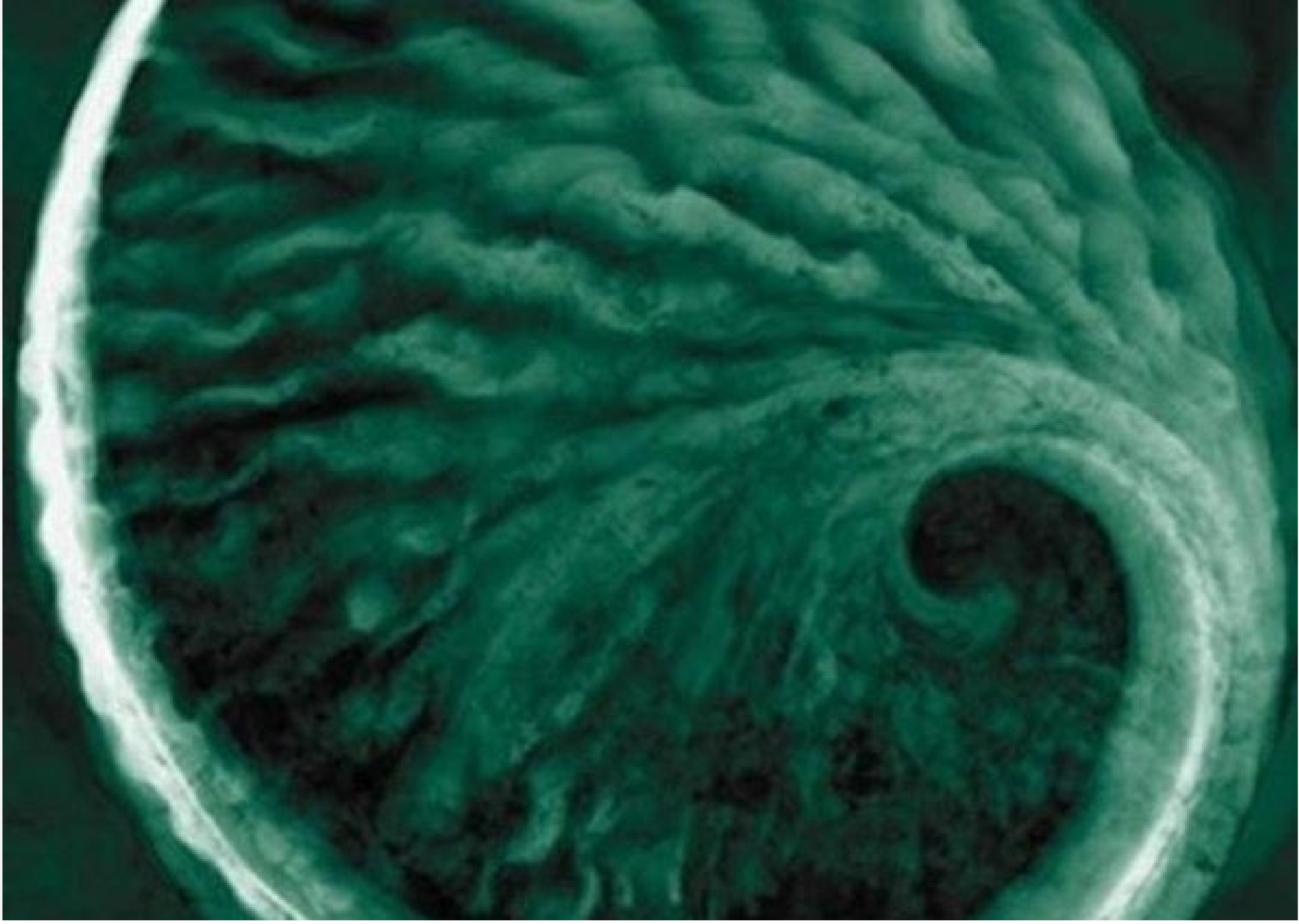

Ørsted Onshore Ireland Midco Limited

Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.1 Hydrological Unit Assessment

06 September 2023

Project No.: 0696177

The business of sustainability

ERM

Signature Page

06 September 2023

Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.1 Hydrological Unit Assessment

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CONTENTS

List of Tables

Acronyms and Abbreviations

Name	Description
APA	Active Peat Assessment
HUA	Hydrological Unit Assessment
mbgl	metres below ground level
NIEA	Northern Ireland Environmental Agency
OSNI	Ordnance Survey Northern Ireland

1. INTRODUCTION

1.1 Overview

This Technical Appendix outlines the results of the hydrological unit assessment (HUA) and dipwell monitoring carried out at the site of the proposed Owenreagh / Craignagapple Wind Farm ('the Development') on behalf of for Ørsted Onshore Ireland Midco Limited ('the Applicant').

The Development is located within Derry City and Strabane District Council ('the Council') on land approximately 5 kilometres (km) east of Strabane, in County Tyrone ('the Site') as shown on Environmental Statement (ES) **Figure 1.1: Site Location**.

Following scoping and consultation exercises carried out during 2021 for the Development, it was determined that an active peat assessment (APA) would be required for the Development to determine the extent of areas of active peat and ensure the design seeks to minimise detrimental impact on areas of active peat. Active peat requires the area to be hydrologically intact (i.e., the unit is not hydrologically degraded for example by the presence of artificial features such as drains or cuttings). The APA is provided within **Technical Appendix A10.4: Active Peat Assessment**.

This assessment forms **Technical Appendix A8.1** to the ES **Chapter 8: Hydrology and Hydrogeology**.

1.2 Project Description

The Development is described in the **ES Chapter 3: Project Description**. A brief summary is provided here.

The Development includes:

- Decommissioning of the operational Owenreagh I and Owenreagh II Wind Farms;
- Repowering of the Owenreagh I and II sites and consented Craignagapple site through construction of 14 wind turbines with tip height up to 156.5 m and rotor diameter up to 136 m; and
- Associated ancillary infrastructure, including but not limited to the following:
  - Substation compound including control building and other electrical infrastructure;
  - New and upgraded access tracks including turning heads;
  - Crane hardstands;
  - Construction compounds; and,
  - Cable trenches.

1.3 Scope of Assessment

The purpose of the HUA is to determine the spatial extent of intact hydrological units across the site, and to determine whether they are intact or non-intact based onsite observations and monitoring. The "site", for the purposes of this assessment, included all land within which the Development was proposed at the time of the assessment; the Assessment Boundary is shown on **Figure A8.1.1: Existing Drainage Survey**. Since that time, and partially as informed by this HUA, the locations of proposed turbines and infrastructure have been refined.

The definition of an intact unit, for the purposes of this assessment, is *"a hydrological unit that is not damaged or impaired in anyway"* i.e., that has not been artificially modified.

The assessment is carried out in line with NEIA Guidance Note on Active Peat[1].

2. METHODOLOGY

2.1 Introduction

This Section outlines the methodology for the HUA.

[1] Northern Ireland Environment Agency (NIEA) (2018) Guidance Note on Active Peat [Online]. Available at: https://www.daera-ni.gov.uk/sites/default/files/publications/doe/natural-guidance-NIEA-natural-heritage-development-management-team-advice-note-2012.pdf (Accessed 18/12/2021)

A review of hydrological and hydrogeological conditions is included within the **Chapter 8: Hydrology and Hydrogeology** of the ES, including a review of the hydrological baseline.

The following figures are provided in Appendix A at the end of this report:

- **Figure A8.1.1: Existing Drainage Survey;**
- **Figure A8.1.2: Dipwell Locations;**
- **Figure A8.1.3: Hydrological Unit Assessment; and,**
- **Figure A8.1.4: Flushes.**

2.2 Site Surveys

The following surveys were completed as part of this HUA:

- An initial site walkover was carried out in September 2021 to ground-truth hydrological conditions on-site for baseline data review;
- Dipwells were installed in September 2021; and
- A qualitative drainage survey was undertaken in November 2021 to ground-truth hydrological features identified from desktop mapping.

Further information on each survey is detailed within Sections 3 and 4 of this HUA. The survey area is represented on Figure A8.1.1.

2.3 Assessment Methodology

The assessment methodology is detailed within each relevant section below.

2.4 Limitations

Whilst no access limitations were noted, not all hydrological units were visited within the Assessment Boundary during drainage surveys. Hydrological units that were not surveyed were: 7, 12, 17, 18, 19, 20, 21, 27, 28, 29, 54, 56, 57, 60, 70, 71, 72, 73, 74, 76, 77, 85, 86, 87, 94, 97, 98, 99, 100, 102, 103, 109, 110, and 111. The hydrological units in proximity to the proposed turbines and infrastructure were prioritised where possible. The unit characteristics for the units not surveyed were determined from aerial photography, photography from other site specific surveys, and OSNI 1:50,000 mapping.

Dipwells were installed in areas noted as having the potential for development at the time of monitoring. Due to the size of the site not all areas could be monitored. No topographical survey or LIDAR data was available for the site to inform the assessment.

The interpretation of the origin and classification of any hydrological features is based on site observations or review at the time of survey and may be subject to interpretation as features may not always be wet.

The above limitations are normal for wind farm developments. The assessment draws on information from multiple sources and multiple assessors, so that assessment conclusions are not limited to a single source of information. As a result, the uncertainty that these limitations will lead to is not expected to be sufficient to cause substantial errors in the assessment findings relating to the status of the hydrological units.

3. DIPWELL MONITORING

Thirty-five dipwells were installed up to 1.5 metres (m) in depth from August to September 2021 to measure groundwater levels in peat. Dipwells were installed at locations where potential active peat had been recorded during ecology surveys and in areas where Development infrastructure was potentially (at that time) to be located. Dipwells were placed in clusters of three to allow flow direction to be determined. The location of the dipwells is shown on Figure A8.1.2. Dipwell monitoring results were then used to inform later design iterations and to avoid direct impacts to areas of active peat.

Monthly dipwell monitoring was carried out over a year period from September 2021 to August 2022. The rainfall during the month preceding each visit is summarised in Table A8.1.1. below. [2]

Table A8.1.1. Precipitation Recorded during Dipwell Monitoring Period

Dipwell Monitoring Period Month	Date of Monitoring	Rainfall (mm)	Rainfall (percentage of 1981 – 2010 average)	Comment
September 2021	29/09/2021	85	93%	Slightly Below Average
October 2021	28/10/2021	127	105%	Average
November 2021	29/11/2021	69	62%	Below Average
December 2021	22/12/2021	137	120%	Above Average
January 2022	25/01/2022	53	47%	Below Average
February 2022	02/03/2022	145	159%	Above Average
March 2022	31/03/2022	49	56%	Below Average
April 2022	26/04/2022	71	96%	Average
May 2022	25/05/2022	89	120%	Above Average
June 2022	28/06/2022	85	104%	Average
July 2022	25/07/2022	46	51%	Below Average
August 2022	31/08/2022	45	45%	Below Average

Results from dipwell monitoring are reported in **Technical Appendix A8.6: Dipwell Monitoring Dataset**.

The highest groundwater level recorded during the monitoring period, 0.02 metres below ground level (mbgl) recorded during June 2022, was used as the groundwater level for the HUA to provide a conservative approach.

4. HYDROLOGICAL USNIT ASSESSMENT METHODOLOGY

4.1 Baseline Review

Baseline hydrological mapping was initially carried out to map hydrological features within the Assessment Boundary using the GIS package ArcGIS Pro. Hydrological features were digitised and classified into four categories of either natural features (mapped watercourses and unmapped drains) or artificial features (ditches and cuttings), as shown on Figure A8.1.1:

- Watercourses are defined as natural features that are mapped on OSNI 1:50,000;
- Drains are defined as natural features which are unmapped and permanently wet (including flushes);

[2] National River Flow Archive (NRFA) (2021) Monthly Hydrological Summaries [online] Available at: https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk (Accessed 15/12/2021)

- Ditches are linear artificial features which are seasonally wet; and,
- Cuttings are artificial features created from peat extraction which may be dry or act as a seasonally wet feature.

Baseline hydrological mapping was initially carried out to map hydrological features within the Assessment Boundary using the GIS package ArcGIS Pro. Hydrological features were digitised and classified into four categories of either natural features (mapped watercourses and unmapped drains) or artificial features (ditches and cuttings), as shown on Figure A8.1.1:

- Watercourses are defined as natural features that are mapped on OSNI 1:50,000;
- Drains are defined as natural features which are unmapped and permanently wet (including flushes);
- Ditches are linear artificial features which are seasonally wet; and,
- Cuttings are artificial features created from peat extraction which may be dry or act as a seasonally wet feature.

4.2 Drainage Survey

Following the initial site walkover (September 2021) and desktop review, a drainage survey was undertaken in November 2021 to ground truth the baseline hydrological mapping, focussing on areas where turbines were proposed at that time. Additional information collected on the walkover included additional smaller water features and information on hydrological features flow and water levels.

4.3 Hydrological Unit Assessment

Following the walkover, the Assessment Boundary area was divided into hydrological units, using linear hydrological features as boundaries. The basis for using hydrological features as boundaries reflects where groundwater flow is likely to coincide with surface water features and topographical features, for example, a hydrological unit would be separated by the valley and location of a watercourse. The units were then analysed to determine if they were 'Intact', 'Non-Intact', or 'Compromised'.

Analysis of hydrological units considered the following parameters:

- Depth of groundwater (from analysis of dipwell data where maximum groundwater level is within 0.2 m of ground surface);
- Presence of artificial ditches;
- Hummocky and pool topography; and
- Dry or wet conditions underfoot.

Whether a unit is Intact, Non-Intact, or Compromised (i.e., whether the unit is degraded or not) was determined by a set of criteria based on the Arcus criteria developed in line with the NIEA Advice Note[3] and Flynn et al.[4], outlined in Table A8.1.2. The use of three categories, including the 'Compromised' class, was developed as there were areas with limited or conflicting information.

[3] NIEA (2012) Natural Heritage, Development Management Team Advice Note Active Peatland and PPS18 [online] Available at: https://www.daera-ni.gov.uk/sites/default/files/publications/doe/natural-guidance-NIEA-natural-heritage-development-management-team-advice-note-2012.pdf (Accessed 16/12/2021)

[4] Flynn et al. (2021) *Towards the Quantification of Blanket Bog Ecosystem Services to Water* EPA Research Report (2015-NC-MS-5)

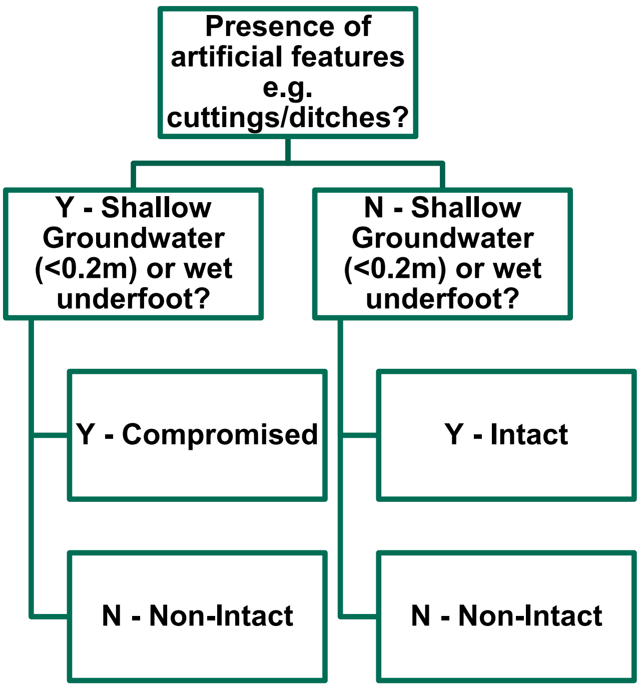
Table A8.1.2. Criteria for Classification of Hydrological Units

Classification	Definition	Criteria (based on NIEA Advice Note) in order of priority
Intact	Hydrological unit undegraded i.e., no artificial modification	▪ Shallow groundwater levels (<0.2 m bgl); ▪ No artificial drains or cuttings present; ▪ Hummocky/pool topography; and, ▪ Wet underfoot.
Non-Intact	Hydrological unit degraded and altered by artificial features	▪ Deeper groundwater levels (>0.2 m bgl); ▪ Presence of artificial drains or cuttings; ▪ No hummocky/pool topography; and, ▪ Dry underfoot.
Compromised	Hydrological unit that may be artificial in origin or contain artificial features, however, may still remain intact in areas	▪ Presence of both features above; and, ▪ Presence of minor cuttings or ditches which show modification/drainage, but unit may still be intact.

4.4 Intact unit classification process

To classify the units as Intact, Non-Intact, and Compromised according to the methodology outlined above the following flow diagram was followed for each unit.

Flow Diagram for Intact Unit Classification



4.5 Flushes

Identification of flushes has been incorporated within the HUA. Flushes are defined as areas where groundwater flows onto the surface, creating an area of saturated ground as opposed to a defined channel.

Flushes can hydrologically disconnect hydrological units and where flushes are large enough, a hydrological unit may consist of flush habitat. After mapping the hydrological units, units were compared with the habitat assessment areas and were categorised as follows:

- Flush (polygon) – mapped hydrological unit consists largely of flush habitat;
- Flush (line) – flush habitat is present either as drain within or at the boundaries of the mapped hydrological unit; and
- No Flush.

The categorisation of the hydrological units is shown within Table A8.1.2.

Flushes can influence the assessment of an Intact unit depending on their origin. Flushes can either be natural (groundwater source) or artificial where a saturated area of ground is created by surface water run-off from tracks or ditches. As shown on the flow diagram above, if an otherwise Intact area is determined to be fed by an artificial flush and is wet underfoot the area is considered Compromised due to the artificial drainage immediately upstream of the unit.

4.6 Hydrological Units Assessment Areas

Hydrological units were determined using hydrological features that disconnect areas, such as watercourses, and drains, along with soil type and soil condition.

4.7 Results

The results of the hydrological assessment are shown in Table A8.1.3 and Figure A8.1.3 and Figure A8.1.4.

4.8 Hydrological Unit Assessment Results

Table A8.1.3. Summary of Hydrological Unit Assessment

Hydrological Unit	Status (Non-Intact/ Intact/ Compromised)	Reasons for Status	Presence of cuttings/ artificial features (Y/N)	Shallow Groundwater Average (<0.2 m) or Dry/Wet Underfoot	Dipwells in Unit	Flush within Unit (Y/N)	Proposed Turbine within Unit
1	Non-Intact	Parallel ditches present and dry underfoot.	Y	Dry	N	N	T10, 55m north-west
2	Compromised	No ditches and groundwater <0.2m, flush habitat, however, is considered compromised due to artificial source of flush.	N	<0.2m	Y - T11a	Y - flush line	T10, downhill 47m north-west
3	Compromised	Parallel ditches present, however, groundwater <0.2m.	Y	<0.2m	Y - T11b, T11c	N	T10
4	Non-Intact	Linear ditches present, and area considered to be dry underfoot with dry modified bog habitat.	Y	Dry	N	N	No turbine
6	Compromised	Compromised as only one ditch is present within area and both wet and dry habitats present.	Y	Both	N	N	No turbine
7	Intact	As not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	Y - flush polygon	No turbine
9	Non-Intact	Ditches and damaged surface present, bound by flushes. However, area dry underfoot.	Y	Dry	N	Y - flush line	T9
10	Intact	No artificial features present and wet underfoot.	N	Wet	N	Y - flush polygon	T9 50 m south-west, access track within unit

11	Intact	No artificial features present and wet underfoot.	N	Wet	N	Y - flush polygon	No turbine, access track within unit
12	Intact	No artificial features present and wet underfoot.	N	Wet	N	Y - flush polygon	No turbine
13	Non-Intact	Minor parallel ditches present and bound by old access tracks, dry underfoot in area.	Y	Dry	N	N	No turbine
14	Non-Intact	No cuttings or ditches within polygon, area dry underfoot.	N	Dry	N	N	No turbine, access track within unit
15	Non-Intact	No cuttings or ditches within polygon, area dry underfoot.	N	Dry	N	N	No turbine, access track within unit
16	Compromised	No cuttings or ditches within polygon, area wet underfoot, flush habitat within polygon, however, compromised as immediately downslope of artificial features.	N	Wet	N	Y - flush line	No turbine, access track within unit
17	Non-Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	Y	Not visited	N	N	No turbine
18	Non-Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	Y	Not visited	N	N	No turbine
19	Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	Y - flush line	No turbine
20	Compromised	No cuttings or ditches within polygon, area wet underfoot, however is compromised as bound by ditch and tracks.	N	Wet	N	Y – flush polygon	No turbine
21	Intact	No cuttings or ditches within polygon, area wet underfoot.	N	Wet	N	Y - flush polygon	No turbine, access track within unit

22	Non-Intact	No artificial features present and dry underfoot.	N	Dry	N	Y - flush line	No turbine
23	Non-Intact	Artificial features present and dry underfoot.	Y	>0.2m	Y - T4a/b/c	Y - flush line	T8
24	Non-Intact	No artificial features present. Although wet habitats are present, groundwater is >0.2 m so area is non-intact.	Y	>0.2m	Y - T10b	Y - flush line	No turbine
25	Compromised	Compromised as artificial features present and dry and wet habitats in area.	Y	Both	N	Y - flush line	T11, 50m south, T12 100m south-east
26	Intact	No artificial features present and area wet underfoot, area surrounded by flush habitat.	N	Wet	N	Y - flush line	No turbine
27	intact	No artificial features present and area wet underfoot, flush habitat with polygon.	N	Wet, <0.2m	Y - T5a/T5c	Y - flush polygon	T11
28	Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	Y – flush polygon	No turbine, access track within unit
29	Intact	3ot visited, intactness will be determined by presence of artificial features only – as none are present the area is Intact	N	Not visited	N	Y – flush polygon	No turbine, access track within unit
30	Compromised	Minor cuttings present, however, wet underfoot.	Y	Wet	N	N	T12, 55m downhill (north)
31	Compromised	No artificial features present and wet underfoot, however is compromised due to surrounding access tracks.	N	Wet	N	N	T12, 88m downhill (north-east)
32	Non-Intact	Minor cuttings present and groundwater >0.2m.	Y	>0.2m	Y - B1/B3	Y - flush line	No turbine

33	Intact	No artificial features present and wet underfoot.	N	Wet	N	N	T5, 20m downhill west, divided by road
34	Compromised	No artificial features, however, as recovering blanket bog likely to be wet underfoot and therefore compromised.	N	Both	N	N	T5, 85m uphill south-west, divided by road
35	Non-Intact	Artificial features present and dry underfoot.	Y	Dry bog	N	N	No turbine, access track in unit
36	Compromised	Artificial features present, wet underfoot.	Y	Wet	N	N	T3 30 m west, access track in unit
37	Non-Intact	No artificial features, dry underfoot.	N	Dry	N	N	T3
38	Compromised	Artificial cuttings and exposed peat present, wet underfoot.	Y	Wet	N	N	No turbine, access track within unit
39	Compromised	Minor parallel cuttings present, wet underfoot.	Y	Wet	N	Y - flush line	T6
40	Compromised	Cuttings and ditches present, wet underfoot.	Y	Wet	N	N	T6 67m north
41	Compromised	Area bound by flush and ditch to the south draining area, area largely dry underfoot but wet habitats also present.	Y	Dry	N	Y - flush line	No turbine
42	Intact	Groundwater <0.2m and no artificial features present.	N	<0.2m	Y - B2	Y - flush line	No turbine
43	Compromised	Area wet underfoot but artificial features present.	Y	Wet	N	Y - flush line	T11, 75m north-west
44	Non-Intact	Area dry underfoot, however, minor drains and cuttings present within area.	Y	Dry	N	N	T6

45	Compromised	Area compromised as wet underfoot with artificial features present.	Y	Wet	N	Y - flush line	No turbine, access track within unit
46	Non-Intact	Non-Intact as several cuttings present and dry underfoot.	Y	Dry	N	Y - flush line	T4, 43m west
47	Compromised	Compromised as several cuttings present, area is wet underfoot.	Y	<0.2m	Y - T8a/c	Y - flush line	T4
48	Compromised	Compromised as several cuttings present, area is wet underfoot.	Y	<0.2m	Y - T8b, A1/2	Y - flush line	T4
49	Intact	Intact as wet underfoot and no artificial features present.	N	Wet	N	N	No turbine
50	Compromised	Compromised as artificial features present and dry and wet habitats in area.	Y	Dry/Wet	N	Y - flush polygon	T12
51	Intact	Intact as wet underfoot and no artificial features present.	N	>0.2m	Y - T5b	Y - flush polygon	T11 15m south east
52	Intact	Intact as wet underfoot and no artificial features present.	N	Wet	N	Y - flush line	No turbine
53	Intact	Intact as wet underfoot and no artificial features present.	N	Wet	N	Y - flush polygon	T8 80m west
54	Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	Y - flush line	T9 55 m north
55	Non-Intact	Non intact as artificial features present but was dry underfoot - area likely drained by flushes at boundary.	N	Dry	N	Y - flush line	No turbine

56	Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	N	No turbine
57	Intact	Not visited, intactness will be determined by presence of artificial features only - as none are present the area is Intact.	N	Not visited	N	Y – flush line	T9 45 m south-west
58	Non-Intact	Non-Intact as minor ditches are present within the area and was noted to be largely dry onsite.	Y	Dry	N	N	No turbine, access track within unit
59	Compromised	Compromised as the area is wet underfoot, however, there is a large cutting present within the area.	Y	Wet	N	Y – flush line	T8 60m south
60	Intact	Intact as the area is wet underfoot, largely intact blanket bog and was noted to be wet underfoot.	N	Wet	N	N	T4, downhill (north) 60m
61	Compromised	Compromised as the area is largely wet underfoot onsite, however, there are several parallel ditches.	Y	Wet	N	N	No turbines
62	Intact	Intact as the area is not affected by artificial features and was wet underfoot - area is bound by flushes.	N	Wet	N	Y - flush line	T7
63	Non-Intact	Non-Intact as minor parallel ditches present and the area was noted to be largely dry out with the ditches, area bound by large cuttings.	Y	Dry	N	N	T17 56m north west
64	Intact	Intact as the area was wet underfoot and no artificial features were present.	N	Wet	N	Y - flush line	T7 45m west
65	Intact	Intact as wet underfoot and no artificial features present within area.	N	Wet	N	N	No turbines
66	Compromised	Compromised as there is minor cutting/ditch in the area and is cut off upstream by track, but it is wet underfoot.	Y	Wet	N	Y - flush polygon	T7 16m north

67	Compromised	Compromised as extensive cutting present across the area, including old access track, both wet and dry habitats present in area.	Y	Dry/Wet	N	Y - flush polygon	No turbines
68	Compromised	Compromised as groundwater is <0.2m despite large cuttings and drains present within the area.	Y	<0.2m	Y - T12 d/e/f	Y - flush line	No turbines
69	Compromised	Compromised as area is wet underfoot despite large cuttings and minor drains within area.	Y	Wet	N	N	No turbines
70	Non-Intact	Non-Intact as large cuttings are present within the area and the ground was noted to be dry underfoot.	Y	Dry	N	Y - flush line	No turbines
71	Compromised	Compromised as large cuttings present within area, but groundwater is <0.2m.	Y	<0.2m	Y - T12a/c	Y - flush line	No turbines
72	Intact	Intact as no artificial features present and the area is wet underfoot.	N	Wet	N	N	No turbines
73	Intact	Intact as artificial features are present, and the groundwater is not taken into account due to the area not being peat.	N	Dry	N	N	T13, 26m north
74	Intact	Intact as no artificial features present and the area is wet underfoot.	N	Wet	N	N	No turbines
75	Non-Intact	Non-Intact as cuttings and ditches present within the area and area was noted to be largely dry.	Y	Dry	N	Y - flush line	T14, 10m west
76	Non-Intact	Non-Intact as cuttings and ditches present within the area and area was noted to be largely dry.	Y	Dry	N	Y - flush line	T14, 60m east
77	Non-Intact	Non-Intact as cuttings and ditches present within the area and area was noted to be largely dry.	Y	Dry	N	Y - flush line	No turbines

78	Compromised	Compromised as cuttings and ditches present within area, however, was noted to be wet underfoot.	Y	Wet	N	Y - flush line	T14
79	Compromised	Compromised as cuttings and ditches present within area, however, was noted to be wet underfoot.	Y	Wet	N	N	No turbines
80	Non-Intact	Non-Intact as parallel ditches present within area and was noted to be largely dry underfoot onsite.	Y	Dry	N	Y - flush line	T3 13 m east
81	Non-Intact	Non-Intact as cuttings and minor track present in area and the groundwater was noted to be deep (>0.2m).	Y	>0.2m	Y - T7a/b/c	N	No turbine, construction compound within unit
82	Compromised	Compromised as there are parallel cuttings present within area, however, it was noted to be wet underfoot.	Y	Wet	N	N	No turbine, access track within unit
83	Non-Intact	Non-Intact as extensive cutting present within the area and the area was noted to be dry underfoot.	Y	Dry	N	N	T2 86m north-east
84	Compromised	Compromised as artificial cuttings upslope, both wet and dry underfoot were noted onsite, but was decided due to flush habitat noted it was likely to be largely wet.	N	Wet	N	Y - flush polygon	T2 6 m north
85	Intact	Despite being farmland, considered to be an intact unit as no artificial features present and has shallow groundwater.	N	<0.2m	Y - T2b	N	No turbine
86	Intact	Not visited, intactness was decided by presence of artificial features. Since no cuttings or ditches are present, the area is Intact.	N	Not visited	N	N	No turbine
87	Intact	Not visited, intactness was decided by presence of artificial features. Since no cuttings or ditches are present, the area is Intact.	N	Not visited	N	N	No turbine

88	Intact	Not visited, intactness was decided by presence of artificial features. Since no cuttings or ditches are present, the area is Intact.	N	Not visited	N	N	No turbine
89	Non-Intact	Non-Intact as groundwater present at >0.2m and artificial features present upslope were determined to be minor and could also have been result of peat slides.	N	>0.2m	Y = T9b	Y - flush line	T2
90	Compromised	Compromised as ditch present at downslope boundary of unit, but groundwater is <0.2m.	Y	<0.2m	Y - T9a/c	Y - flush polygon	T5
91	Intact	Intact as the area was wet underfoot and no artificial features were present.	N	Wet	N	Y - flush line	No turbine, access track within unit
92	Compromised	Determined to be compromised as the area was wet underfoot, however, artificial features present were minor cuttings.	N	Wet	N	Y - flush polygon	T5 100m south west, access track within unit
93	Intact	Intact as no artificial features present and the area is wet underfoot.	N	Wet	N	Y - flush polygon	T5 35m south
94	Intact	Not visited, intactness was decided by presence of artificial features. Since no cuttings or ditches are present, the area is Intact.	N	Not visited	N	N	, construction compound and access track within unit
95	Non-Intact	Non-Intact as artificial features present and the area was largely dry underfoot.	Y	Dry	N	Y - flush line	T3 50m west
96	Compromised	Compromised as the area is wet underfoot, however, there are cuttings present within the area.	Y	Wet	N	N	No turbine, access track within unit
97	Intact	Intact as wet underfoot and no artificial features present within area.	N	Wet	N	N	T13 20 m north-west

98	Intact	Intact as wet underfoot and no artificial features present within area.	N	Wet	N	N	No turbine
99	Compromised	Compromised as large cuttings present in uphill of area but was found to be wet underfoot.	Y	Wet	N	Y - flush line	T13
100	Compromised	Compromised as large cuttings present in uphill of area but was found to be wet underfoot.	Y	Wet	N	N	T13 47m south
101	Compromised	Compromised as although wet underfoot, a minor drain is present within area and the area is bound by large cuttings.	Y	Wet	N	Y - flush line	No turbine
102	Intact	No cuttings or ditches present within area with boundary, as not visited and no dipwells present, intactness can only be determined by presence of artificial features.	N	Not visited	N	Y - flush polygon	No turbine
103	Intact	No cuttings or ditches present within area with boundary, as not visited and no dipwells present, intactness can only be determined by presence of artificial features.	N	Not visited	N	Y - flush line	No turbine
104	Non-Intact	Non-Intact as area bound by cuttings either side and downslope of artificial features, area is dry underfoot.	Y	Dry	N	N	No turbine, access track within unit
105	Non-Intact	Non-Intact as area bound by cuttings either side and downslope of artificial features, area is dry underfoot.	Y	Dry	N	N	No turbine, access track within unit
106	Non-Intact	Non-Intact as artificial features present and underlying area is dry modified bog habitat.	Y	Both	N	N	No turbine
107	Non-Intact	Artificial features present and dry underfoot.	Y	Both	N	Y - flush line	No turbine

108	Intact	Intact as no artificial features present and the area is wet underfoot.	N	Both	N	Y - flush line	T11 65 m south, access track within unit
109	Non-Intact	No artificial features present, used for grazing, dry underfoot.	N	Dry	N	N	Access track within unit.
110	Non-Intact	No artificial features present, used for grazing, dry underfoot.	N	Dry	N	N	T1 turbine and access track within unit.
111	Non-Intact	No artificial features present, used for grazing, dry underfoot.	N	Dry	N	N	T1 turbine and access track within unit.

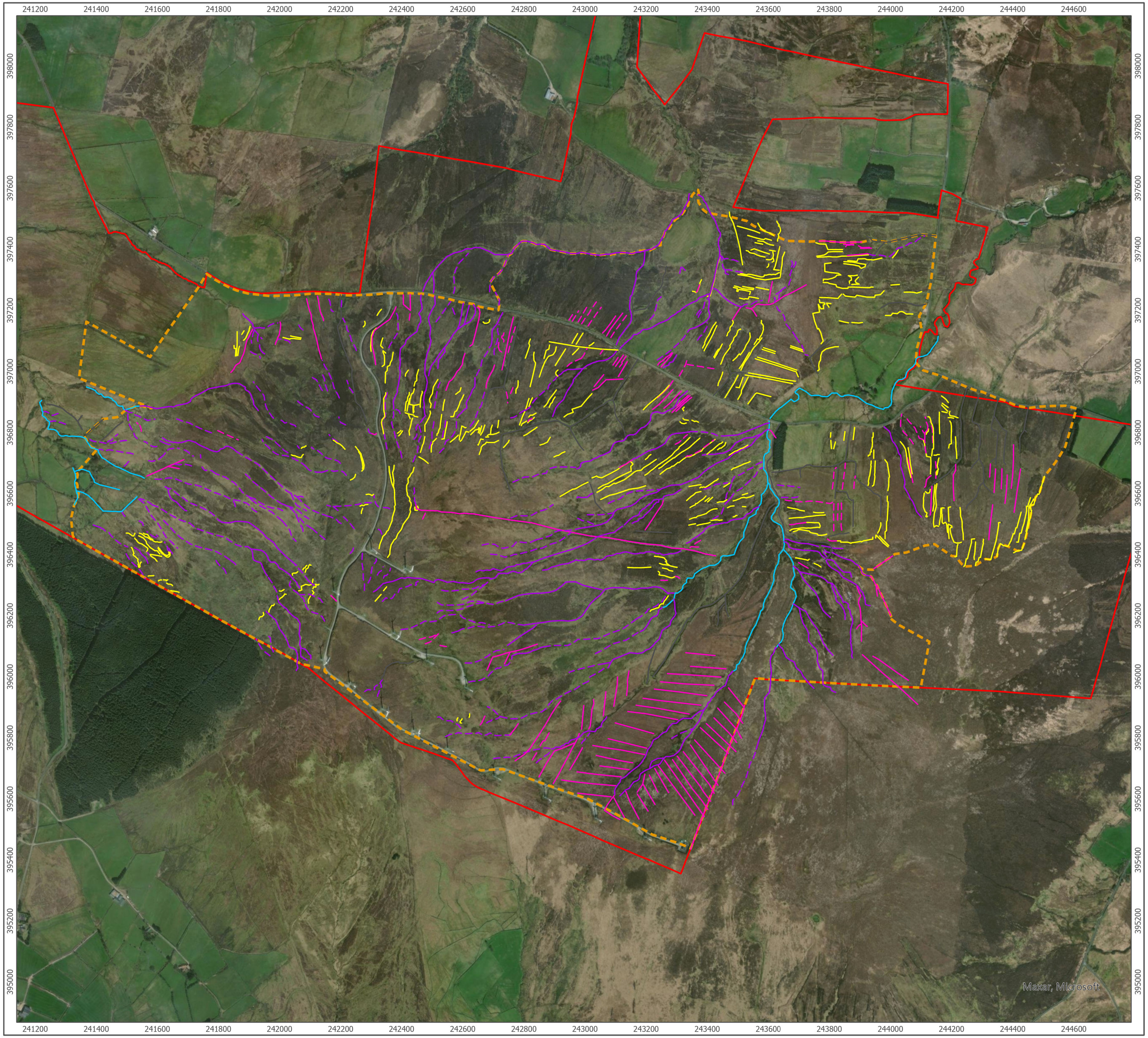
5. CONCLUSION

Following review of the data sources, including dipwell data, the hydrological units were assessed to be either Intact, Non-Intact or Compromised. Active peat may be present within Intact or Compromised units. No infrastructure or turbines are sited within Intact units; however, the following Compromised units will contain Development infrastructure and/or turbines (as detailed on Table A8.1.3):

- Units 3, 29, 47, 48, 50, 78, 90, and 99 have turbines sited within the units; and
- Units 16, 36, 38, 45, 82, 92, and 96 have other infrastructure (i.e. access tracks, hardstanding, etc.).

As detailed in Section 6 of **Technical Appendix 10.4: Active Peat Assessment**, direct impacts to 'high constraint' active peat areas from the Development's proposed turbines and infrastructure has been avoided. The results from this Technical Appendix will inform **Chapter 8: Hydrology and Hydrogeology** and **Chapter 10: Ecology** of the ES.

APPENDIX A FIGURES



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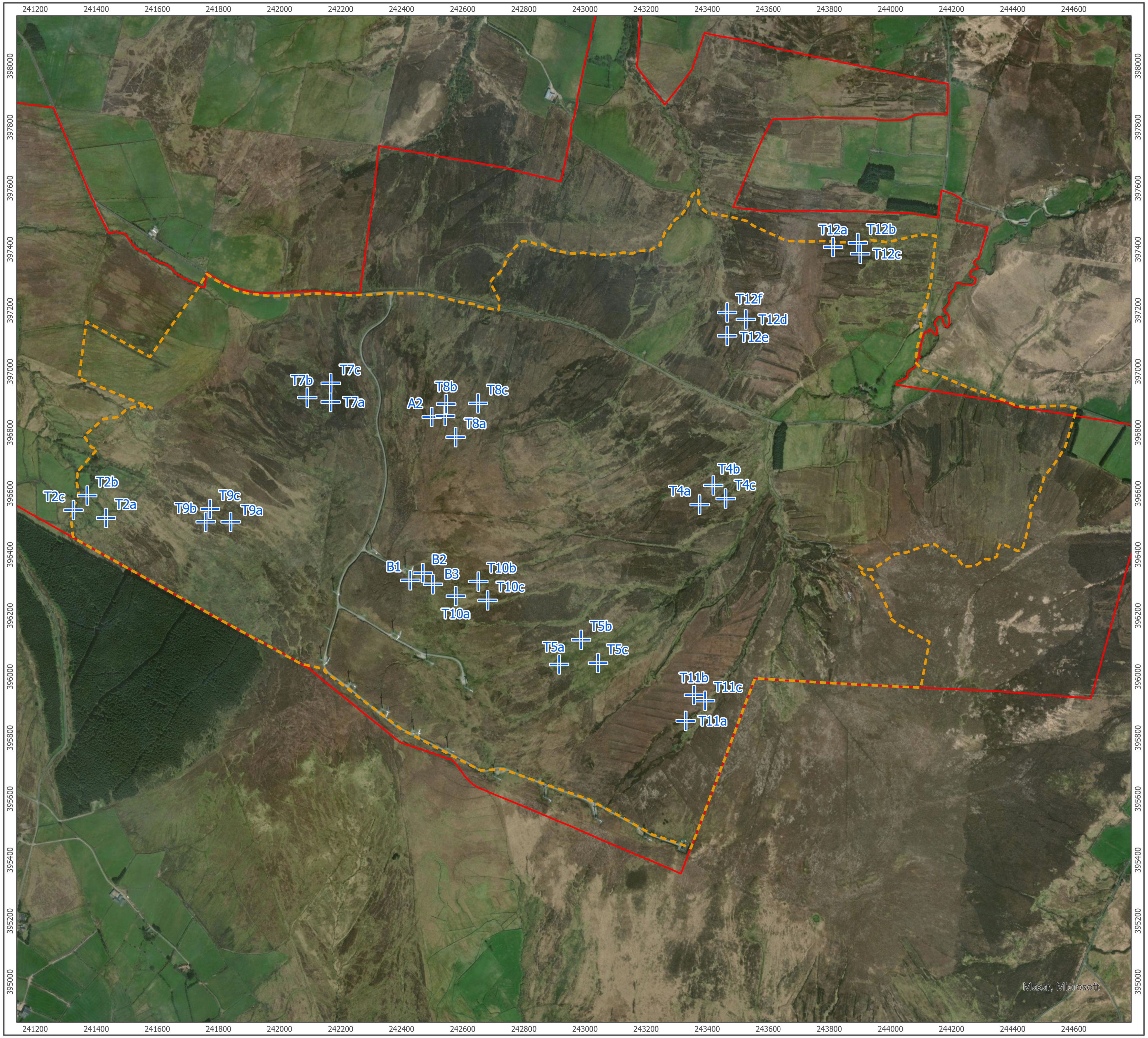
Checked By: SC	Date: 04/07/2023

Existing Drainage Survey
Figure A8.1.1

Owenreagh / Craignagapple Wind Farm Hydrological Units Assessment

Y:\GIS-CAD\GIS\Hydrology\Projects\4172 Owenreagh Wind Farm\4172 Owenreagh Wind Farm.aprx\4172-REP-009 Fig A8.1.1 Drainage Assessment



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Site Boundary

Assessment Boundary

1:12,000 Scale @ A3

0 200 400 m

NORTH

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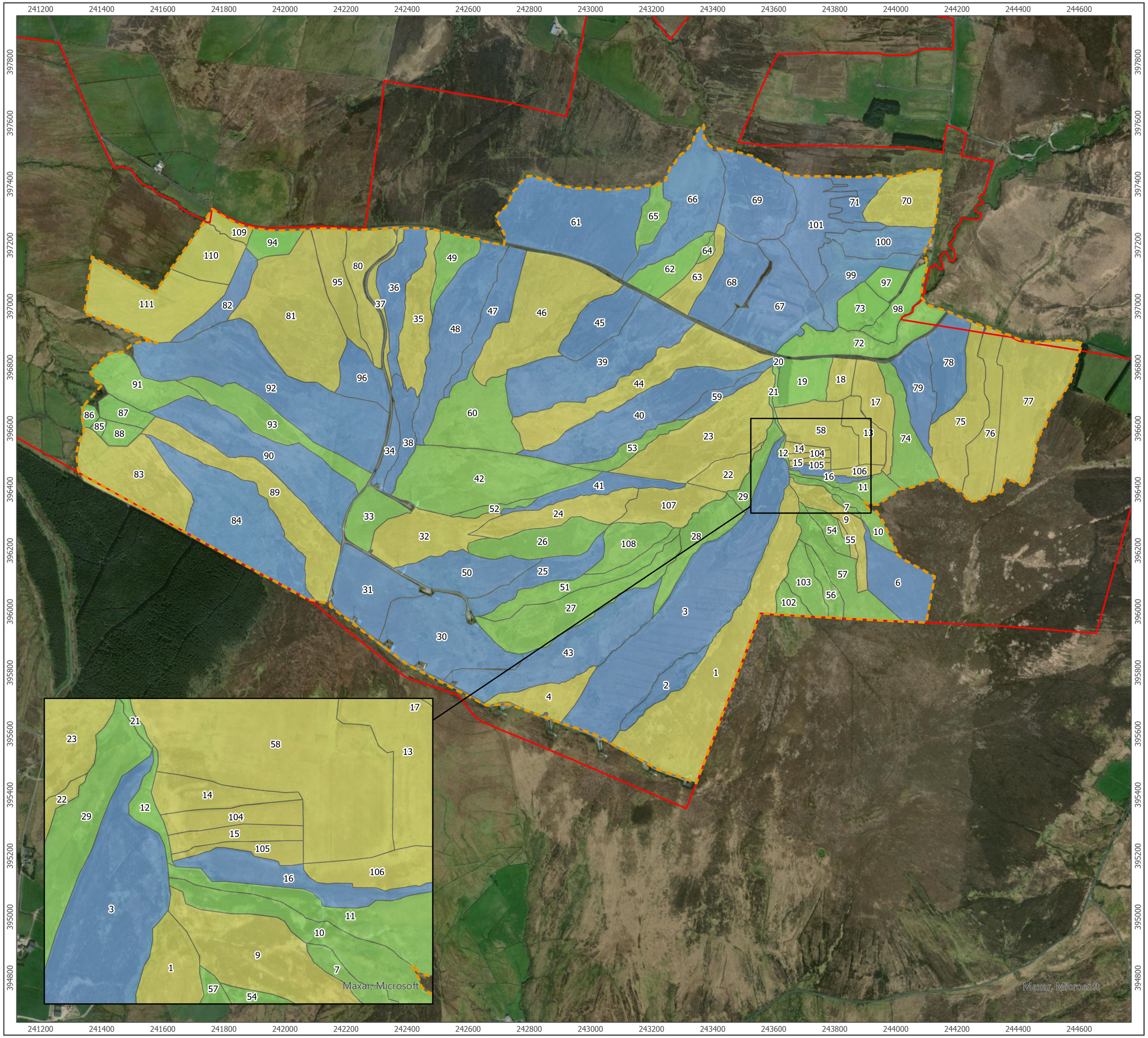
Dipwell Locations

Figure A8.1.2

Owenreagh / Craignagapple Wind Farm Hydrological Units Assessment

Y:\GIS-CAD\GIS\Hydrology\Projects\4172 Owenreagh Wind Farm\4172 Owenreagh Wind Farm.aprx\4172-REP-010 Fig A8.1.2 Dipwell Locations



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ERM

- Site Boundary
- Assessment Boundary
- Intact
- Compromised
- Non-Intact

1:12,000 Scale @ A3

0 250 500 m

NORTH

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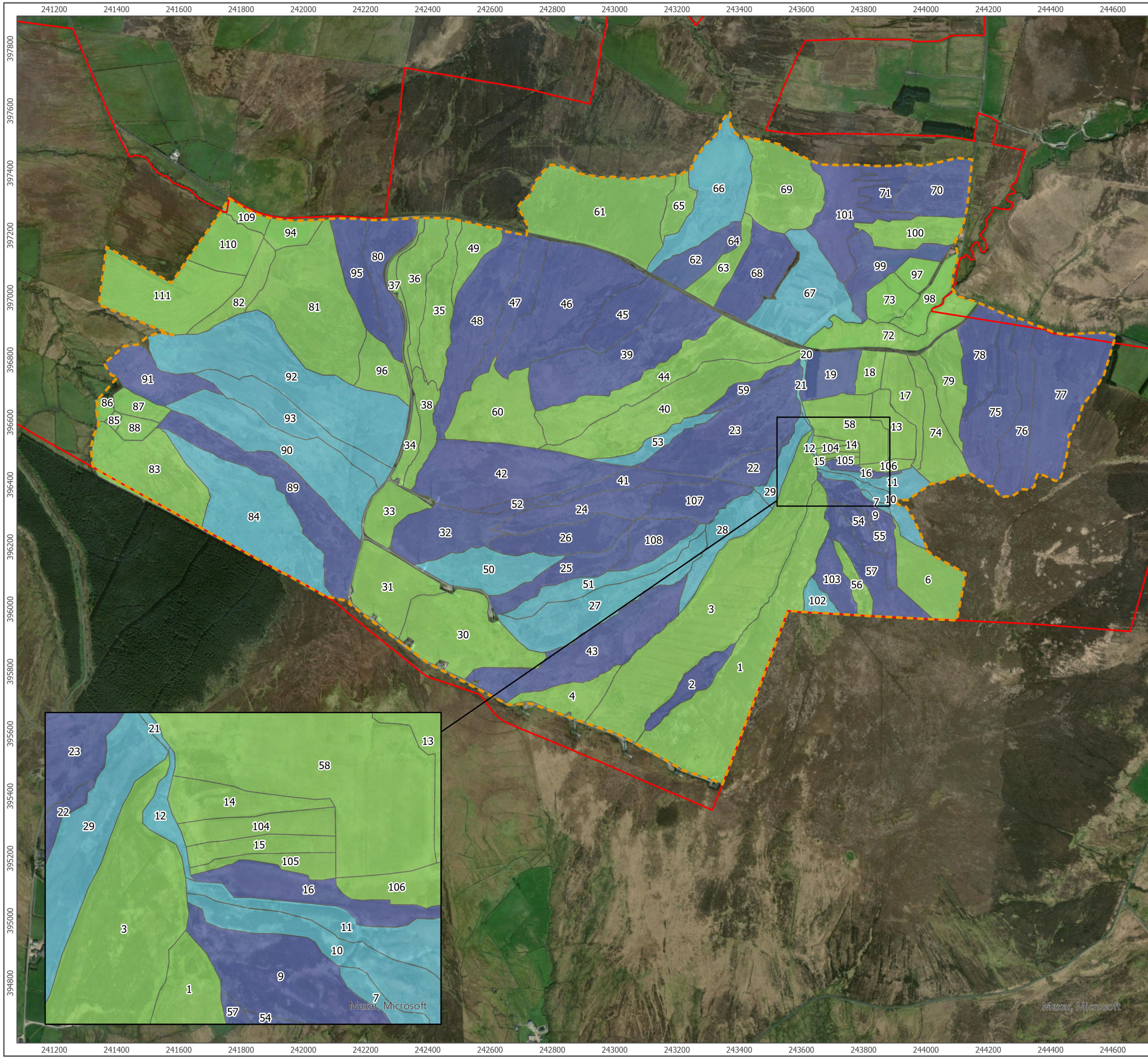
Hydrological Unit Assessment
Figure A8.1.3

Owenreagh / Craignagapple Wind Farm Hydrological Units Assessment

Y:\GIS-CAD\GIS\Hydrology\Projects\4172 Owenreagh Wind Farm\4172 Owenreagh Wind Farm.aprx\4172-REP-008 Fig A8.1.3 Hydrological Unit Assessment



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ERM

Site Boundary
Assessment Boundary
Flush Polygon
Flush Line
No Flush

1:12,000 Scale @ A3
0 250 500 m
NORTH

Produced By: JC	Ref: 4172-REP-011
Checked By: SC	Date: 04/07/2023

Flush Assessment
Figure A8.1.4

Owenreagh / Craignagapple Wind Farm Hydrological Units Assessment

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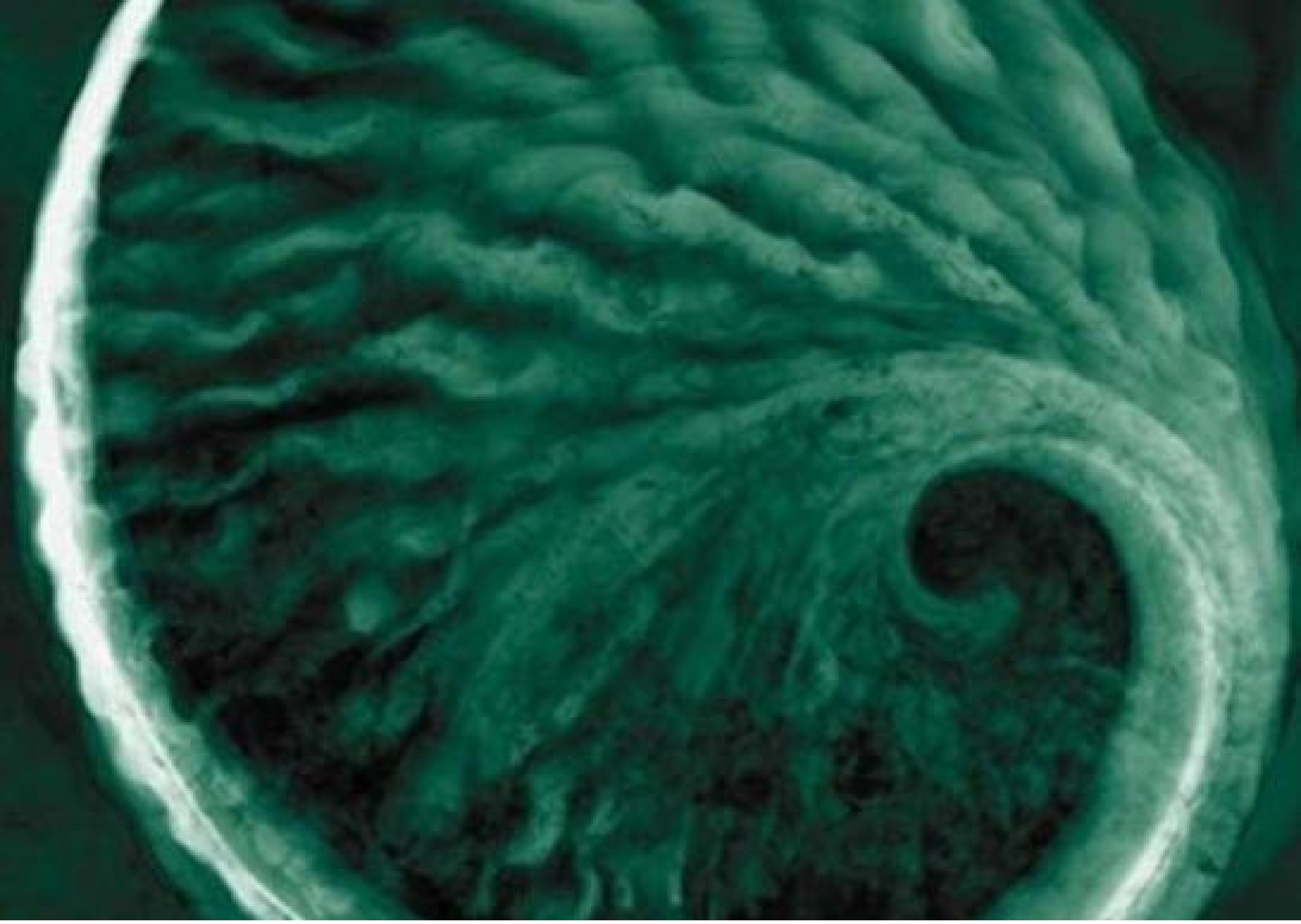

Ørsted Onshore Ireland Midco Limited

Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.2 Private Water Supply Risk Assessment

06 September 2023

Project No.: 0696177

ERM

The business of sustainability

Signature Page

06 September 2023

Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.2 Private Water Supply Risk Assessment

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CONTENTS

List of Tables

Acronyms and Abbreviations

Name	Description
AOD	Above Ordnance Datum
CLO	Community Liaison Officer
DAERA	Department of Agriculture, Environment and Rural Affairs
EIA	Environmental Impact Assessment
ES	Environmental Statement
FEI	Further Environmental Information
oCEMP	Outline Construction Environmental Management Plan
PWS	Private Water Supply
PSWRA	Private Water Supply Assessment
SEPA	Scottish Environmental Protection Agency

1. INTRODUCTION AND BACKGROUND

1.1 Overview

Environmental Resources Management Ltd (ERM), on behalf of Ørsted Onshore Ireland Midco Limited (the Applicant), have produced a Private Water Supply Risk Assessment (PWSRA) which contains an assessment relating to properties with Private Water Supplies (PWS) within the area surrounding the proposed Owenreagh/Craignagapple Wind Farm (referred to as the Development).

The Development is located within Derry City and Strabane District Council ('the Council') on land approximately 5 kilometres (km) east of Strabane, in County Tyrone ('the Site') as shown on Figure 1.1.

This risk assessment forms **Technical Appendix A8.2** to the Environmental Statement **Chapter 8: Hydrology and Hydrogeology**.

1.2 Project Description

The Applicant proposes the construction and operation of Owenreagh/Craignagapple Wind Farm, which includes:

- Decommissioning of the operational Owenreagh I and Owenreagh II;
- Repowering of the Owenreagh I and II sites and consented Craignagapple site through construction of 14 wind turbines with tip height up to 156.5 m and rotor diameter up to 136 m; and
- Associated ancillary infrastructure, including but not limited to the following:
  - Substation compound including control building and other electrical infrastructure;
  - New and upgraded access tracks including turning heads;
  - Crane hardstands;
  - Construction compounds; and,
  - Cable trenches.

1.3 Scope of Assessment

Private Water Supplies within 2 km of the wind farm development, indicated by the Private Water Supply Study Area on Figure 8.1 of the ES.

2. METHODOLOGY

The ERM methodology for this PWSRA has been developed historically in conjunction with Scottish Environmental Protection Agency (SEPA) and has been adapted for the purposes of a PWSRA in Northern Ireland. This includes:

- Identification of PWS through public consultation and a survey letter drop within the 2 km Private Water Supply Study Area and review of other potential PWS identified using Ordnance Survey (OS) 1:50,000 raster mapping;
- Review of all PWS recorded by the Drinking water Inspectorate within the Private Water Supply Study Area as shown on the Drinking Water Inspectorate Viewer[1];
- Resident or property owner consultation via letter or by communication with a community liaison officer (CLO) to those properties identified to be supplied by a PWS;
- A site walkover to verify location and type of PWS;
- Identify the source of water feeding the water supply and its catchment;
- Identify proposed infrastructure and construction activities within the catchment or in proximity to the water supply and its infrastructure (*e.g.*, pipes) if required;
- Identify the potential effect on the water supply *i.e.*, whether construction of the Development has the potential to change the quality and/or quantity of water at the receptor;

[1] Drinking Water Inspectorate (2020) Drinking Water Inspectorate Viewer [Online] Available at: https://gis.daera-ni.gov.uk/arcgis/apps/webappviewer/index.html?id=8d99c8761b12414dbc88c42fdbca7431 (Accessed: 07/11/2022).

- Determine whether the PWS is at risk; and,
- Outline mitigation techniques that will be implemented to minimise any potential impact of construction and operation on drinking water quality, if required.

Where conflicting information has been provided by the supply owner and local authority, information provided by the supply owner has been used.

In addition to consultation with residents, a review of previous PWS assessments conducted for Craignagapple Wind Farm. These documents include:

- Craignagapple Wind Farm Environmental Statement (2010)[2];
- Craignagapple Wind Farm – FEI Report, Appendix 7 (2014)[3]; and,
- Craiganagapple Wind Farm FEI Report (2016)[4].

2.1 Risk Assessment Methods

The risk assessment reviewed desk-based information associated with PWS, including geological maps, historical maps, and surface water catchments. Where locations of the PWS water source were provided, this detail was overlain with mapped infrastructure associated with the Development to inform an initial source-pathway-receptor model.

Following the initial desk-based review, PWS and associated properties were identified as potentially 'at-risk' or 'not at-risk' from the Project. The level of risk was attributed to each of the PWS based on the sensitivity level of the receptor (source water, distribution infrastructure and point of supply), the criteria of which is outlined in Table A8.2.1, combined with the level of magnitude of change, for which the criteria is outline in Table A8.2.2.

The resultant level of risk is based on the risk matrix outlined in Table A8.2.3.

Table A8.2.1. Estimating the Sensitivity of Receptors

Sensitivity of Receptor	Definition
High	The hydrological receptor will support abstractions for public water supply or private water abstractions for more than 25 people.
Medium	The hydrological receptor supports abstractions for public water supply or private water abstractions for up to 25 people.
Low	The hydrological receptor does not support abstractions for public water supply or private water abstractions.

Table A8.2.2. Magnitude of Potential Impacts

Magnitude of Change	Description
High	A major permanent or long term negative change to groundwater quality or available yield.
Medium	The yield of existing supplies may be reduced or quality slightly deteriorated.
Low	Changes to groundwater quality, levels or yields do not represent a risk to existing baseline conditions.

[2] SKM Enviros (2010) Environmental Statement – Craignagapple Wind Farm (planning reference number: J/2010/0481/F).

[3] Jacobs (2014) Craignagapple Wind Farm FEI Report Appendix 7 – Geology, Hydrogeology and Hydrology Assessment (Planning reference: J/2010/0481/F).

[4] Jacobs (2016) Craignagapple Wind Farm Further Environmental Information (Planning Ref: J/2010/0481/F).

Magnitude of Change	Description
Negligible	A very slight change from the baseline conditions. The change is barely distinguishable, and adopts a 'no-change' situation.

Table A8.2.3. Risk Matrix

Magnitude of Effect	Sensitivity of Resource or Receptor		
	High	**Medium**	**Low**
High	Major	Major	Moderate
Medium	Major	Moderate	Minor
Low	Moderate	Minor	Negligible
Negligible	Negligible	Negligible	Negligible

2.1.1 Legislation and Guidance

The procedure for identifying and risk assessing PWS is based on the following legislation and guidance:

- The Private Water Supplies Regulations (Northern Ireland) 2017[5];
- The Water Supplies (Water Quality) (Amendment) Regulations (Northern Ireland) Regulations 2017[6];
- Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption (2015)[7];
- The Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017[8];
- The Groundwater (Amendment) Regulations (Northern Ireland) 2014[9]; and,
- DAERA Best Practice Guidance Documents – Wind farms and groundwater impacts[10]

[5] The Private Water Supplies Regulations (Northern Ireland) 2017 [Online] Available at: https://www.legislation.gov.uk/nisr/2017/211/contents/made (Accessed 07/11/2022).
6 The Water Supply (Water Quality) (Amendment) Regulations (Northern Ireland) 2017.
http://www.legislation.gov.uk/nisr/2017/211/contents/made. Accessed 15 Dec. 2022.

[7] European Union (2015) Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31998L0083 (Accessed: 07/11/2022).
[8] The Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017 [Online] Available at: https://www.legislation.gov.uk/nisr/2017/81/contents/made (Accessed 07/11/2022).
[9] The Groundwater (Amendment) Regulations (Northern Ireland) 2014 [Online] Available at: https://www.legislation.gov.uk/nisr/2014/208/contents/made (Accessed 07/11/2022).
[10] DAERA (2019) Environmental Advice for Planning – Practice Guide, Wind farms and groundwater impacts – a guide to EIA and Planning considerations [Online] Available at: https://www.daera-ni.gov.uk/sites/default/files/publications/daera/AE1%2019%20573928%20%20Practice%20Guide%20-%20Wind%20farms%20and%20groundwater%20impacts%202019.pdf (Accessed 08/11/2022).

The PWSRA will assess the risk for all PWS which are located within the following categories as outlined by DAERA Practice Guide – Wind farms and groundwater impacts and consultation response information received from the Drinking Water Inspectorate:

- Drinking water features within 250 m of all infrastructure (including foundations, access tracks, hardstanding and substation); and,
- All properties which are located within 500 m of a turbine were contacted to determine if they utilise a private water supply.

2.1.2 Identification of Private Water Supplies through Consultation

A survey letter drop was initially carried out in the vicinity of the Development, which was conducted on 21st December 2021. ArcGIS Pro was used to identify those located within a 2 km buffer ('the Study Area') of the Project. This process identified nine PWS to be located within the PWS Study Area and these are shown on Figure 8.3 of the ES. The nine properties identified through this consultation are:

- 8 Koram Road;
- 10 Ballykeery Road;
- 12 Ballykeery Road;
- 31 Koram Road;
- 33 Koram Road;
- 91 & 93 Holyhill Road; and,
- 84 & 86 Meendamph Road.

Consultation with residents and landowners of these properties was conducted on 3rd December 2021. The consultation process was conducted by posting a letter and questionnaire to residents to obtain further information on the PWS supplying their property, as well as a corresponding map indicating the location of each PWS supply. The questionnaire and reasoning for each of the questions are outlined in Table A8.2.4.

Table A8.2.4. Resident Consultation Questionnaire and Reasoning

Question	Reasoning
Type of supply (with list of options)	Allows for identification of the likely PWS source water and provide an understanding of its potential connectivity to the Development and developing a source-pathway-receptor model. This allows for an initial level of sensitivity to be applied to the PWS source as part of the final risk assessment.
Use of supply	Aids in developing the source-pathway-receptor model and conceptual site model. Also attributes sensitivity for the final risk assessment. Also provides information on the likely volumes of water abstracted at the PWS.
Type of water treatment	Understanding of the baseline vulnerability of the source and existing protection measures in place.
Number of people supplied	Provides information on the likely volumes of water abstracted at the PWS. Also helps to attribute sensitivity for the final risk assessment. It is acknowledged that this number can vary, particularly if the PWS supplies a commercial property.
Number of livestock supplied	Provides information on the likely volumes of water abstracted at the PWS. Also, to attribute sensitivity for the final risk assessment. It is acknowledged that this number can vary seasonally.

Question	Reasoning
Volume of water abstracted (m^3)	Allows for initial assessment on the catchment or 'zone of influence' of the water supply. This is the likely area the supply is draining water from. This informs an understanding of the PWS potential connectivity to the Development. For example, a large groundwater abstraction further from the Development may be hydrologically connected due to its larger zone of influence. A smaller abstraction, closer to the Development, may not be hydrologically connected because it has a very small zone of influence. It is acknowledged that this is often unknown or estimated by residents.
Any comment of the condition of your water supply	This informs an understanding of the existing level of vulnerability of the PWS and potential need for additional protection measures. For example, PWS that have previously been influenced by quantity reductions during drought periods may be more vulnerable than those who have not experienced this. Any information regarding previous water quality issues or quantity issues can inform an understanding of where the water is likely to be sourced from and the pathway it takes to get to the property.

This method of consultation identified one additional property, 78 Holyhill Road, and obtained further information on previously identified properties.

A review of the 2010 Craignagapple Wind Farm Environmental Statement was conducted. Within the 2010 ES hydrology chapter, two additional properties were found to be served by a PWS within 2 km of the Development. These properties were:

- 60 Glemmornan Road; and,
- 125 Curlyhill Road.

In June and July 2022, an Ørsted CLO visited previously identified property to obtain this information and confirm the presence of PWS. During this consultation process two additional PWS were identified:

- 11 Koram Road; and,
- 40 Koram Road.

The above consultation process identified a total of 14 properties which were potentially served by PWS.

2.2 Review of Properties Consulted

Table A8.2.5 below reviews the 14 properties identified throughout the consultation process.

Table A8.2.5. Properties with potential PWS within PWS Study Area

Property	Grid Reference	Location relative to the Development	Supply present?	Scoped in/out, and reasoning
8 Koram Road	241093 394610	1.73 km south (240 m AOD)	Yes – Spring Source	**Scoped out** of the assessment – hydrologically disconnected as property and source are in separate catchments from infrastructure.

Property	Grid Reference	Location relative to the Development	Supply present?	Scoped in/out, and reasoning
10 Ballykeery Road	242640 394139	876 m south (240 m AOD)	Yes - Well	**Scoped out** of the assessment – hydrologically disconnected as both source and property are in separate catchments from the infrastructure.
12 Ballykeery Road	242792 394660	920 m south (240 m AOD)	Yes - Borehole	**Scoped out** of the assessment – hydrologically disconnected as both source and property are in separate catchments from infrastructure.
31 Koram Road	240890 397415	60 m east (160 m AOD)	Yes - Well	**Scoped into** the assessment – hydrologically connected as property and source are in proximity to and downslope of infrastructure.
33 Koram Road	240866 397470	83 m east (160 m AOD)	No – mains water supply	**Scoped out** of the assessment – confirmed to be on mains supply.
91 Holyhill Road	240940 398434	525 m northwest (160 m AOD)	Yes- well	**Scoped into** the assessment – property is downslope of infrastructure and in proximity to road used for access.
93 Holyhill Road	241015 398504	602 m northwest (160 m AOD)	Yes - well	**Scoped into** the assessment – property is downslope of infrastructure and in proximity to road used for access.
84 & 86 Meendamph Road	246057 398670	2 km northeast (150 m AOD)	Yes – four wells	**Scoped out** of the assessment – hydrologically disconnected by Ballykeery and Dunnyboe Burn
78 Holyhill Road	No coordinates provided for this property	Approximately 1 km northwest	No – mains water supply	**Scoped out** of the assessment – confirmed to be on mains supply.
60 Glenmornan Road	241500 397460	76 m north (220 m AOD)	Yes - well	**Scoped into** the assessment – groundwater source downslope of infrastructure.

Property	Grid Reference	Location relative to the Development	Supply present?	Scoped in/out, and reasoning
125 Curlyhill Road	239800 396600	856 m southwest (230 m AOD)	Yes - well	**Scoped out** of the assessment – hydrologically disconnected as both source and property are in separate hydrological catchments from infrastructure.
11 Koram Road	241130 394876	1.47 km south (260 m AOD)	Yes - spring	**Scoped out** of the assessment – hydrologically disconnected as both source and property are in separate hydrological catchments from infrastructure.
40 Koram Road	240520 398115	360 m northwest (150 m AOD)	Yes - Well	**Scoped out** of the assessment – source is disconnected from the Development by Owenreagh Burn.

Of these 14 properties, 10 properties, 8 Koram Road, 40 Koram Road, 10 Ballykeery Road, 12 Ballykeery Road, 33 Koram Road, 78 Holyhill Road, 125 Curlyhill Road, 84 & 86 Meendamph Road and 11 Koram Road are hydrologically disconnected from Project and so were scoped out of the assessment.

2.3 Site Visits

In June/July 2022 PWS property visits were carried out by a community Liaison Officer (CLO) on behalf of Ørsted. The purpose of these visits was to provide more detailed information on properties which Arcus had partial information for, such as PWS type and location of source. This visit also enabled the CLO to verify the potential PWS and gather more information about other previously unknown PWS in the area. During these visits, the CLO gathered information on 91 & 93 Holyhill Road, 8 Koram Road, 10 & 12 Ballykeery Road, 11 Koram Road, 40 Koram Road, 60 Genmornan Road, 84 & 86 Meendamph Road and 125 Curlyhill Road.

Following these PWS visits by the CLO, a visit was made by ERM hydrologists on 26th September 2022 to potential source locations for 60 Glenmornan Road. This allowed conflicting information regarding the location of the groundwater source for 31 Koram Road to be resolved.

3. RISK ASSESSMENT

3.1 Potential Hydrogeological connectivity

3.1.1 Introduction

The sections below provide a review of potential hydrogeological connectivity between the Development and each supply. The conceptual site model (source, pathway, receptor) approach is outlined below:

Source – pollutants or sediment from the site during the decommissioning and construction phase or during the operational phase (should the drainage system fail);

Pathway – as the Development includes a drainage system, any run-off would capture, treat and discharge run-off to the nearest watercourse in line with the Outline Drainage Assessment.

However, this assessment considers the decommissioning and construction phase and also if this would fail for any reason. Therefore, these pathways would consider the following:
Run-off via overland flow; and,

Infiltration into the underlying superficial and bedrock aquifers.
Receptor – each private water supply is considered as a receptor within this assessment.

Table A8.2.6 below provides a summary of PWS which have the potential to be hydrologically connected.

Table A8.2.6. Private Water Supply detail

PWS Supply Property	31 Koram Road	91 Holyhill Road	93 Holyhill Road	60 Glemmornan Road
Distance to Source	380 m north-west of Development infrastructure	1.44 km north-west of Development infrastructure	1.3 km north-west of Development infrastructure	278 m north-west of Development infrastructure
Source of supply (type)	Well	Well	Well	Well
Use(s)	Information not provided by resident	One of the wells is used for domestic and agricultural purposes, the other is used for livestock only - not indicated which serves which purpose		Domestic and Livestock
Bedrock Geology	Dart Formation - Psammite			Dart Formation – Semipelite & Dart Formation - Metalimestone
Superficial Deposits	Peat Deposits	Till - Diamicton		Partial area not mapped, partially underlain by Dart Formation – Psammite, area partially not mapped
Hydrogeology	Bedrock aquifer - Limited potential productivity fracture flow, Moderate yields unusual. Low yields more common. Regional flow limited. Mainly shallow, local flow.			
Groundwater Vulnerability	5 – highest level of vulnerability	4a — sand and gravel cover (non-aquifer)		4a — sand and gravel cover (non-aquifer)

3.1.2 31 Koram Road

Through initial consultation and follow up emails from ERM personnel, it was concluded that a borehole is located 380 m northwest of Development infrastructure. As per DAERA Best Practice Guidance Documents – Wind farms and groundwater impacts, this groundwater source lies outside of the 250 m buffer indicated by this guidance, however, the source is thought to be located immediately downslope of a turbine foundation and associated hardstanding. Therefore, due to the distance between infrastructure and the groundwater abstraction, it is unlikely the borehole will be affected by the Development track however there is potential for hydrological connectivity.

3.1.3 91 & 93 Holyhill Road

These properties were initially identified through an initially survey letter drop in the area, however, a CLO visited the property in June/July 2022 to obtain further information. This information showed that 91 & 93 Holyhill Road are owned by the same resident but are served by two separate well sources. One of these wells is used for domestic purposes while the other is used for livestock, however the resident is unsure of which well serves which purpose.

The sources for the PWS of 91 & 93 Holyhill Road are 1.44 km and 1.3 km, respectively, northwest of Development infrastructure. This means the well locations are situated far outside of the 250 m buffer established by DAERA. This distance will mitigate the effects of pollution, sediment, and impediments to flow. In addition to this, the well which serves 93 Holyhill Road is hydrologically disconnected by Glenmornan Road which runs generally east to west, north of the Development. Due to the reasons listed above, it is unlikely for there to be hydrological connectivity between the PWS of 91 & 93 Holyhill Road and the Development, therefore there will be no impacts to the PWS.

3.1.4 60 Glenmornan Road

This property was initially identified within the 2010 Environmental Statement for Craignagapple Wind Farm and follow up consultation was carried out by a CLO in June/July 2022. This consultation provided the source type and location which is a well situated 278 m northwest of the Development infrastructure. While the source for this PWS is situated outside of the 250 m buffer established by DAERA, there is still a potential for a hydrological pathway between Development infrastructure and the source. Due to the distance between infrastructure and the source, in addition to the intervening Glenmornan Road, potential effects from the Development are unlikely. However, there is potential for hydrological connectivity.

3.2 Impact Assessment

Following a review of the survey information and potential for supplies to be impacted, Table A8.2.7 provides a review of each supply and the potential risk to each. The assessment of impacts considers the embedded mitigation outlined within the Environmental Statement and oDCEMP for the Development, set out in **Technical Appendix A3.1: oDCEMP** of the ES.

Table A8.2.7. Properties with potential PWS within PWS Study Area

PWS	Sensitivity	Source-Pathway-Receptor link present?	Magnitude	Significance	Additional Mitigation?	Post mitigation significance
31 Koram Road	Medium	Yes	Low	Minor	Monitoring of the supply will be implemented to monitor the quality, quantity, and continuity of the PWS. Following any adverse change in quantity or quality of the water, an investigation into the source of the problem and, if it is at the Development, to address the cause so as to remove the effect. In the meantime, a drinking water bowser should be provided to the property affected.	Minor
91 Holyhill Road	Medium	No	Negligible	Negligible	No	Negligible
93 Holyhill Road	Medium	No	Negligible	Negligible	No	Negligible
60 Glenmornan Road	Medium	Yes	Low	Minor	Monitoring of the supply will be implemented to monitor the quality, quantity, and continuity of the PWS. Following any adverse change in quantity or quality of the water, an investigation into the source of the problem and, if it is at the Development, to address the cause so as to remove the effect. In the meantime, a drinking water bowser should be provided to the property affected.	Minor

4. PROVISION OF MEASURES TO MINIMISE THE IMPACT ON DRINKING WATER QUALITY DURING CONSTRUCTION

The desk based Private Water Supply Risk Assessment has identified potentially sensitive drinking water receptors within 2 km of the Development, and the supplies at two of properties identified are hydrologically connected to the Development and have the potential to be impacted. Industry good practice measures will be implemented at the Development to protect the water environment and any additional drinking water supplies identified during the pre-construction phase.

5. SUMMARY

The Private Water Supply Risk Assessment (PWSRA) identified fourteen properties within 2 km which may have a PWS – ten identified by the survey letter consultation process, two identified on review of the 2010 EIA Report and a further two properties identified during CLO PWS visits. However, ten properties were scoped out of further assessment during the resident consultation stage of the PWSRA.

The PWSRA concludes that the PWS at 91 & 93 Holyhill Road are hydrologically disconnected from the Development due to intervening distances beyond the limits of potential effects and intervening features such as topography, watercourses, or roads. While the PWS sources for 31 Koram Road and 60 Glenmornan Road are unlikely to be subject to effects, the PWSRA concludes that there is the potential for hydrological connectivity. Therefore, it is proposed that these the PWS of these two properties is monitored to ensure quality, quantity, and continuity. Following any adverse change in quantity or quality of the water, an investigation into the source of the problem and, if it is due to the Development, will be conducted to address the cause and to remove the effect. In the meantime, a drinking water bowser should be provided to the property affected.

On this basis, this PWSRA concludes that the two PWS identified may be hydrologically connected to the Development. Therefore the Development may result in impacts to the PWS water quality, quantity, or continuity, based on an existing pathway in the ‘source-pathway-receptor’ model. Monitoring and adaptive mitigation have been proposed to eliminate the issue.

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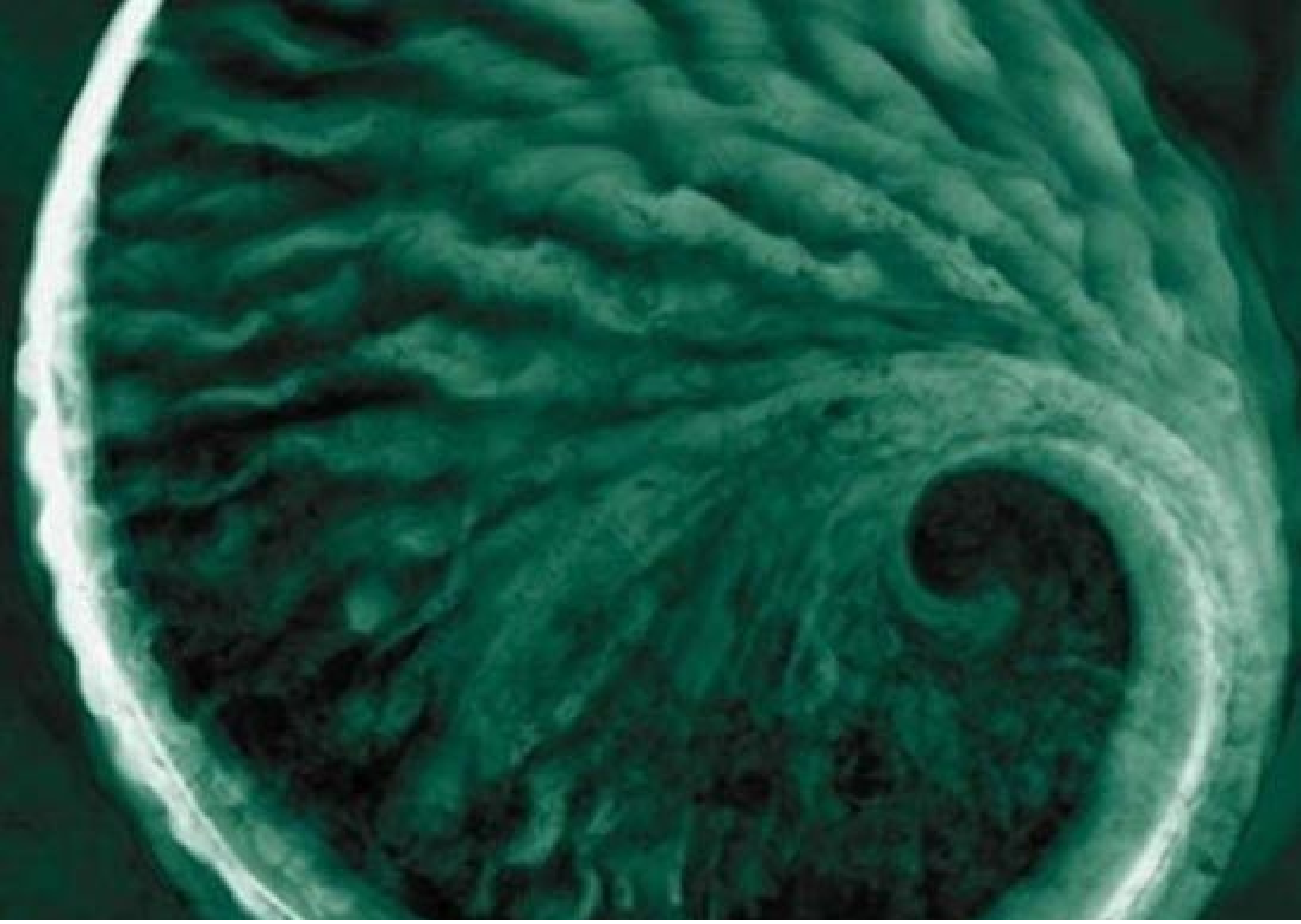

Owenreagh/Craignagapple Wind Farm

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Environmental Statement – Technical Appendix A8.3: Note on Indirect Effects of Dewatering

06 September 2023

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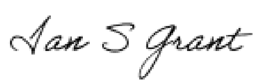
Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.3: Note on Indirect Effects of Dewatering

Nick Walker
Principal Hydrologist



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1. INTRODUCTION

The wind farm infrastructure and associated drainage ditches may disrupt local shallow groundwater levels, potentially impacting groundwater flow to soils supporting Active Peat at the site and risking their dewatering. A buffer distance is therefore required defining how far away from Active Peat the infrastructure, including drainage features, should be.

2. METHODOLOGY

We have made a calculation of the buffer distance using the most appropriate analytical solutions for the site conditions at this stage of design with the information available. These equations will determine the distance away from infrastructure at which drawdown is minimal. This has been supported by a review of relevant literature, which is referenced where appropriate.

3. CALCULATION

Based on the application of Sichardt's equation (as appropriate for dewatering of groundwater in an unconfined aquifer) with R (radius of the zone of influence (ZOI)), d (depth) and k (hydraulic conductivity):

$$R = 3000 * d * Sqrt(k)$$

The following parameters have been used:

Table A8.3.1. Calculation Parameters

Parameter	Value	Assumption
d	5 m	For turbine foundation excavations during construction. Assumed maximum drawdown based on turbine foundation excavation depths of up to 5 m (at depths below this it is assumed that the foundation would be piled, with no dewatering required). Assumes groundwater level is at the surface, as a worst case. Site monitoring data showed groundwater levels were between 0 m and 1.1 m below ground level (mbgl). Assumes the peat is continuous from the surface to the base of the foundation – i.e., the aquifer is not confined. The foundation will sit on a competent base, so this assumption is likely to be realistic or overly conservative. There will not be upwelling from the bottom of the turbine excavation and into the drain which dewaters the turbine excavation.
d	1 m	For other infrastructure during construction and operation. Assumed maximum drawdown based on drainage ditch depth relative to current ground level. Drainage ditches are likely to have a maximum depth of 1 m. Assumes groundwater level is at the surface, as a worst case. Site monitoring data showed groundwater levels were between 0 m and 1.1 m below ground level (mbgl). Assumes the peat is of depth at least 1 m, as a worst case.

K	$1x10^{-6}$ cm/s	Based on literature values[1], and viewed as conservative/worst case for this site (as assuming a higher conductivity for more fibrous peat) as no site-specific conductivity values are available. A range of hydraulic conductivity values will be present at the Site. Using a higher conductivity value would provide a higher radius of influence, but at greater distances the lowering of the groundwater level is minimal and the gradient is very flat.

4. CONSTRUCTION PHASE (ACTIVE DEWATERING/PUMPING OF TURBINE FOUNDATIONS

The excavation for the turbine base is up to 5 m deep. The ZOI of the groundwater level drawdown cone is calculated to be 15 m from the excavation based on the calculation methodology described above.

Note that any drawdown from turbine foundation construction would be temporary, lasting only for the duration of the dewatering of the foundation (estimated as a maximum of 2 months) and the groundwater level would return to baseline levels following completion of the turbine foundation.

5. OPERATIONAL PHASE (NO ACTIVE PUMPING/DEWATERING, APPLIES TO ALL INFRASTRUCTURE

The infrastructure will feature adjacent drainage ditches to allow for surface water to flow from areas of hardstanding and from upslope areas as part of the surface water drainage design. The drains are assumed to have a maximum depth of 1 m.

In areas where the groundwater level lies above the bottom of the ditch there will be a dewatering action via any surface water drainage and the groundwater level will be drawn down. The zone of influence on the drawdown is calculated as a maximum of 3 m from the drain.

Other literature evidence (Boelter 19722) outlines evidence that water table drawdown in well humified peatlands can extend as far as 5 m from the edge of the drain. Based on consideration of both a theoretical approach outlined above, and this site-based evidence, a buffer of 5 m is recommended as a conservative approach.

Mitigation measures and buffer distances are summarised below.

Table A8.3.2. Mitigations Measures and Buffers

	Infrastructure		
	Access track (excavated)	**Access track (floating)**	**Turbine foundation**
Likely excavation depths	Circa 1 m	Limited to surface vegetation clearance	5 m (conservative approach)
Construction Phase - *Hydrology Mitigation Measures*	Track design to include:	Floating track design (limited peat excavation at surface) assumes presence of ditches during operational phase	Dewatering in line with NetRegs best practice guidance Dewatering requirement

[1] [A Review on Hydraulic Conductivity and Compressibility of Peat (scialert.net)]
[2] Boelter (1972). Water Table Drawdown around an open ditch in organic soils. Journal of Hydrology, 15, (1972) 329-340.

	Infrastructure		
	Access track (excavated)	**Access track (floating)**	**Turbine foundation**
	■ culverts for flushes/watercourses ■ permeable conduits /cross drains within track bed ■ flushes identified within design and connectivity maintained	Design in line with good practice[3] including use of culverts, ditches with drainage design to preserve local hydrology	dependent on cut/fill depths Water redirected from upslope to downslope areas
Operational Phase - Hydrology Design Mitigation measures			Redirection of surface water drainage around turbine infrastructure through surface water drainage
Construction Phase - Extent of dewatering impacts (from drainage infrastructure and groundwater pumping) (not permanent)	5 m	5 m	15 m
Operational Phase - Extent of dewatering impact (from drainage infrastructure)	5 m	5 m	3 m

.

[3] Forestry Commission - Scottish Natural Heritage (2010) Floating Roads on Peat. http://www.roadex.org/wp-content/uploads/2014/01/FCE-SNH-Floating-Roads-on-Peat-report.pdf

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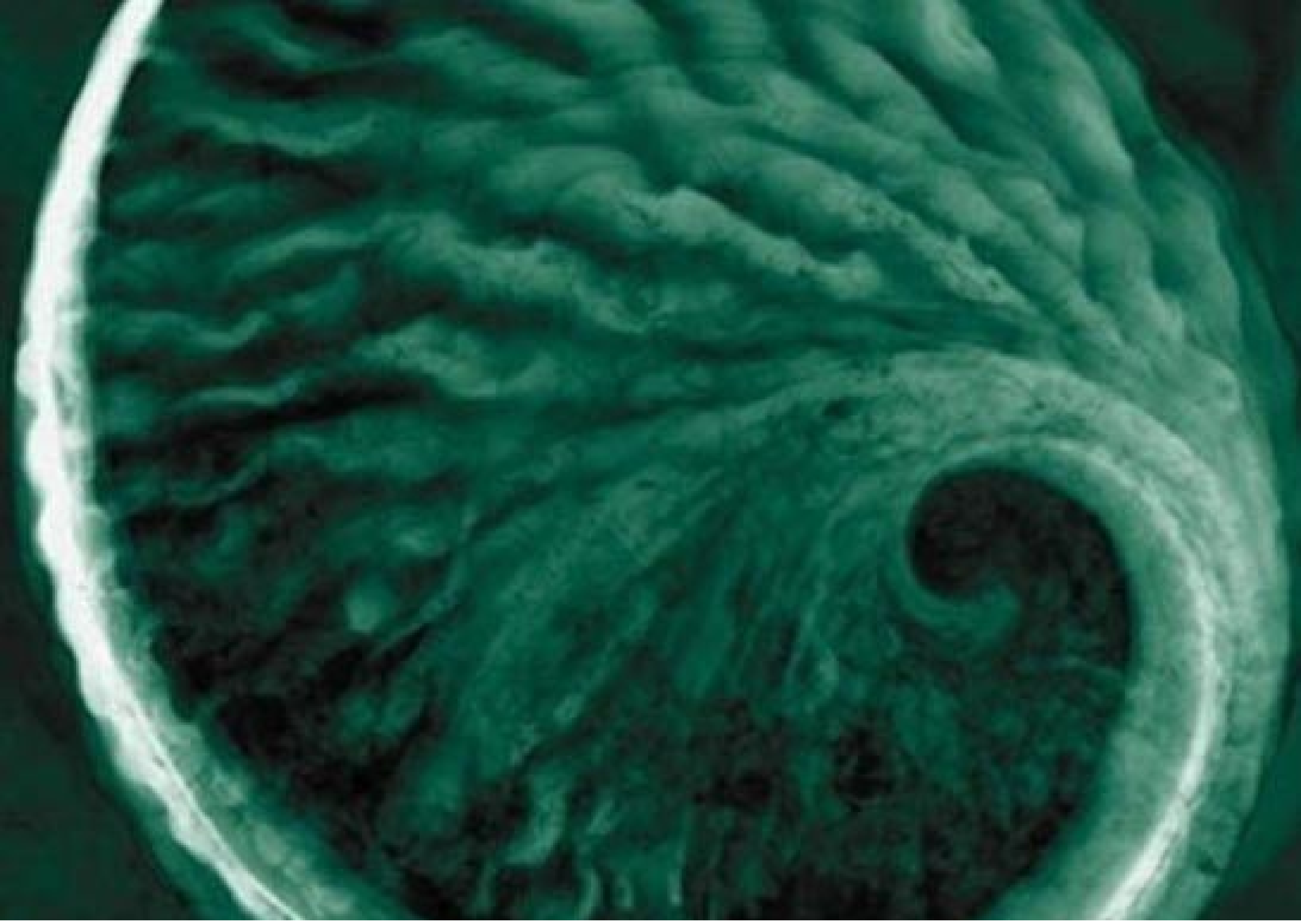

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Environmental Statement – Technical Appendix A8.4: Watercourse Crossing Inventory (WCI)

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Owenreagh/Craignagapple Wind Farm

Environmental Statement – Technical Appendix A8.4: Watercourse Crossing Inventory (WCI)

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Table A8.4.1. WC01

Watercourse description	Is it an existing watercourse crossing?	Watercourse Scale	Width of watercourse > 2 m?	Ecological constraints	If channel width >2 m, what is the total length of bank to be affected?	New proposed watercourse crossing type
Flow: Moderate Level: Low Gradient: Low Watercourse bed substrate: Cobbles and silt Surrounding land use: Grassland	No	1:50,000	No 1 m	None	N/A	Culvert

Location Upstream

Photograph taken approximately 40 m downstream of crossing location

Location Downstream

Photograph taken approximately 40 m downstream of crossing location

Type of Crossing

Map

Table A8.4.2. WC02

Watercourse description	Is it an existing watercourse crossing?	Watercourse Scale	Width of watercourse > 2 m?	Ecological constraints	If channel width >2 m, what is the total length of bank to be affected?	New proposed watercourse crossing type
Flow: Moderate Level: Moderate Gradient: Low Watercourse bed substrate: Pebbles and silt Surrounding land use: Grassland and existing track	No	1:10,000	No 0.4 m	None	N/A	Culvert

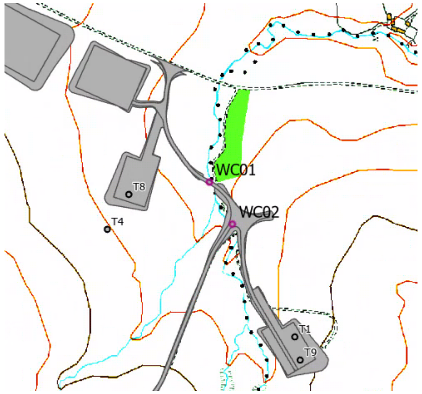
Location Upstream

Photograph taken at the crossing location

Location Downstream

Photograph taken at the crossing location

Type of Crossing



Map

Table A8.4.3. Watercourse Diversions

Watercourse ID	Scale	Hydrological Feature	Crossing Type	Crossing length (m)	Diversion
WC03	<1:10,000	Drain	Culvert	9	Diverted northwards avoiding T1 infrastructure before being culverted beneath access track.
WC04	<1:10,000	Drain	Diversion	-	Diverted into WC03 Drain
WC05	<1:10,000	Drain	Diversion	-	Yes – to drain East of T9 infrastructure
WC06	<1:10,000	Drain	Diversion and Culvert	13	Diversion north east of drain before crossing access track of T5.
WC07	<1:10,000	Drain	Diversion	-	Diversion of two Drains located west of T8 northward into drain of WC11
WC08	<1:10,000				
WC09	<1:10,000				
WC10	<1:10,000				
WC11	<1:10,000	Drain	Culvert	21	-
WC12	<1:10,000	Drain	Diversion	-	Diversion of Drain eastward towards drain of WC11
WC13	<1:10,000	Drain	Diversion	-	Southwest of T3 and T6, minor drain is diverted east to avoid turbine infrastructure
WC14	<1:10,000	Drain	Diversion	-	Diversion around T4 infrastructure using a minor drain approx. 30m east of the turbine location
WC15	<1:10,000		Diversion and Culvert	10	Diversion of watercourse to cross access tracks of Turbine 4
WC16	<1:10,000				

WC17	<1:10,000	Drain			
WC18	<1:10,000				
WC19	<1:10,000	Drain	Diversion	16	Diversion and culvert of drain at WC19 required.
WC20	<1:10,000	Drain	Culvert	10	-
WC23	<1:10,000	Drain	Diversion	-	Diversion to the west of T7 infrastructure.

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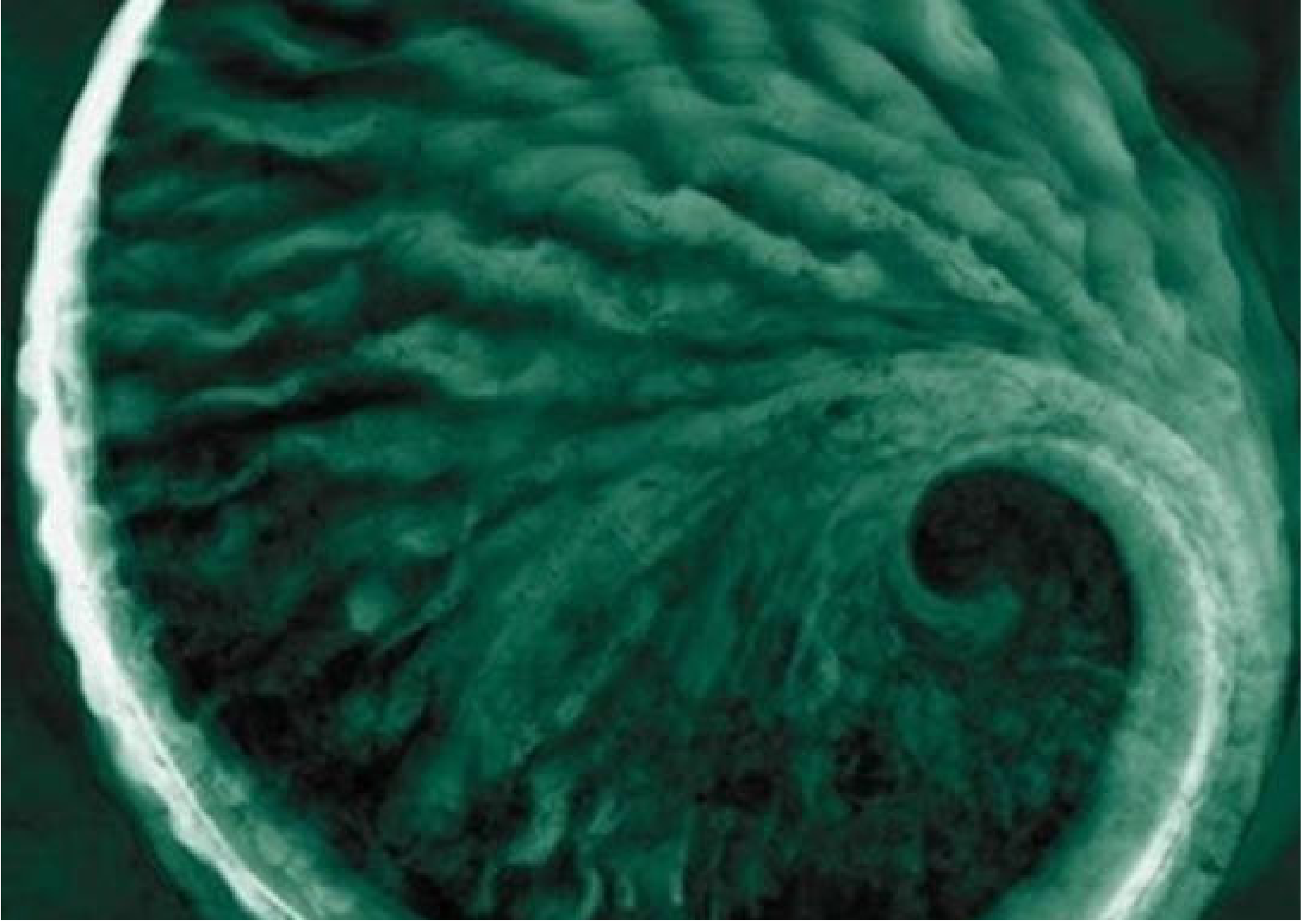

Owenreagh/Craignagapple Wind Farm

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Technical Appendix A8.5: Outline Surface Water Drainage Strategy

06 September 2023

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Owenreagh/Craignagapple Wind Farm

Technical Appendix A8.5: Outline Surface Water Drainage Strategy

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Acronyms and Abbreviations

Name	Description
1D	One Dimensional
2D	Two Dimensional
CC	Climate Change
DTM	Digital Terrain Model
FEH	Flood Estimation Handbook
GIS	Geographical Information Systems
GRR	Greenfield Runoff Rate
HR Wallingford	Hydraulic Research Wallingford
ICM	Integarted Catchment Model
m	Metre
ReFH	Revitalised Flood Hydrograph
SPRHOST	Surface Percentage Runoff HOST

EXECUTIVE SUMMARY

This report summarises the outline surface water drainage strategy that was prepared for the Owenreagh/Craignagapple Wind Farm.

The following conclusions are drawn:

- The Greenfield Runoff Rate (GRR) for the development is 10 l/s/ha;
- Based on the results of the InfoWorks ICM modelling, 11 attenuation features with hydraulic controls (e.g. orifice) are required to attenuate the 1 in 100 year plus climate change (+20%) storm event to GRRs. The drainage alignments are provided in Appendix A.3 and Appendix A.4;
- Detailed design should consider whether the 11 attenuation features can be incorporated into an open channel roadside ditch with check dams serving as hydraulic controls to attenuate flows;
- The Schedule 6 application forms are completed and submitted along with this report as supporting evidence that an outline surface water drainage strategy has been developed and can be used to guide forward work on the scheme.

It is recommended that the drainage strategy be designed to a detailed level once consent has been obtained to do works near a watercourse (Schedule 6 application).

1. BACKGROUND

The operational Owenreagh I Wind Farm was developed and constructed in 1997 and comprised of 10 turbines with 40m hub heights and 40m blade diameters. A turbine was then decommissioned and removed to leave 9 operational. The operational Owenreagh II Wind Farm was constructed in 2009 and comprised a further 6 turbines with a 40m hub height and 52m blade diameter

Ørsted Onshore Ireland Midco Limited is now currently applying for consent to install and operate Owenreagh/Craignagapple Wind Farm ('the Development'). The application includes:

- Decommissioning of the operational Owenreagh I and Owenreagh II Sites;
- Repowering of the Owenreagh I and II sites and modification, as well as an extension of the consented Craignagapple site through construction of 14 wind turbines with tip height up to 156.5m and rotor diameter up to 136m; and
- Associated ancillary infrastructure, including, but not limited to, the following:
  - Substation compound, including control building and other electrical infrastructure;
  - New and upgraded access tracks, including turning heads and 2 new water crossings;
  - Crane hardstands and turbine foundations, including temporary hardstands;
  - Construction compound(s); and
  - Cable trenches.

The Development is located approximately 5 km east of Strabane and 6 km southeast of Antigarvan, in County Tyrone, Northern Ireland. The Site is centred on Irish National Grid Reference (NGR) 242862, 396786.

2. INTRODUCTION

This report provides a summary of the work undertaken to prepare an outline surface water drainage strategy for the re-powering of the wind farm and the associated ancillary infrastructure at Owenreagh/Craignagapple, Northern Ireland.

The outline surface water drainage strategy was prepared in the context of issues being identified with the existing peat and drainage. This was studied with surface water features classified and hydrological units determined across the terrain under a separate commission (Arcus Consultancy Services, 2023), but there were no readily apparent trends.

The outline surface water drainage strategy has required the development of an InfoWorks ICM model, which is documented in this report, as well as the specification of a Schedule 6 application form to gain approval to undertake works to watercourses.

3. CATCHMENT CHARACTERISATION

The Development is situated on a hillside, whereby one primary catchment can be delineated (Appendix A.1), and the rest of terrain reflects heads of catchment from the Owenreagh hilltop. The FEH (Flood Estimation Handbook) catchment characteristics for the primary catchment are provided in Appendix B.1, which indicate the following about the catchment and the broader surrounding area –

- The soils are wet for the majority of the time;
- Rainfall preferentially runs off; and
- Standard Average Annual Rainfall is moderately high.

The UKSO Soils of Northern Ireland define the soil as Histosol (UKSO, 2023), which is essentially peat.

4. BASELINE MODEL BUILD

This section of the report describes how an InfoWorks ICM model (Version 21.0.284) was developed to prepare an outline surface water drainage strategy for the wind farm expansion at the Development. InfoWorks ICM is able to represent flows in channels and pipes, as well as flows overland and is appropriate software to prepare an outline surface water drainage strategy.

4.1 Introduction

A one dimensional model (1D model) and a two dimensional model (2D model) were developed to prepare the outline surface water drainage strategy at the Development. The 1D model was developed to initially size drainage alignments and capacities, while the 2D model was developed to determine Greenfield Runoff Rates (GRRs) due to more standard methods not appropriately representing highland peat-based soils.

4.2 2D Model – Ground Model

A 10m Digital Terrain Model (DTM) was used to represent the ground surface in 2D in InfoWorks ICM. This was assumed to have filtered out trees and bushes (if present) and therefore no additional checks were undertaken. The Ground Model is shown in Figure A8.5.1 below with the 2D Zone (Mesh) highlighted.

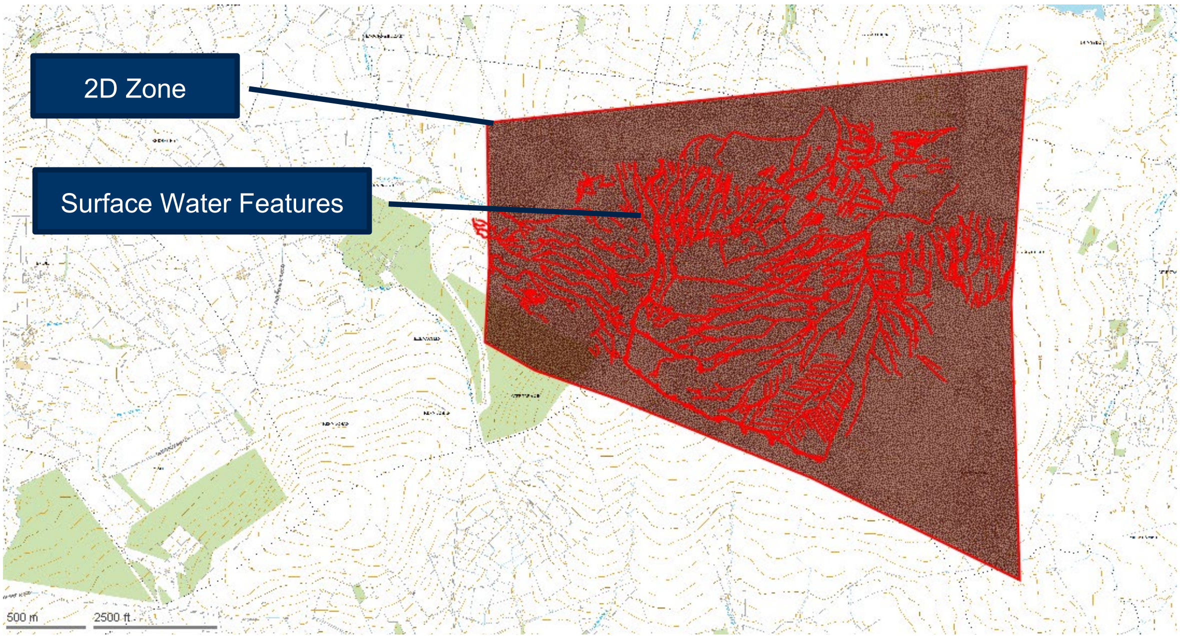
Figure A8.5.1 Ground Model with 2D Zone (Mesh)

4.3 2D Model – 2D Zone (Mesh)

The 2D model represented the peat hill slope with design rainfalls applied to the mesh that then subsequently converted rainfall to runoff using the terrain. This approach was adopted in place of a lumped hydrological model because the InfoWorks ICM model was considered to better represent runoff due to catchment steepness, as well as the conversion of rainfall to runoff through the use of the catchment characteristic, SPRHOST, which defined the fixed runoff coefficient for the peat.

The 2D runoff was simulated as an infiltration surface applied to the 2D Zone, representing the peat, and the existing road was not included in defining GRR conditions for the 2D model. In constructing a mesh the 2D model was, however, enforced with the surface water drainage features that were previously identified in the drainage and peat assessments (Arcus Consultancy Services, 2023). These features were enforced as Breaklines in ensuring that features would be represented in the 2D Zone if they had been identified in the drainage and peat assessments. The enforced surface water features are shown in Figure A8.5.2 below.

Figure A8.5.2. 2D Zone Surface Water Features



The 2D Zone (Mesh) was setup as follows, such that rainfall was applied to the mesh for simulation

Table A8.5.1. 2D Zone Definition

2D Component	2D Value	Comments/Source
Maximum triangle area (m2)	100	
Minimum element area (m2)	25	
Mesh generation	Clip meshing	Default
Boundary points	Normal condition	Normal Depth
Terrain sensitive meshing	Un-selected	
Maximum height variation (m)	1.0	
Minimum angle (degree)	25.0	
Roughness (Mannings n)	0.07	(HEC, 2023)
Apply rainfall etc. directly to mesh	Selected	Rain on mesh
Apply rainfall	Everywhere	
Rainfall profile	100.00	
Infiltration surface	Peat	SPRHOST 0.6
Rainfall percentage	100.00	

4.4 2D Model – Design Rainfall

Design rainfalls were generated using InfoWorks ICM's internal generator for ReFH rainfall and FEH catchment characteristics that were obtained for the Development from the FEH Web Service (UK CEH, 2023). The FEH catchment characteristics are provided in Appendix B.1.

No account was made to represent seasonal variability within the 2D model, but design summer and winter design rainfall profiles were simulated to determine Greenfield Runoff Rates (GRRs).

4.5 1D Model – Introduction

A 1D model using InfoWorks ICM was prepared to initially size drainage alignments and capacities. The 1D model is made up of surface water drainage alignments and subcatchments.

4.6 1D Model – Subcatchments

Subcatchments to generate road runoff were defined using Geographical Information System (GIS) information that delineated the new infrastructure (refer to Section 0). This required the specification of separate land uses setup for road runoff, which were then applied to the subcatchments to ensure that new road surfaces would generate a road response. As a precaution it was assumed that the roads would be sealed, so all predictions made by the model, as well as the subsequent drainage alignments, are conservative of what surface water drainage needs to be provided for the Development.

The subcatchments of the 1D model are presented in Figure A8.5.3 below with those that are construction compounds and the substation are highlighted in red, as these have been modelled as road surface. The land uses and runoff surfaces that were defined for the 1D model are provided below in Table A8.5.2 and Table A8.5.3.

Figure A8.5.3. Subcatchment Road Runoff Definition with the Substation and Construction Compounds Highlighted

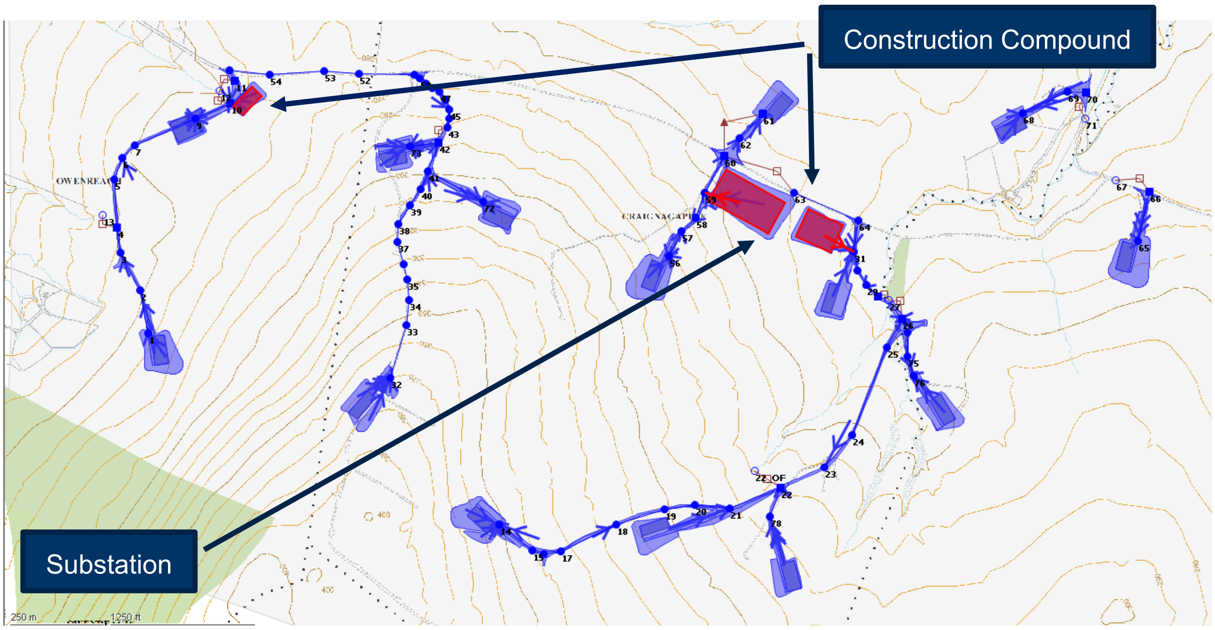


Table A8.5.2 Landuses

Land use	Runoff Surface 1	%
Road	10	100

Table A8.5.3. Runoff Surfaces

Runoff Surface	Routing	Runoff Routing Value	Runoff Volume Type	Ground Slope	Initial Loss Type	Initial Loss	Routing Model	Runoff Coefficient
10	Relative	1	Fixed		Slope	0.0000 7100	Wallingford	1.0

4.7 1D Model – Surface Water Drainage Alignments

Surface water drainage alignments were incorporated into the 1D model as part of developing an outline surface water drainage strategy. Further details are provided in Section 6.

5. GREENFIELD RUNOFF RATE

5.1 Introduction

This section of the report outlines how the 2D model that was built for the Development was used to define GRRs for the outline surface water drainage strategy. GRRs have been defined to ensure the development proposals are able to attenuate surface water generated as a result of the development.

5.2 Greenfield Runoff Rate Estimation Tool

The Greenfield Runoff Rate Estimation Tool developed by Hydraulic Research Wallingford (HR Wallingford) was used to estimate GGRs for the primary catchment (HR Wallingford, 2023). This was undertaken for:

- default parameters using the IH124 method;
- the IH124 method using values based on FEH catchment characteristics; and
- the FEH statistical method using values based on FEH catchment characteristics.

The results are provided in Appendix B.2 and summarised in Table A8.5.4 below together with the results of the 2D modelling undertaken using InfoWorks ICM that is discussed in the subsequent sections of the report.

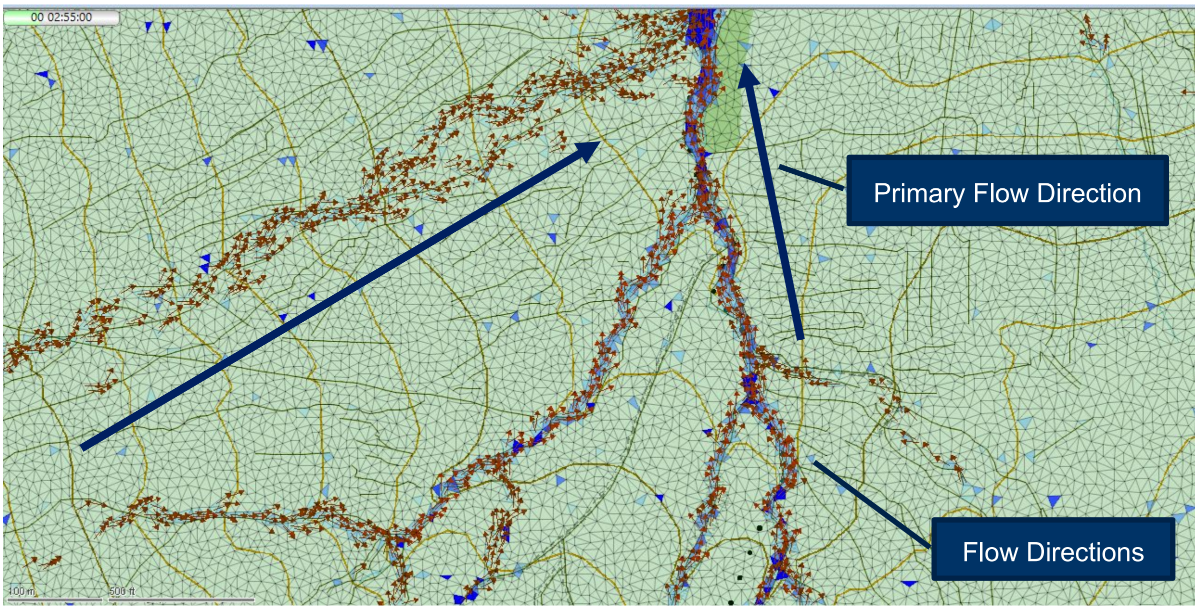
Table A8.5.4. Greenfield Runoff Rates

Greenfield Runoff Rates	HR Wallingford - IH124 (l/s/Ha) Default	HR Wallingford - IH124 (l/s/Ha) Edited	HR Wallingford - FEH (l/s/Ha) Edited	InfoWorks ICM (l/s/Ha)
QBAR	11.27	14.76	15.50	
1 in 1 year	**9.92**	**12.99**	**13.64**	**9.30**
1 in 30 years	18.60	24.35	25.58	28.09
1 in 100 years	22.10	28.92	30.38	44.47
1 in 200 years	23.67	30.99	32.55	57.09

5.3 2D Runoff Modelling – Design Rainfall Events

A suite of design rainfall events (15, 30, 60, 120, 240, 360, 480, and 600 minutes) for both the summer and winter design rainfall profiles were simulated across the 2D model to determine the critical storm duration (summer 240 minutes) and GRRs for the primary catchment. The results are presented in Table A8.5.4 above and a screen shot of the 2D model simulating runoff is provided in Figure A8.5.4 below, which is provided to help visualise the 2D runoff model shows flow arrow vectors in the primary catchment and areas where ponding would occur.

Figure A8.5.4. Simulation of 2D Runoff



5.4 2D Runoff Modelling – Model Verification

The InfoWorks ICM model that was built for the Development was verified against GRRs estimated using HR Wallingford's Greenfield Runoff Rate Estimation Tool (HR Wallingford, 2023).

As can be seen in Table A8.5.4 above, the InfoWorks ICM model estimates that GRR during a 1 in 1 year is approximately 9.30 l/s/ha, which compares favourably to HR Wallingford's Sustainable Drainage System tools (HR Wallingford, 2023) default estimate of 9.92 l/s/ha, as well as 12.99 l/s/ha and 13.64 l/s/ha where map based values have been edited to align with FEH catchment characteristics.

The predicted GRRs also compare favourably with the GRR specified in the Schedule 6 application form of 10L/Ha, but the rate of growth predicted by the InfoWorks ICM model generated by applying rainfall directly to the mesh, as part of the 2D model, predicts greater peak flows for more infrequent events, such as the 1 in 200 year. These results remain unverified, but are regarded as plausible due to the manner in which the 2D runoff model was setup.

5.5 Greenfield Runoff Rates

The GRR that is to be used to attenuate flows of the development back to is 10l/s/ha.

6. OUTLINE SURFACE WATER DRAINAGE STRATEGY

6.1 Introduction

This section of the report outlines how a 1D InfoWorks ICM model was used to prepare an outline surface water drainage strategy for the Development.

6.2 Strategic Surface Water Drainage Principles

The outline surface water drainage strategy was developed using the following strategic principles –

- Drainage system to be unlined open channel or closed, buried pipe;
- Where practicable, discharge by gravity to existing watercourses;
- Attenuate additional runoff from roads to GRR;
- Drainage alignments shall follow road alignments;
- Drainage alignments shall not be compromised by the weight loadings of cranes that are required for the wind farm;
- Only use pumps where necessary and in lieu of having an infiltration test of soakaways that may, or may, not be present;
- The drainage system shall be designed for the 1 in 30 years storm event, but be able to manage additional flows up to a 1 in 100 plus climate change (CC) storm event (Department for Infrastructure, 2019); and
- CC will be represented by applying a 20% uplift to design rainfall events (Department for Infrastructure, 2019).

6.3 Drainage Alignments

The drainage alignments that have been modelled using the 1D InfoWorks ICM model are shown in Appendix A.3 and Appendix A.4 for the 1 in 100 year plus CC. This shows the points of discharge, as modelled, the alignments of the drainage infrastructure, location of an electric pump that is required, and settlement lagoons that display area coverage based on the assumption that these will be 1m deep. This is to be detailed upon approval of the Schedule 6 application.

All drainage alignments drain to a hydraulic control arrangement that attenuates flows to GRRs.

6.4 Attenuation Requirements

The attenuation requirements have been determined by multiplying the total area draining to the respective drainage alignments by the GRR of 10 l/s/ha, so that the points of discharge can restrict all flows that exceed GRR within suitable attenuation.

The critical storm (Summer 15 minute) was determined through simulation of a suite of summer and winter storms for a range of durations to determine the critical storm in terms of peak flow within the network.

The GRRs for the respective locations of storage and the volume of attenuation required for the 15 - minute 1 in 100 year + 20% (CC) storm are provided in Appendix B.3.

The attenuation ponds, like the drainage alignments are to be detailed during further levels of design, but are envisaged to either be:

- settlement lagoons located along the road alignments; and/or
- attenuated volume provided for in an open channel roadside ditch with check dams serving as hydraulic controls to attenuate flows.

As stated above, this is to be considered in respect to the drainage alignments that are provided in Appendix A.3 and Appendix A.4.

7. CONCLUSIONS

The following conclusions are drawn in preparing an outline surface water drainage strategy for the Development:

- The Greenfield Runoff Rate (GRR) for the Development is 10 l/s/ha;
- Based on the results of the InfoWorks ICM modelling, 11 attenuation features with hydraulic controls (e.g. orifice) are required to attenuate the 1 in 100 year plus climate change (+20%) storm event to GRRs. The drainage alignments are provided in Appendix A.3 and.Appendix A4;
- Detailed design should consider whether the 11 attenuation features can be incorporated into an open channel roadside ditch with check dams serving as hydraulic controls to attenuate flows;
- The Schedule 6 application forms are completed and submitted along with this report as supporting evidence that an outline surface water drainage strategy has been developed and can be used to guide forward work on the scheme

8. RECOMMENDATIONS

It is recommended that the drainage strategy be designed to a detailed level once consent has been obtained to do works near a watercourse (Schedule 6 application).

REFERENCES

Arcus Consultancy Services. (2023). *Owenreagh / Craignagapple Wind Farm Environmental Statement Technical Appendix A8.1: Hydrological Unit Assessment.* York: Arcus Consultancy Services.

Department for Infrastructure. (2019). *Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland.* Belfast: Department for Infrastructure - Water & Drainage Policy Division.

HEC. (2023). *HEC-RAS River Analysis System.* HEC.

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UK CEH. (2023, 01 27). *Flood Estimation Handbook Web Service*. Retrieved from UK CEH - Flood Estimation Handbook Web Service: https://fehweb.ceh.ac.uk/

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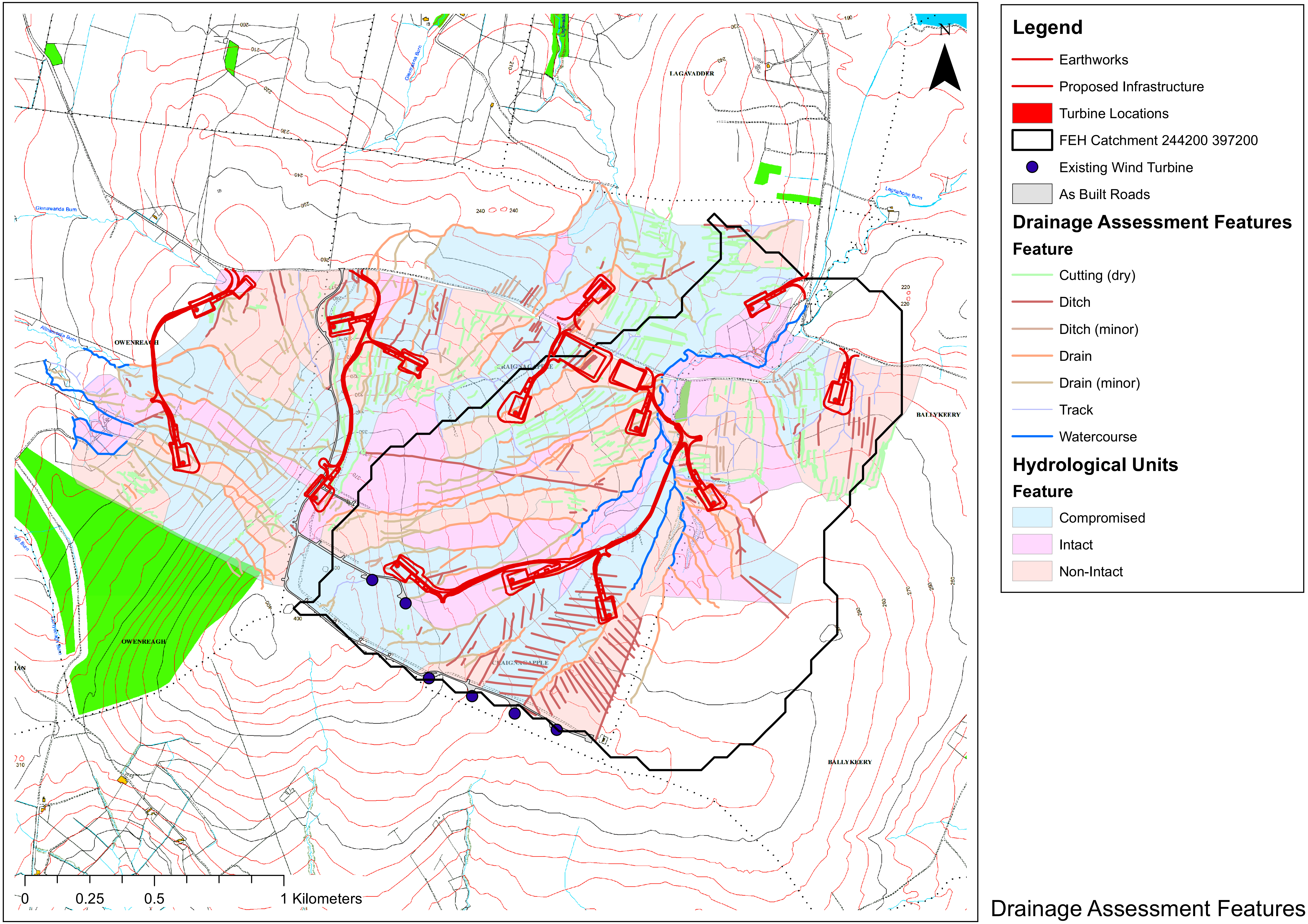
APPENDIX A DRAWINGS & FIGURES

Appendix A.1 – Drainage Assessment Features

Appendix A.2 – Site Layout Owenreagh Wind Farm

Appendix A.3 – Surface Water Drainage Alignments Overview

Appendix A.4 – Surface Water Drainage Alignments



Drainage Assessment Features

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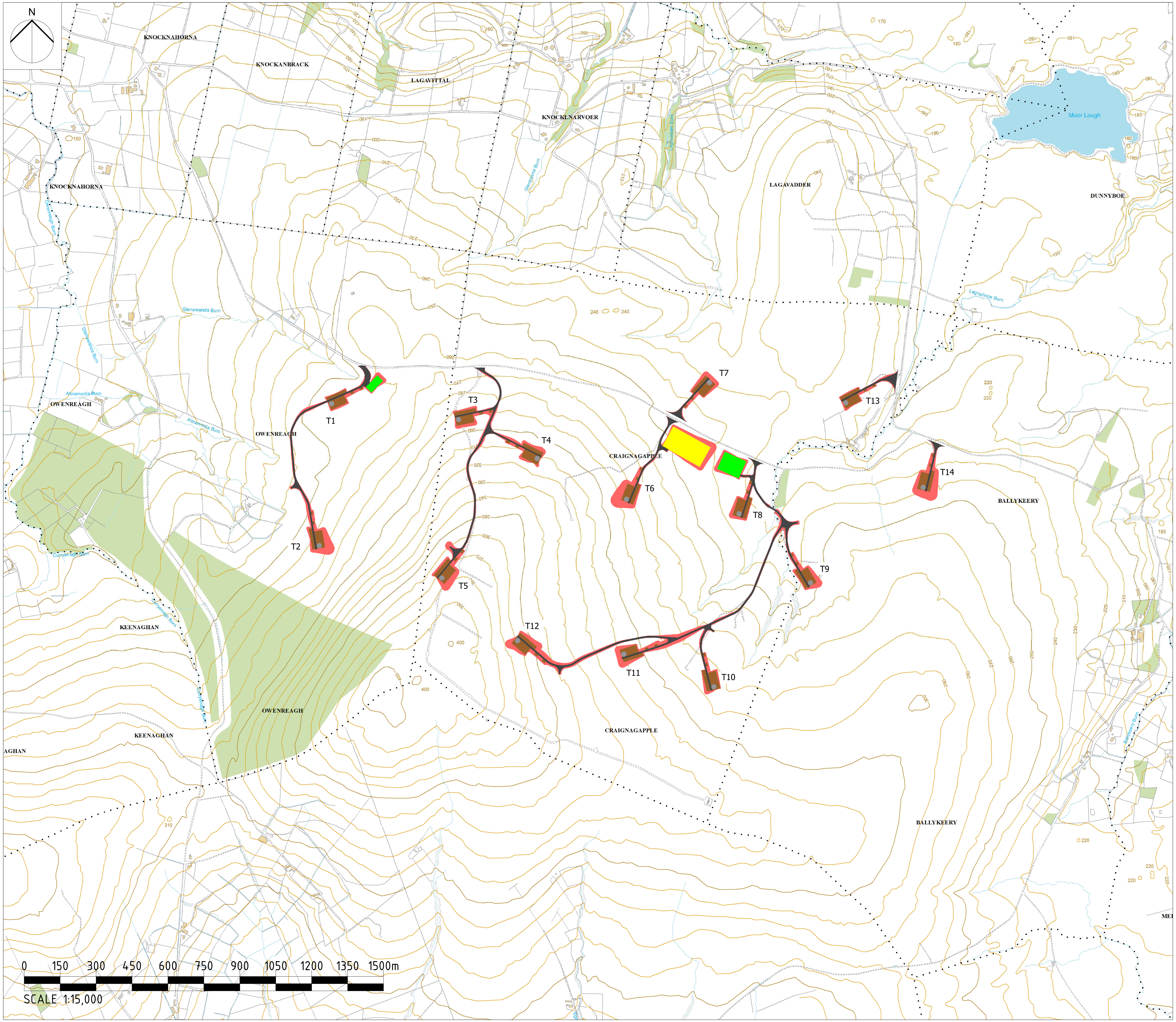

LEGEND

- TURBINE
- ACCESS TRACK
- CONSTRUCTION COMPOUND
- CRANE HARDSTANDING
- EARTHWORKS
- SUBSTATION COMPOUND

1:15,000 Scale @ A3

Produced: SR Reviewed: RC Approved: AC	Ref: 4172_DR_P_0009_P1 Date: 13/07/23

APPENDIX A.2 - SITE LAYOUT

OWENREAGH/CRAIGNAGAPPLE WIND FARM

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Purpose of issue

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Drawing Title: APPENDIX A.3 OVERVIEW

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APPENDIX A.4 - SHEET 1 OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title
APPENDIX A.4 - SHEET 2
OUTLINE SURFACE WATER DRAINAGE STRATEGY -
ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title: APPENDIX A.4 - SHEET 4 OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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APPENDIX A.4 - SHEET 5 OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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APPENDIX A.4 - SHEET 7
OUTLINE SURFACE WATER DRAINAGE STRATEGY -
ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title: APPENDIX A.4 - SHEET 8 OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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- PUMP
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Drawing Title
APPENDIX A.4 - SHEET 9
OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title
APPENDIX A.4 - SHEET 10
OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title: APPENDIX A.4 - SHEET 11 OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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OWENREAGH/CRAIGNAGAPPLE WIND FARM

Drawing Title

APPENDIX A.4 - SHEET 12
OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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Drawing Title
APPENDIX A.4 - SHEET 13
OUTLINE SURFACE WATER DRAINAGE STRATEGY - ALIGNMENTS & POINTS OF DISCHARGE

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APPENDIX B TABLES & GRAPHS

Appendix B.1 - FEH Catchment Characteristics

CATCHMENT	Ireland	244200	397200
CENTROID	Ireland	243448	396301
AREA	2.8725		
ALTBAR	284		
ASPBAR	38		
ASPVAR	0.6		
BFIHOST	0.226		
BFIHOST19	0.254		
DPLBAR	1.61		
DPSBAR	94.4		
FARL	1		
FPEXT	0.0078		
FPDBAR	0.102		
FPLOC	0.568		
LDP	2.94		
PROPWET	0.64		
RMED-1H	8.4		
RMED-1D	32.9		
RMED-2D	47		
SAAR	1293		
SAAR4170	1207		
SPRHOST	59.99		
URBCONC1990	-999999		
URBEXT1990	0		
URBLOC1990	-999999		
URBCONC2000	-999999		
URBEXT2000	0		
URBLOC2000	-999999		
C	-0.03		
D1	0.42475		
D2	0.47508		
D3	0.34231		
E	0.28938		
F	2.2188		
C(1 km)	-0.03		
D1(1 km)	0.431		
D2(1 km)	0.479		
D3(1 km)	0.343		
E(1 km)	0.289		
F(1 km)	2.22		

HR Wallingford
Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Adam Cambridge
Site name:	Owenreagh Hill
Site location:	Owenreagh Hill

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	54.82272° N
Longitude:	7.31361° W
Reference:	3505300555
Date:	Mar 06 2023 12:06

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 287.25

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Specify SPR manually

Soil characteristics

	Default	Edited
SOIL type:	5	5
HOST class:	N/A	N/A
SPR/SPRHOST:	0.53	0.6

Hydrological characteristics

	Default	Edited
SAAR (mm):	1363	1293
Hydrological region:	11	11
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.65	1.65
Growth curve factor 100 years:	1.96	1.96
Growth curve factor 200 years:	2.1	2.1

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	3238.28	3985.05
1 in 1 year (l/s):	2849.68	3506.84
1 in 30 years (l/s):	5343.16	6575.33
1 in 100 year (l/s):	6347.02	7810.7
1 in 200 years (l/s):	6800.38	8368.6

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Adam Cambridge
Site name:	Owenreagh Hill
Site location:	Owenreagh Hill

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	54.82272° N
Longitude:	7.31361° W
Reference:	2866897222
Date:	Mar 06 2023 12:13

Runoff estimation approach FEH Statistical

Site characteristics

Total site area (ha): 287.25

Methodology

Q_{MED} estimation method:	Calculate from BFI and SAAR
BFI and SPR method:	Specify BFI manually
HOST class:	N/A
BFI / BFIHOST:	0.254
Q_{MED} (l/s):	
Q_{BAR} / Q_{MED} factor:	1.05

Hydrological characteristics	Default	Edited
SAAR (mm):	1363	1293
Hydrological region:	11	11
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.65	1.65
Growth curve factor 100 years:	1.96	1.96
Growth curve factor 200 years:	2.1	2.1

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):		4133.29
1 in 1 year (l/s):		3637.29
1 in 30 years (l/s):		6819.92
1 in 100 year (l/s):		8101.24
1 in 200 years (l/s):		8679.9

Appendix B.3 – Greenfield Runoff Rate Discharge and Attenuated Volumes

Reference	4		Reference	10		Reference	42
Subcatchment	Area (Ha)		Subcatchment	Area (Ha)		Subcatchment	Area (Ha)
1	0.059		16	0.362		2	0.300
17	0.352		60	0.126		13	0.334
25	0.610		64	0.018		14	0.348
1!!!	0.177		65	0.075		15	0.310
1!	0.291		22	0.244		26	0.229
			71	0.029		32	0.045
			72	0.103		61	0.139
			1!!	0.247		62	0.127
						63	0.232
						73	0.100
						74	0.002
						75	0.138
						76	0.053
						77	0.040
						78	0.022
						79	0.095
						80	0.239
						81	0.135
						2!	0.199
Total Area (Ha)	1.489		Total Area (Ha)	1.204		Total Area (Ha)	3.087
Discharge ($m^3/s/Ha$)	0.015		Discharge ($m^3/s/Ha$)	0.012		Discharge ($m^3/s/Ha$)	0.031
Attenuation Volume (m^3)	419.1		Attenuation Volume (m^3)	202.8		Attenuation Volume (m^3)	702.9

Reference	11		Reference	60		Reference	61
Subcatchment	**Area (Ha)**		**Subcatchment**	**Area (Ha)**		**Subcatchment**	**Area (Ha)**
2!!	0.187		3	0.147		4	0.236
			11	0.332		8	0.352
			23	1.652		27	0.405
			33	0.001			
			34	0.004			
			35	0.783			
			36	0.028			
			37	0.007			
			38	0.013			
			40	0.613			
			3!	0.226			
Total Area (Ha)	**0.187**		**Total Area (Ha)**	**3.806**		**Total Area (Ha)**	**0.993**
Discharge (m³/s/Ha)	**0.002**		**Discharge (m³/s/Ha)**	**0.038**		**Discharge (m³/s/Ha)**	**0.010**
Attenuation Volume (m^3)	**593.5**		**Attenuation Volume (m^3)**	**1125.6**		**Attenuation Volume (m^3)**	**461.6**

Reference	**28**		**Reference**	**22**		**Reference**	**26**
Subcatchment	**Area (Ha)**		**Subcatchment**	**Area (Ha)**		**Subcatchment**	**Area (Ha)**
24	0.792		5!!!!!!!!!	0.116		94	0.078
7	0.583		9	0.361		95	0.051
30	0.218		86	0.293		5!!!!!	0.212
100	0.241		5!!!!!!!!	0.123		6	0.366
5!	0.169		5	0.094		93	0.237
5!!	0.075		10	0.345		99	0.255
			12	0.348		5!!!!	0.147
			31	0.407		5!!!	0.306
			82	0.226			
			83	0.139			
			84	0.056			
			85	0.830			
			5!!!!!!	0.356			
			5!!!!!!!	0.272			
Total Area (Ha)	**2.078**		**Total Area (Ha)**	**3.966**		**Total Area (Ha)**	**1.652**
Discharge ($m^3/s/Ha$)	**0.021**		**Discharge ($m^3/s/Ha$)**	**0.040**		**Discharge ($m^3/s/Ha$)**	**0.017**
Attenuation Volume (m^3)	**480.2**		**Attenuation Volume (m^3)**	**896.3**		**Attenuation Volume (m^3)**	**380.8**

Reference	70		Reference	66
Subcatchment	**Area (Ha)**		**Subcatchment**	**Area (Ha)**
18	0.351		19	0.350
21	0.306		20	0.178
28	0.049		29	0.876
90	0.150			
92	0.024			
Total Area (Ha)	**0.880**		**Total Area (Ha)**	**1.404**
Discharge ($m^3/s/Ha$)	**0.009**		**Discharge ($m^3/s/Ha$)**	**0.014**
Attenuation Volume (m^3)	**205.4**		**Attenuation Volume (m^3)**	**325.0**

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