108	917.04	
29	219560.8	246635.6	58.49	927.04	
30	219570.2	246632	58.647	937.04	
31	219579.5	246628.5	58.725	947.04	
32	219580.7	246628.1	58.732	948.31	

X Section 14

Id	E	N	Elevation	Distance	WL
1	218731.6	246964.7	60.132	0	
2	218741.5	246963.9	59.908	10	
3	218751.5	246963	59.629	20	
4	218761.5	246962.1	59.389	30	
5	218771.4	246961.2	59.163	40	
6	218781.4	246960.3	58.833	50	
7	218791.3	246959.4	58.546	60	
8	218801.3	246958.5	58.315	70	
9	218811.3	246957.6	58.203	80	
10	218821.2	246956.8	58.089	90	
11	218831.2	246955.9	57.964	100	
12	218841.1	246955	57.86	110	
13	218851.1	246954.1	57.882	120	
14	218861.1	246953.2	58.01	130	
15	218871	246952.3	57.965	140	
16	218881	246951.4	57.85	150	
17	218890.9	246950.5	57.774	160	
18	218900.9	246949.6	57.712	170	
19	218910.9	246948.8	57.721	180	
20	218920.8	246947.9	57.782	190	
21	218930.8	246947	57.792	200	
22	218940.8	246946.1	57.748	210	
23	218950.7	246945.2	57.635	220	
24	218960.7	246944.3	57.485	230	
25	218970.6	246943.4	57.394	240	
26	218980.6	246942.5	57.29	250	
27	218990.6	246941.6	57.172	260	
28	219000.5	246940.8	57.073	270	
29	219010.5	246939.9	56.924	280	
30	219020.4	246939	56.787	290	
31	219030.4	246938.1	56.64	300	
32	219040.4	246937.2	56.45	310	
33	219050.3	246936.3	56.319	320	
34	219060.3	246935.4	56.239	330	
35	219070.2	246934.5	56.233	340	
36	219080.2	246933.7	56.236	350	
37	219090.2	246932.8	56.192	360	
38	219100.1	246931.9	56.127	370	
39	219110.1	246931	56.069	380	
40	219120	246930.1	55.991	390	
41	219130	246929.2	55.948	400	
42	219140	246928.3	55.945	410	
43	219149.9	246927.4	55.873	420	
44	219159.9	246926.5	55.743	430	
45	219169.9	246925.7	55.638	440	
46	219179.8	246924.8	55.554	450	
47	219189.8	246923.9	55.491	460	
48	219199.7	246923	55.464	470	
49	219209.7	246922.1	55.409	480	

Id	E	N	Elevation	Distance	WL
50	219219.7	246921.2	55.347	490	
51	219229.6	246920.3	55.303	500	
52	219239.6	246919.4	55.257	510	
53	219249.5	246918.5	55.255	520	
54	219259.5	246917.7	55.248	530	
55	219269.5	246916.8	55.23	540	
56	219279.4	246915.9	55.25	550	
57	219289.4	246915	55.366	560	
58	219299.3	246914.1	55.604	570	
59	219309.3	246913.2	55.786	580	
60	219319.3	246912.3	55.913	590	
x14-1	619269	746933	55.704	593.25	53.342
x14-2	619271	746933	55.043	595.25	53.342
x14-3	619272	746933	54.675	596.13	53.342
x14-4	619274	746933	53.43	598.10	53.342
x14-5	619274	746933	52.747	598.38	53.342
x14-6	619276	746933	52.556	600.03	53.342
x14-7	619277	746933	52.779	601.70	53.342
x14-8	619278	746933	53.46	602.27	53.342
x14-9	619278	746932	53.81	602.83	53.342
2	219341.9	246911	55.511	612.83	
3	219351.8	246910.4	55.874	622.83	
4	219361.8	246909.9	55.854	632.83	
5	219371.8	246909.3	55.774	642.83	
6	219381.8	246908.7	55.677	652.83	
7	219391.8	246908.1	55.687	662.83	
8	219401.8	246907.6	55.772	672.83	
9	219411.7	246907	55.954	682.83	
10	219421.7	246906.4	56.133	692.83	
11	219431.7	246905.8	56.233	702.83	
12	219441.7	246905.3	56.219	712.83	
13	219451.7	246904.7	56.247	722.83	
14	219461.7	246904.1	56.267	732.83	
15	219471.7	246903.5	56.261	742.83	
16	219481.6	246903	56.278	752.83	
17	219491.6	246902.4	56.376	762.83	
18	219501.6	246901.8	56.43	772.83	
19	219511.6	246901.2	56.361	782.83	
20	219521.6	246900.7	56.357	792.83	
21	219531.6	246900.1	56.345	802.83	
22	219541.5	246899.5	56.343	812.83	
23	219551.5	246898.9	56.456	822.83	
24	219561.5	246898.4	56.596	832.83	
25	219571.5	246897.8	56.724	842.83	
26	219581.5	246897.2	56.838	852.83	
27	219591.5	246896.6	57.106	862.83	
28	219601.4	246896.1	57.483	872.83	
29	219611.4	246895.5	57.983	882.83	
30	219621.4	246894.9	58.626	892.83	

Id	E	N	Elevation	Distance	WL
31	219631.4	246894.3	59.436	902.83	
32	219641.4	246893.7	60.268	912.83	
33	219646	246893.5	60.578	917.44	

X Section 15

Id	E	N	Elevation	Distance	WL
1	218747.6	247175.3	60.458	0	
2	218757.5	247174.4	60.064	10	
3	218767.5	247173.4	59.774	20	
4	218777.4	247172.4	59.574	30	
5	218787.4	247171.4	59.315	40	
6	218797.4	247170.5	59.011	50	
7	218807.3	247169.5	58.758	60	
8	218817.3	247168.5	58.526	70	
9	218827.2	247167.5	58.332	80	
10	218837.2	247166.6	58.206	90	
11	218847.1	247165.6	58.11	100	
12	218857.1	247164.6	58.059	110	
13	218867	247163.6	57.983	120	
14	218877	247162.6	57.869	130	
15	218886.9	247161.7	57.748	140	
16	218896.9	247160.7	57.631	150	
17	218906.8	247159.7	57.53	160	
18	218916.8	247158.7	57.444	170	
19	218926.7	247157.8	57.368	180	
20	218936.7	247156.8	57.309	190	
21	218946.6	247155.8	57.216	200	
22	218956.6	247154.8	57.107	210	
23	218966.5	247153.9	57.017	220	
24	218976.5	247152.9	56.993	230	
25	218986.5	247151.9	56.934	240	
26	218996.4	247150.9	56.819	250	
27	219006.4	247150	56.703	260	
28	219016.3	247149	56.579	270	
29	219026.3	247148	56.489	280	
30	219036.2	247147	56.421	290	
31	219046.2	247146.1	56.331	300	
32	219056.1	247145.1	56.244	310	
33	219066.1	247144.1	56.163	320	
34	219076	247143.1	56.081	330	
35	219086	247142.2	55.994	340	
36	219095.9	247141.2	55.892	350	
37	219105.9	247140.2	55.837	360	
38	219115.8	247139.2	55.818	370	
39	219125.8	247138.3	55.763	380	
40	219135.7	247137.3	55.71	390	
41	219145.7	247136.3	55.645	400	
42	219155.6	247135.3	55.604	410	
43	219165.6	247134.4	55.61	420	
44	219175.6	247133.4	55.643	430	
45	219185.5	247132.4	55.691	440	
46	219195.5	247131.4	55.639	450	
47	219205.4	247130.5	55.572	460	
48	219215.4	247129.5	55.617	470	
49	219225.3	247128.5	55.631	480	

Id	E	N	Elevation	Distance	WL
50	219235.3	247127.5	55.524	490	
51	219245.2	247126.6	55.4	500	
52	219255.2	247125.6	55.326	510	
53	219265.1	247124.6	55.291	520	
54	219275.1	247123.6	55.27	530	
55	219285	247122.7	55.241	540	
56	219295	247121.7	55.163	550	
57	219304.9	247120.7	55.08	560	
58	219314.9	247119.7	55.1	570	
59	219324.8	247118.8	55.288	580	
x15-1	619280	747139	55.172	588.78	53.159
x15-2	619283	747140	55.317	592.251	53.159
x15-3	619287	747140	55.166	596.184	53.159
x15-4	619289	747140	54.606	597.977	53.159
x15-5	619290	747141	53.866	599.474	53.159
x15-6	619292	747141	52.087	601.28	53.159
x15-7	619294	747141	51.936	602.592	53.159
x15-8	619295	747141	52.3	604.408	53.159
x15-9	619296	747141	53.438	604.798	53.159
2	219359	247119.7	55.211	614.798	
3	219369	247119.5	55.469	624.798	
4	219379	247119.4	55.632	634.798	
5	219389	247119.3	55.772	644.798	
6	219399	247119.1	55.82	654.798	
7	219409	247119	55.769	664.798	
8	219419	247118.9	55.719	674.798	
9	219429	247118.8	55.734	684.798	
10	219439	247118.6	55.818	694.798	
11	219449	247118.5	55.894	704.798	
12	219459	247118.4	55.982	714.798	
13	219469	247118.2	56.067	724.798	
14	219479	247118.1	56.141	734.798	
15	219489	247118	56.333	744.798	
16	219499	247117.8	56.648	754.798	
17	219509	247117.7	57.081	764.798	
18	219519	247117.6	57.607	774.798	
19	219529	247117.5	58.091	784.798	
20	219539	247117.3	58.554	794.798	
21	219549	247117.2	58.843	804.798	
22	219559	247117.1	59.061	814.798	
23	219569	247116.9	59.113	824.798	
24	219579	247116.8	58.975	834.798	
25	219589	247116.7	58.862	844.798	
26	219599	247116.6	58.489	854.798	
27	219609	247116.4	58.525	864.798	
28	219619	247116.3	58.67	874.798	
29	219629	247116.2	58.889	884.798	
30	219636.4	247116.1	59.64	892.138	

X Section 16

Id	E	N	Elevation	Distance	WL
1	218850.1	247321.9	60.469	0	
2	218860.1	247321.3	60.008	10	
3	218870	247320.6	59.513	20	
4	218880	247320	59.01	30	
5	218890	247319.4	58.579	40	
6	218900	247318.8	58.194	50	
7	218910	247318.2	57.883	60	
8	218920	247317.6	57.701	70	
9	218929.9	247317	57.58	80	
10	218939.9	247316.4	57.493	90	
11	218949.9	247315.8	57.346	100	
12	218959.9	247315.2	57.155	110	
13	218969.9	247314.6	56.98	120	
14	218979.8	247314	56.8	130	
15	218989.8	247313.4	56.704	140	
16	218999.8	247312.8	56.64	150	
17	219009.8	247312.2	56.551	160	
18	219019.8	247311.6	56.464	170	
19	219029.8	247311	56.418	180	
20	219039.7	247310.4	56.43	190	
21	219049.7	247309.8	56.382	200	
22	219059.7	247309.1	56.288	210	
23	219069.7	247308.5	56.214	220	
24	219079.7	247307.9	56.148	230	
25	219089.6	247307.3	56.094	240	
26	219099.6	247306.7	56.077	250	
27	219109.6	247306.1	56.06	260	
28	219119.6	247305.5	56.024	270	
29	219129.6	247304.9	55.974	280	
30	219139.6	247304.3	55.949	290	
31	219149.5	247303.7	55.932	300	
32	219159.5	247303.1	55.915	310	
33	219169.5	247302.5	55.912	320	
34	219179.5	247301.9	55.906	330	
35	219189.5	247301.3	55.89	340	
36	219199.4	247300.7	55.867	350	
37	219209.4	247300.1	55.856	360	
38	219219.4	247299.5	55.873	370	
39	219229.4	247298.9	55.893	380	
40	219239.4	247298.3	55.879	390	
41	219249.4	247297.6	55.866	400	
42	219259.3	247297	55.885	410	
43	219269.3	247296.4	55.885	420	
44	219279.3	247295.8	55.868	430	
45	219289.3	247295.2	55.84	440	
46	219299.3	247294.6	55.811	450	
47	219309.3	247294	55.783	460	
48	219319.2	247293.4	55.756	470	
49	219329.2	247292.8	55.732	480	

Id	E	N	Elevation	Distance	WL	
50	219339.2	247292.2	55.72	490		
51	219349.2	247291.6	55.599	500		
x16-1	619299	747312	55.283	502.79	53.168	
x16-2	619302	747312	55.24	506.44	53.168	top of bank-west
x16-3	619302	747312	55.235	506.45	53.168	
x16-4	619304	747311	54.507	508.09	53.168	
x16-5	619305	747312	53.708	509.14	53.168	
x16-6	619306	747312	52.323	510.77	53.168	
x16-7	619308	747312	51.784	512.27	53.168	
x16-8	619308	747312	51.781	512.29	53.168	
x16-9	619309	747312	52.04	513.83	53.168	
x16-10	619310	747312	53.005	514.19	53.168	
x16-11	619310	747312	52.997	514.24	53.168	
x16-13	619311	747312	53.624	515.44	53.168	
x16-14	619313	747311	54.8	517.56	53.168	
x16-15	619314	747310	55.251	518.95	53.168	top of bank-east
x16-16	619316	747310	55.31	521.23	53.168	
2	219379.3	247289	55.597	531.23		
3	219389.3	247288.5	55.437	541.23		
4	219399.3	247288	55.349	551.23		
5	219409.3	247287.5	55.362	561.23		
6	219419.2	247287	55.476	571.23		
7	219429.2	247286.5	55.532	581.23		
8	219439.2	247286	55.526	591.23		
9	219449.2	247285.5	55.587	601.23		
10	219459.2	247285	55.779	611.23		
11	219469.2	247284.5	55.938	621.23		
12	219479.2	247284	56.047	631.23		
13	219489.2	247283.5	56.186	641.23		
14	219499.1	247283	56.305	651.23		
15	219509.1	247282.5	56.411	661.23		
16	219519.1	247282	56.818	671.23		
17	219529.1	247281.5	57.139	681.23		
18	219539.1	247281.1	57.464	691.23		
19	219549.1	247280.6	57.501	701.23		
20	219559.1	247280.1	57.648	711.23		
21	219569.1	247279.6	57.784	721.23		
22	219579.1	247279.1	57.657	731.23		
23	219589	247278.6	57.453	741.23		
24	219599	247278.1	57.337	751.23		
25	219609	247277.6	57.381	761.23		
26	219619	247277.1	57.622	771.23		
27	219629	247276.6	58.111	781.23		
28	219639	247276.1	59.238	791.23		
29	219649	247275.6	59.751	801.23		
30	219659	247275.1	59.941	811.23		
31	219668.9	247274.6	60.042	821.23		
32	219678.9	247274.1	60.356	831.23		
33	219688.9	247273.6	60.332	841.23		

X Section 18

Id	E	N	Elevation	Distance 0	WL
1	218952.2	247553.7	60.291	0	
2	218962.1	247552.6	60.045	10	
3	218972.1	247551.6	59.75	20	
4	218982	247550.6	59.43	30	
5	218992	247549.6	59.067	40	
6	219001.9	247548.5	58.654	50	
7	219011.9	247547.5	58.355	60	
8	219021.8	247546.5	58.11	70	
9	219031.7	247545.5	57.841	80	
10	219041.7	247544.4	57.537	90	
11	219051.6	247543.4	57.271	100	
12	219061.6	247542.4	57.046	110	
13	219071.5	247541.4	56.835	120	
14	219081.5	247540.3	56.64	130	
15	219091.4	247539.3	56.461	140	
16	219101.4	247538.3	56.393	150	
17	219111.3	247537.3	56.41	160	
18	219121.3	247536.2	56.4	170	
19	219131.2	247535.2	56.369	180	
20	219141.2	247534.2	56.326	190	
21	219151.1	247533.2	56.227	200	
22	219161.1	247532.1	56.062	210	
23	219171	247531.1	56.048	220	
24	219181	247530.1	56.17	230	
25	219190.9	247529.1	56.258	240	
26	219200.9	247528	56.302	250	
27	219210.8	247527	56.302	260	
28	219220.8	247526	56.281	270	
29	219230.7	247525	56.217	280	
30	219240.7	247523.9	56.13	290	
31	219250.6	247522.9	56.072	300	
32	219260.5	247521.9	56.053	310	
33	219270.5	247520.9	56.057	320	
34	219280.4	247519.8	56.082	330	
35	219290.4	247518.8	55.985	340	
36	219300.3	247517.8	55.867	350	
37	219310.3	247516.8	55.747	360	
38	219320.2	247515.8	55.595	370	
39	219330.2	247514.7	55.539	380	
40	219340.1	247513.7	55.549	390	
41	219350.1	247512.7	55.565	400	
42	219360	247511.7	55.558	410	
43	219370	247510.6	55.401	420	
x18-12	619317	747531	54.964	420.57	53.168
x18-11	619322	747532	54.196	425.10	53.168
x18-10	619322	747532	54.187	426.42	53.168
x18-9	619323	747530	53.623	427.52	53.168
x18-8	619323	747530	53.622	427.53	53.168

Id		E	N	Elevation	Distance	WL
x18-7		619323	747530	53.638	427.58	53.168
x18-6		619325	747528	53.098	430.28	53.168
x18-5		619326	747528	51.82	430.49	53.168
x18-2		619327	747528	51.703	432.22	53.168
x18-1		619328	747526	55.387	434.65	53.168
	2	219391.7	247504.3	55.32	444.65	
	3	219401.6	247503.9	55.617	454.65	
	4	219411.6	247503.4	56.363	464.65	
	5	219421.6	247503	57.172	474.65	
	6	219431.6	247502.5	57.242	484.65	
	7	219441.6	247502.1	57.297	494.65	
	8	219451.6	247501.7	56.969	504.65	
	9	219461.6	247501.2	56.91	514.65	
	10	219471	247500.8	57.237	524.08	

X Section 19

Id	E	N	Elevation	Distance 0	WL
1	219063.4	247715.7	60.608	0	
2	219073.3	247714.2	60.107	10	
3	219083.2	247712.7	59.608	20	
4	219093.1	247711.3	59.175	30	
5	219102.9	247709.8	58.753	40	
6	219112.8	247708.4	58.317	50	
7	219122.7	247706.9	57.932	60	
8	219132.6	247705.4	57.551	70	
9	219142.5	247704	57.183	80	
10	219152.4	247702.5	56.941	90	
11	219162.3	247701.1	56.806	100	
12	219172.2	247699.6	56.777	110	
13	219182.1	247698.1	56.696	120	
14	219192	247696.7	56.517	130	
15	219201.9	247695.2	56.306	140	
16	219211.8	247693.8	56.019	150	
17	219221.7	247692.3	55.784	160	
18	219231.6	247690.8	55.682	170	
19	219241.4	247689.4	55.579	180	
20	219251.3	247687.9	55.378	190	
21	219261.2	247686.4	55.189	200	
x19-1	619215	747706	54.717	206.97	53.091
x19-2	619221	747707	54.545	213.4293217	53.091
x19-3	619225	747703	53.956	219.484191	53.091
x19-4	619226	747703	53.241	220.6859601	53.091
x19-5	619228	747703	52.015	222.0829687	53.091
x19-6	619228	747703	52.029	222.2152789	53.091
x19-7	619229	747703	52.085	223.4525469	53.091
x19-8	619231	747703	52.322	225.2240892	53.091
x19-10	619231	747704	53.261	225.786396	53.091
x19-11	619234	747704	53.601	228.0808766	53.091
2	219297	247683.2	55.55	238.0808766	
3	219307	247683.1	55.526	248.0808766	
4	219317	247683.1	56.278	258.0808766	
5	219327	247683	58.187	268.0808766	
6	219333.8	247682.9	59.09	274.8918766	

X Section 21

Id	E	N	Elevation	Distance	WL
1	220335.5	245876.7	58.131	0	
2	220341	245885	57.883	10	
3	220346.6	245893.3	57.612	20	
4	220352.1	245901.7	57.378	30	
5	220357.7	245910	57.179	40	
6	220363.2	245918.3	57.071	50	
7	220368.8	245926.6	56.982	60	
8	220374.3	245934.9	56.915	70	
9	220379.9	245943.3	56.85	80	
10	220385.4	245951.6	56.757	90	
11	220391	245959.9	56.643	100	
12	220396.5	245968.2	56.613	110	
13	220402	245976.6	56.522	120	
14	220407.6	245984.9	56.416	130	
15	220413.1	245993.2	56.37	140	
16	220418.7	246001.5	56.371	150	
17	220424.2	246009.8	56.418	160	
18	220429.8	246018.2	56.429	170	
19	220435.3	246026.5	56.42	180	
20	220440.9	246034.8	56.405	190	
21	220446.4	246043.1	56.397	200	
22	220452	246051.4	56.387	210	
23	220457.5	246059.8	56.409	220	
24	220463.1	246068.1	56.454	230	
25	220468.6	246076.4	56.535	240	
26	220474.2	246084.7	56.617	250	
27	220479.7	246093	56.774	260	
28	220485.3	246101.4	56.775	270	
21.1	620433	746124	56.797	271.85	54.94
21.2	620435	746127	56.5	275.17	54.94
21.3	620436	746127	55.184	276.76	54.94
21.4	620437	746128	54.257	277.63	54.94
21.5	620437	746128	54.245	277.64	54.94
21.6	620437	746129	54.113	278.80	54.94
21.7	620438	746130	54.276	279.94	54.94
21.8	620438	746131	55.283	280.57	54.94
21.9	620438	746132	55.963	282.14	54.94
21.1	620439	746134	56.839	283.95	54.94
1	220496.7	246121.9	56.874	293.95	
2	220501.1	246130.9	56.719	303.95	
3	220505.4	246139.9	56.603	313.95	
4	220509.8	246148.9	56.542	323.95	
5	220514.1	246157.9	56.556	333.95	
6	220518.5	246166.9	56.522	343.95	
7	220522.8	246175.9	56.461	353.95	
8	220527.2	246184.9	56.416	363.95	
9	220531.5	246193.9	56.428	373.95	
10	220535.9	246202.9	56.44	383.95	
11	220540.3	246211.9	56.477	393.95	

Id	E	N	Elevation	Distance	WL
12	220544.6	246220.9	56.523	403.95	
13	220549	246229.9	56.55	413.95	
14	220553.3	246238.9	56.557	423.95	
15	220557.7	246247.9	56.552	433.95	
16	220562	246256.9	56.572	443.95	
17	220566.4	246265.9	56.61	453.95	
18	220570.7	246274.9	56.67	463.95	
19	220575.1	246283.9	56.772	473.95	
20	220579.4	246292.9	56.886	483.95	
21	220583.8	246301.9	57.006	493.95	
22	220588.1	246310.9	57.21	503.95	
23	220592.5	246319.9	57.47	513.95	
24	220596.9	246328.9	57.639	523.95	
25	220601.2	246338	57.946	533.95	
26	220605.6	246347	58.351	543.95	
27	220609.9	246356	58.571	553.95	
28	220614.3	246365	58.781	563.95	
29	220614.9	246366.3	58.821	565.47	

X Section 21

Id	E	N	Elevation	Distance	WL	
1	220774.9	245665.1	58.282	0		
2	220777.1	245674.9	58.125	10		
3	220779.3	245684.6	57.99	20		
4	220781.5	245694.4	57.888	30		
5	220783.7	245704.1	57.78	40		
6	220785.9	245713.9	57.677	50		
7	220788.1	245723.6	57.58	60		
8	220790.3	245733.4	57.523	70		
9	220792.6	245743.1	57.474	80		
10	220794.8	245752.9	57.394	90		
11	220797	245762.6	57.331	100		
12	220799.2	245772.4	57.282	110		
13	220801.4	245782.1	57.216	120		
14	220803.6	245791.9	57.15	130		
15	220805.8	245801.7	57.117	140		
16	220808	245811.4	57.121	150		
17	220810.2	245821.2	57.093	160		
18	220812.4	245830.9	56.995	170		
19	220814.7	245840.7	56.879	180		
20	220816.9	245850.4	56.825	190		
21	220819.1	245860.2	56.814	200		
22	220821.3	245869.9	56.79	210		
23	220823.5	245879.7	56.795	220		
24	220825.7	245889.4	56.783	230		
25	220827.9	245899.2	56.727	240		
26	220830.1	245908.9	56.693	250		
27	220832.3	245918.7	56.706	260		
28	220834.6	245928.4	56.708	270		
29	220836.8	245938.2	56.703	280		
30	220839	245948	56.711	290		
31	220841.2	245957.7	56.723	300		
32	220843.4	245967.5	56.769	310		
33	220845.6	245977.2	56.937	320		
22.9	620800	746021	57.13	324.31	55.252	Top of bank south
22.1	620799	746019	56.225	326.65	55.252	
22.11	620799	746017	55.627	328.32	55.252	
22.12	620798	746016	54.841	329.21	55.252	
22.13	620798	746015	54.878	330.33	55.252	
22.14	620798	746014	54.935	331.46	55.252	
22.15	620798	746014	55.545	332.05	55.252	
22.16	620798	746013	55.872	332.39	55.252	
22.17	620797	746012	56.749	333.54	55.252	
22.18	620796	746010	57.223	336.07	55.252	top of bank north
22.19	620793	746001	56.627	345.46	55.252	
1	220856.3	246009.6	57.204	355.46		
2	220859.3	246019.2	57.162	365.46		
3	220862.2	246028.7	57.141	375.46		
4	220865.2	246038.3	57.114	385.46		
5	220868.2	246047.8	57.102	395.46		

Id	E	N	Elevation	Distance	WL
6	220871.2	246057.4	57.014	405.46	
7	220874.2	246066.9	56.917	415.46	
8	220877.1	246076.5	56.893	425.46	
9	220880.1	246086	56.955	435.46	
10	220883.1	246095.6	56.946	445.46	
11	220886.1	246105.1	56.9	455.46	
12	220889.1	246114.6	56.844	465.46	
13	220892	246124.2	56.791	475.46	
14	220895	246133.7	56.755	485.46	
15	220898	246143.3	56.744	495.46	
16	220901	246152.8	56.716	505.46	
17	220904	246162.4	56.717	515.46	
18	220906.9	246171.9	56.737	525.46	
19	220909.9	246181.5	56.794	535.46	
20	220912.9	246191	56.989	545.46	
21	220915.9	246200.6	57.195	555.46	
22	220918.9	246210.1	57.315	565.46	
23	220921.8	246219.7	57.44	575.46	
24	220924.8	246229.2	57.696	585.46	
25	220927.8	246238.7	58.13	595.46	
26	220930.8	246248.3	58.481	605.46	
27	220933.8	246257.8	58.862	615.46	
28	220935.8	246264.4	59.127	622.36	

X Section 23

Id	E	N	Elevation	Distance	WL
1	218971.2	245322.7	59.572	0	
2	218977	245330.8	59.128	10	
3	218982.9	245338.9	58.85	20	
4	218988.8	245347	58.597	30	
5	218994.6	245355.1	58.389	40	
6	219000.5	245363.3	58.144	50	
7	219006.3	245371.4	57.753	60	
8	219012.2	245379.5	57.268	70	
9	219018	245387.6	57.01	80	
10	219023.9	245395.7	56.769	90	
11	219029.7	245403.8	56.582	100	
x23.1	618985	745431	56.982	102.375	55
x23.2	618984	745430	55.819	107.62	55
x23.3	618983	745429	55.355	109.17	55
x23.4	618981	745429	54.356	110.01	55
x23.5	618980	745428	55.116	110.60	55
x23.6	618979	745427	55.773	112.17	55
x23.7	618978	745427	56.508	114.22	55
2	219044.2	245418.3	56.529	124.22	
3	219049.9	245426.6	56.544	134.22	
4	219055.5	245434.8	56.498	144.22	
5	219061.2	245443.1	56.446	154.22	
6	219066.8	245451.4	56.445	164.22	
7	219072.5	245459.6	56.467	174.22	
8	219078.1	245467.9	56.477	184.22	
9	219083.8	245476.1	56.434	194.22	
10	219089.4	245484.4	56.37	204.22	
11	219095.1	245492.6	56.364	214.22	
12	219100.7	245500.9	56.401	224.22	
13	219106.4	245509.1	56.413	234.22	
14	219112	245517.4	56.343	244.22	
15	219117.7	245525.6	56.274	254.22	
16	219123.3	245533.9	56.249	264.22	
17	219129	245542.1	56.283	274.22	
18	219134.6	245550.4	56.378	284.22	
19	219140.3	245558.6	56.454	294.22	
20	219145.9	245566.9	56.454	304.22	
21	219151.6	245575.1	56.415	314.22	
22	219157.2	245583.4	56.437	324.22	
23	219162.9	245591.6	56.477	334.22	
24	219168.5	245599.9	56.508	344.22	
25	219174.2	245608.1	56.54	354.22	
26	219179.8	245616.4	56.63	364.22	
27	219185.5	245624.6	56.729	374.22	
28	219190.1	245631.3	56.809	382.35	

X Section 23

Id	E	N	Elevation	Distance	WL
1	220041	246024.8	57.658	0	
2	220044.2	246034.3	57.517	10	
3	220047.4	246043.8	57.372	20	
4	220050.6	246053.3	57.197	30	
5	220053.7	246062.8	57.127	40	
6	220056.9	246072.2	57.168	50	
7	220060.1	246081.7	57.152	60	
8	220063.3	246091.2	57.134	70	
9	220066.4	246100.7	57.085	80	
10	220069.6	246110.2	57.028	90	
11	220072.8	246119.6	56.962	100	
12	220076	246129.1	56.908	110	
13	220079.2	246138.6	56.879	120	
14	220082.3	246148.1	56.832	130	
15	220085.5	246157.6	56.74	140	
16	220088.7	246167.1	56.689	150	
17	220091.9	246176.5	56.773	160	
18	220095	246186	56.873	170	
19	220098.2	246195.5	56.894	180	
20	220101.4	246205	56.86	190	
21	220104.6	246214.5	56.82	200	
22	220107.7	246224	56.807	210	
23	220110.9	246233.4	56.827	220	
24	220114.1	246242.9	56.827	230	
25	220117.3	246252.4	56.76	240	
26	220120.5	246261.9	56.545	250	
27	220123.6	246271.4	56.391	260	
23.1	620071	746293	56.587	261.32	54.577
23.2	620073	746298	56.004	266.57	54.577
23.3	620073	746300	55.429	268.12	54.577
23.4	620074	746301	54.602	268.95	54.577
23.5	620074	746301	54.061	269.54	54.577
23.6	620075	746302	53.867	271.12	54.577
23.7	620077	746303	53.982	273.16	54.577
23.8	620077	746304	55.128	273.51	54.577
1	220133.4	246292.1	56.455	283.51	
2	220136.8	246301.5	56.438	293.51	
3	220140.2	246310.9	56.39	303.51	
4	220143.7	246320.3	56.287	313.51	
5	220147.1	246329.7	56.255	323.51	
6	220150.5	246339.1	56.264	333.51	
7	220154	246348.5	56.266	343.51	
8	220157.4	246357.9	56.307	353.51	
9	220160.8	246367.3	56.32	363.51	
10	220164.2	246376.7	56.276	373.51	
11	220167.7	246386.1	56.261	383.51	
12	220171.1	246395.5	56.258	393.51	
13	220174.5	246404.9	56.254	403.51	
14	220178	246414.3	56.294	413.51	

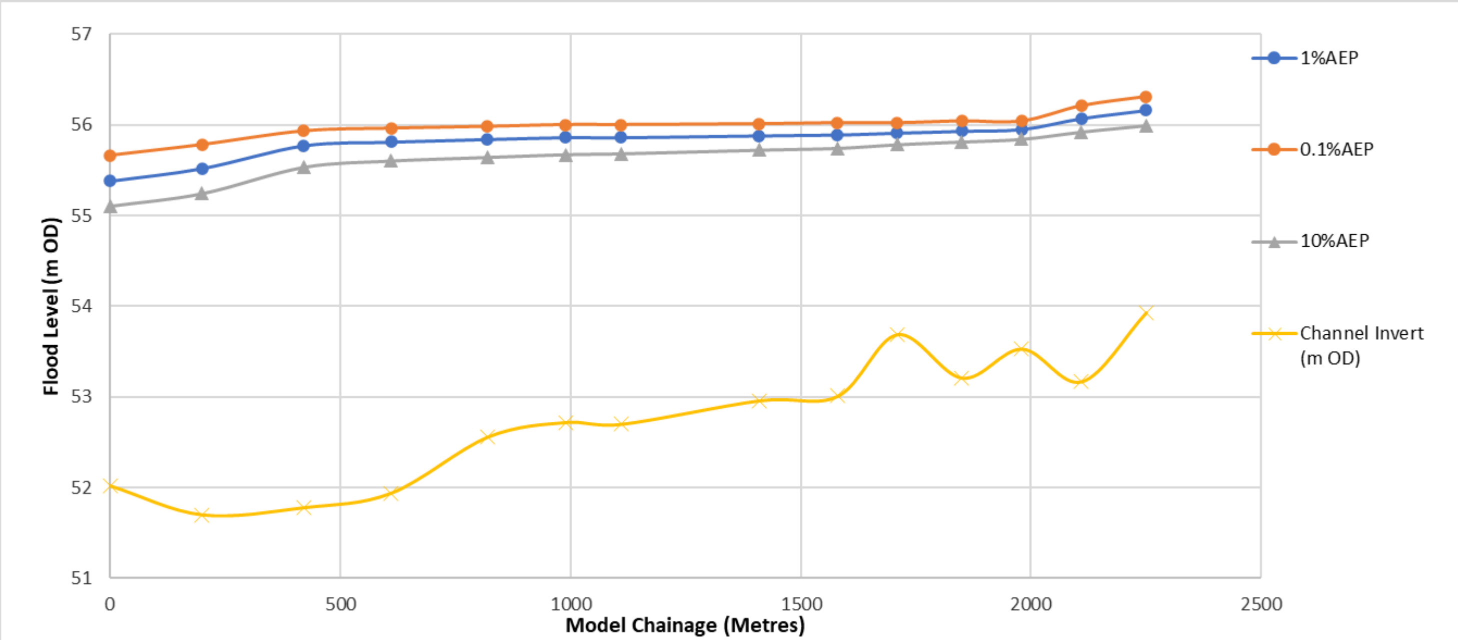
Id	E	N	Elevation	Distance
15	220181.4	246423.7	56.368	423.51
16	220184.8	246433.1	56.473	433.51
17	220188.2	246442.4	56.601	443.51
18	220191.7	246451.8	56.962	453.51
19	220195.1	246461.2	57.784	463.51
20	220198.5	246470.6	58.383	473.51
21	220202	246480	58.803	483.51
22	220205.4	246489.4	59.112	493.51
23	220206.8	246493.2	59.157	497.57

X Section 24

Id		E	N	Elevation	Distance	WL
	1	218817.4	245430	57.158	0	
	2	218822.4	245438.7	57.144	10	
	3	218827.4	245447.4	57.167	20	
	4	218832.4	245456	57.321	30	
	5	218837.3	245464.7	57.503	40	
	6	218842.3	245473.4	57.526	50	
	7	218847.3	245482.1	57.535	60	
	8	218852.3	245490.7	57.461	70	
	9	218857.3	245499.4	57.319	80	
	10	218862.2	245508.1	57.18	90	
	11	218867.2	245516.8	57.193	100	
	12	218872.2	245525.4	57.239	110	
	13	218877.2	245534.1	57.357	120	
	14	218882.1	245542.8	57.333	130	
x24.1		618834	745573	56.544	133.84	54.495
x24.2		618834	745572	55.951	135.094	54.495
x24.3		618832	745570	54.773	136.82	54.495
x24.4		618832	745570	54.172	137.253	54.495
	2	218920.1	245626.2	57.192	147.253	
	3	218916	245617.1	57.009	157.253	
	4	218912	245607.9	56.839	167.253	
	5	218908	245598.7	56.707	177.253	
	6	218904	245589.6	56.61	187.253	
	7	218900	245580.4	56.539	197.253	
	8	218896	245571.3	56.536	207.253	
	9	218891.9	245562.1	56.701	217.253	
	10	218887.9	245553	56.874	227.253	
	11	218887.6	245552.1	56.903	228.16	

APPENDIX II: HEC-RAS MODEL OUTPUT DATA

Chainage	HECRAS XS ID	XS Start Point		XS Finish Point		Channel Survey ID	Min Channel invert	10-year	100-year	1000-year
		Easting	Northing	Easting	Northing					
0	1	219,073.27	247,714.21	219,327.02	247,682.98	19	52.02	55.1	55.38	55.66
200	2	218,962.11	247,552.64	219,461.59	247,501.23	18	51.7	55.24	55.52	55.78
420	3	218,860.06	247,321.25	219,698.91	247,273.13	16	51.78	55.53	55.77	55.93
610	4	218,757.54	247,174.35	219,629.02	247,116.17	15	51.94	55.6	55.81	55.96
820	5	218,731.57	246,964.75	219,645.97	246,893.48	14	52.56	55.64	55.84	55.98
990	6	218,727.35	247,015.22	219,579.53	246,628.50	13	52.72	55.67	55.86	56
1110	7	218,521.77	246,677.97	219,549.11	246,635.55	12	52.7	55.68	55.86	56
1410	8	218,484.01	246,632.42	219,621.82	246,165.74	10.1	52.96	55.72	55.88	56.01
1580	9	218,384.50	246,594.22	219,736.36	245,886.67	10	53.01	55.74	55.89	56.02
1710	10	218,482.50	246,344.79	219,622.36	245,824.73	8	53.69	55.78	55.91	56.02
1850	11	218,512.78	246,226.97	219,541.47	245,698.52	7	53.21	55.81	55.93	56.04
1980	12	218,391.94	246,154.20	219,491.07	245,514.26	9	53.53	55.84	55.95	56.04
2110	13	218,581.44	245,858.78	219,411.97	245,458.83	6	53.17	55.92	56.07	56.21
2250	14	218,507.58	245,736.27	219,309.28	245,361.55	5	53.93	55.99	56.16	56.31



	Easting				Northing	Flood Elevation_10 yr	Flood Elevation_100 yr	Flood Elevation_1000 yr
Section Ch 0 start	219231.556				247690.829	55.1	55.38	55.66
Section Ch 0 end	219317.02				247683.065	55.1	55.38	55.66
Section Ch 200 start	219300.337				247517.8	55.24	55.52	55.78
Section Ch 200 end	219421.631				247502.976	55.24	55.52	55.78
Section Ch 420 start	219149.538				247303.7	55.53	55.77	55.93
Section Ch 420 end	219469.185				247284.516	55.53	55.77	55.93
Section Ch 610 start	219076.026				247143.14	55.6	55.81	55.96
Section Ch 610 end	219459.031				247118.365	55.6	55.81	55.96
Section Ch 820 start	219120.046				246930.098	55.64	55.84	55.98
Section Ch 820 end	219421.731				246906.416	55.64	55.84	55.98
Section Ch 990 start	219275.945				246748.429	55.67	55.86	56
Section Ch 990 end	219476.679				246667.528	55.67	55.86	56
Section Ch 1110 start	219150.926				246644.941	55.68	55.86	56
Section Ch 1110 end	219329.128				246638.981	55.68	55.86	56
Section Ch1410 start	218838.553				246514.711	55.72	55.88	56.01
Section Ch 1410 end	219445.617				246231.148	55.72	55.88	56.01
Section Ch 1580 start	219046.485				246241.624	55.74	55.89	56.02
Section Ch 1580 end	219200.543				246160.365	55.74	55.89	56.02
Section Ch 1710 start	218857.925				246179.947	55.78	55.91	56.02
Section Ch 1710 end	219204.112				246016.274	55.78	55.91	56.02
Section Ch 1850 start	218838.704				246051.796	55.81	55.93	56.04
Section Ch 1850 end	219084.208				245924.417	55.81	55.93	56.04
Section Ch 1980 start	218877.557				245875.278	55.84	55.95	56.04
Section Ch 1980 end	218897.837				245858.058	55.84	55.95	56.04
Section Ch 2110 start	218782.088				245768.531	55.92	56.07	56.21
Section Ch 2110 end	218900.854				245710.83	55.92	56.07	56.21
Section Ch 2250 start	218716.493				245640.052	55.99	56.16	56.31
Section Ch 2250 end	218783.697				245608.36	55.99	56.16	56.31

APPENDIX 9-2

WFD ASSESSMENT REPORT

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WATER FRAMEWORK DIRECTIVE ASSESSMENT
UMMA MORE RENEWABLE ENERGY DEVELOPMENT, CO. WESTMEATH

FINAL REPORT

Prepared for:
Umma More Ltd

Prepared by:
HYDRO-ENVIRONMENTAL SERVICES

DOCUMENT INFORMATION

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TABLE OF CONTENTS

FIGURES (IN TEXT)

TABLES IN TEXT

1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO, acting on behalf of Umma More Ltd, to complete a Water Framework Directive (WFD) Compliance Assessment for a planning application for the proposed Umma More Renewable Energy Development, the Proposed Development (Wind Farm Site and Grid Connection). The Wind Farm Site is located approximately 3.5km southwest of Ballymore village and 14km northwest of Athlone (distance from proposed Wind Farm Site boundary). The townlands in which the proposed Wind Farm Site is located are listed in Table 1-1 in Chapter 1 of the EIAR.

The underground electrical cabling route includes for a substation and temporary construction compound located within the Wind Farm Site and associated underground electrical cabling route situated between the proposed onsite substation and the Thornsberry 110KV substation. The underground electrical cabling route is ~31km long located along local and regional roads and the N52 road.

The full description of the Proposed Development is provided in Chapter 4 of this EIAR. As detailed in Section 1.1.1 in Chapter 1, for the purposes of this EIAR, the various project components are described and assessed using the following references: 'Proposed Development', 'the Site', 'Wind Farm Site' and 'Grid Connection'.

The purpose of this WFD assessment is to determine if any specific components or activities associated with the Proposed Development will compromise WFD objectives or cause a deterioration in the status of any surface water or groundwater body and/or jeopardise the attainment of good surface water or groundwater status. This assessment will determine the water bodies with the potential to be impacted, describe the proposed mitigation measures and determine if the project is in compliance with the objectives of the WFD.

This WFD Assessment is intended to supplement the EIAR submitted as part of the Wind Farm Site planning application.

1.2 STATEMENT OF AUTHORITY

Hydro-Environmental Services (HES) are a specialist geological, hydrological, hydrogeological, and environmental practice that delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types including wind farms.

This WFD assessment was prepared by Michael Gill, Adam Keegan, Conor McGettigan and Adrian Tanner.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Slievecallan WF, Cahermurphy (Phase I & II) WF, Carrownagowan WF, and Croagh WF and over 100 other wind farm related projects across the country.

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

Conor McGettigan (BSc, MSc) is an Environmental Scientist with two years of experience in the environmental sector in Ireland. Conor routinely prepares Environmental Impact Assessment Reports (EIARs), flood risk assessments and Water Framework Directive Assessments for a wide variety of projects including proposed wind farm developments. Conor holds an M.Sc. in Applied Environmental Science (2020) and a B.Sc. in Geology (2016) from University College Dublin.

1.3 WATER FRAMEWORK DIRECTIVE

The EU Water Framework Directive (2000/60/EC), as amended by Directives 2008/105/EC, 2013/39/EU and 2014/101/EU ("**WFD**"), was established to ensure the protection of the water environment. The Directive was transposed in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722/2003).

The WFD requires that all member states protect and improve water quality in all waters, with the aim of achieving good status by 2027 at the latest. Any new development must ensure that this fundamental requirement of the WFD is not compromised.

The WFD is implemented through the River Basin Management Plans (RBMP) which comprises a six-yearly cycle of planning, action and review. RBMPs include identifying river basin districts, water bodies, protected areas and any pressures or risks, monitoring and setting environmental objectives. In Ireland the first RBMP covered the period from 2010 to 2015 with the second cycle plan covering the period from 2018 to 2021.

The River Basin Management Plan (2018 - 2021) objectives, which have been integrated into the design of the Proposed Development, include:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration and maintain a 'high' status where it already exists;
- Protect, enhance and restore all waters with aim to achieve at least good status by 2027;
- Ensure waters in protected areas meet requirements; and,
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objectives and (2) addressing more complex issues that will build knowledge for the third cycle.

Our understanding of these objectives is that water bodies, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed.

We note that the River Basin Management Plan 2022-2027 was out for public consultation in 2021 and early 2022, and that process closed at the end of March 2022. No further updates are available at present (https://www.gov.ie/en/consultation/2bda0-public-consultation-on-the-draft-river-basin-management-plan-for-ireland-2022-2027/).

2. WATERBODY IDENTIFICATION & CLASSIFICATION

2.1 INTRODUCTION

This section identifies those surface water and groundwater bodies with potential to be affected by the Proposed Development and reviews any available WFD information.

2.2 SURFACE WATERBODY IDENTIFICATION

On a regional scale, the Wind Farm Site is located in the Upper Shannon surface water catchment within Hydrometric Area 26F of the Shannon International River Basin District.

On a more local scale the Wind Farm Site is located in the Inny [Shannon]_SC_090 sub-catchment and 3 no. WFD river sub-basins. A small area in the northwest of the Wind Farm Site is located within the Inny_110 river sub-basin while a small section in the southwest of the Wind Farm Site is mapped within the Dungolman_020 river sub-basin. The vast majority of the Wind Farm Site is situated in the Dungolman_030 river sub-basin.

Within the Dungolman_020 River sub-basin, the southwestern corner of the Wind Farm Site drains into the Dungolman_020 river waterbody. Within the Dungolman_030 river sub-basin, the Dungolman River (Dungolman_030) flows to the northeast between T4 and T5. This watercourse then flows along the EIAR Site Boundary to the east of T2 and T3 before veering to the northeast to the east of T1. Drainage in this river sub-basin is directed towards the Dungolman River via several smaller streams and drains. The Dungolman River continues to flow to the north before discharging into the Tang River approximately 5.15km north of the Wind Farm Site. Here the Tang River is located in the Inny_110 river sub-basin and forms part of the Inny_110 river waterbody. The Tang River then continues to flow to the northwest and eventually discharges into the Inny River approximately 8.3km northwest of the Wind Farm Site. The Inny River drains into the eastern side of Lough Ree.

As stated above, a small section in the northwest of the Wind Farm Site is located within the Inny_110 river sub-basin. This are of the Wind Farm Site drains to the northwest via the Ardnacrany south stream which discharges into the Dungolman River approximately 4.3km north of the Wind Farm Site.

Table A presents the total catchment area of the river waterbodies in the vicinity and downstream of the Wind Farm site. The Dungolman_030 river waterbody has a total upstream catchment of 64.11km^2. The catchment area of river waterbodies increase further downstream as more streams and rivers confluence. Downstream of the Dungolman_030 river, the Inny_110 river waterbody catchment has an area is 1,229km^2.

The Grid Connection (temporary construction compound, onsite substation and underground electrical cabling route) is located within the Upper Shannon (26) and the Lower Shannon (25A) surface water catchments.

On a more local scale, the underground electrical cabling route is located within the Inny (Shannon) SC_090, the Brosna_SC_030, Brosna_SC_020, Silver[Tullamore]_SC_010 and Tullamore_SC_010 sub-catchments and a total of 11 no. WFD river sub-basins.

The underground electrical cabling route starts from the on-site substation which is located in the south of the Wind Farm Site in WFD Dungolman_030 river sub-basin Upper Shannon (26F) surface water catchment. The underground electrical cabling route then enters the Ballynagrenia Stream_010 and _020 river sub-basins located within the Lower Shannon surface water catchment (25A). A section of the underground electrical cabling route is located in the Gageborough_030 and _020 river sub-basins. The underground electrical cabling route then enters the Brosna_070 river sub-basin west of Kilbeggan and from here travels south along the N52 road into the following WFD river sub-basins, Tonaphort_010, Durrow Abbey Stream_010, Silver (Tullamore)_020 and ending in the WFD river sub-basin Tullamore_030, all in the WFD catchment 25A (Lower Shannon).

Within the Lower Shannon (25A) catchment all SWBs draining the proposed underground electrical cabling route drain into the Brosna River. The Ballynageira stream discharges into the Gageborough River which in turn discharges into the Brosna_080 river waterbody. Further to the south the Silver River and the Tullamore River discharge into the Brosna_100 river waterbody.

Table A presents the total catchment area of the river waterbodies in the vicinity and downstream of the proposed underground electrical cabling route. The Durrow Abbey Stream_010 river waterbody has the smallest total upstream catchment of 8.78km^2. Meanwhile downstream of its confluence with the Silver River, the Brosna has the largest total upstream catchment and will be less susceptible to potential impacts arising from works along the proposed underground electrical cabling route.

Table A: Downstream Catchment Size for River Waterbodies

WFD River Sub-Basin	Total Catchment Area (km^2)
Wind Farm Site	
Dungolman_030	64.11
Inny_110	1,229
Grid Connection	
Ballynagrenia Stream_010	9.88
Ballynagrenia Stream_020	22.41
Gageborough_030	125.07
Gageborough_020	62.13
Brosna_070	289.44
Brosna_080	432.93
Brosna_090	470.82
Tonaphort_010	10.33
Durrow Abbey Sream_010	8.78
Silver (Tullamore) _020	41.58
Silver (Tullamore) _030	62.06
Silver (Tullamore)_040	76.94
Tullamore_030	111.24
Tullamore_040	124.51
Clodiagh Tullamore_050	253.72
Brosna_100	850.79

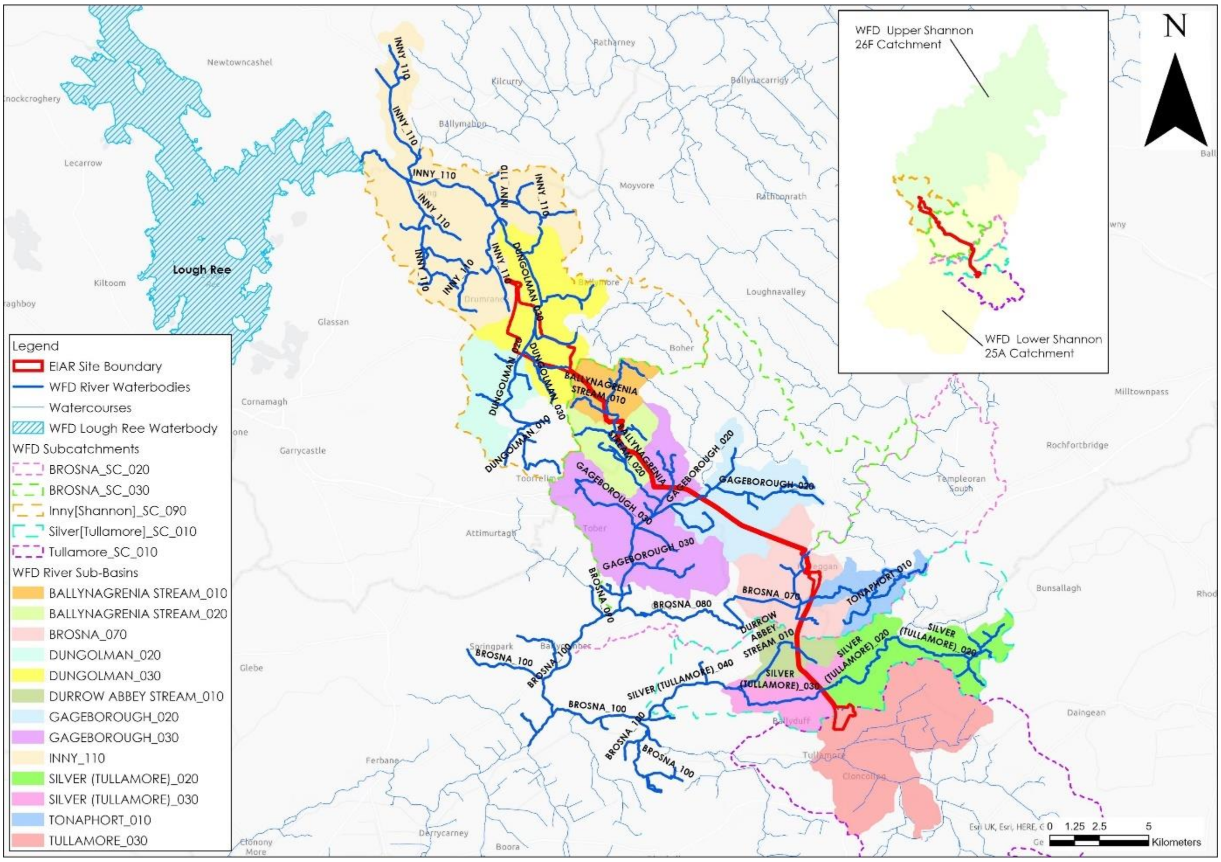

Figure A: Local Hydrology Map

2.3 SURFACE WATER BODY CLASSIFICATION

A summary of the WFD status and risk result for Surface Water Bodies (SWBs) downstream of the Wind Farm Site and the Grid Connection are shown in **Table B**. The overall status of SWBs is based on the ecological, chemical and quantitative status of each SWB. Surface water Body (SWB) status information is available from (www.catchments.ie).

As stated above the majority of the Wind Farm Site is located in the Dungolman_030 WFD river sub-basin. The Dungolman_030 SWB achieved 'Poor Status' in all 3 no. WFD cycles (2010-2015, 2013-2018 and 2016-2021) and has been deemed to be 'at risk' of failing to meet its WFD objectives. Meanwhile, the Dungolman_020 SWB previously achieved 'Good' status in both the 2010-2015 and the 2013-2018 WFD Cycles but more recently achieved 'Poor' status in the latest 2016-2021 WFD Cycle. The Dungolman_020 however, is 'not at risk' of failing to meet its WFD objectives. The Inny_011 SWB achieved 'Moderate Status' in the latest WFD cycle (2016-2021). The risk status of this SWB is currently 'under review'.

The 3rd Cycle Draft Upper Shannon Catchment Report (HA 26F) states that excess nutrients and morphological impacts are the most prevalent issues in this catchment. Urban wastewater is listed as a significant pressure on the Dungolman_030 SWB which is impacted by the Ballymore agglomeration. No significant pressures have been identified on the Dungolman_020 or the Inny_110 SWBs. Meanwhile the 3rd Cycle Draft Upper Shannon (Lough Ree) Catchment Report (HA 26E) does not identify any significant pressures on the Lough Ree lake waterbody.

The proposed underground electrical cabling route is approximately 31km in length, orientated in a south-westerly direction that ends approximately 1km northwest of Tullamore town. There are 11 no. watercourse crossings across 9 no. river waterbodies along the proposed underground electrical cabling route which are located over mapped EPA watercourses. In the vicinity of the Wind Farm Site, the Dungolman_030 SWB is of 'Poor' status and is under significant pressure from urban wastewater. Meanwhile, within the Lower Shannon surface water catchment (26F), the Ballynagrenia Stream_010, the Durrow Abbey Stream and the Tullamore_030 SWBs in the vicinity of the underground electrical cabling route achieved 'Poor' status in the latest WFD cycle whilst the Tonaphort_010 SWB achieved 'Moderate' status. Other waterbodies in the vicinity and downstream of the underground electrical cabling route, including the Brosna_070 and the Brosna_090 SWB's, the Ballynagrenia Stream_020 SWB, the Gageborough River (_020 and _030) and the Silver (Tullamore)_020 and Silver (Tullamore)_030 SWB's achieved 'Good' status. The Clodiagh Tullamore_050, Silver (Tullamore)_040, Tullamore_040, Brosna_080 and Brosna_100 SWB's downstream of the underground electrical cabling route all achieved 'Moderate' status in the latest WFD cycle (2016-2021).

The 3rd Cycle Lower Shannon (Brosna) Catchment Report (HA 25A) states that excess nutrients and morphological impacts remain the most prevalent issues in this catchment. Agriculture is identified as a significant pressure on Ballynagrenia_020, Gageborough_020, Durrow Abbey Stream, Silver (Tullamore)_040 and Tullamore_030 SWBs. The draft report states that the main issues related to farming are primarily nutrients and morphological, with diffuse sources of phosphate in poorly draining areas and pressures from farmyards. Meanwhile hydromorphology is listed as a significant pressure on the Ballynagrenia Stream_010 and the Gageborough Stream_020 SWBs in the vicinity of the underground electrical cabling route. The draft report states that these types of pressures either have the effect of degrading the habitat or the riparian zone of the waterbody.

The SWB status for these waterbodies are shown on **Figure B.**

Table B: Summary WFD Information for Surface Water Bodies

SWB	Overall Status (2010-2015)	Risk Status (2nd Cycle)	Overall Status (2013-2018)	Overall Status (2016-2021)	Risk Status (3rd Cycle)	Pressures
Wind Farm Site						
Dungolman_020	Good	Not at risk	Good	Poor	Not at risk	-
Dungolman_030	Poor	At risk	Poor	Poor	At risk	Urban Wastewater
Inny_110	Unassigned	Under Review	Moderate	Moderate	Under Review	-
Lough Ree	Moderate	Not at risk	Good	Good	At risk	-
Grid Connection						
Ballynagrenia Stream_010	Moderate	At Risk	Moderate	Poor	At Risk	Hydromorphology & Agriculture
Ballynagrenia Stream_020	Good	Not at Risk	Good	Good	Not at Risk	-
Gageborough_030	Good	Not at Risk	Good	Good	Not at Risk	-
Gageborough_020	Moderate	At Risk	Good	Good	Under Review	Hydromorphology & Agriculture
Brosna_070	Good	Not at Risk	Good	Good	Not at Risk	-
Brosna_080	Moderate		Good	Moderate	Not at Risk	-
Brosna_090	Good		Good	Good	Not at Risk	-
Tonaphort_010	Unassigned	Under Review	Unassigned	Moderate	Under Review	Industry
Durrow Abbey Stream_010	Moderate	At Risk	Moderate	Poor	At Risk	Forestry & Agriculture
Silver (Tullamore) _020	Good	Not at Risk	Good	Good	Not at Risk	-
Silver (Tullamore) _030	Good	Not at Risk	Good	Good	Not at Risk	-
Silver (Tullamore)_040	Good	Not at risk	Moderate	Moderate	At risk	Agriculture
Tullamore_030	Unassigned	Under Review	Moderate	Poor	At risk	Agriculture & Urban Runoff
Tullamore_040	Poor	At risk	Moderate	Moderate	At risk	Urban Runoff
Clodiagh Tullamore_050	Poor	At risk	Poor	Moderate	At risk	Hydromorphology & Other
Brosna_100	Moderate	At risk	Moderate	Moderate	At risk	Industry & Agriculture

2.4 GROUNDWATER BODY IDENTIFICATION

According to data from the GSI database and bedrock geology series (www.gsi.ie), the Wind Farm Site is underlain by a Locally Important Aquifer (LI – Bedrock which is generally moderately productive only in local zones), which consists of Dinantian Upper Impure Limestones (DUIL).

The Inny Groundwater Body (GWB) (IE_SH_G_110) underlies the Wind Farm Site .

The underground electrical cabling route is located within several groundwater bodies, which include, from north to south, the Inny groundwater body (GWB), the Clara GWB, the Gageborough-Brosna Gravels Group 1 GWB, the Kilbeggan gravels GWB and the Tullamore GWB.

2.5 GROUNDWATER BODY CLASSIFICATION

All GWBs in the vicinity of the Wind Farm Site and along the underground electrical cabling route (Inny GWB (IE_SH_G_110), Clara GWB (IE_SH_G_240), Gageborough-Brosna Gravels Group 1 (IE_SH_G_253), Kilbeggan Gravels (IE_SH_G_242) and Tullamore GWB (IE_SH_G_232)) achieved 'Good Status' in all 3 no. WFD cycles (2010-2015, 2013-2018 and 2016-2021). This status applies to both the quantitative status and the chemical status of the GWB. These GWBs have been deemed to be 'Not at risk' of failing to meet their respective WFD objectives. The GWB status for the 2013-2018 WFD cycle are shown on **Figure B**.

Table C: Summary WFD Information for Groundwater Bodies

GWB	Overall Status (2010-2015)	Risk Status (2nd Cycle)	Overall Status (2013-2018)	Overall Status (2016-2021)	Risk Status (3rd Cycle)	Pressures
	Wind Farm Site					
Inny IE_SH_G_110	Good	Under review	Good	Good	Not At risk	-
	Grid Connection					
Clara IE_SH_G_240	Good	Not at Risk	Good	Good	Not At Risk	-
Gageborogh-Brosna Gravels Group 1 IE_SH_G_253	Good	Under review	Good	Good	Not At risk	-
Kilbeggan gravels IE_SH_G_242	Good	Under review	Good	Good	Not At risk	-
Tullamore IE_SH_G_232	Good	Not at Risk	Good	Good	Not At Risk	-

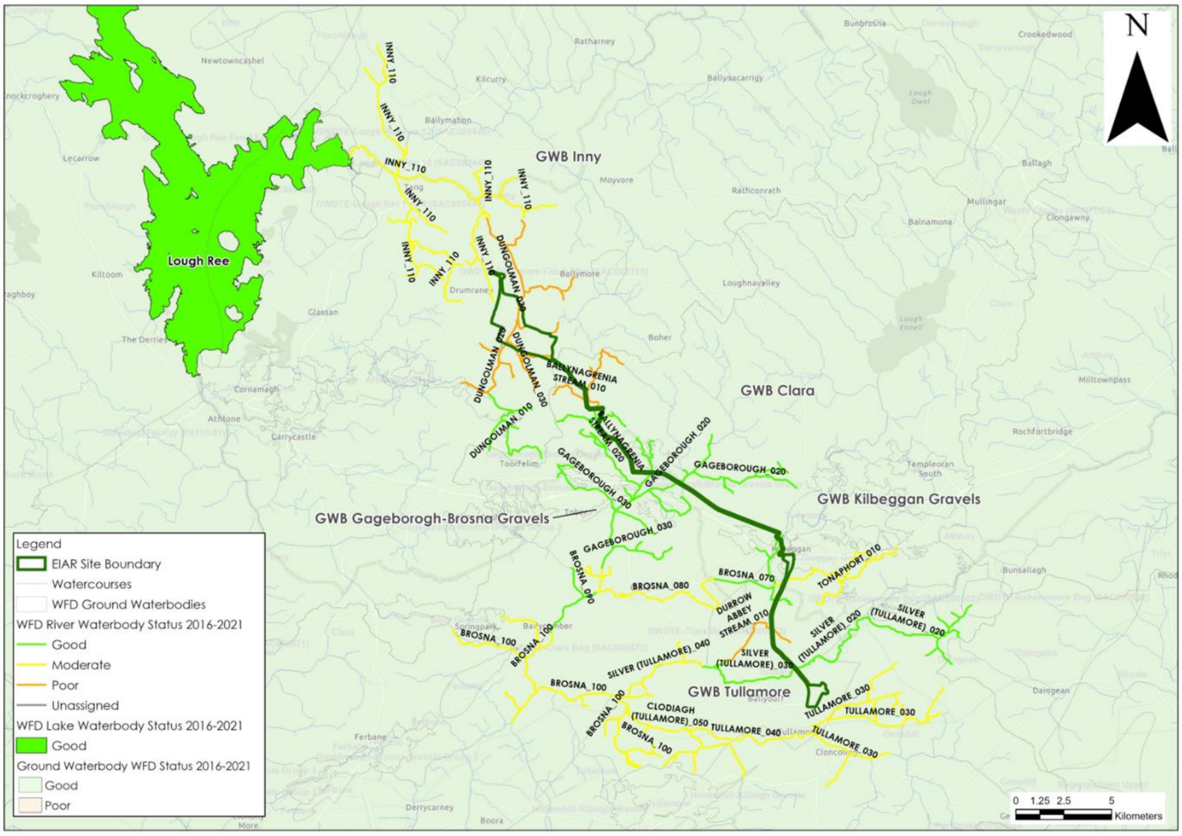

Figure B: WFD Groundwater and Surface Waterbody Status (2016-2021)

3. WFD SCREENING

3.1 WIND FARM SITE

As discussed in **Section 2**, there are a total of 3 no. river water bodies that are located in the vicinity or downstream of the Wind Farm Site. In addition, there is 1 no. lake waterbody located downstream. Furthermore, the Wind Farm Site is underlain by 1 no. groundwater body.

3.2 GRID CONNECTION

There are a total of 34 identified watercourse and existing culvert/drain crossings along the proposed Grid Connection underground electrical cabling route, of which 11 no. are WFD mapped watercourses. The proposed underground electrical cabling route is located in 11 no. WFD River sub-basins with a total of 11 no. proposed watercourse crossings. In addition, the underground electrical cabling route is underlain by 4 no. groundwater bodies.

3.3 SURFACE WATER BODIES

With consideration for the construction, operational and decommissioning phases of the Proposed Development at the Wind Farm Site, it is considered that the Dungolman_030 and Inny_110 rivers that are located in the vicinity and downstream of the Wind Farm Site are carried through into the WFD Impact Assessment. The Proposed Development works within the Wind Farm Site must not in any way result in a deterioration in the status of these SWBs and/or prevent them from meeting the biological and chemical characteristics for good status in the future.

The Dungolman_020 SWB has been screened out of further assessment as all works associated with the Proposed Development are located downstream of this SWB. Consequently the proposed works have no potential to cause a deterioration in the status of this SWB and/or jeopardise the attainment of good surface water status.

Further downstream, the Lough Ree (IE_SH_26_750a) SWB has been screened out due to the large volumes of water within this lake waterbody and the large catchment area to Lough Ree. The Proposed Development works in the Wind Farm Site have no potential to cause a deterioration in the status of this SWB and/or jeopardise the attainment of good surface water status.

All waterbodies along the underground electrical cabling route (Ballynagrenia Stream_010, Ballynagrenia Stream_020, Gageborough_020, Gageborough_030, Brosna_070, Tonaphort_010, Durrow Abbey Sream_010, Silver (Tullamore) _020, Silver (Tullamore) _030 and Tullamore_030) are carried through to the WFD Impact Assessment. The Proposed Development works along the Grid Connection underground electrical cabling route must not in any way result in a deterioration in the status of these SWB's and/or prevent them from meeting the biological and chemical characteristics for good status in the future.

Further downstream the Brosna_080, Brosna_090, Brosna_100, Silver(Tullamore)_040, Tullamore_040 and Clodiagh Tullamore_050) SWBs have all been screened out of further assessment due to the increasing volumes of water within these SWBs, the absence of any works within their respective sub-basins and the nature of the proposed works along the underground electrical cabling route. The proposed works have no potential to cause a deterioration in the status of this SWB and/or jeopardise the attainment of good surface water status.

3.4 GROUNDWATER BODIES

With respect to groundwater bodies, the Inny GWB has been screened in due to its location directly underlying the Wind Farm Site. The Proposed Development works at the Wind Farm Site must not in any way result in a deterioration in the status of this GWB and/or prevent it from meeting the biological and chemical characteristics for good status in the future.

With respect to GWBs along the underground electrical cabling route, the Inny GWB, Clara GWB, Gageborough-Brosna Gravels Group 1 GWB, Kilbeggan Gravels GWB and Tullamore GWB have been screened in as they directly underlie the Proposed Development. The Proposed Development works along the Grid Connection underground electrical cabling route must not in any way result in a deterioration in the status of these GWB and/or prevent them from meeting the biological and chemical characteristics for good status in the future.

3.5 WFD SCREENING SUMMARY

A summary of WFD Screening discussed above is shown in **Table D**.

Table D: Screening of WFD water bodies located within the study area

Type	WFD Classification	Waterbody Name/ID	Inclusion in Assessment	Justification
Surface Water Body	River	Dungolman_020	No	While a small section in the southwest of the Wind Farm Site is located in the Dungolman_020 river sub-basin, no development works are proposed in this area. The Dungolman_020 SWB is therefore located upstream of all Proposed Development works and the Proposed Development has no potential to impact the status of this SWB.
	River	Dungolman_030	**Yes**	The majority of the Proposed Development site, including all 9 no. turbines are mapped within the catchment area of the Dungolman_030. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Inny_110	**Yes**	The Inny_110 SWB is located directly downstream of the Dungolman_030 and in close proximity to the Proposed Wind Farm Site (<1km). An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	Lake	Lough Ree	No	The Lough Ree SWB has been screened out due to the large volumes of water within the SWB. The Proposed Development has no potential to impact the status of this SWB
	River	Ballynagrenia Stream_010	**Yes**	The proposed underground electrical cabling route is located within the Ballynagrenia Stream_010 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Ballynagrenia Stream_020	**Yes**	The proposed underground electrical cabling route is located within the Ballynagrenia Stream_020 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Gageborough_020	**Yes**	The proposed underground electrical cabling route is located within the Gageborough_020 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Gageborough_030	**Yes**	The proposed underground electrical cabling route is located within the Gageborough_030 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Brosna_070	**Yes**	The proposed underground electrical cabling route is located within the Brosna_070 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Brosna_080	No	The Brosna_080 SWB has been screened out due to absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB.

	River	Brosna_090	No	The Brosna_090 SWB has been screened out due to absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB
	River	Tonaphort_010	**Yes**	The proposed underground electrical cabling route is located within the Tonaphort_010 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Durrow Abbey Sream_010	**Yes**	The proposed underground electrical cabling route is located within the Durrow Abbey Sream_010 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Silver (Tullamore) _020	**Yes**	The proposed underground electrical cabling route is located within the Silver (Tullamore) _020 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Silver (Tullamore) _030	**Yes**	The proposed underground electrical cabling route is located within the Silver (Tullamore) _030 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Silver (Tullamore)_040	No	The Silver (Tullamore)_040 SWB has been screened out due to the absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB
	River	Tullamore_030	**Yes**	The proposed underground electrical cabling route is located within the Silver (Tullamore) _030 river sub-basin. An assessment is required to consider the potential impacts of the Proposed Development on this SWB.
	River	Tullamore_040	No	The Tullamore_040 SWB has been screened out due to the absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB
	River	Clodiagh Tullamore_050	No	The Clodiagh Tullamore_050 SWB has been screened out due to the absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB
	River	Brosna_100	No	The Brosna_100 SWB has been screened out due to absence of any works within its river sub-basin, the nature of the upstream underground electrical cabling route works and the increasing volumes of water within this SWB, The Proposed Development has no potential to impact the status of this SWB
Groundwater Body	Groundwater	Inny	**Yes**	The majority of the Wind Farm site including 9 no. turbines overlies the Suck South GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB.

	Groundwater	Clara	**Yes**	The proposed underground electrical cabling route overlies the Clara GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB
	Groundwater	Gageborogh-Brosna Gravels Group 1	**Yes**	The proposed underground electrical cabling route overlies the Gageborough-Brosna Gravels Group 1 GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB
	Groundwater	Kilbeggan Gravels	**Yes**	The proposed underground electrical cabling route overlies the Kilbeggan Gravels GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB
	Groundwater	Tullamore	**Yes**	The proposed underground electrical cabling route overlies the Tullamore GWB. An assessment is required to consider potential impacts of the Proposed Development to this GWB

4. WFD COMLIANCE ASSESSMENT

4.1 DEVELOMENT PROPOSAL

The Proposed Development works within the Wind Farm Site includes 9 no. turbines, 2 no. temporary construction compounds, a 110kV substation, 1 no. meteorological met mast, spoil management areas, and associated access roads (new and upgrade of existing) within the Wind Farm Site.

The Proposed Development works for the Grid Connection include the substation and construction compound within the Wind Farm Site and the underground 110kV electricity cabling connecting the proposed onsite substation to the existing 110kV Thornsbury substation near Tullamore, Co. Offaly. This will involve the excavation of a trench primarily along the public road, placement of ducting and backfilling of the trench.

The Proposed Development also includes works along the Turbine Delivery Route (TDR) and all associated site development works including tree felling, drainage infrastructure and landscaping.

Due to the nature of wind farm developments (and associated grid connections and TDR works), 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 risks to groundwater at the site will be from cementitious materials, hydrocarbon spillage and leakages, and potential piling works.

The primary risk to surface waters will be entrained suspended sediments (soil and subsoil particles) in site runoff during earthworks and tree felling along with cement-based compounds.

The Proposed Development includes works over and in close proximity to waterbodies. There are a number of potential adverse effects to both surface and groundwater.

The primary risks of degradation of surface water bodies include:

- Changes in surface runoff flow volumes and flow patterns;
- Entrainment of suspended solids in surface waters; and,
- Chemical pollution of surface waters by concrete, oil and or fuels.

The primary risks of degradation of groundwaters include:

- Chemical pollution of groundwaters by concrete, oils and fuels.

4.2 POTENTIAL EFFECTS

4.2.1 Construction Phase (Unmitigated)

4.2.1.1 Potential Surface Water Quality Effects from Works within Wind Farm Site

Construction phase activities including site levelling/construction and building turbine foundation excavation will require earthworks resulting in removal of vegetation cover and excavation of mineral soil/subsoil (where present). The main risk will be from surface water runoff from spoil management areas and excavation drainage/dewatering during construction works. These activities can result in the entrainment of suspended solids in surface waters. However, no direct pathways exist between the Wind Farm site and downstream surface waterbodies. Therefore, construction phase activities within the Wind Farm Site do not have the potential to increase the suspended sediment load or turbidity in downstream surface water receptors.

Hydrocarbons and cement-based compounds will also be used during the construction phase. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to surface waters at all construction. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. It is also a nutrient supply for adapted micro-organisms, which can rapidly deplete dissolved oxygen in waters, resulting in the death of aquatic organisms. However, no direct surface water pathways exist between the Wind Farm Site and downstream surface waterbodies. Therefore, accidental spillage of hydrocarbons within the Wind Farm Site have limited potential to impact the water quality in downstream surface watercourses.

It is also estimated that 6.4ha (hectares) in of existing forestry will be felled in the area near T4 to allow for development of the Wind Farm Site. The area to be felled as part of the Proposed Development accounts for just 0.67% of the total Wind Farm Site area. Potential water quality impacts resulting from tree felling will arise 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; and,
- Nutrient release.

In addition, groundwater seepages may occur in turbine base excavations, particularly those on lower elevations and this will create additional volumes of water to be treated by the drainage management system. Inflows will likely require management and treatment to reduce suspended sediments.

Surface water quality impacts may also arise during the diversion, culverting, road and site underground cabling crossing of surface watercourses during the construction phase. These activities 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 1 no. watercourse crossings will be constructed across the Dungolman river and 11 no. minor field drain crossings will be required to facilitate access roads within the Wind Farm Site.

The surface water receptors likely to be impacted by these activities include the Dungolman_030 SWB and the Inny_110 SWB. However, as shown in **Table A**, the Inny_110 SWB is less susceptible to potential surface water quality effects due to the large volumes of water within this SWB associated with its large upstream catchment.

A summary of potential status change to SWBs arising from potential water pollution (suspended solids entrainment, hydrocarbon spillage, release of cement-based products and/or wastewater) during the unmitigated construction phase are outlined in

Table E.

Table E: Potential Surface Water Quality Effects from Works Within Wind Farm Site during Construction Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Dungolman_030	IE_SH_26D060400	Poor	Bad
Inny_110	IE_SH_26I011400	Moderate	Moderate

4.2.1.2 Potential Surface Water Quality Effects on the Grid Connection

Based on the WFD mapping, there will be a requirement for 11 no. watercourse crossings along the proposed underground electrical cabling route (located at existing bridges and culverts).

No in-stream works are required at any of these watercourse crossings, however due to the close proximity of local waterbodies to the Grid Construction work at the crossing locations, there is a potential for surface water quality impacts during trench excavation work due to runoff from the road surface. This runoff may contain elevated concentrations of suspended sediment, cementitious runoff and/or hydrocarbons.

Some minor groundwater/surface water seepages will likely occur in trench excavations and this will create additional volumes of water to be treated by the runoff management system. Inflows will likely require management and treatment to reduce suspended sediments.

Construction activities along the Underground electrical cabling route have the potential to adversely impact the status of the Dungolman_030, Ballynagrenia Stream_010 and _020, Gageborough_020 and _030, Brosna_070, Tonaphort_010, Durrow Abbey Stream_010, Silver (Tullamore)_020 and _030 and Tullamore_030 SWBs.

A summary of potential status change to SWBs arising from works along the proposed underground electrical cabling route during the unmitigated construction phase are outlined in **Table F**.

Table F: Potential Surface Water Quality Effects on the Grid Connection during Construction Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Dungolman_030	IE_SH_26D060400	Poor	Bad
Ballynagrenia Stream_010	IE_SH_25B160400	Poor	Bad
Ballynagrenia Stream_020	IE_SH_25B160600	Good	Moderate
Gageborough_020	IE_SH_25G010300	Good	Moderate
Gageborough_030	IE_SH_25G010500	Good	Moderate
Brosna_070	IE_SH_25B090450	Good	Moderate
Tonaphort_010	IE_SH_25T450930	Moderate	Poor
Durrow Abbey Sream_010	IE_SH_25D120200	Poor	Bad

Silver (Tullamore) _020	IE_SH_25S030100	Good	Moderate
Silver (Tullamore) _030	IE_SH_25S030300	Good	Moderate
Tullamore_030	IE_SH_25T030300	Poor	Bad

4.2.1.3 Potential Effects on Groundwater Quality/Quantity at the Wind Farm Site

The accidental spillage of hydrocarbons, the release of effluent from wastewater treatment systems and the release of cement-based products have the potential to negatively impact on groundwater water quality at the Proposed Wind Farm Site.

In addition, groundwater seepages may occur in turbine base excavations, particularly those on lower elevations and this will create additional volumes of water to be treated by the drainage management system.

A summary of potential status change to GWBs arising from works at the proposed Wind Farm Site during the unmitigated construction phase are outlined in **Table G**.

Table G: Potential Groundwater Quality/Quantity Effects at Proposed Wind Farm Site during Construction Phase (Unmitigated)

GWB	WFD Code	Current Status	Assessed Potential Status Change
Inny	IE_SH_G_110	Good	Moderate

4.2.1.4 Potential Effects on Groundwater Quality/Quantity on the Grid Connection

The accidental spillage of hydrocarbons, the release of effluent from wastewater treatment systems and the release of cement-based products have the potential to negatively impact on groundwater water quality along the Proposed underground electrical cabling route.

Some minor groundwater/surface water seepages will likely occur in trench excavations which will impact local groundwater quantity.

A summary of potential status change to GWBs arising from works along the grid connection during the unmitigated construction phase are outlined in **Table H**.

Table H: Potential Groundwater Quality/Quantity Effects on the Grid Connection during Construction Phase (Unmitigated)

GWB	WFD Code	Current Status	Assessed Potential Status Change
Inny	IE_SH_G_110	Good	Moderate
Clara	IE_SH_G_240	Good	Moderate
Gageborogh-Brosna Gravels Group 1	IE_SH_G_253	Good	Moderate
Kilbeggan gravels	IE_SH_G_242	Good	Moderate
Tullamore	IE_SH_G_232	Good	Moderate

4.2.1.5 Groundwater and Surface Water Impacts due to Temporary Junction Works

Minor haul route works are required at 7 no. locations listed below, however all proposed road works are small-scale and localised, and no significant water quality impacts are anticipated.

- Location 1 – M6 Junction 10 left slip/N55 junction in Athlone
- Location 2 – N55/R916 Cornamaddy Roundabout
- Location 3 – N55/R390 Junction in Athlone
- Location 4 – Bend on R390 at Coolteen
- Location 5 – Bends on R390 at Beechlawn
- Location 6 – R390/L5363 Junction
- Location 7 – Access Junction on L5363

Due to the shallow nature of the temporary junction works, impacts on groundwater flows and levels are not anticipated.

4.2.1.6 Surface Water Quality Impacts from Tree Felling

Tree felling will be carried out during the construction phase of the Proposed Development at the Wind Farm Site.

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; and,
- Nutrient release.

Table I: Surface Water Quality Impacts from Felling During Operational Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Dungolman_030	IE_SH_26D060400	Poor	Bad
Inny_110	IE_SH_26I011400	Moderate	Moderate

4.2.2 Operational Phase (Unmitigated)

4.2.2.1 Increased Site Runoff and Hydromorphology Effects on River Water Bodies

Progressive replacement of the vegetated surfaces with impermeable surfaces could potentially result in an increase in the proportion of surface water runoff reaching the surface water drainage network. The site footprint and all components of the Proposed Development are listed in Chapter 4 of the EIAR. 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.

The emplacement of the proposed permanent development footprint within the Wind Farm Site, assuming emplacement of impermeable materials as a worst-case scenario, could result in an average total site increase in surface water runoff of 2,392 m^3/month at the Wind Farm Site. This represents a potential increase of 0.29 % 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 site being developed, the Proposed Development total permanent development footprint being approximately 8.2ha, representing ~0.84 % of the total study area.

A summary of potential status change to SWBs arising from increased runoff during the operation stage of the Proposed Development in the unmitigated scenario are outlined in **Table J**.

Table J: Potential Impact on Surface Water Flows during Operational Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Dungolman_030	IE_SH_26D060400	Poor	Bad
Inny_110	IE_SH_26I011400	Moderate	Poor

4.2.2.2 Surface Water Quality Impacts from Site Maintenance

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

A summary of potential status change to SWBs arising from surface water quality impacts during the operation stage of the Proposed Development in the unmitigated scenario are outlined in **Table K**.

Table K: Surface Water Quality Impacts from Site Maintenance During Operational Phase (Unmitigated)

SWB	WFD Code	Current Status	Assessed Potential Status Change
Dungolman_030	IE_SH_26D060400	Poor	Bad
Inny_110	IE_SH_26I011400	Moderate	Moderate

4.3 MITIGATION MEASURES

In order to mitigate against the potential negative effects on surface and groundwater quality, quantity and flow patterns, mitigation measures will be implemented during the construction and operational phases of the Proposed Development. These are outlined below.

4.3.1 Construction Phase

4.3.1.1 Mitigation Measures to Protect Surface Water Quality during Felling Operations

All tree felling will be done in accordance with the current best practice methods.

A suite of mitigation measures relating to clear felling of coniferous plantations are summarised below. These include avoidance controls and mitigation by design which includes source controls, in-line controls, water treatment controls, and outfall controls.

In addition to these mitigation measures, drains in the vicinity and downstream of the proposed felling areas will be subject to frequent inspection both pre and post-felling. Additionally, surface water quality monitoring shall be completed before, during (if the operation is conducted over a protracted time period) and after felling operations and until the water quality has returned to pre-activity status if an impact has occurred. Daily surface water monitoring forms will also be utilised at every works location in close proximity to a watercourse.

Summary of Mitigation Measures Associated with Proposed Felling Operations

Avoidance Controls:

- 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"
- During the Wind Farm Site construction phase a buffer zone of 50m will be maintained for all streams and rivers where possible, and a 10m buffer will be applied to main drains.
- All proposed tree felling areas are 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:

- 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;
- 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 spoil management 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 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;
- Any diesel or fuel oils stored at the temporary site compounds will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- Refuelling or maintenance of machinery will not occur within 100m of a watercourse. Mobile bowser, drip kits, qualified personnel will be used where refuelling is required; and,
- 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 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 near 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; and,
- 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 will 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 passes, 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); and,
- The above sampling strategy will be undertaken for all on-site sub-catchments streams where tree felling is proposed

4.3.1.2 Mitigation Measures to Protect Surface Water Quality during Excavation Dewatering and Potential Impacts on Surface Water Quality

A suite of general SuDs drainage controls available for surface water management are summarised (along with their application) below. These include avoidance controls, source controls, in-line controls, water treatment controls, and outfall controls.

The key mitigation measure during the construction phase is the avoidance of sensitive aquatic areas where possible, by application of suitable buffer zones (i.e. 50m to main watercourses, and 10m to main drains). From Figure 9-4, it can be seen that all of the key Proposed Development areas within the Wind Farm Site are located significantly away from the delineated 50m watercourse buffer zones with the exception of the upgrading of the existing watercourse crossing, new drain crossing and upgrades to existing site tracks. Spoil management areas for removed soil/subsoil will be localised to turbine locations outside of these buffer zones and will be designed and constructed with the minimal amount of surface area exposed. In these spoil management areas, the vegetative top-soil layer will be removed and re-instated where applicable. In certain areas where reinstated of the vegetative top-soil layer is not possible, these areas will be reseeded directly after construction, allowing for rapid re-vegetation which will mitigate against erosion. Additional control measures, which are outlined further on in this section, will be undertaken at the proposed watercourse and drain crossing locations.

It should be noted that an extensive network of agricultural and forestry drains already exists, and these will be integrated and enhanced as required and used within the Wind Farm Site drainage system. The integration of the existing drainage network and the Wind Farm Site 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 Wind Farm Site 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;
- Buffered outfalls which will be numerous over the site which 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; and,
- 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.

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 hydrological buffer zones.

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 Proposed Development will also take account of weather forecasts, and predicted rainfall in particular. Large excavations and movements of soil/subsoil or vegetation stripping will be suspended or scaled back if heavy rain is forecast. The extent to which works will be scaled back or suspended will relate directly to the amount of rainfall forecast.

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

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

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

Works will be suspended if forecasting suggests any of the following is likely to occur, or if on-site monitoring indicates any of the following has occurred:

- >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, and after, works being suspended the following control measures will be undertaken:
- All open excavations will be secured and sealed off;
- Provide temporary or emergency drainage to prevent back-up of surface runoff; and,
- Avoid working during heavy rainfall and for up to 24 hours after heavy events to ensure drainage systems are not overloaded.

Management of Runoff from Soil and Subsoil Storage Areas:
It is proposed that excavated soil will be used for landscaping where required.

During the initial construction of roads, silt fences, straw bales and biodegradable geogrids will be used to control surface water runoff from works areas.

Where required temporary soil/subsoil storage areas will be sealed with a digger bucket and vegetated as soon possible to reduce sediment entrainment in runoff.

Management of Runoff from existing road upgrade areas:
Where construction is undertaken along sections of proposed access road or existing roads requiring upgrade, the Wind Farm Site drainage infrastructure (as outlined above) will be in place to manage and control runoff from the trench excavation area. Where the cable trench is to be constructed off-road (within the Wind Farm Site) or along public roads surface water control measures such as silt fences will be employed when work is required within hydrological buffer zones.

Timing of Site Construction Works:
Construction of the Wind Farm 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).

4.3.1.3 Mitigation Measures to Protect Against the Release of Hydrocarbons during Construction and Storage

Mitigation measures proposed to avoid the release of hydrocarbons at the Wind Farm Site and Grid Connection include:

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. The fuel bowser, a double-axel custom-built refuelling trailer will be re-filled off site (Wind Farm Site and Grid Connection), 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;

- Refuelling or maintenance of machinery will not occur within 100m of a watercourse;
- Fuels stored on site will be minimised;
- Any diesel or fuel oils stored at the temporary site compound will be bunded. The bund capacity will be sufficient to contain 110% of the storage tank's maximum capacity;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within Construction Environmental Management Plan (CEMP). Spill kits will be available to deal with accidental spillages.

4.3.1.4 Mitigation Measures to Prevent Groundwater and Surface Water Contamination from Wastewater Disposal

Mitigation measures proposed to avoid the release of wastewater at the Wind Farm site include:

- The site compound(s) for the Wind Farm Site will be used for the construction of the underground electrical cabling route;
- Port-a-loos with an integrated waste holding tank will be used at the site compounds, maintained by the providing contractor, and removed from Wind Farm Site on completion of the construction works;
- Water supply for the Wind Farm Site office and other sanitation will be brought to site and removed after use from the Wind Farm Site to be discharged at a suitable off-site treatment location; and,
- No water will be sourced on the Wind Farm Site, or discharged to the Wind Farm Site.

4.3.1.5 Mitigation Measures to Prevent the Release of Cement-Based Products

Best practice methods for cement-based compounds will be implemented throughout the construction phase. Mitigation measures include:

- No batching of wet-cement products will occur on site/along the grid route works or near other ancillary construction activities. 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 will need to be cleaned, using the smallest volume of water possible. No discharge of cement contaminated waters to the construction phase drainage system or directly to any artificial drain or watercourse will be allowed. Chute cleaning water is to be directed into a dedicated concrete wash out pit. Decommissioning of this pit will occur at the end of the construction phase and water and solids will be tanked and removed from the site to a suitable, non-polluting, discharge location;
- All concrete will be paced in shuttering and will not be in contact with soils or groundwater until after it has set;
- Use weather forecasting to plan dry days for pouring concrete; and,
- Ensure pour site is free of standing water and plastic covers will be ready in case of sudden rainfall event.

4.3.1.6 Mitigation Measures to Prevent Morphological Changes to Surface Water Crossing and Drainage Patterns

The proposed mitigation measures include:

- 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;
- Within the Wind Farm Site where the underground electrical cabling route runs adjacent to a proposed access road or an existing access road proposed for upgrade, the underground electrical cabling route cable will pass over the culvert (where one exists or is proposed) within the access road;
- Within the Wind Farm Site, where a proposed access road crosses an existing field drain, the crossing will include a suitably sized pipe at the correct invert level to maintain the existing flow regime and prevent ponding;
- Where a underground electrical cabling route cable stream crossing is required, the cable will pass over the watercourse via suspended ducting thereby avoiding any morphological impacts;
- Any guidance / mitigation measures proposed by the OPW or the Inland Fisheries Ireland will be incorporated into the design of the proposed crossings. A 10m buffer is applied to main drains to allow for future OPW maintenance;
- Works will be completed in accordance with the requirements of "*Inland Fisheries Ireland (2016): Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters"*; and,
- 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.

4.3.1.7 Mitigation Measures to Protect Potential Groundwater and Surface Water Impacts due to Temporary Junction Works

Proposed Mitigation Measures:

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

The purpose of the constraint zone is to:

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

General Best Practice Pollution Prevention Measures will also include

- Protection of the riparian zone watercourses by implementing a constraints zone around stream crossings, in which construction activity will be limited to the minimum, i.e. works solely in connection with duct laying at the stream crossing;

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

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

- Onsite re-fuelling of machinery will be carried out using a mobile double skinned fuel bowser. No maintenance of construction vehicles or plant will take place along the temporary junction works areas;
- The plant used will be regularly inspected for leaks and fitness for purpose; and,
- Spill kits will be available to deal with accidental spillage.

4.3.2 Operational Phase

4.3.2.1 Increased Site Runoff and Hydromorphology Effects

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:
- Runoff from individual turbine hardstanding areas will not be discharged into the existing drain network, but discharged locally at each turbine location through settlement ponds and buffered outfalls onto vegetated surfaces;
- 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.

4.3.2.2 Surface Water Quality from Site Maintenance

During the operational phase, plant will be required on site for maintenance of the wind farm. These vehicles will be refuelled off site, thus preventing hydrocarbon spills. There will be no discharge of wastewater during the operational phase.

Mitigation measures relating to hydrocarbons, wastewater disposal and cement-based materials, as outlined in **Sections 4.3.1.3**, **4.3.1.4** and **4.3.1.5** will continue to provide adequate protection to groundwater and surface water quality during the operational phase.

4.3.3 Decommissioning Phase Potential Impacts

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

Potential impacts would be similar to the construction phase but to a lesser degree. There would be increased trafficking and an increased risk of disturbance to underlying soils at the Wind Farm Site, during the decommissioning phase, in this instance, leading to the potential for silt laden run-off entering receiving watercourses from the wheels of vehicles. Any such potential impacts would be likely to be less than during the construction stage as the drainage swales would be fully mature and would provide additional filtration of runoff. Any diesel or fuel oils stored on site would be bunded. In the event of decommissioning of the Umma More Renewable Energy Development, the proposed access tracks may be used in the decommissioning process.

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

Removal of this infrastructure would result in considerable disturbance to the local environment in terms of disturbance to underlying soils and an increased sedimentation (if turbine foundations, access tracks and hardstandings are being reinstated there is a risk of silt laden run-off entering the receiving watercourses), erosion, dust, noise, traffic and an increased possibility of contamination of the local water table. However, if removal is deemed to be required all infrastructure will be removed with mitigation measures similar to those during construction being employed.

Grid Connection

The onsite substation will remain in place as it will be under the ownership of the ESB. There are no impacts associated with this.

The cabling along the underground electrical cabling route will also remain in place and as such there will be no impacts associated with this.

4.3.4 Potential Effects with the Implementation of Mitigation

In all instances, the mitigation measures described in **Section 4.3** are sufficient to meet the WFD Objectives of each of the screened in Surface Water Bodies and Groundwater Bodies. The assessment of WFD elements for the WFD waterbodies is summarised in **Table L** below.

Table L: Summary of WFD Status for Unmitigated and Mitigated Scenarios

SWB	WFD Code	Current Status (2016-2021)	Assessed Potential Status Change - Unmitigated	Assessed Status with Mitigation Measures
Dungolman_030	IE_SH_26D060400	Poor	Bad	Poor
Inny_110	IE_SH_26I011400	Moderate	Poor	Moderate
Ballynagrenia Stream_010	IE_SH_25B160400	Poor	Bad	Poor
Ballynagrenia Stream_020	IE_SH_25B160600	Good	Moderate	Good
Gageborough_020	IE_SH_25G010300	Good	Moderate	Good
Gageborough_030	IE_SH_25G010500	Good	Moderate	Good
Brosna_070	IE_SH_25B090450	Good	Moderate	Good
Tonaphort_010	IE_SH_25T450930	Moderate	Poor	Moderate
Durrow Abbey Stream_010	IE_SH_25D120200	Poor	Bad	Poor
Silver (Tullamore) _020	IE_SH_25S030100	Good	Moderate	Good
Silver (Tullamore) _030	IE_SH_25S030300	Good	Moderate	Good
Tullamore_030	IE_SH_25T030300	Poor	Bad	Poor
Inny GWB	IE_SH_G_110	Good	Moderate	Good
Clara GWB	IE_SH_G_240	Good	Moderate	Good
Gageborogh-Brosna Gravels Group 1 GWB	IE_SH_G_253	Good	Moderate	Good
Kilbeggan Gravels GWB	IE_SH_G_242	Good	Moderate	Good
Tullamore GWB	IE_SH_G_232	Good	Moderate	Good

5. WFD ASSESSMENT CONCLUSION

WFD status for SWBs (Surface Water Bodies) and GWBs (Groundwater Bodies) hydraulically linked to the Proposed Development site are defined in **Section 2** above.

The Proposed Development does not involve any abstraction of groundwater or alteration of drainage patterns. Therefore, the quantitative status (i.e., the available quantity (volume) of groundwater and surface water locally) to the receiving waters will remain unaltered during the construction and operational phase of the Proposed Development.

There is no direct discharge from the Proposed Development site to downstream receiving waters. Mitigation for the protection of surface water during the construction, operation and decommissioning phases of the Proposed Development will ensure the qualitative status of the receiving waters will not be altered by the Proposed Development.

There is also mitigation proposed to protect groundwater quality within the Proposed Development scheme during the construction, operational and decommissioning phases of the Proposed Development. These mitigation measures will ensure the qualitative status of the underlying GWB will not be altered by the Proposed Development.

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

In the event where the current status of the waterbody is Poor (i.e. Dungolman_030, Ballynagrenia Stream_010, Durrow Abbey Stream_010 and Tullamore_030) the Proposed Development will not prevent them from achieving Good Status in the future.

As such, the Proposed Development:

- will not cause a deterioration in the status of all surface and groundwater bodies assessed;
- will not jeopardise the objectives to achieve 'Good' surface water/groundwater status;
- does not jeopardise the attainment of 'Good' surface water/groundwater chemical status;
- does not jeopardise the attainment of 'Good' surface water/groundwater quantity status;
- does not permanently exclude or compromise the achievement of the objectives of the WFD in other waterbodies within the same river basin district;
- is compliant with the requirements of the Water Framework Directive (2000/60/EC); and,
- is consistent with other Community Environmental Legislation including the EIA Directive (2014/52/EU), the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) (Note that a full list of legislation complied with in relation to hydrology and hydrogeology is included in Section 9.1.4 of EIAR Chapter 9).

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APPENDIX 9-3

WATER QUALITY LAB REPORTS

ALS Life Sciences Ltd
Trading as ALS
Carrigeen Business Park, Clonmel, Co. Tipperary
Tel: +353 (0) 52 617 8100
Fax:+353 (0) 52 617 8103
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Report No:	HYDR-828070721
Document No:	EF0011

CERTIFICATE OF ANALYSIS

Client **Hydro Environmental Services**
22 Lower Main Street
Dungarvan
Co. Waterford

Date Received	07/07/2021
Date Reported	16/07/2021
Order Number	P1553

For the Attention of: Hydro Environmental Services

Sample Reception 3 sample(s) received in good condition.

Comments N/A

Report Authorised by: Rosemary Thomas

Rosemary Thomas
Environmental Chemistry Manager

Conditions:
1. Results in this report relate only to the items tested
2. Reports may not be reproduced except in full without the approval of ALS Life Sciences Ltd
3. All queries regarding this report should be addressed to the Technical Manager at the above address
*4. A * next to a method reference signifies that ALS Life Sciences Ltd is NOT INAB accredited for this method*
5. Results reported as CFU/cm² are calculated based on information supplied by customer regarding area swabbed
6. SUBCON indicates analysis subcontracted to approved subcontractors who do not hold accreditation for this test*
7. SUBCON^ indicates analysis subcontracted to approved subcontractors who hold accreditation for this test
8. Where sampling is undertaken by ALS personnel, sampling activities are outside the scope of INAB accreditation
9. Dil next to a method reference indicates that a dilution of the water sample was undertaken during testing

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Report No: HYDR-828070721

Document No: EF0011

CERTIFICATE OF ANALYSIS

Date Received 07/07/2021
Date Reported 16/07/2021
Order Number P1553

Sample Type Water
Client ID Ballynacora SW1
Date Tested 08/07/2021
ALS ID 4561986

Test	Result	Unit	Method
Suspended Solids	6	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	13.5	mg/l Cl	P281
Nitrate	<5.0	mg/l NO3	P281
Nitrite	0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	2.7	mg/L N	P285

Sample Type Water
Client ID Ballynacora SW2
Date Tested 08/07/2021
ALS ID 4561987

Test	Result	Unit	Method
Suspended Solids	6	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	17.3	mg/l Cl	P281
Nitrate	6.5	mg/l NO3	P281
Nitrite	0.07	mg/l NO2	P281
Ammonia	0.03	mg/l NH3-N	P281
Nitrogen (Total)	1.7	mg/L N	P285

Report Authorised by: Rosemary Thomas

Rosemary Thomas
Environmental Chemistry Manager

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ISO 17025 INAB ACCREDITED TESTING
DETAILED IN SCOPE REG NO.166T

Report No: HYDR-828070721

Document No: EF0011

CERTIFICATE OF ANALYSIS

Date Received 07/07/2021
Date Reported 16/07/2021
Order Number P1553

Sample Type Water
Client ID Ballynacora SW3
Date Tested 08/07/2021
ALS ID 4561988

Test	Result	Unit	Method
Suspended Solids	7	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	2	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	15.2	mg/l Cl	P281
Nitrate	<5.0	mg/l NO3	P281
Nitrite	0.28	mg/l NO2	P281
Ammonia	0.14	mg/l NH3-N	P281
Nitrogen (Total)	1.2	mg/L N	P285

Report Authorised by: Rosemary Thomas

Rosemary Thomas
Environmental Chemistry Manager

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Report No:	HYDR-366240322
Document No:	EF0011

CERTIFICATE OF ANALYSIS

Client **Hydro Environmental Services**
22 Lower Main Street
Dungarvan
Co. Waterford

Date Submitted	24/03/2022
Date Reported	05/04/2022
Order Number	1553

For the Attention of: Hydro Environmental Services

Sample Reception 10 sample(s) received in good condition.

Comments N/A

Report Authorised by: Rosemary Thomas

Rosemary Thomas
Environmental Chemistry Manager

Conditions:
1. Results in this report relate only to the items tested
2. Reports may not be reproduced except in full without the approval of ALS Life Sciences Ltd
3. All queries regarding this report should be addressed to the Technical Manager at the above address
*4. A * next to a method reference signifies that ALS Life Sciences Ltd is NOT INAB accredited for this method*
5. Results reported as CFU/cm² are calculated based on information supplied by customer regarding area swabbed
6. SUBCON indicates analysis subcontracted to approved subcontractors who do not hold accreditation for this test*
7. SUBCON^ indicates analysis subcontracted to approved subcontractors who hold accreditation for this test
8. Where sampling is undertaken by ALS personnel, sampling activities are outside the scope of INAB accreditation
9. Dil next to a method reference indicates that a dilution of the water sample was undertaken during testing

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Report No: HYDR-366240322

Document No: EF0011

CERTIFICATE OF ANALYSIS

Date Submitted 24/03/2022
Date Reported 05/04/2022
Order Number 1553

Sample Type Water
Client ID Ballynacorra SW1
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947295

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	14.2	mg/l Cl	P281
Nitrate	10.3	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	2.6	mg/L N	P285

Sample Type Water
Client ID Ballynacorra SW2
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947296

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	17.0	mg/l Cl	P281
Nitrate	12.4	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	0.04	mg/l NH3-N	P281
Nitrogen (Total)	3.4	mg/L N	P285

Report Authorised by: Rosemary Thomas

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Sample Type Water
Client ID Ballynacorra SW3
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947297

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	16.0	mg/l Cl	P281
Nitrate	9.5	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	3.2	mg/L N	P285

Sample Type Water
Client ID Ballynacorra SW4
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947298

Test	Result	Unit	Method
Suspended Solids	11	mg / l	P202
Phosphorus	0.12	mg/l P	P207
BOD 5 day Total with ATU	2	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	12.5	mg/l Cl	P281
Nitrate	<5.0	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	2.1	mg/L N	P285

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Sample Type Water
Client ID Ballynacorra SW5
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947299

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	14.3	mg/l Cl	P281
Nitrate	<5.0	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	0.03	mg/l NH3-N	P281
Nitrogen (Total)	1.8	mg/L N	P285

Sample Type Water
Client ID Ballynacorra SW6
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947300

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	<1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	12.9	mg/l Cl	P281
Nitrate	11.5	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	1.5	mg/L N	P285

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Sample Type Water
Client ID Ballynacorra SW7
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947301

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	<1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	16.8	mg/l Cl	P281
Nitrate	16.7	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	5.6	mg/L N	P285

Sample Type Water
Client ID Ballynacorra SW8
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947302

Test	Result	Unit	Method
Suspended Solids	25	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	15.3	mg/l Cl	P281
Nitrate	18.9	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	4.2	mg/L N	P285

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Order Number 1553

Sample Type Water
Client ID Ballynacorra SW9
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947303

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	18.6	mg/l Cl	P281
Nitrate	6.6	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	1.0	mg/L N	P285

Sample Type Water
Client ID Ballynacorra SW10
Date Tested 24/03/2022
Scheduled date 24-Mar-2022
ALS ID 4947304

Test	Result	Unit	Method
Suspended Solids	<5	mg / l	P202
Phosphorus	<0.10	mg/l P	P207
BOD 5 day Total with ATU	<1	mg/l O2	P280
Orthophosphate	<0.02	mg/l P	P281
Chloride	17.5	mg/l Cl	P281
Nitrate	25.3	mg/l NO3	P281
Nitrite	<0.05	mg/l NO2	P281
Ammonia	<0.02	mg/l NH3-N	P281
Nitrogen (Total)	4.6	mg/L N	P285

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APPENDIX 9-4

DRAINAGE DRAWINGS

Included as standalone Appendix 4 to the NIS