MWP

FLOOD RISK ASSESSMENT

Ballinla Wind Farm,

Co. Offaly

Ballinla Wind Farm Limited

June 2025

MWP

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MWP, Engineering and Environmental Consultants
Address: Park House, Bessboro Road, Blackrock, Cork, T12 X251, Ireland

www.mwp.ie

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1. General

1.1 Introduction

MWP Engineering and Environmental Consultants have been commissioned to carry out a Flood Risk Assessment on behalf of Ballinla Wind Farm Limited who propose to develop a wind farm comprising seven (7) No. wind turbines and a new on-site 110Kv substation approximately 5Km west of Edenderry town in the townland of Leitrim, Co. Offaly.

1.2 Overview of Existing Site

The lands within the proposed development area are owned by a number of different private landowners and one semi state body. The lands consist of agricultural farmland and commercial forestry.

The proposed project area is approximately 5Km west of Edenderry town in the townland of Leitrim, Co. Offaly. Figure 1-1 shows the proposed wind farm development site location.

The Leitrim watercourse is the main hydrological feature in proximity to the proposed development. The watercourse flows from north to south through the proposed development site. The Lumville watercourse is a tributary of the Leitrim watercourse. The Lumville watercourse is located in the southern portion of the wind farm. It flows around Turbine 5 and joins the Leitrim watercourse approximately 400m west of Turbine 5.

The Rogerstown watercourse is located in the northeastern part of the proposed development site. The Rogerstown Stream flow regime is complex as a result of channel modifications. Part of the Rogerstown watercourse flows west towards the main Leitrim watercourse while the remainder flows in an easterly direction away from the proposed development.

The Rathmoyle watercourse flows from north to south along the proposed development site's western boundary where it joins the Rathcobican watercourse. The Rathcobican watercourse flows from north to south where it joins the Esker watercourse approximately 2.4Km south west of Turbine 7.

The Grand Canal is located approximately 500m north of the proposed development. The canal is slightly raised above the surrounding landscape and the canal waters are contained within embanked sections running at a higher level than the surrounding countryside. There is no Hydrological link with the canal from the proposed development. The Rogerstown watercourse crosses the canal via an under canal culvert.

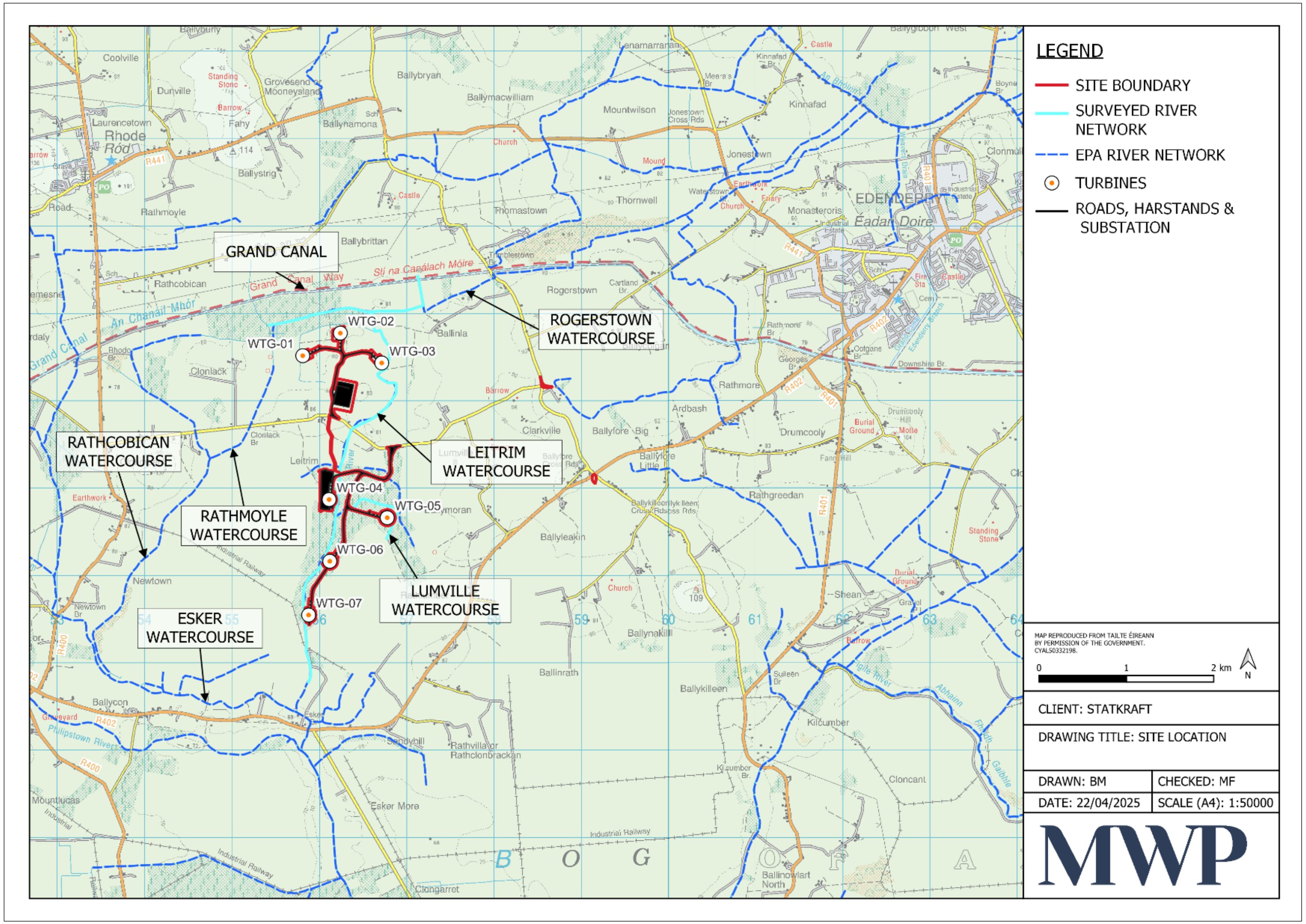

Figure 1-1: Proposed Development Site Location

1.3 Overview of Proposed Development

The development for which planning permission is sought in the planning application (the proposed development) consists of the following:

- Seven Wind Turbine Generators (WTGs) (blade tip height 185m).
- Seven WTG foundations and hardstand areas.
- One electrical substation (110kV) including associated ancillary buildings, security fencing and all associated works.
- One Met LiDAR station based on the ground.
- Underground cable (UGC) grid connection from the proposed onsite 110kV substation via a route on public road for 8Km to the existing Philipstown 110kV substation.
- Two proposed site entrances to provide access to the northern and southern sections of the proposed development site from the L5010.
- New and upgraded internal site access tracks.
- All associated underground electrical and communications cabling connecting the proposed turbines to the proposed onsite substation.
- Temporary works on sections of the public road network along the turbine delivery route
- One temporary construction site compound and additional mobile welfare unit.
- One spoil deposition area.
- Associated surface water management systems.

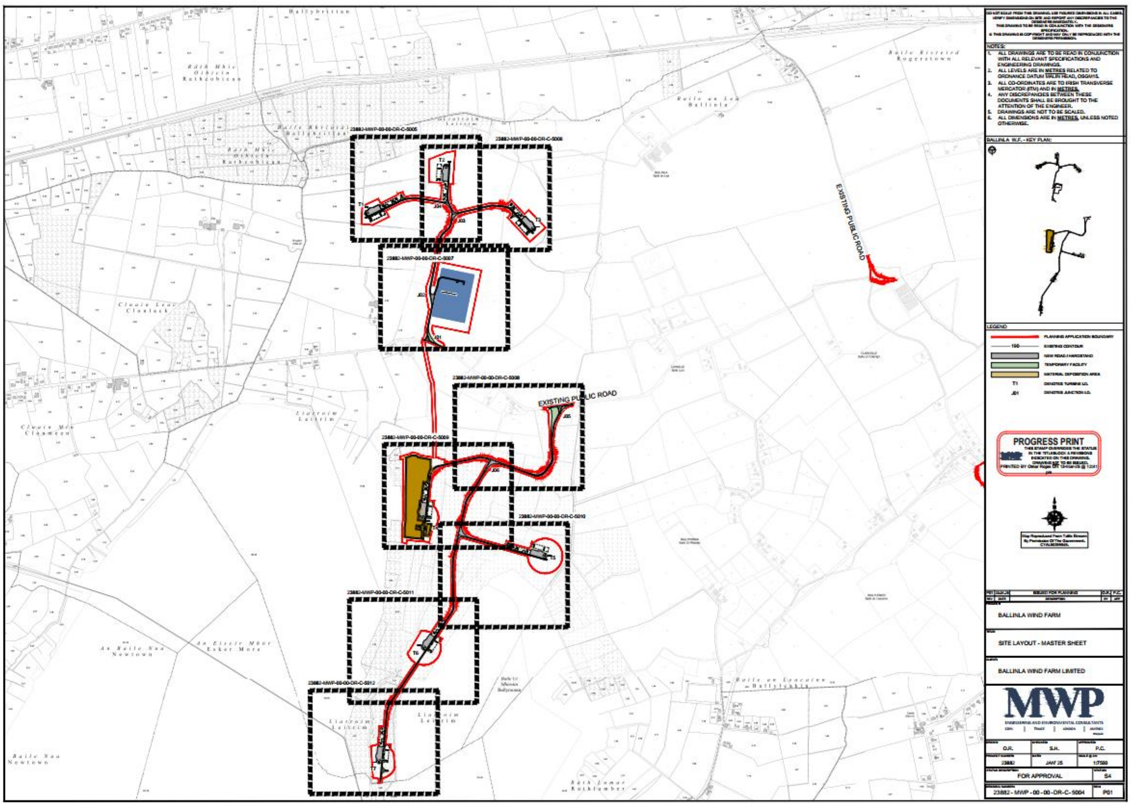

Figure 1-2: Proposed Development Site Layout

1.4 Objectives

The purpose of the report is to establish the flood risk associated with the proposed development and, if appropriate, to recommend mitigation measures to prevent any increase in flood risk within the proposed development site or externally in the wider area.

The report has been prepared in the context of *The Planning System and Flood Risk Management – Guidelines for Planning Authorities, November 2009*, published by the Office of Public Works and the Department of Environment, Heritage and Local Government. Flood Risk Assessments are carried out at different scales by different organisations. The hierarchy of assessment types are Regional (RFRA), Strategic (SFRA) and Site-specific (FRA). This report is site-specific.

1.5 Methodology

The Flood Risk Management Guidelines document outlines three stages in the assessment of flood risk as follows:

Stage 1 Flood risk identification – to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation.

Stage 2 Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to determine what surveys and modelling approach is appropriate to match the spatial resolution required and complexity of the flood risk issues. The extent of the risk of flooding should be assessed which may involve preparing indicative flood zone maps. Where existing river or coastal models exist, these should be used broadly to assess the extent of the risk of flooding and potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures; and

Stage 3 Detailed risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures. This will typically involve use of an existing or construction of a hydraulic model or a river or coastal cell across a wide enough area to appreciate the catchment wide impacts and hydrological processes involved.

This report has been prepared generally in accordance with these stages.

1.6 Flood Risk & Zones

In the Planning System and Flood Risk Management Guidelines document, the likelihood of a flood occurring is established through the identification of Flood Zones which indicate a high, moderate or low risk of flooding from fluvial or tidal sources. **Table 1-1** below includes the definition of Flood Zones as well as the implications for planning. The flood zone type is determined based on current water surface levels without allowance for climate change and without the benefit of any flood defences. It is important to note that the Flood Zones do not take other sources of flooding, such as groundwater or pluvial, into account, so an assessment of risk arising from such sources should also be made, where appropriate.

Table 1-1: Definition of Flood Zones

Flood Zone	Description & Summary of Planning Implications
Zone A High probability of flooding	More than 1% probability (1 in 100) for river flooding and more than 0.5% probability (1 in 200) for coastal flooding. Most types of development would be considered inappropriate in this zone.
Zone B Moderate probability of flooding	0.1% to 1% probability (between 1 in 100 and 1 in 1,000) for river flooding and 0.1% to 0.5% probability (between 1 in 200 and 1 in 1,000) for coastal flooding. Highly vulnerable development, such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses and primary strategic transport and utilities infrastructure, would generally be considered inappropriate in this zone.
Zone C Low probability of flooding	This zone defines areas with a low risk of flooding from rivers and the coast (i.e. less than 0.1% probability or less than 1 in 1,000). Development in this zone is appropriate from a flooding perspective (subject to assessment of flood hazard from sources other than rivers and the coast).

The Guidelines have outlined three Vulnerability Classifications for developments based on the proposed land use and type of development. These classifications and particular examples of development types which would be included in each classification are summarised as follows;

- **Highly Vulnerable Development:** This would include emergency services, hospitals, schools, residential institutions, dwelling houses, essential infrastructure, water & sewage treatment etc.
- **Less Vulnerable Development:** Retail, leisure, commercial, industrial buildings, local transport infrastructure.
- **Water-compatible development:** Docks, marinas and wharves. Amenity and open space, outdoor sports and recreation and essential facilities such as changing rooms.

The Guidelines include a matrix that determines the appropriateness of different types of development based on their vulnerability classification and the Flood Zones in which they are located. The matrix is reproduced in **Table 1-2** below.

The proposed sub-station falls under the essential infrastructure category and is considered a highly vulnerable development. The Guidelines state that development types not listed should be considered on their own merits. The construction of wind turbines and the associated infrastructure are not listed, therefore the assumption is that they can be constructed in any of the flood zones provided that they are protected from flooding and that their presence does not increase flood risk elsewhere.

Where the matrix indicates that a development is not appropriate it may still be justified based on a procedure described as a Justification Test. If the Justification Test is passed, development within Flood Zone A/B could be appropriate.

Table 1-2: Vulnerability Matrix

Vulnerability Classification	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

2. Flood Risk Identification (Stage 1)

Possible sources of flood risk were identified by;

- Geology & Soil Mapping
- Flood History - examination of available information on the OPW website (www.floodinfo.ie)
- National Indicative Fluvial Mapping (NIFM)
- South Eastern Catchment Flood Risk And Management Study (SE CFRAMS)
- GSI Winter 2015/2016 Surface Water Flooding
- Internet Searches
- Walkover survey of the subject site and the nearby watercourses

2.1 Geology & Soil Mapping

The geology and soils at the proposed development site have been reviewed using the Geological Survey of Ireland database. The Teagasc soil map is an indicative soils map which classifies the soils of Ireland on a categorically simplified but cartographically detailed basis into 25 classes, using an expert rule-based methodology. The proposed development site location is predominantly underlain by Cutaway/cutover peat according to Teagasc soil data. Quaternary geology is the soft material that has been deposited in the last 2.6 million years. In Ireland much of this is related to the movement of glaciers and ice sheets. The quaternary sediment map indicates that the proposed development site is underlain by Cut over raised peat and Till derived from limestones. The Bedrock Geology dataset is simply a representation of the sub-surface of the Republic of Ireland if all the surface materials such as soil and gravel were removed down to the hard, solid rock beneath (bedrock). As such, it is an interpretation, as in most places rock is not exposed at the surface. The bedrock geology in this area is dominated by the Edenderry Oolite Member which is described as Oolitic limestone.

2.2 Flood History – OPW Local Area Summary Report

There are no recorded past flood events within 2.5Km of the proposed development site as seen in **Figure 2-4**.

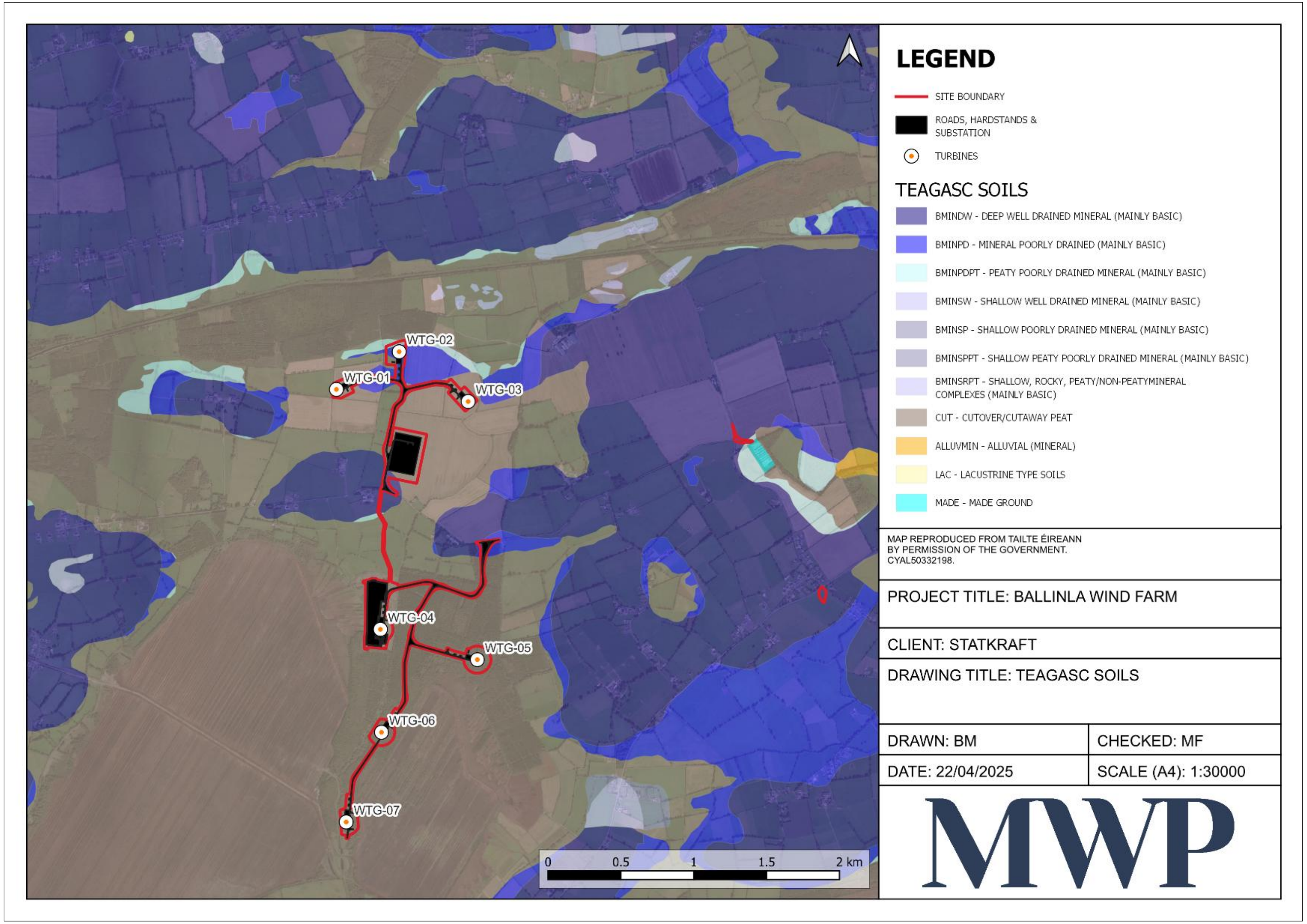

Figure 2-1: Teagasc Soil Map

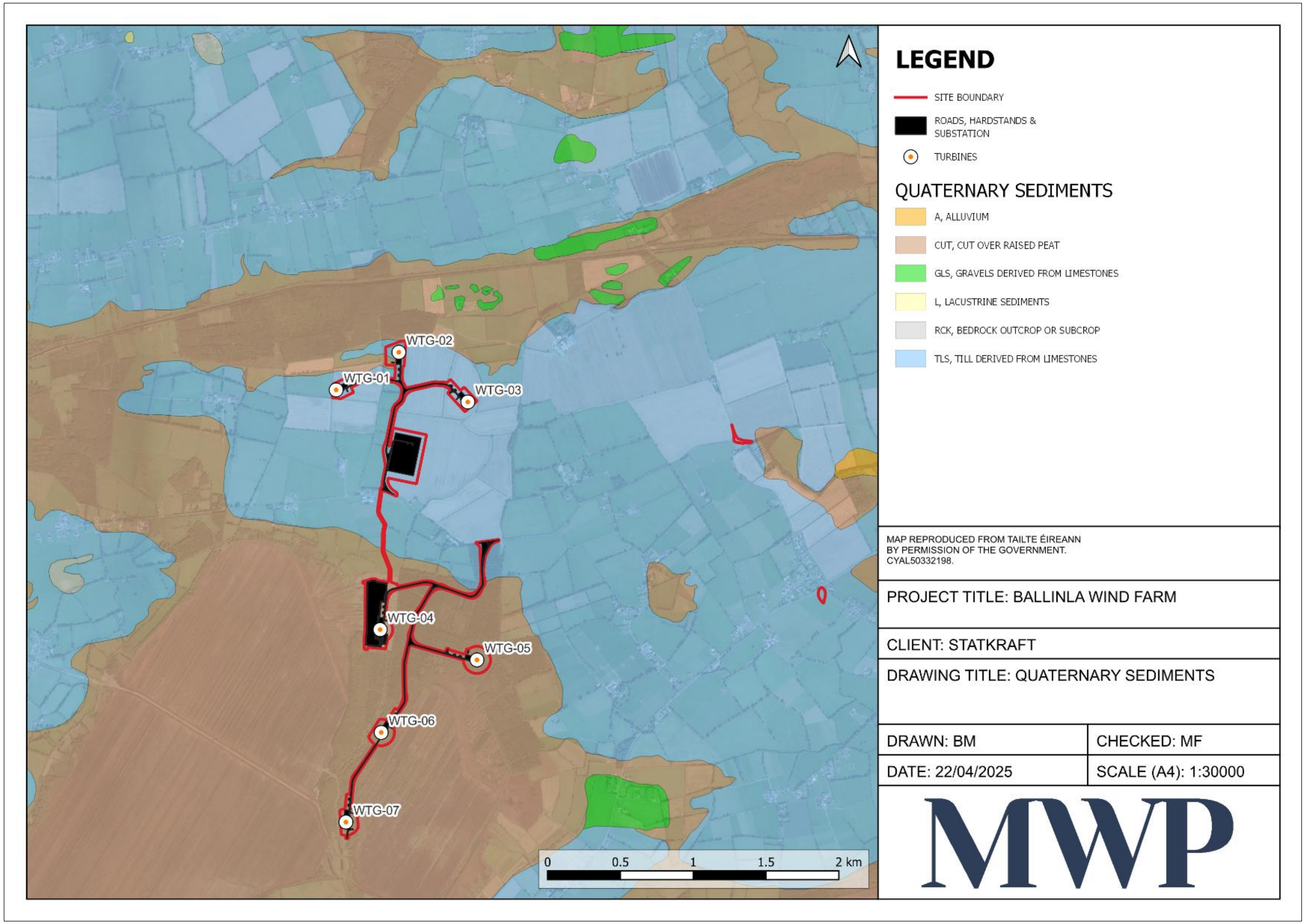

Figure 2-2: Quaternary Sediment Map

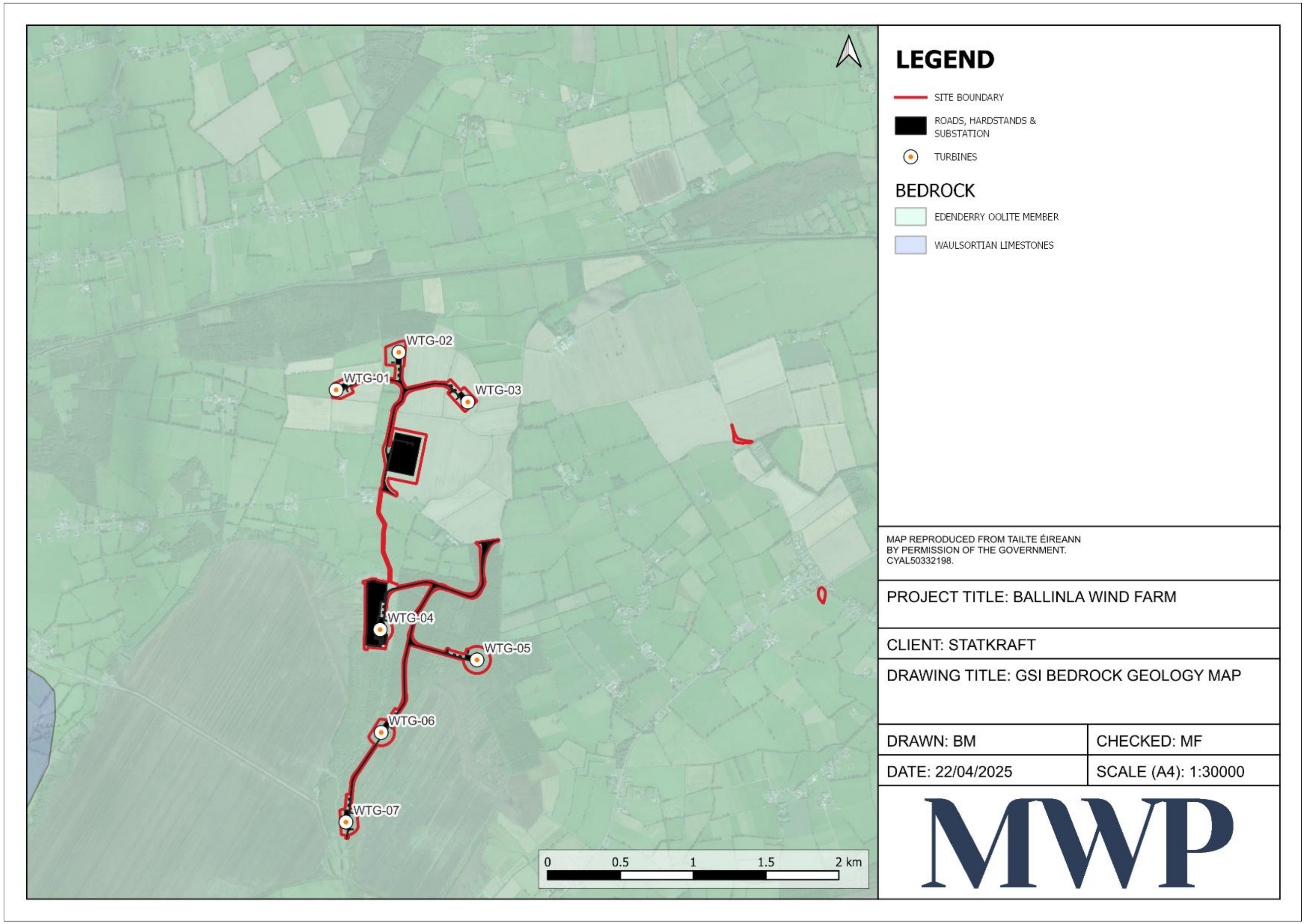

Figure 2-3: GSI Bedrock Geology Map

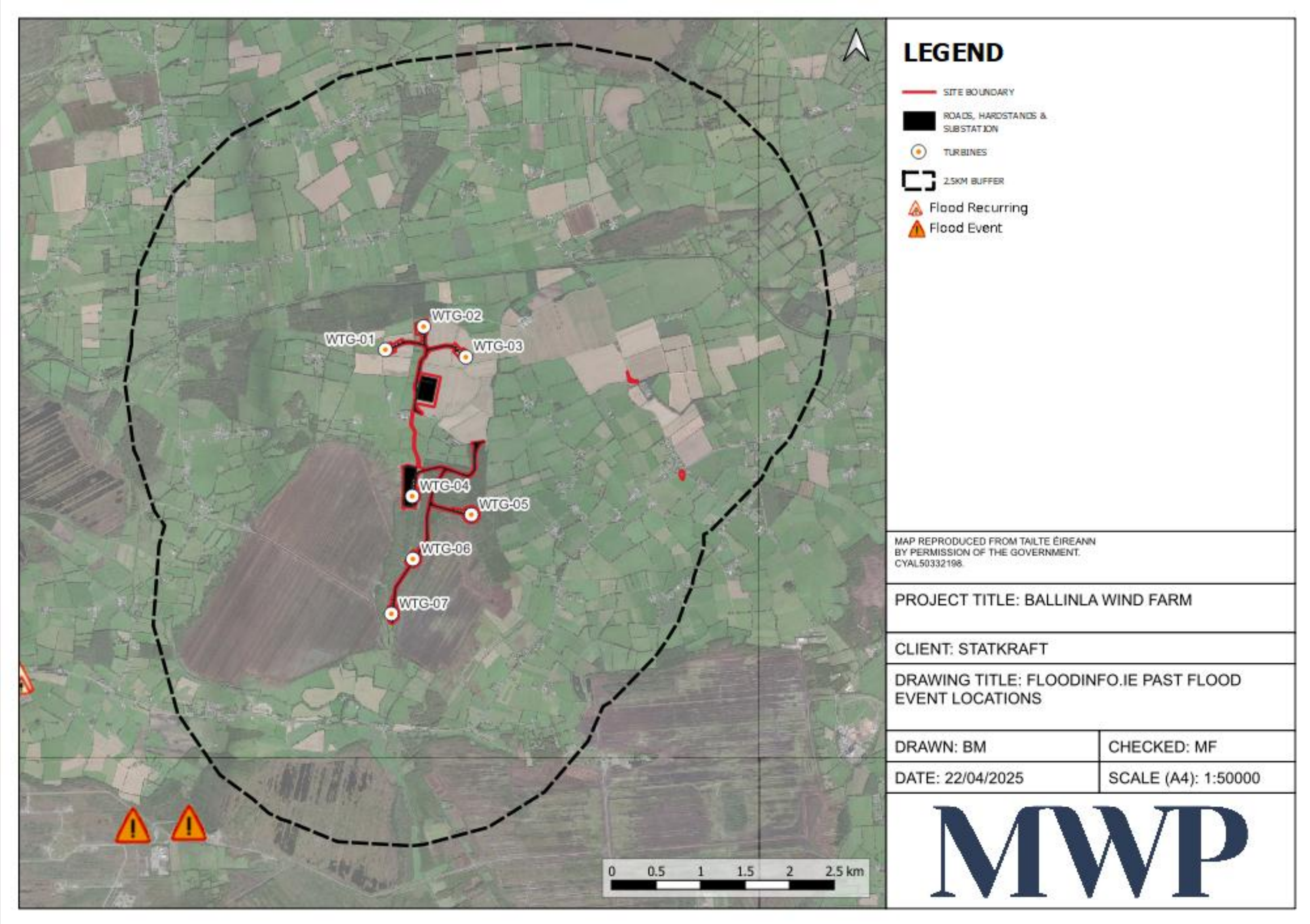

Figure 2-4: Floodinfo.ie Past Flood Event Locations

2.3 National Indicative Fluvial Mapping (NIFM)

The National Indicative Fluvial Flood Maps have been produced for catchments greater than 5Km² in areas for which flood maps were not produced under the National Catchment Flood Risk Assessment and Management Programme (CFRAM). The Leitrim watercourse has been mapped under the National Indicative Fluvial Mapping program. An extract of the fluvial flood mapping for the current scenario is shown in Figure 2-5. These maps are not the best achievable representation of projected flood extents, such as those that could be generated through detailed hydraulic modelling, and are only indicative of the predicted flood extent of any given probability at any particular location. They should not be used for local decision-making or any other purpose without verification and seeking the advice of a suitable professional.

The flood maps may be used in the Stage 1 Flood Risk Assessment (Flood Risk Identification) to identify areas where further assessment would be required if development is being considered within or adjacent to the flood extents shown on the maps. Similarly, the maps may be used to identify whether flood risk might be a relevant issue when considering a planning application, or when discussing a potential application at pre-planning stage. Local site inspections, and / or making use of the knowledge of staff familiar with a particular area, are essential to determine if the maps for a given area are reasonable. For the purposes of flood zoning, or making decisions on planning applications, it is strongly recommended that a Stage 2 Flood Risk Assessment (Initial Flood Risk Assessment), as set out in the Planning System and Flood Risk Management Guidelines, is undertaken (where there are proposals for zoning or development, and where the area may be prone to flooding, as described above). These maps are 'predictive' flood maps showing indicative areas predicted to be inundated during a theoretical fluvial flood event with an estimated probability of occurrence, rather than information for actual floods that have occurred in the past, which is presented, where available, on the 'past' flood maps.

The maps refer to flood event probabilities in terms of a percentage Annual Exceedance Probability, or 'AEP'. This represents the probability of an event of this severity occurring in any given year. They are also commonly referred to in terms of a return period (e.g. the 100-year flood). The flood extents for the 1% (100-year flood) and 0.1% (1000-year flood) AEP Present Day Scenario (Current Scenario) flood events are illustrated below in Figure 2-5 below.

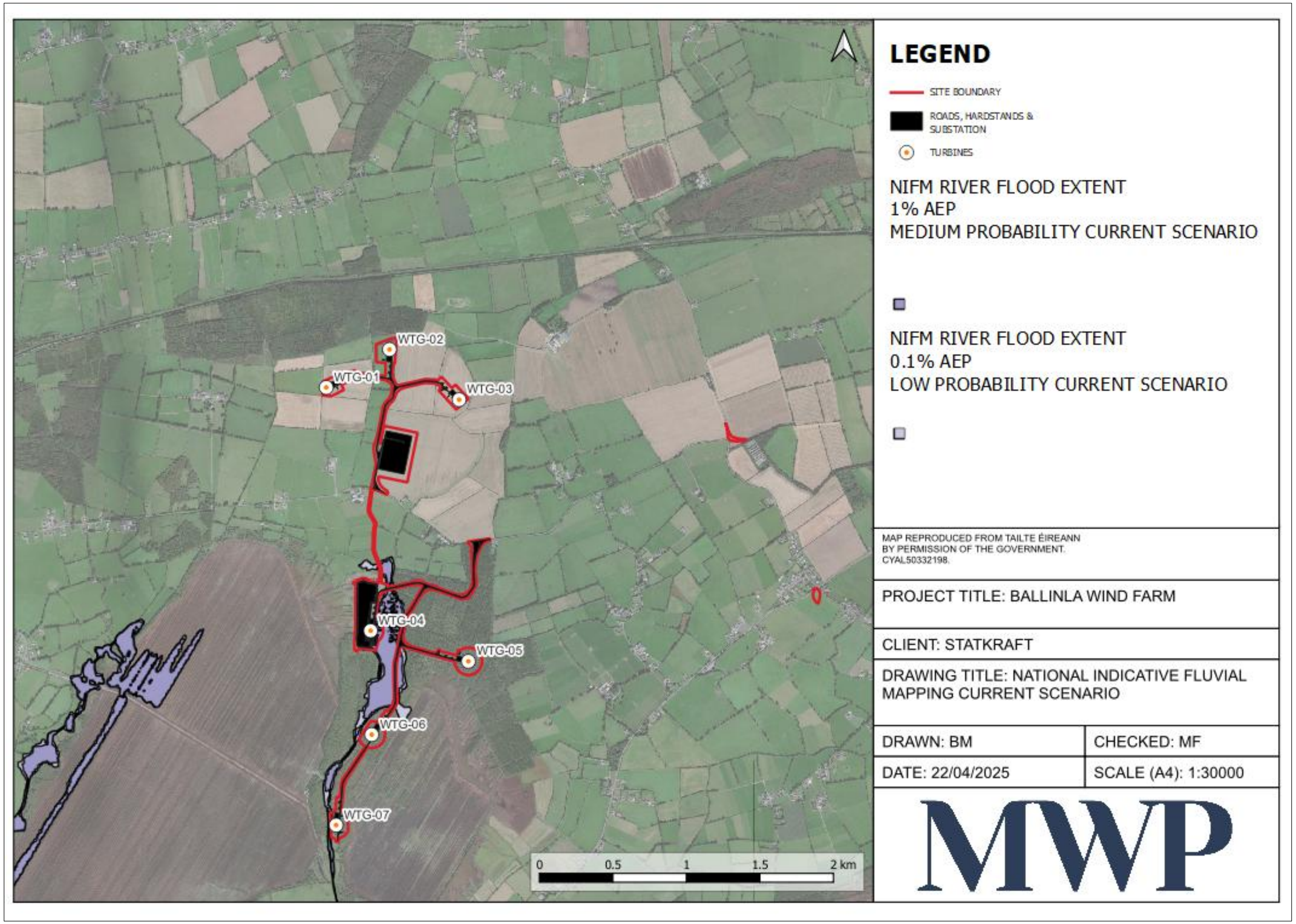

Figure 2-5: National Indicative Fluvial Mapping Current Scenario

2.4 South Eastern Catchment Flood Risk and Management Study (SE CFRAMS)

The OPW South Eastern CFRAM study is the most detailed mapping in the area. The South Eastern CFRAM involved detailed hydraulic modelling of rivers and their tributaries along with coastal flooding. Flood extents have been generated for the Philipstown watercourse which is located south of the proposed development. The Leitrim watercourse discharges into the Esker Stream which discharges into the larger Philipstown watercourse approximately 1.4Km south of the proposed development. An extract of the flood extent map for the present-day scenario is shown in **Figure 2-6** below.

2.5 GSI Winter 2015/2016 Surface Water Flooding

The Winter 2015/2016 Surface Water Flooding map shows fluvial (rivers) and pluvial (rain) floods, excluding urban areas, during the winter 2015/2016 flood event. There is flooding indicated within the landholding boundary and within close proximity to the proposed wind farm infrastructure during this flood event as seen in **Figure 2-7**.

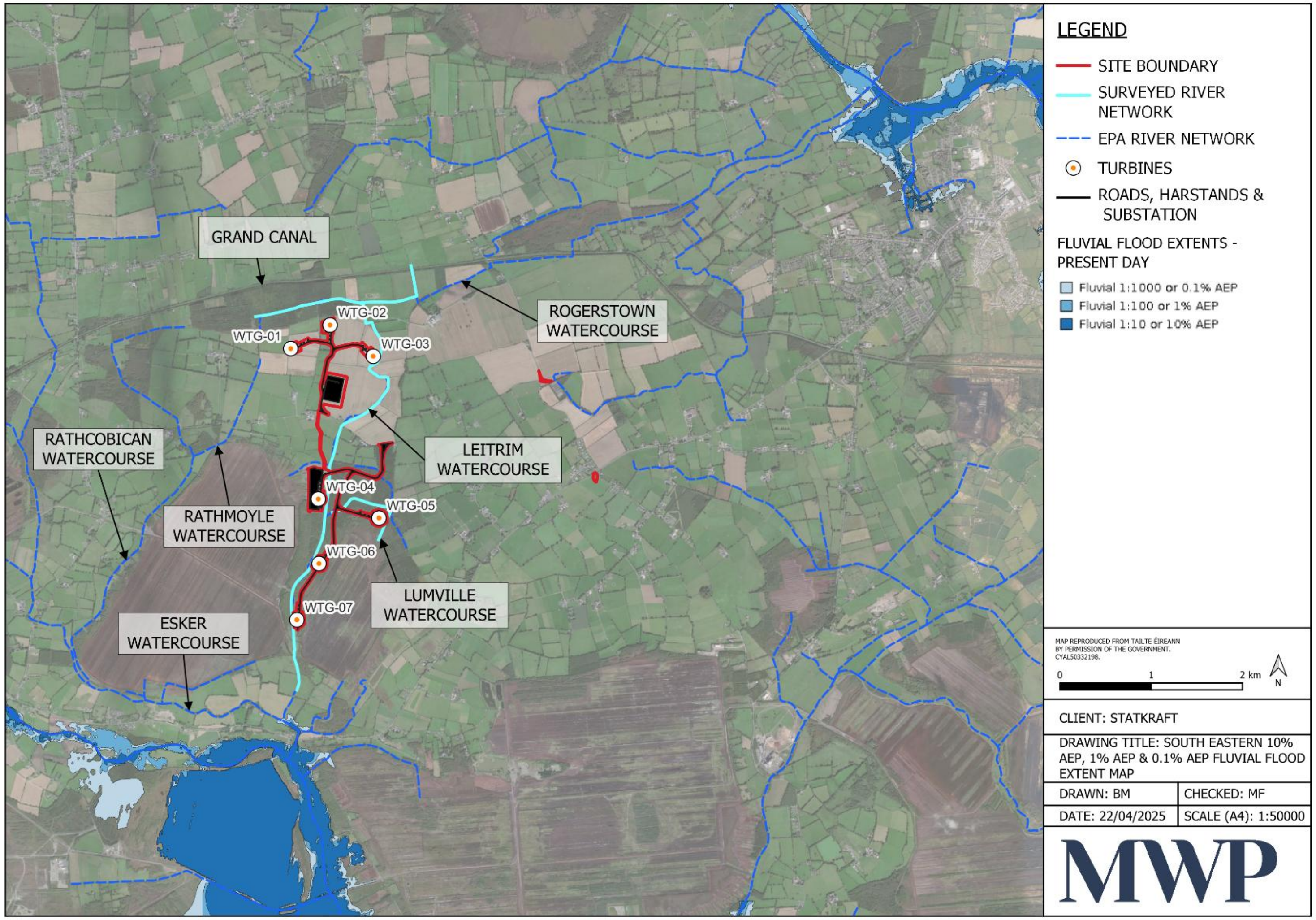

Figure 2-6: South Eastern CFRAM 10%, 1%AEP and 0.1%AEP Fluvial Flood Extent Map

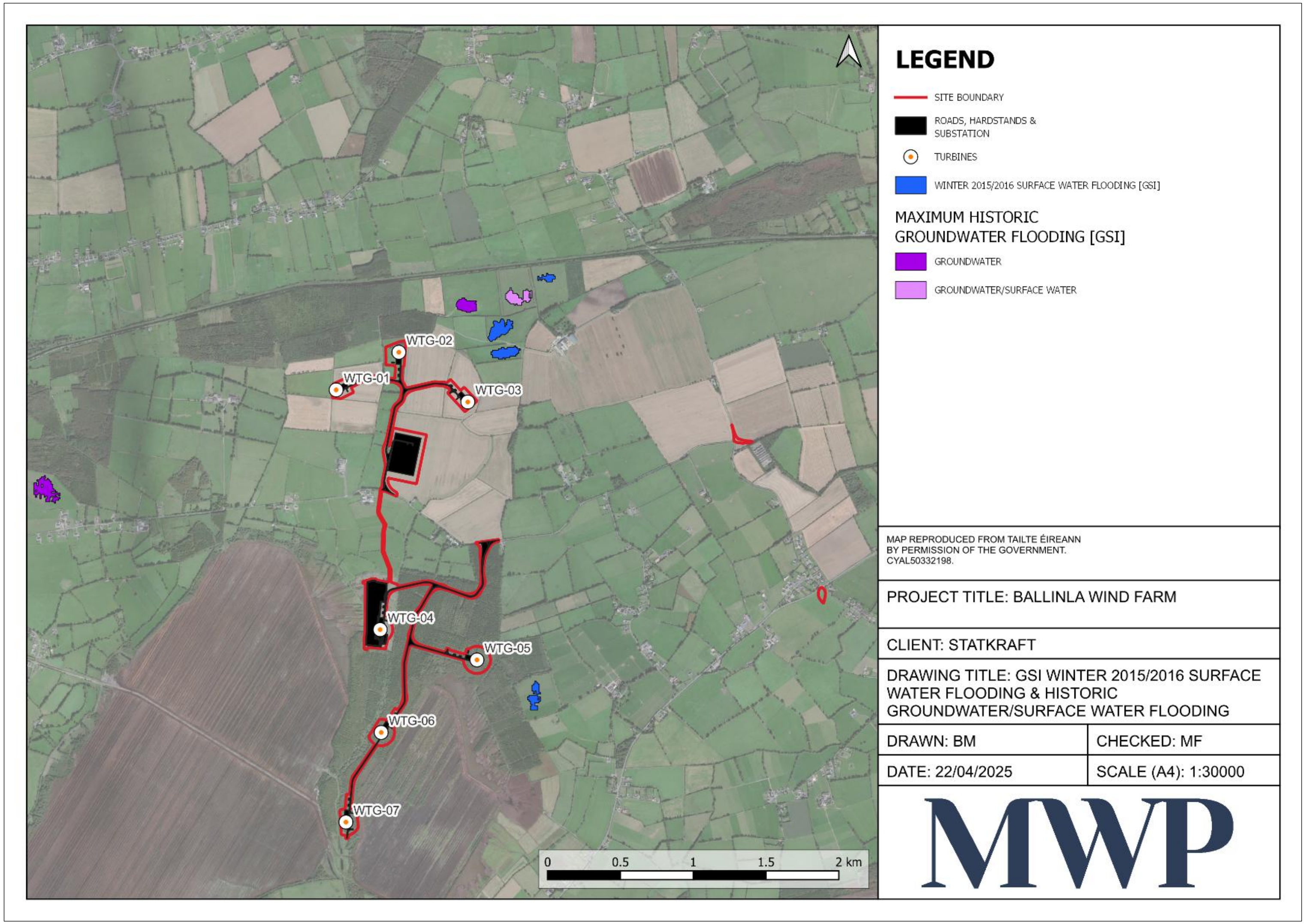

Figure 2-7: GSI Winter 2015/2016 Surface Water Flooding & Historic Groundwater/Surface Water Flooding

2.6 Internet Searches

An internet search was conducted to gather information about whether the proposed development site was affected by flooding previously. There were no reports of flooding.

2.7 Walkover Survey of the Subject Site and the nearby Watercourses/Drainage Ditches

A site walkover was carried out by MWP on the 13th October 2023. The main purpose of the site walkover was to identify any features that have not already been identified in the desktop study. The following observations were noted;

- The main channel of the Leitrim watercourse in the northern portion of the proposed development site is deep, widened, straight and has no significant vegetation within the main channel.
- The overbank areas in northern portion of the proposed development site are dominated by pastural farming greenfields with short grass.
- The main channel of the Leitrim watercourse in the southern portion of the proposed development site is less modified. The channel in the southern portion of the proposed development site is also deep, straight and no has significant vegetation within the main channel.
- The overbank areas in the southern portion of the proposed development site are predominantly forestry, with heavy stands of timber, fallen trees, scattered brush and heavy weeds.
- There are approximately 12 No. existing crossings on the Leitrim watercourse which are predominantly local farm crossings consisting of pipe culverts ranging in size from 0.6m up to 1.4m.
- There is 1 No. crossing that consists of a 0.6m pipe allowing flow under the local road (L5010).
- The Lumville watercourse is shallow, straight and the vegetation varies from weedy to no significant vegetation.
- The overbank areas of the Lumville watercourse are predominantly forestry, with heavy stands of timber, fallen trees, scattered brush and heavy weeds.

2.8 Grid connection

The trench for the Grid Connection Route will be temporary, and the existing road surface will be fully reinstated following the installation of the grid cable. No permanent increase in hardstanding is proposed, and therefore, the road surface will not be subject to lasting alteration. Consequently, the installation of the Grid Connection Route will not impact the existing flow paths or increase flood risk to people, property or the surrounding environment.

2.9 Turbine Delivery Route

It should be noted that there will be no works proposed along the vast majority of the Turbine Delivery Route, with only relatively minor temporary works proposed at three specific locations, two of which are located east of the wind turbines as seen in **Figure 1-1** above. Works at these two locations will involve installation of temporary unsealed roads/tracks to allow passage of the wind turbine components. There will be no alteration to existing flow paths, no impediment to surface water movement, and no increase in flood risk to people, property, or the surrounding environment. The works are minimal in nature and will be fully reversible upon completion of the turbine deliveries. The third location only requires reinstatement as the works have already taken place from a previous permitted development.

2.10 Summary of Stage 1 FRA

The Stage 1 FRA has identified a potential flood risk at the wind farm element of the proposed development. Therefore, a Stage 2 FRA will be carried out to provide a more comprehensive assessment of the flood risk.

3. Initial Flood Risk Assessment (Stage 2)

The purpose of Initial Flood Risk Assessment is primarily to ensure that the relevant flood risk sources are identified so that they can be addressed appropriately in the Detailed Flood Risk Assessment.

3.1 Flooding Sources

The potential sources of flooding and their relevance to the flood risk at the proposed development site are outlined in the following sub-sections.

3.1.1 River Flooding

Fluvial flooding occurs when the capacity of a river channel is exceeded and water flows onto the adjacent land or floodplain. The main watercourses in proximity of the proposed development site are the Leitrim and Lumville watercourses which flow from north to south and east to west through the proposed development site respectively. The Rogerstown watercourse is located to the north of the proposed development site. Part of the Rogerstown watercourse adjacent to the proposed development flows south towards the main Leitrim watercourse. Further east the Rogerstown watercourseflows in an easterly direction away from the proposed development.

The NIFM is the only available flood extent mapping available for the proposed development site. This mapping demonstrates that there is a significant flood risk within the southern portion of proposed development site for the 1% and 0.1% AEP flood events.

It will be necessary to complete a Stage 3 - Detailed Flood Risk Assessment for this proposed development site in order to assess the flood risk from fluvial flooding in sufficient detail and to provide a quantitative appraisal on potential flood risk to the proposed development site, its potential impact on flood risk elsewhere and the effectiveness of any proposed mitigation measures. As part of the Stage 3 – Detailed Flood Risk Assessment, a hydraulic model will be required. The Stage 3 – Detailed Flood Risk Assessment assessment will determine adequate freeboard for the proposed turbines and associated hardstanding areas, substation and any internal access roads that could be potentially at risk of flooding. The Stage 3 Assessment will deliver flood extent maps, water surface elevations(mOD), depth(m) and flow(m^3/sec) for the proposed development site.

3.1.2 Pluvial Flooding

Overland flow or pluvial flooding occurs when rainfall intensity exceeds the infiltration capacity of the ground. The excess water flows overland to the nearest watercourse or piped drainage system. Intense rainfall events can result in ponding in low areas or upstream of physical obstructions. Overland flow is most likely to occur following periods of sustained and intense rainfall when the ground surface becomes saturated. Flood risk from pluvial sources exists in all areas. The existing site is a greenfield site. Increase in hardstanding area will increase the risk of pluvial flooding. There is history of pluvial or surface water flooding on the proposed development site. Adequate storm water drainage systems will minimise pluvial flood risk and therefore this risk does not require further consideration in this report.

3.1.3 Estuarial Flooding

Estuarial or tidal flooding is caused by higher-than-normal sea levels which occur primarily due to extreme high tides, storm surges, wave action or due to high river flows combining with high tides. This risk is not relevant to this proposed development site as the proposed development site is located inland at a minimum elevation of approximately 80mOD. Therefore, this does not require further consideration in this report.

3.1.4 Groundwater Flooding

Groundwater flooding occurs when the water table rises to the level of the ground surface due to rainfall and flows out over the surface. Groundwater flooding occurs relatively slowly and generally poses a low hazard to people. There is a history of such an occurrence within the landholding boundary. There are no karstic landforms within the proposed development site and the groundwater flooding is very localised. For these reasons this source of flooding will not be considered further in this report.

3.2 Stage 2 Summary of Identified Flood Risk

The information collected during the Stage 2 FRA indicates that the flood risk at this proposed development site is high and a Stage 3 Flood Risk Assessment is required.

Table 3-1: Stage 2 Requirements Summary

Flooding Source	Stage 3 Requirement	Comment
Fluvial	Required	The NIFM mapping indicates that there is a risk of fluvial flooding within the proposed development site for the present day 1% AEP event and above.
Pluvial/Overland Flow	Not Required	Pluvial flooding exists in all areas. Adequate storm water drainage systems will minimise pluvial flood risk.
Estuarial/Coastal	Not Required	The proposed development site is located inland and at an elevation of approximately 80mOD. Therefore, this flood risk is not relevant to the proposed development site.

Groundwater	Not Required	There is a localised area of groundwater flooding within the proposed development site. This source of flooding will not be considered further in this report

3.3 Appraisal of Availability and Adequacy of Existing Information

A topographical survey of the proposed development site has been provided to MWP Engineering and Environmental Consultants by the client. River survey data was commissioned to improve the accuracy of the hydraulic model and subsequently collected by Murphy Geospatial in March 2024. The client has provided Malachy Walsh & Partners with a 1m and 5m Digital Terrain Model (DTM). The DTM is required for floodplain modelling. Therefore, the 1m and 5m DTM data will be used to create a digital terrain model of the floodplain.

3.4 Potential Impacts of Flooding Elsewhere

Depending on the findings of the State 3 FRA, the proposed development may have the following potential impacts on flooding outside of the proposed development site;

- Construction on or filling up of existing floodplains would result in a reduced floodplain storage volume which could increase the flood risk downstream of the proposed development site.
- It is generally considered that new developments constructed without flood attenuation on greenfield sites will result in an increased outflow from the site. This could cause an overall increase in the flood level (and hence flood risk) downstream of the proposed development site, particularly if large portions of the catchment are developed over time.

A Stage 3 FRA will be required to confirm the flood risk mitigation required for the proposed development site and to confirm the proposed development will not adversely impact flood risk elsewhere.

3.5 Requirements for a Stage 3 FRA

A Stage 3 detailed flood risk assessment will be carried out in **Section 4** of this report in order to provide a quantitative appraisal of potential flood risk to the proposed development site and to examine the potential impact of the development on flood risk elsewhere. This will require the construction of a hydraulic model of the Rogerstown watercourse, Leitrim watercourse and tributaries of the Leitrim watercourse and the completion of a hydrological assessment of the catchments. Any relevant mitigation measures will be reviewed and residual risks will be assessed.

4. Detailed Flood Risk Assessment (Stage 3)

4.1 Introduction

The purpose of this Stage 3 FRA is to assess flood risk issues in sufficient detail to provide a quantitative appraisal of potential flood risk to the proposed development site, of the potential impact of the development on flood risk elsewhere and to establish what mitigation measures, if any, may be required. The Stage 3 FRA will therefore require carrying out a detailed review of the Leitrim watercourse and tributaries of the Leitrim watercourse catchment hydrology to establish appropriate flood flows for various scenarios. A hydraulic model of the river reaches will then be created to determine key flood risk parameters such as flood levels and flood extents.

4.2 Hydrology & Flow Estimation

4.2.1 Overview

In this section a detailed assessment will be carried out to estimate the flood flows at the proposed development site for various Annual Exceedance Probabilities (AEP's). The AEP is the likelihood or probability of a flood of a given magnitude occurring or being exceeded in any given year. The results of this analysis will then form a key input into the subsequent hydraulic modelling of the study area which will enable the flood levels and extents to be determined.

4.2.2 Catchment Description

The catchment delineations for the proposed development site are shown in **Figure 4-1** below. The catchment areas are summarised in **Table 4-1**.

Table 4-1: Catchment Characteristics

Catchment	Area (Km^2)
001	5.86
002	1.36
003	2.34

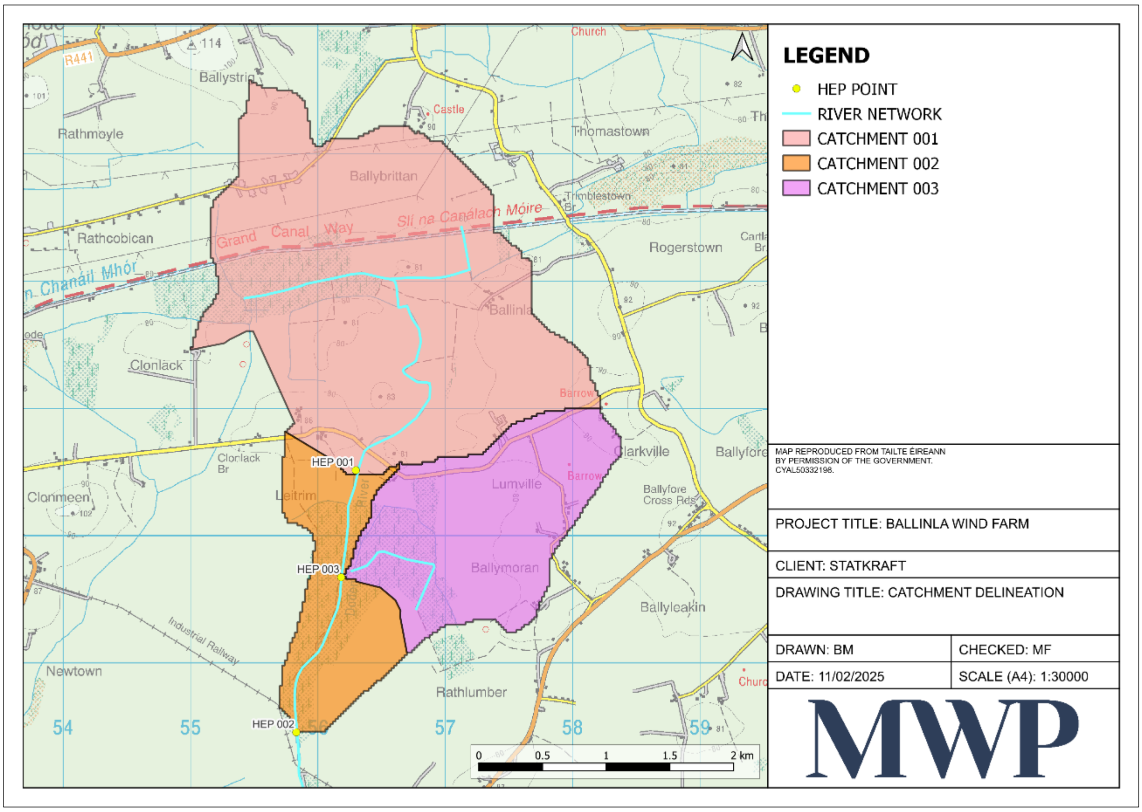

Figure 4-1: Catchment Delineation

4.3 Hydrological Estimation Point

In order to build a suitable hydraulic model of the river reach and floodplain it will be necessary to estimate the design flows at suitable locations along the reach. These are referred to as Hydrological Estimation Points (HEP's). HEP's are typically located at the upstream and downstream ends of the modelled reach, at confluences and at key inflow points. The HEP's selected for this study are included on **Table 4-1** and **Figure 4-1**.

4.3.1 Climate Change Allowance

In order to allow for the effects of climate change, the calculated flows have been increased by a factor of 1.2. This corresponds to the Mid-Range Future Scenario (MRFS) which has been adopted by the OPW to reflect a potential future scenario on the impacts of climate change on flooding.

4.4 Flow Estimation

4.4.1 Overview of Methodology

The Flood Studies Update (FSU) programme was undertaken by the OPW in order to provide improved extreme rainfall and flood estimation methods for Ireland. It is the most recent major study of its kind to be carried out in Ireland and is broadly recognised as the best practice method for estimating peak flood flows.

One of the key outputs from the FSU was the 7 variable regression equation for estimating the Index Flood (i.e. Q_{MED}) based on Physical Catchment Descriptors (PCD's). The Index Flood is the flow that can statistically be expected to be equalled or exceeded once in a 2-year period. Ideally the application of this equation would be limited to catchments greater than $25Km^2$.

The FSU 7 variable equation has been superseded by the FSU2 7 variable equation which was released in 2024 for flow estimation. The equation has recently been revised and will be used for flow estimation for the proposed development site. The initial PCD estimate can be improved by using data from a hydrologically and/or geographically similar gauged site, referred to as a Pivotal Site**.** The general procedure for estimating the Index Flood at any HEP can be summarised as follows;

1. Review the Physical Catchment Descriptors at each HEP and identify suitable pivotal site(s);
2. Estimate the Index Flood at the potential pivotal site(s) using annual maxima data;
3. Estimate the Index Flood at the potential pivotal site(s) using Physical Catchment Descriptors and determine the appropriate adjustment factor (i.e. Q_{MED} Gauged / Q_{MED} PCD Rural);
4. Estimate the Index Flood at each HEP using Physical Catchment Descriptors;
5. Estimate the Design Index Flood flow at each HEP using the relevant gauging station as a pivotal site and adjust the rural estimate for urbanisation.

There are no hydrometric stations on the Leitrim watercourse that would be of use for flow estimation. Notably, two of the catchment areas are less than $5km^2$. Zero stations with catchments less than $5km^2$ were employed to develop the new FSU2 equation which makes the updated FSU2 equation unsuitable for small catchments. It is for these reasons that flood estimation has been performed using a range of methods in addition to the FSU2 7 variable regression equation. The peak flows for the watercourses have been estimated using the following methods;

1. FSU2 7-Variable Equation
2. Institute of Hydrology 124 Method
3. Rational Method

4.4.2 FSU2 7-Variable Equation

The FSU2 method for ungauged catchments uses Physical Catchment Descriptors (PCD's) to establish an initial estimate of the Index Flood (i.e. Q_{MED}) based on a seven variable regression equation.

The Index Flow Q_{MED} is estimated using the following seven variable regression equation which was presented in the Flood Frequency and Hydrograph spreadsheet provided by the OPW.

$$Q_{MED} = 3.117 \times 10^{-6} \times AREA^{1.07} \times BFIsoils^{-1.342} \times SAAR^{1.351} \times FARL^{2.419} \times DRAIND^{0.273} \times S1085^{0.185} \times (1 + ARTDRAIN2)^{0.53}$$

The factorial standard error (FSE) of this equation is 1.21

The initial PCD estimate can be improved by using data from a hydrologically and/or geographically similar gauged site, referred to as a Pivotal Site. The analysis for Catchment 001, Catchment 002 and Catchment 003 is summarised on Table 4-2.

Table 4-2: Catchment 001, Catchment 002 & Catchment 003 Q_{MED} Estimation using FSU2 7- Variable Equation & 25034 (Rochfort) Adjustment Factor

Flow Estimation Using FSU2 7 -Variable Equation – Based on FSU2 Spreadsheet					
	Data Description	Units	Catchment 001	Catchment 002	Catchment 003
1a	Catchment Area	Km^2	5.86	1.36	2.34
1b	Urban Catchment Area	Km^2	0.00	0.00	0.00
2	Stream Slope S1085	m/Km	0.89	3.18	1.48
3	BFIsoil		0.68	0.64	0.69
4	SAAR	mm	911	908	903.00
5	FARL		1.00	1.00	1.00
6	DRAIND	Km/ Km^2	0.73	1.57	0.47
8	ARTDRAIN2		0.00	0.00	0.00
9	URBEXT		0.00	0.00	0.00
10	Q_{MED} Rural PCD Estimate	m^3/s	0.31	0.11	0.11
11	Q_{MED} Urban PCD Estimate	m^3/s	0.31	0.11	0.11
12	Pivotal Site Adjustment Factor (25034 – ROCHFORT)		1.82	1.82	1.82
13a	Design Q_{MED} Adjusted	m^3/s	0.56	0.20	0.20

4.4.3 Institute of Hydrology 124 Method

The Institute of Hydrology Report 124 method has been widely used in Ireland and the UK for flood estimation in small catchments. The equation uses three variables from the FSR to determine the mean annual flood flow Q_{bar}, namely Soil, SAAR and Area. This is the flow that can statistically be expected to be equalled or exceeded once in a 2.33 year period.

$$Q_{BAR} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$$

The FSR's regional growth curve for Ireland was used to determine the extreme flood flows for various return periods. A summary of the calculations carried out to determine the design flow at the proposed development site is included in Table 4-3.

Table 4-3: Institute of Hydrology Report 124 Method

IH124 Flood Estimation			
	Catchment 001	Catchment 002	Catchment 003
Area (Km^2)	5.86	1.36	2.34

IH124 Flood Estimation			
Urban Area (Km²)	0.00	0.00	0.00
SAAR (mm)	911	908	903
Soil	0.38	0.47	0.43
Catchment Wetness Index (CWI)	125	125	125
Catchment Index (CIND)	38.91	48.13	44.03
Rainfall Continentality Factor (NC)	0.70	0.70	0.70
Urban	0.00	0.00	0.00
Q_{BAR} Urban/Q_{BAR} Rural	1.00	1.00	1.00
Q_{BAR} Rural (m³/s)	1.85	0.80	1.06
Q_{BAR} Urban (m³/s)	1.85	0.80	1.06

A summary of the flows using the Institute of Hydrology Report 124 Method is presented in **Table 4-4**.

Table 4-4: 1% & 0.1% AEP Institute of Hydrology Report 124 Method

	Q_{bar} Estimate (m³/sec)	1% AEP Growth Factor	0.1% AEP Growth Factor	Q100 (m³/sec)	Q1000 (m³/sec)
Catchment 001	1.85	1.96	2.6	3.63	4.81
Catchment 002	0.80	1.96	2.6	1.57	2.08
Catchment 003	1.06	1.96	2.6	2.08	2.76

4.4.3.1 Rational Method

Flood flows for the Rational Method are calculated using the following equation:

$$Q = 0.278\ CiA$$

Where:

C is the runoff coefficient, i is the rainfall intensity (mm/hr) corresponding to the time of concentration for the catchment, and A is the catchment area (Km²).

Runoff Coefficient

The runoff coefficient was calculated based on the land use, the soil type and the catchment slope. The land use was obtained from the Corine landcover maps. The soil type was established using the Irish Forest Service (IFS) Soils codes obtained from the EPA soil data and correlated with the SCS Soil Groups. An overlay of the soil types and land use in the catchment is provided in **Figure 4-2**.

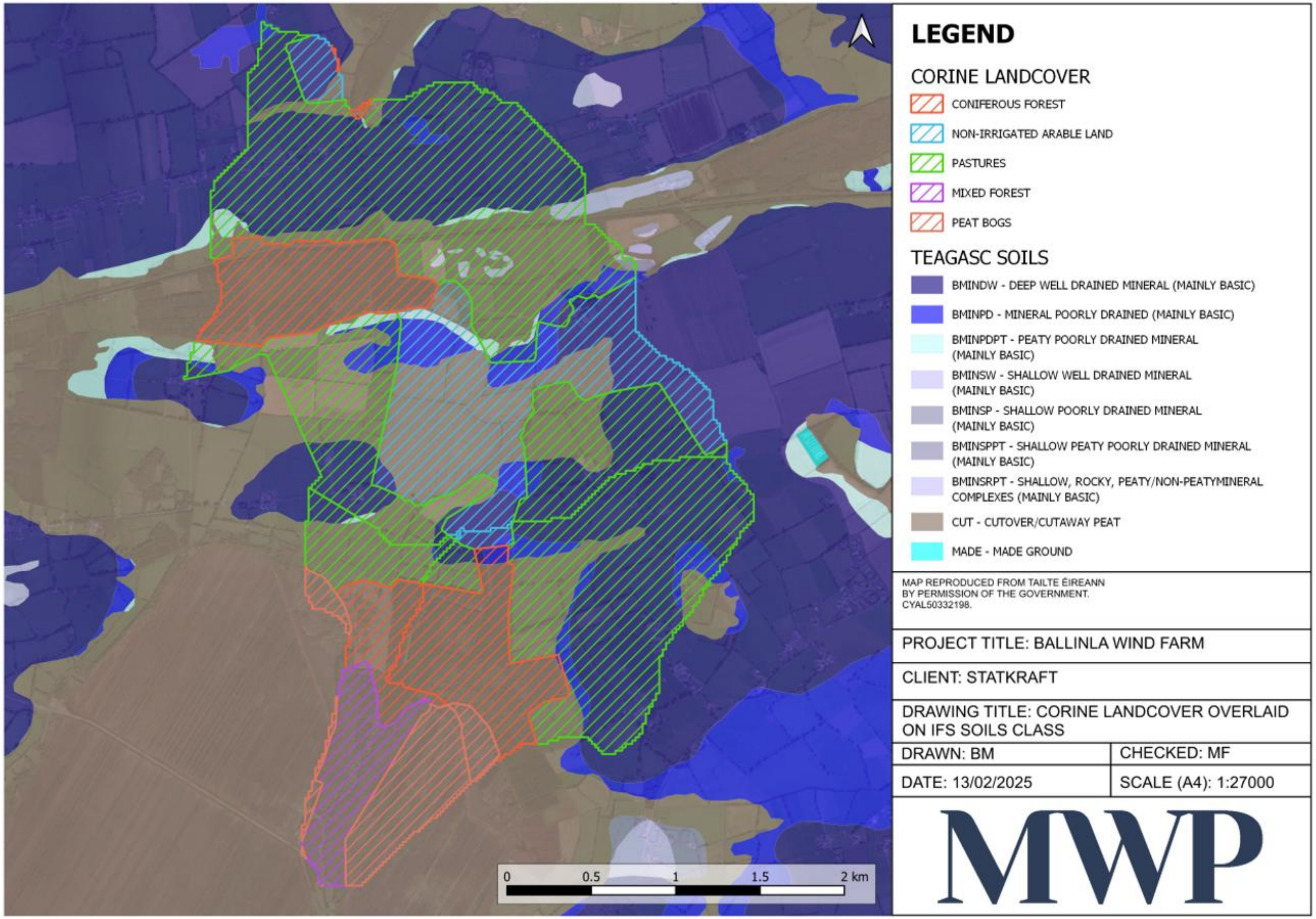

Figure 4-2: Corine Landcover Overlaid on IFS Soil Class

Time of Concentration

Numerous studies have been carried out to develop equations for estimating the time of concentration for a catchment. The US Soil Conservation Service Watershed Lag Method and Bransby-Williams method is applicable to the catchment.

The Soil Conservation Service (SCS) Watershed Lag method is presented in Chapter 15 of the Natural Resources Conservation Service (NRCS) National Engineering Handbook Part 630, May 2010. The time of concentration equation is calculated as follows:

$$T_c = \frac{l^{0.8}\,(S+1)^{0.7}}{1{,}140\,Y^{0.5}}$$

Where:

l = flow length, ft

S = maximum potential retention = (1,000/cn') – 10

Cn' = retardance factor, approximately equal to CN

Y is the average land slope from Chow (1964) = 100 CI/A

The curve number for each land use was determined from Chapter 9 NRCS National Engineering Handbook Part 630, July 2004.

The Time of Concentration for the catchment calculated using the SCS Watershed Lag Method is provided on Table 4-5.

Table 4-5: Time of Concentration from SCS Watershed Lag Method

Time of Concentration Calculation – SCS Watershed Lag Method				
Data Description	Units	Catchment 001	Catchment 002	Catchment 003
Flow Length, *l*	ft	16830.71	9186.35	10629.92
Average Land Slope of Watershed, Y	%	2.03	0.29	1.31
Weighted Average Curve Number, CN (=cn')		57.27	61.59	57.02
Max. Potential Retention, S		7.46	6.24	7.53
Time of Concentration, T_c	Minutes	396.22	575.31	343.68

Table 4-6: 1% AEP MRFS Peak Flows from Rational Method - SCS Watershed Lag Method

Rational Method – SCS Watershed Lag Method – 1% AEP MRFS Peak Flow Estimate				
Data Description	Units	Catchment 001	Catchment 002	Catchment 003

Rational Method – SCS Watershed Lag Method – 1% AEP MRFS Peak Flow Estimate				
Time of Concentration, Tc	Minutes	396.22	575.31	343.68
Design Rainfall Intensity, i	mm/hr	9.32	6.96	10.6
1% AEP MRFS Peak Flow	m³/sec	7.86	1.90	2.97

When converted to metric units, the time of concentration after Bransby-Williams can be calculated as follows:

$$t_c = 0.605 \frac{L}{A^{0.1}.S^{0.2}}$$

Where L is the catchment flow length (Km), S is the average catchment slope (m/m) and A is the catchment area (Km²).

The Time of Concentration for calculated using the Bransby-Williams Method is provided on Table 4-7.

Table 4-7: Time of Concentration from Bransby-Williams

Time of Concentration Calculation – Bransby-Williams				
Data Description	Units	Catchment 001	Catchment 002	Catchment 003
Flow Length, L	Km	5.13	2.8	3.24
Average Catchment Slope, S	m/m	0.02	0.003	0.013
Catchment Area, A	Km²	5.86	1.36	2.34
Time of Concentration, Tc	Minutes	135.84	125.40	102.50

Rainfall Intensity

The design storm duration corresponds to the time of concentration. The total rainfall depth is then converted to rainfall intensity in mm/hour to determine the flow for the corresponding return period. Rainfall depths were obtained from the Met Eireann Return Period Rainfall Depth Table.

Rational Method – Bransby-Williams – 1% AEP MRFS Peak Flow Estimate				
Data Description	Units	Catchment 001	Catchment 002	Catchment 003
Time of Concentration, Tc	Minutes	135.84	125.40	102.50
Area Weighted Runoff Coefficient, C	C	0.43	0.60	0.36

Rational Method – Bransby-Williams – 1% AEP MRFS Peak Flow Estimate				
Design Rainfall Intensity, i	mm/hr	21.09	22.59	26.9
1% AEP MRFS Peak Flow	m³/sec	17.79	6.18	7.54

Table 4-8: 1% AEP MRFS Peak Flows from Rational Method - Bransby-Williams

4.4.4 Summary of Design Flows

The FSU2 7- Variable Equation has recently been revised. There is no published paper on the development of the revised FSU2 7-Variable Equation. When the revised equation is used on its own, without the use of a pivotal site, the equation seems to give lower Q_{MED} values for smaller catchments and larger values for larger catchments. The Rational Method was considered but is likely to be overpredicting peak flow. Whilst the revised FSU2 7-Variable Equation is likely to provide the most reliable estimate, a precautionary approach was taken and the IH124 method was selected for the purpose of flood risk assessment. The design peak flows at the proposed development site for the catchments are summarised in **Table 4-9** below using the IH124 method. **Table 4-10** below presents the design peak flows for the Mid-Range Future Scenario taking in the potential effects of climate change using an increase in peak flow of 20%.

Table 4-9: Summary of Design Flows – IH124 Method

Return Period, T	AEP(%)	Growth Factor	Catchment 001 Peak Flow (m³/sec)	Catchment 002 Peak Flow (m³/sec)	Catchment 003 Peak Flow (m³/sec)
2	0.50	0.95	1.76	0.76	1.01
5	0.20	1.20	2.22	0.96	1.27
10	0.10	1.37	2.54	1.09	1.45
20	0.05	1.60	2.87	1.24	1.64
30	0.033	1.65	3.05	1.32	1.75
50	0.02	1.77	3.28	1.41	1.87
100	0.01	1.96	3.63	1.56	2.08
200	0.005	2.14	3.96	1.71	2.27
1000	0.001	2.60	4.81	2.07	2.75

Table 4-10: Summary of Design Flows – IH124 Method Mid-Range Future Scenario

Return Period, T	AEP(%)	Growth Factor	Catchment 001 Peak Flow (m³/sec)	Catchment 002 Peak Flow (m³/sec)	Catchment 003 Peak Flow (m³/sec)
2	0.50	0.95	2.11	0.91	1.21

5	0.20	1.20	2.66	1.15	1.52
10	0.10	1.37	3.05	1.31	1.74
20	0.05	1.60	3.44	1.49	1.97
30	0.033	1.65	3.66	1.58	2.10
50	0.02	1.77	3.94	1.69	2.24
100	0.01	1.96	4.36	1.87	2.50
200	0.005	2.14	4.75	2.05	2.72
1000	0.001	2.60	5.77	2.48	3.30

4.5 Hydrograph Derivation

In order to produce a design hydrograph to provide input to the unsteady-state hydraulic model, a hydrograph shape is required in addition to a design peak flow. The OPW's Flood Frequency and Hydrograph Spreadsheet allows the user to derive a hydrograph for an ungauged site from a statistical analysis of the continuous flow records for gauged sites.

Based on this approach, the design flow hydrographs are plotted on **Figure 4-3** and **Figure 4-4** below for the 2-Year, 100-Year and 1000-Year return periods for Catchment 001 and Catchment 003.

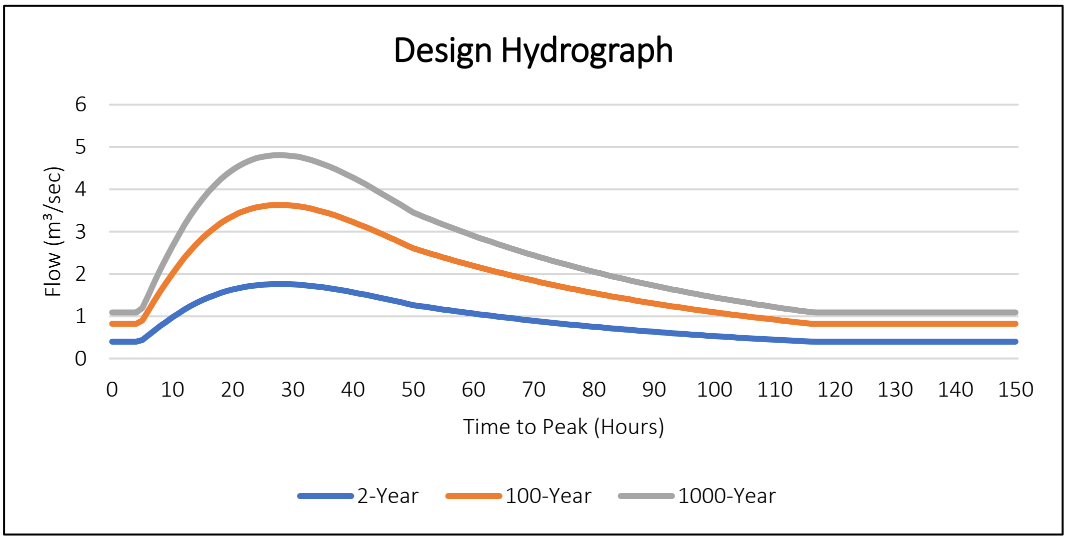

Figure 4-3: Design Flow Hydrograph Catchment 001

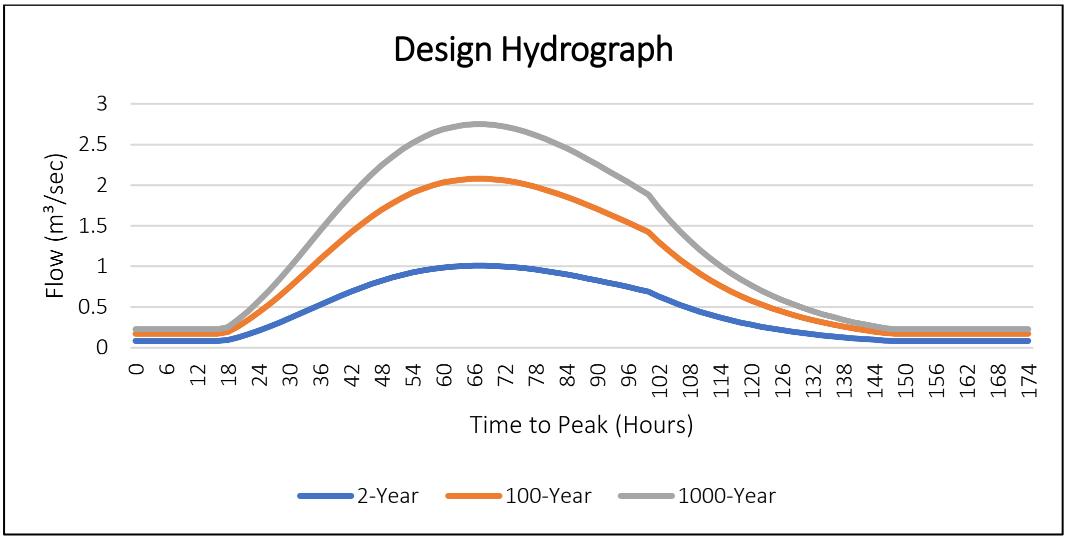

Figure 4-4: Design Flow Hydrograph Catchment 003

5. Hydraulic Modelling

5.1 Modelling Approach

The hydraulic analysis was carried out using the Hydraulic Engineering Centre River Analysis System (HEC-RAS 6.6) software which was developed by the US Army Corps of Engineers.

It was identified at an early stage that there is potential for complex overland flow paths to exist within the proposed development site boundary, therefore a 1D-2D hydraulic model was created.

The 1-dimensional (1D) model incorporates approximately 53 cross sections representing 6Km of the Leitrim watercourse and 5 cross sections representing 1Km of the Lumville watercourse. The 1D domain is intended to model the in-bank flows.

The 2D model domain includes the floodplains surrounding the proposed project. Its purpose is to model overland flows towards the turbines and other complex flow paths within the proposed wind farm which cannot be adequately represented by a 1D model. A 10m x 10m cell size was adopted however this was refined along roads and other areas for a more accurate assessment of flow paths.

The 1D and 2D models are linked by lateral weirs positioned adjacent to the main banks of the river. The weir elevation was set to coincide with the ground elevation at the interface between the 1D and 2D domains and positive or negative flow is permitted so that any water which enters the floodplain at one location could potentially flow back into the main channel at another location. A weir coefficient of 0.28 was generally adopted. This represents an upper bound value for non-elevated overbank terrain and a lower bound value for natural high ground 0.3 to 1m high.

The hydraulic model schematic is included in Figure 5-1.

An unsteady flow analysis was performed using flow hydrographs which were derived during the hydrological analysis. The downstream boundary condition of the 1D model was set to match the water surface gradient downstream of the proposed development site.

Given the complexity of the flow regime associated with the Rogerstown watercourse to the north of the proposed development site, the outflow associated with this watercourse is unknown. A sensitivity analysis was performed to check the flood extent maps and flood levels for an outflow of $0.5m^3$/sec and $2.5m^3$/sec. The analysis indicates that there was no appreciable difference between the two outflows. It was decided to adopt the $0.5m^3$/sec as the outflow for the Rogerstown watercourse.

Based on a walkover of the river reach, Manning's 'n' values were assigned based broadly on land use type and terrain. The river channel was assigned a value of 0.04 while the overbank and 2D areas were assigned a value of 0.06.

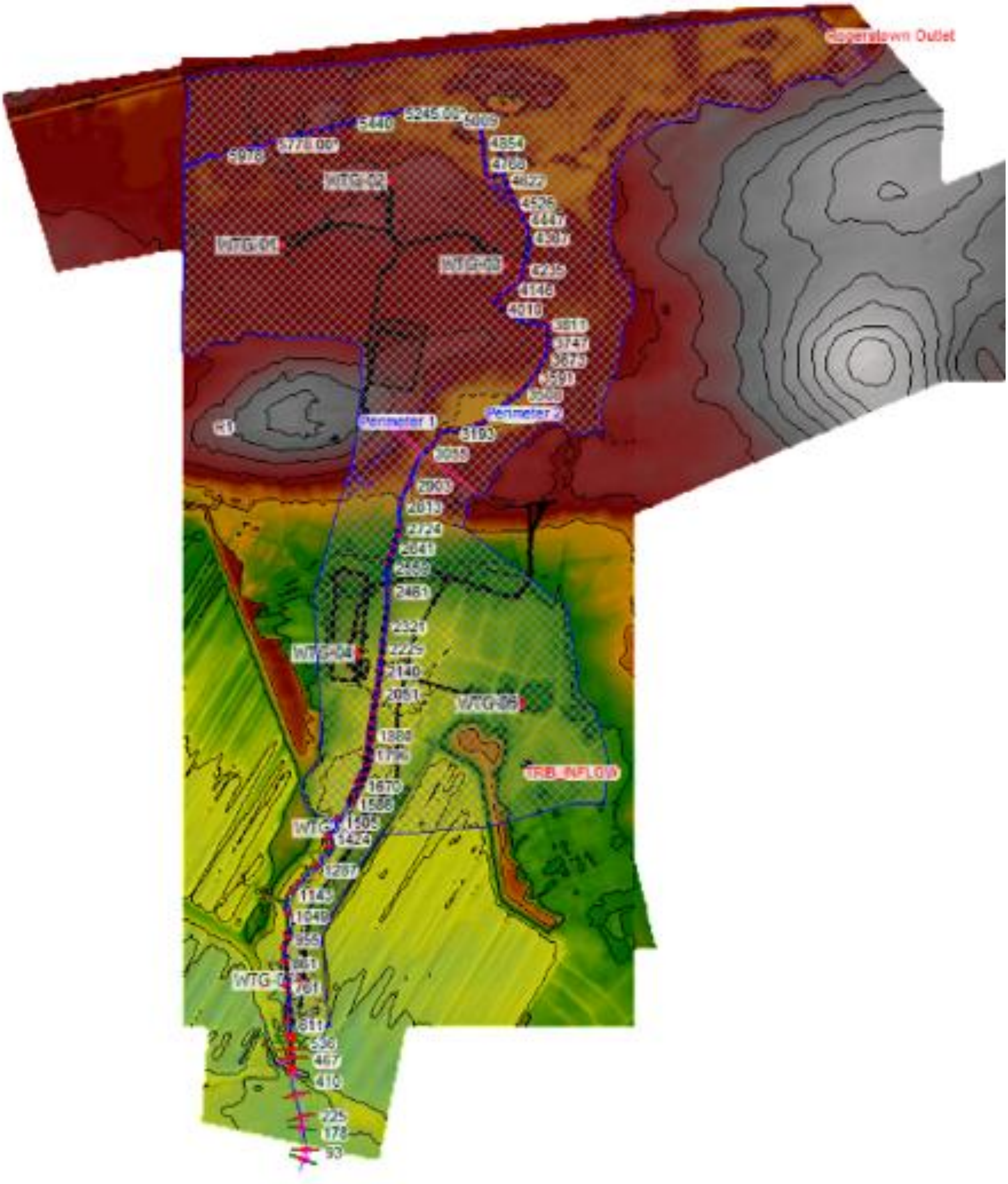

Figure 5-1: Model Schematic

5.2 Flood Zone Mapping – Baseline Situation

The PSFRM Guidelines document defines three flood zone types as follows:

> *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 flood zones are defined without taking the effects of future climate change into account.

The hydraulic model was used to establish the design flood levels at the proposed development site for the 1% AEP and 0.1% AEP flows and these were used to produce flood zone maps for the proposed development site and surrounding floodplains. The Flood Zone Map, which indicate the extent of Flood Zones A and B is shown on **Figure 5-2**.

As can be seen in **Figure 5-2** the proposed sub-station and Turbine 1 is located within Flood Zone B. The majority of the turbines are located outside of Flood Zone A and Flood Zone B, therefore placing the turbines in Flood Zone C. Turbine 3 is in Flood Zone C, even though its ground level indicates flood zone B, this is because there is a natural area of raised ground between Turbine 3 and the flood water. This has the effect of a natural bund preventing the flooding of Turbine 3 in a 0.1% AEP flooding event.

The zoning and baseline flood level of each of the turbine and substation is summarised in **Table 5-1**.

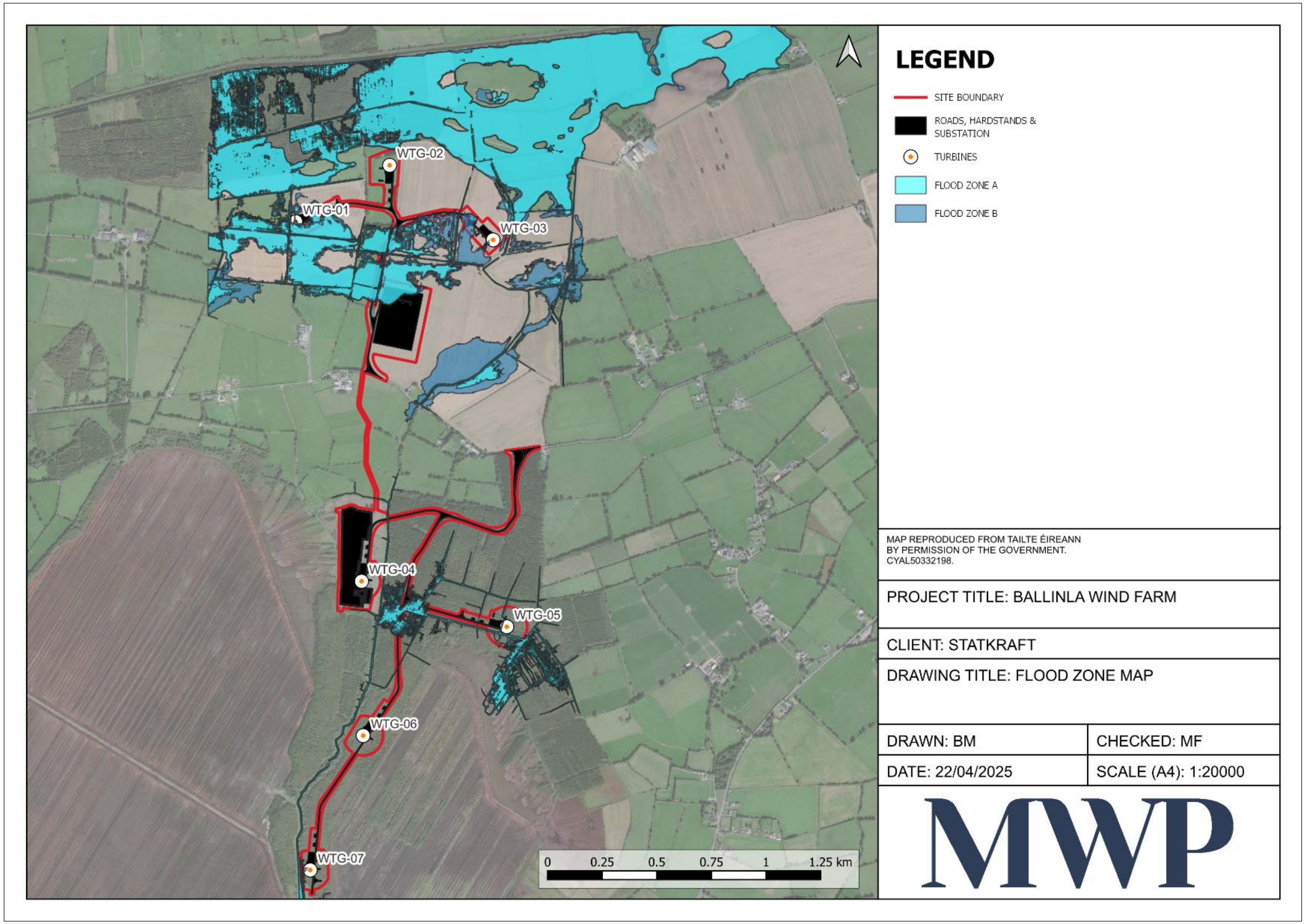

Figure 5-2: Flood Zone Map

Table 5-1: Wind Turbine Generator (WTG) and Flood Zoning Summary

Turbine	Flood Zone	Existing Ground Level (mOD)	Baseline Flood Level (mOD)		
			1% AEP	0.1% AEP	1% AEP MRFS
WTG-01	B	77.44	77.42	77.48	77.46
WTG-02	C	78.67	*77.50	*77.77	*77.73
WTG-03	C	77.43	*77.41	*77.48	*77.45
WTG-04	C	72.72	*72.16	*72.23	*72.20
WTG-05	C	73.91	*72.82	*72.92	*72.88
WTG-06	C	74.40	*70.40	*70.53	*70.49
WTG-07	C	69.74	*68.81	*69.21	*69.11
Substation	A & B	77.15 – 80.65	77.42	77.48	77.46
*Predicted flood level obtained from nearest modelled watercourse – no floodplain flow occurs at this location.					

5.3 Vulnerability of the Proposed Development

The PSFRM Guidelines have outlined three Vulnerability Classifications for developments based on the proposed land use and type of development. These classifications and particular examples of development types which would be included in each classification are summarised as follows;

1. **Highly Vulnerable Development**: This would include emergency services, hospitals, schools, residential institutions, dwelling houses, essential infrastructure, water & sewage treatment etc.
2. **Less Vulnerable Development**: Retail, leisure, commercial, industrial buildings, local transport infrastructure.
3. **Water-compatible development**: Docks, marinas and wharves. Amenity and open space, outdoor sports and recreation and essential facilities such as changing rooms.

The Guidelines also include a matrix of vulnerability versus flood zone to differentiate between developments which are appropriate in various flood zones and those which require a Justification Test. This table is reproduced as **Table 5-2** below.

Table 5-2: Vulnerability Matrix

Vulnerability Classification	Flood Zone A	Flood Zone B	Flood Zone C
Highly Vulnerable Development	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water Compatible Development	Appropriate	Appropriate	Appropriate

The proposed substation falls under the essential infrastructure category. As the proposed substation is within Flood Zone B, the development will require a Justification Test. The Guidelines state that development types not listed should be considered on their own merits. The construction of wind turbines and the associated infrastructure are not listed, therefore the assumption is that they can be constructed in any of the flood zones provided that they are protected from flooding and that their presence does not increase flood risk elsewhere. A design water surface level was established along the Leitrim watercourse and its tributaries. The turbines will be set with a freeboard above the adjacent calculated 100-year flood level taking a 20% climate change factor into account, where applicable. Since the development is considered to be an appropriate type in all three flood zones, a Justification Test, as described in Chapter 3 of the Guidelines, is not required for the 7 no. turbines.

5.4 Post Development Scenario

The post-development situation includes for the proposed substation, turbine hardstands, access tracks and turning heads. The hydraulic model was adjusted to include the proposed access track alignment and hardstands. This involved adjusting the DTM to include new internal site access tracks and 7 No. Wind Turbine foundations and Hardstand areas. The DTM was raised by 600mm above existing ground levels at locations where the access tracks and hardstands are proposed. The revised DTM of the model is indicated on below Figure 5-3.

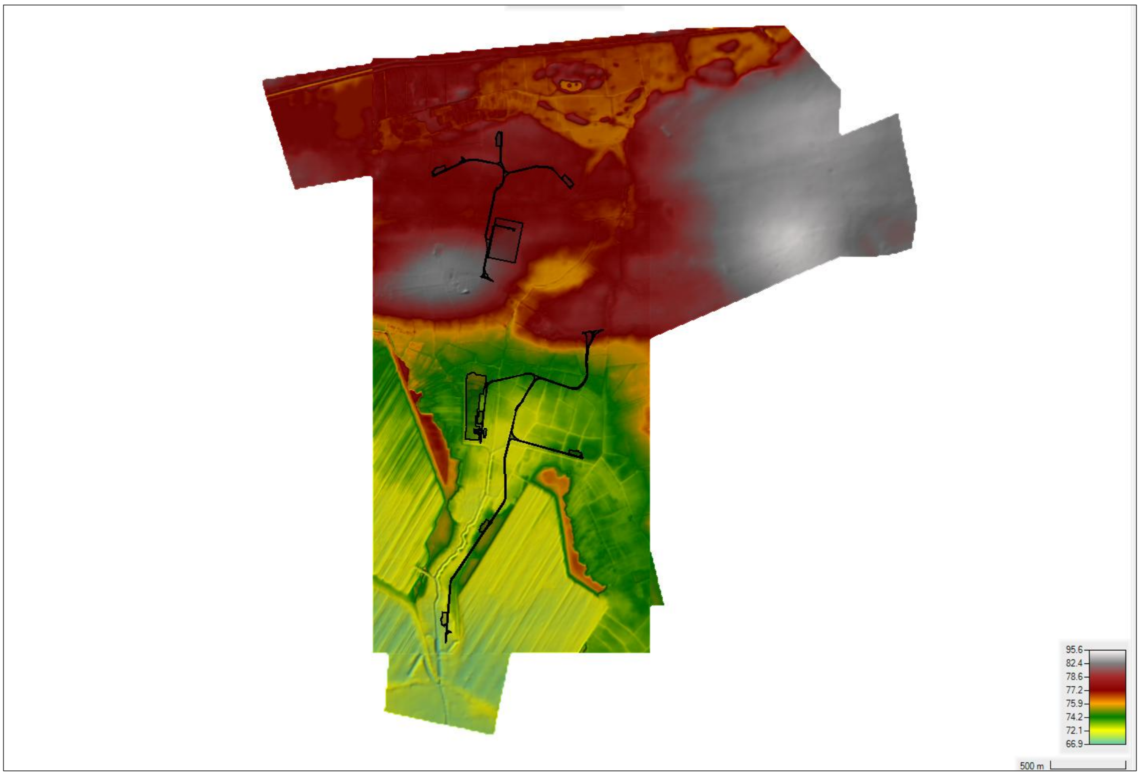

Figure 5-3: Post Development Revised DTM

The changes to the flood extents are highlighted on **Figure 5-4** below. There is an increase in flood extent east of Turbine 4 . The increase in flood extent is outside the proposed development site boundary. The increase in flood extents occurs in lands used for forestry. The impact of the proposed development on flood levels is mapped on **Figure 5-5** below for the 0.1% AEP event, as this provides a slightly more conservative value when compared to the 1% AEP MRFS. There is no difference in water surface elevation for the proposed development. However, there is a localised area west of Turbine 5 which indicates an increase in water surface elevation of approximately 20mm. This afflux can be attributed to the proposed access track which intersects the floodplain at this location. However, the afflux as a result of the proposed access track is well within the 300mm, which is a recommendation of the OPW for land affected by the construction of a bridge/culvert and at locations where properties are not at risk of flooding. The flood levels upstream and downstream of the proposed development site will not be adversely affected. **Figure 5-6** below shows the existing and proposed flow hydrograph downstream of Turbine 7. As can be seen, there is no appreciable difference in hydrograph shape and the peak flow passed downstream is unchanged. Therefore, it is concluded that the proposed development will not adversely impact flood risk elsewhere.

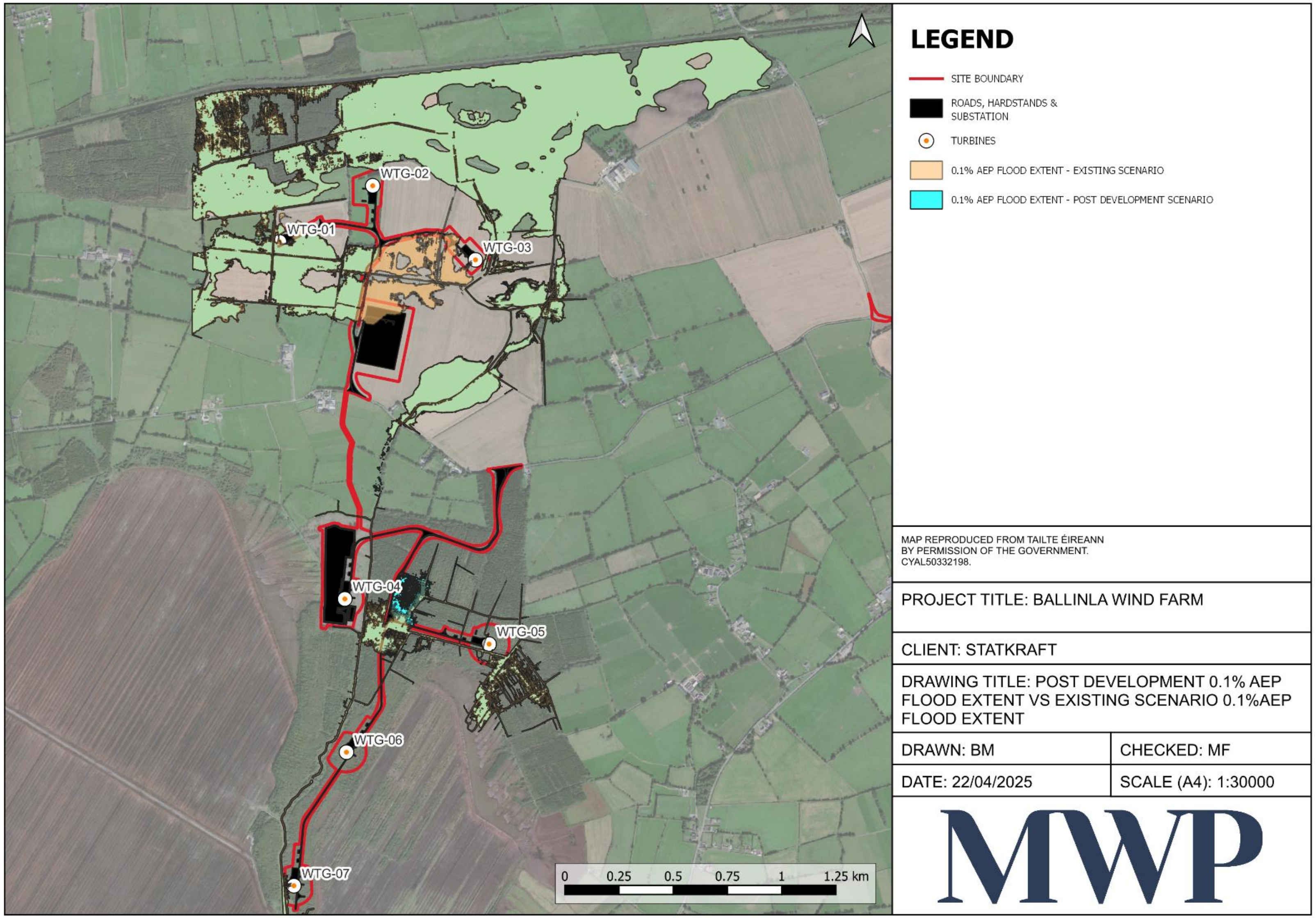

Figure 5-4: Post Development 0.1%AEP Flood Extent vs Existing Scenario 0.1%AEP Flood Extent

Figure 5-5: Post Development 0.1%AEP Water Surface Elevation vs Existing Scenario 0.1%AEP Water Surface Elevation

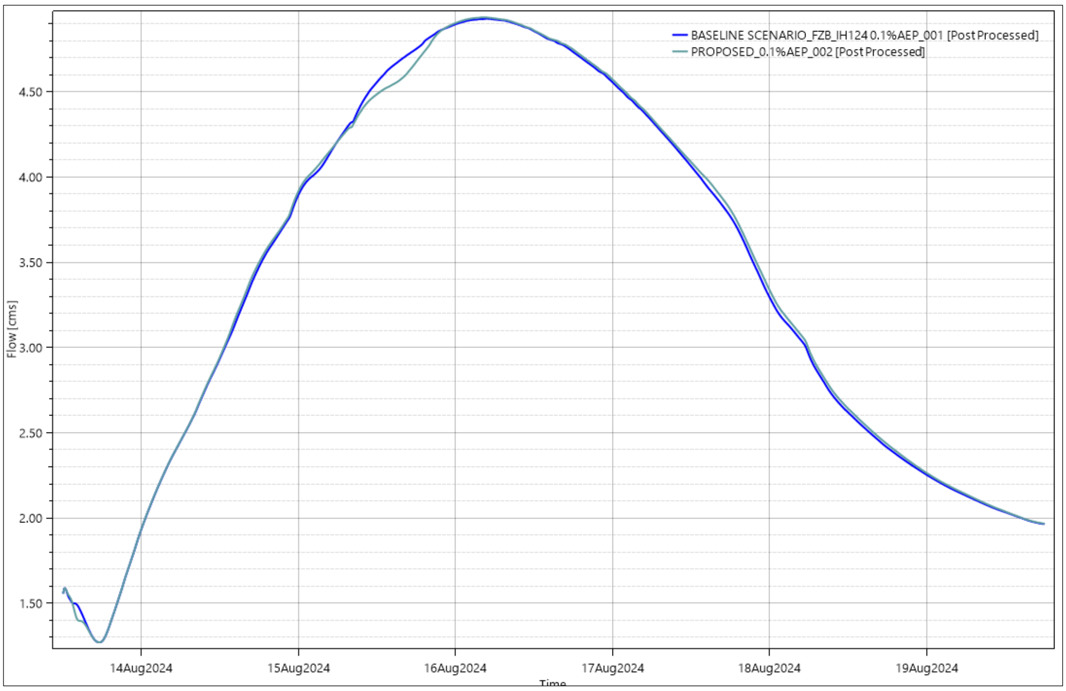

Figure 5-6: 0.1% AEP Existing Scenario Flow Hydrograph & 0.1%AEP Post Development Scenario Flow Hydrograph

5.5 Mitigation Measures

The PSFRM Guidelines recommend a precautionary approach be taken to allow for various uncertainties therefore requirements for flood mitigation would generally be assessed using higher confidence interval flows.

To ensure that there is no unacceptable flood risk to the proposed substation and 7 no. turbines, the following mitigation measures are recommended:

1. The proposed substation should be set above the 0.1% AEP MRFS flood level of 77.52mOD, plus 500mm freeboard. Therefore, the minimum proposed finished floor level of the proposed substation is 78.02mOD. However, as per planning drawings the proposed finished floor level of the proposed substation is 78.35mOD.

The proposed 7 no. turbines should be set above the 1% AEP MRFS flood level plus 500mm freeboard. The minimum proposed finished levels for the 7 no. turbines are also presented in **Table 5-3**.

Turbine	Flood Level 1% AEP MRFS (mOD)	Existing Ground Level (mOD)	Proposed Finished Turbine Level – Minimum 500mm Freeboard Included (mOD)
WTG-01	77.46	77.44	77.96
WTG-02	*77.73	78.67	78.67
WTG-03	77.45	77.43	77.95
WTG-04	*72.20	72.72	72.72
WTG-05	*72.88	73.91	73.91
WTG-06	*70.49	74.40	74.40
WTG-07	*69.11	69.74	69.74
**Predicted flood level obtained from nearest modelled watercourse – no floodplain flow occurs at this location.*			

Table 5-3: Turbine Flood Levels

5.6 Residual Risks

The following residual risks have been identified;

1. Climate change effects larger than currently estimated
2. Flood Flows Larger than estimated

5.6.1 Climate Change Effects & Larger Flood Flows

During the sensitivity analysis an assessment was carried out to determine the impact a 0.1% AEP flood event for the MRFS (i.e. 20% increase in flows to allow for climate change). As would be expected, this event would result in an increase in flood level and extent throughout the proposed development. At most locations the increase would not cause flooding to the turbines and hardstanding areas and the extents would not differ significantly from the current scenario.

6. Justification Test

The PSFRM Guidelines outlines two types of Justification Test, namely Plan-making Justification Tests and Development Management Justification Tests. The latter is appropriate at the planning application stage for developments in moderate or high risk flood areas. The proposed substation is at moderate risk of flooding.

The PSFRM Guidelines state that when applying the Justification Test to developments which may be vulnerable to flooding a number of criteria should be satisfied. These are listed and commented on below.

> ***Criterion 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".

Offaly County Council have written a County Wind Energy Strategy which forms part of the Offaly County Development Plan 2021-2027. The report aims to guide the development of wind energy developments in County Offaly up to 2027. Wind energy development construction consists of turbine foundations, site access roads, power cables and an electrical sub-station; the installation of wind turbines; and the connection of the wind energy development site to the existing electricity grid via underground cables. As part of the Wind Energy Strategy, Offaly County Council have identified suitable locations for wind energy development using a 'step by step' approach, which take into account environmental, landscape and technical criteria. Twelve potential wind energy areas were identified in County Offaly as seen in the screenshot presented in **Figure 6-1**. The proposed development is located between areas 1 and 2 which have been identified as having wind energy potential as summarised in **Figure 6-1** below. As mentioned in area 2 Mount Lucas wind farm is located southeast of the proposed development with a total of 28 No. turbines. There is a history of wind farm and renewable energy initiatives established in the region.

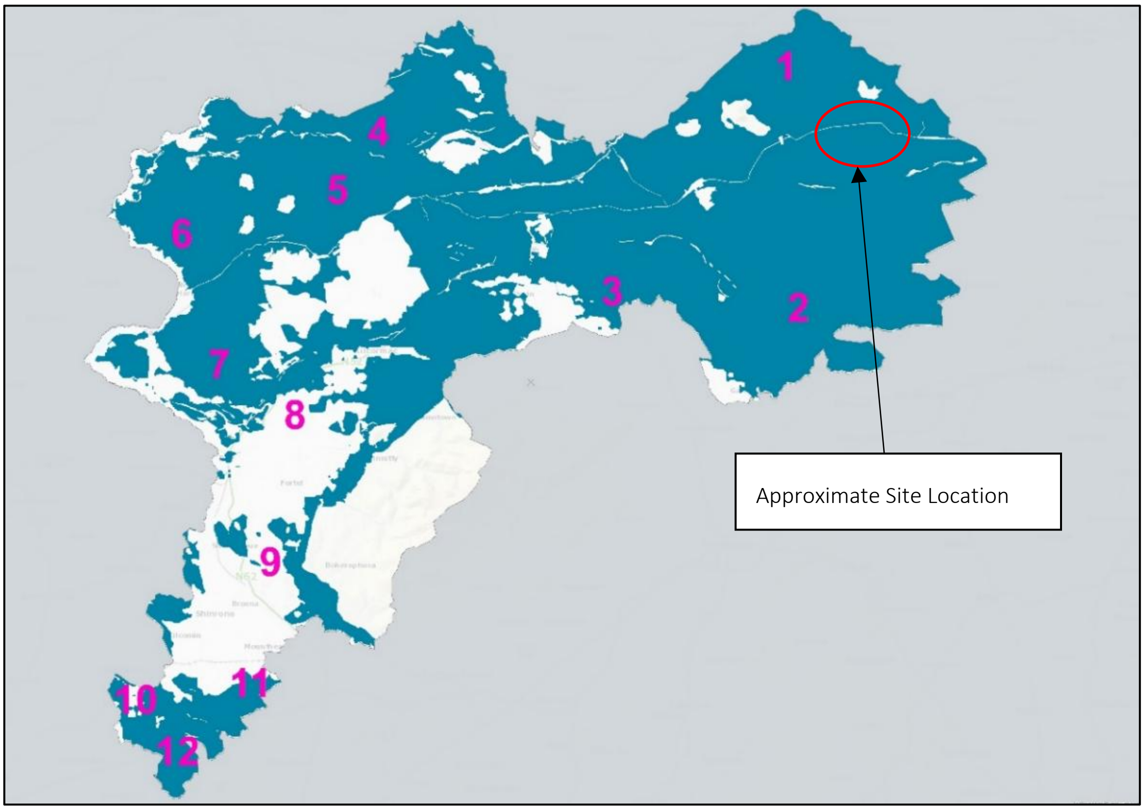

Figure 6-1: Twelve Potential Wind Energy Area (Offaly County Council)

Table 6-1: Assessment of Wind Energy Potential Areas (Offaly County Council)

Ref No.	Area	Recommendation
1	**Area generally north of Rhode** This area is characterised by significant tracts of peatlands and improved agricultural land to the north of the village and large landholdings. In addition, there exists a precedent of windfarm and renewable energy projects being deemed suitable while there exists both good wind speeds and electricity infrastructure in the area. There is sensitivity in relation to views of Croghan Hill to the north and west which can be mitigated by suitable layout minimising visual conflict or compromising this focal feature in the area by considering the clustering of turbines and adequate separation of turbines from the vista of Croghan Hill from Rhode village.	Area deemed 'Open for consideration for Wind Energy development' in principle *
2	**Area generally from Cloneygowan to Clonbullogue** This area is characterised by a predominantly flat and in places slightly undulating landscape with a number of significant tracts of peatlands and transitional woodlands and coniferous forestry, in particular in areas around Walsh Island, Bracknagh and Clonbulloge, along with improved agricultural land, large landholdings and a dispersed pattern of rural housing. The extensive tracts of flat peatlands in this area offer potential to accommodate a wind farm layout with depth, comprising a grid formation giving a better sense of balance and visual cohesion. In addition, there exists a precedent of windfarm and renewable energy projects developed in the area such as Mount Lucas windfarm while other projects have been deemed suitable and are awaiting commencement of development. There exists both good wind speeds and electricity infrastructure in the area. A potential constraint in this area is the objective in Chapter 4 to examine the feasibility of developing Wilderness Corridors at bogs at Cavemount, Esker, Ballycon, Derrycricket, Clonsast North, Clonsast and Derryounce. The Council will not be in favour of any developments proposed on these bogs with the potential to impact upon the character, uniqueness and wilderness potential of these areas. The impact on a potential Wilderness Corridor from any wind farm development will be assessed at project level by the Council.	Area deemed 'Open for consideration for Wind Energy development' in principle *

Criterion 1 of the justification test is therefore considered to be satisfied.

Criterion 2: Table 6-2 outlines the justification for Criterion 2 of the Justification Test.

Table 6-2: Justification Test Criterion 2

Justification Test Criterion 2	
Justification Criteria	**Justification**
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	These criteria are addressed in the previous sub-sections and have been fulfilled by carrying out appropriate risk assessments, the implementation of mitigation measures and by adequately assessing all associated risks as summarised below: i. As outlined in Section 5.4, there is no increase in flood levels due to the proposed substation and the proposed development will not increase flood risk elsewhere. ii. As outlined in the site-specific FRA, the provision of mitigation measures such as ensuring the substation have appropriate freeboard above flood levels, will

Justification Test Criterion 2	
Justification Criteria	**Justification**
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 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.	minimise flood risk to people, property, the economy and the environment as far as reasonably possible. iii. As outlined in Section 5.6, there are uncertainties with regard to climate change impacts on peak flows. The best approach is to be flexible with regard to management of flood risk. The proposed minimum F.F.L of the substation 78.02mOD. This provides 0.5m freeboard above the 0.1% AEP MRFS flood event. The MRFS is deemed an appropriate uplift in flood levels due to climate change for residual risk assessment. The development proposed therefore 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. iv. As outlined throughout the FRA, 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.

7. Conclusion & Recommendations

A summary of the main findings of this FRA is as follows;

1. This report has been prepared in the context of *The Planning System and Flood Risk Management – Guidelines for Planning Authorities, November 2009 (PSFRM)*, published by the Office of Public Works and the Department of Environment, Heritage and Local Government.
2. The proposed development includes for the construction of no.7 turbines, hardstands, foundations, access tracks, internal underground connector cable, substation, LiDAR station, felling areas and soil deposition areas.
3. The Stage 1 Flood Risk Assessment indicated that the temporary works associated with the Grid Connection Route and Turbine Delivery Route will not increase hardstanding areas, and therefore, no alteration to existing flow paths, no impediment to surface water movement, and no increase in flood risk to people, property, or the surrounding environment is expected.
4. The Stage 1 and 2 flood risk assessments indicated that there is potential for flooding at this proposed development site. The potential source of flooding was identified as fluvial flooding from the Leitrim watercourse and the Lumville watercourse.
5. In particular, the NIFM published flood extents which indicate that the proposed development site may be vulnerable to flooding.
6. A Stage 3 Detailed Flood Risk Assessment (FRA) was carried out to assess flood risk issues in sufficient detail to provide a quantitative appraisal of potential flood risk to the proposed development site.

7. There are no flow records available for the Leitrim watercourse and the Lumville watercourse. The IH124 flood estimation method was selected as the most appropriate flood estimation method to calculate the flood flows for catchments.
8. In order to predict the flood extents and flood levels at the proposed development site, a combined 1D-2D hydraulic model was created using HEC-RAS river modelling software.
9. The model was used to create a flood zone map of the existing site which indicates the extent of Flood Zones A and B. Areas of the proposed development site outside of these Flood Zones are in Flood Zone C.
10. The flood zone map is included on Figure 5-2. It indicates that the proposed substation is located within Flood Zone B. Turbine 1 is located in Flood Zone B which has a moderate probability of flooding (0.1% to 1% probability (between 1 in 100 and 1 in 1,000) for river flooding. The remainder of the 6 no. turbines are located in Flood Zone C which has a low probability of flooding (less than 0.1% annual exceedance probability or 1 in 1000).
11. To ensure that there is no unacceptable flood risk, the following mitigation measures are recommended:
    i. The design flood level for the proposed substation is the 0.1%AEP MRFS flood level plus 500mm freeboard.
    ii. The design flood level for the proposed 7 no. turbines is the 1%AEP MRFS flood level plus 500mm freeboard
12. It was concluded that, once the above mitigation measures are implemented, the proposed development will not have an adverse impact on flooding elsewhere.
13. Residual risks associated with the development were also assessed and are considered to be acceptable.