



## APPENDIX 7.1



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# Ground Investigations Ireland

## Castlelost

## Halston

# Factual Ground Investigation Report

## May 2025





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## **DOCUMENT CONTROL SHEET**

Project Title	Castlelost
Client	Halston Environmental and Planning Limited
Project No	14311-11-24
Document Title	Factual Ground Investigation Report

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
A	Final	J Cashen	B Sexton	F McNamara	Dublin	01 May 2025

*Ground Investigations Ireland Ltd. present the results of the fieldworks and laboratory testing in accordance with the specification and related documents provided by or on behalf of the client. The possibility of variation in the ground and/or groundwater conditions between or below exploratory locations or due to the investigation techniques employed must be taken into account when this report and the appendices inform designs or decisions where such variation may be considered relevant. Ground and/or groundwater conditions may vary due to seasonal, man-made or other activities not apparent during the fieldworks and no responsibility can be taken for such variation. The data presented and the recommendations included in this report and associated appendices are intended for the use of the client and the client's geotechnical representative only and any duty of care to others is excluded unless approved in writing.*



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**GROUND INVESTIGATIONS IRELAND**  
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## 1.0 Preamble

On the instructions of Halston Environmental and Planning Limited, a site investigation was carried out by Ground Investigations Ireland Ltd. (GII) between March and April 2025, at the site of the proposed power station in Castlelost, County Westmeath.

## 2.0 Overview

### 2.1. Background

It is proposed to construct a power station with associated services, access roads and car parking at the proposed site. At the time of the site investigation the site consisted of greenfield agricultural land. The site is situated in the townland of Kiltotan and Collinstown near Rochfordbridge in County Westmeath. The site is bordered to the east by the Castlelost 220kV GIS substation.

### 2.2. Purpose and Scope

The purpose of the site investigation was to investigate subsurface conditions utilising a variety of investigative methods in accordance with the project specification. The scope of the work undertaken for this project included the following:

- Visit project site to observe existing conditions
- Carry out 6 No. Trial Pits to a maximum depth of 2.50m BGL
- Carry out 6 No. Soakaway tests to determine a soil infiltration value to BRE Digest 365
- Carry out 15 No. Rotary Core Boreholes to a maximum depth of 14.20 BGL
- Installation of 5 No. Groundwater monitoring wells
- Factual Report

## 3.0 Subsurface Exploration

### 3.1. General

During the ground investigation a programme of intrusive investigation specified by the Consulting Engineer was undertaken to determine the sub surface conditions at the proposed site. Regular sampling and in-situ testing were undertaken in the exploratory holes to facilitate the geotechnical descriptions and to enable laboratory testing to be carried out on the soil samples recovered during excavation and drilling.

The procedures used in this site investigation are in accordance with Eurocode 7 Part 2: Ground Investigation and testing (ISEN 1997 – 2:2007) and B.S. 5930:2015+A1:2020.

### **3.2. Trial Pits**

The trial pits were excavated using a JCB 3CX excavator at the locations shown in the exploratory hole location plan in Appendix 1. The locations were checked using a CAT scan to minimise the potential for encountering services during the excavation. The trial pits were sampled, logged and photographed by a Geotechnical Engineer/Engineering Geologist prior to backfilling with arisings. Notes were made of any services, inclusions, pit stability, groundwater encountered, and the characteristics of the strata encountered and are presented on the trial pit logs which are provided in Appendix 2 of this Report.

### **3.3. Soakaway Testing**

The soakaway testing was carried out in selected trial pits at the locations shown in the exploratory hole location plan in Appendix 1. These pits were carefully excavated and filled with water to assess the infiltration characteristics of the proposed site. The pits were allowed to drain and the drop in water level was recorded over time as required by BRE Digest 365. The pits were logged prior to completing the soakaway test and were backfilled with arising's upon completion. The soakaway test results are provided in Appendix 3 of this Report.

### **3.4. Rotary Boreholes**

The rotary coring was carried out by a track mounted T44 Beretta rig at the locations shown on the location plan in Appendix 1. The rotary boreholes were completed from the ground surface.

The T44 Beretta is equipped with rubber tracks which allow for short travel on pavement surfaces avoiding any damage to the surface. The T44 Beretta utilises a triple tube core barrel system operated using a wireline drilling process. The outer barrel is rotated by the drill rods and at its lower end, carries the coring bit. The inner barrel is mounted on a swivel so that it does not rotate during the process. The third barrel or liner is placed within the second one to retain the core intact and to preserve as much as possible the fabric of the drilling stratum. The core is cut by the coring bit and passes to the inner liner. The core is brought up to the surface within the inner barrel on a small diameter wire rope or line attached to the "overshoot" recovery tool which is then placed into a core box in order of recovery. A drilling fluid, typically air mist or water flush is passed from the surface through hollow drill rods to the drill bit and is used to cool the drill bit. Temporary casing is used in some situations to support unstable ground or to seal off fissures or voids. It should be noted that the rotary coring can only achieve limited recovery in overburden, particularly granular or weakly cemented strata due to the flushing medium washing away the cohesive fraction during coring. The recovery achieved, where required is noted on the borehole logs and core photographs are provided to allow assessment of the core recovered. The rotary borehole logs are provided in Appendix 4 of this Report.

### 3.5. Surveying

The exploratory hole locations have been recorded using a KQGeo M8 GNSS System which records the coordinates and elevation of the locations to Irish Transverse Mercator (ITM) as required by the project specification. The coordinates and elevations are provided on the exploratory hole logs in the appendices of this Report.

### 3.6. Groundwater Monitoring Installations

Groundwater monitoring installations were installed upon the completion of the boreholes to enable sampling and the determination of the equilibrium groundwater level. The typical groundwater monitoring installation consists of a 50mm uPVC/HDPE slotted pipe with a pea gravel response zone and bentonite seal installed to the Engineers specification. Where required the standpipe is sealed with a gas tap and finished with a durable steel cover fixed in place with a concrete surround. The installation details are provided on the exploratory hole logs in the appendices of this Report.

## 4.0 Ground Conditions

### 4.1. General

The ground conditions encountered during the investigation are summarised below with reference to in-situ and laboratory test results. The full details of the strata encountered during the ground investigation are provided in the exploratory hole logs included in the appendices of this report.

The sequence of strata encountered was consistent across the site and generally comprised;

- Topsoil
- Cohesive Deposits
- Granular Deposits
- Bedrock

**TOPSOIL:** Topsoil was encountered in all the exploratory holes and was present to a maximum depth of 0.30m BGL.

**COHESIVE DEPOSITS:** Cohesive deposits were encountered beneath the Topsoil at all locations and were described typically as *brown / greyish brown / light brown slightly sandy gravelly CLAY with medium cobble and boulder content*. The secondary sand and gravel constituents varied across the site and with depth, with granular lenses occasionally present in the glacial till matrix. These deposits had low (<5%), medium (5%-20%) or high (20%-50%) cobble and boulder content, where noted on the exploratory hole logs.

**GRANULAR DEPOSITS:** Granular deposits were encountered at the base of the cohesive deposits in SA01 and were typically described as *grey slightly clayey sandy subangular to subrounded fine to coarse*

*GRAVEL with medium cobble and low boulder content.* The secondary sand and fines constituents varied across the site and with depth, while low (<5%), medium (5%-20%) or high (20%-50%) cobble and boulder content was also present, where noted on the exploratory hole logs.

**BEDROCK:** The rotary core boreholes generally recovered *medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE.* This is typical of the Waulsortian Limestones, which are noted on Geological Survey Ireland's geological mapping of the site. The degree of weathering ranged from fresh to moderately weathered with the strength of the rock varying at each location. At BH-14, the upper weathered zone (3.50m to 12.30m) of the bedrock was dolomitised, with small vugs and clay infill also noted. The depth to rock varies from 0.55m BGL at BH05 to 6.60m BGL in BH06.

#### **4.2. Groundwater**

No groundwater was noted during the excavation works, while water strikes cannot be accurately identified during rotary drilling as water is added as part of the drilling process. Groundwater levels would be expected to vary with the time of year, rainfall, nearby construction, and other factors. For this reason, standpipes were installed in BH-01, BH-08, BH-12, BH-13 and BH-15.

# APPENDIX 1 - Figures



643200E

643600E

644000E

644400E

644800E

645200E

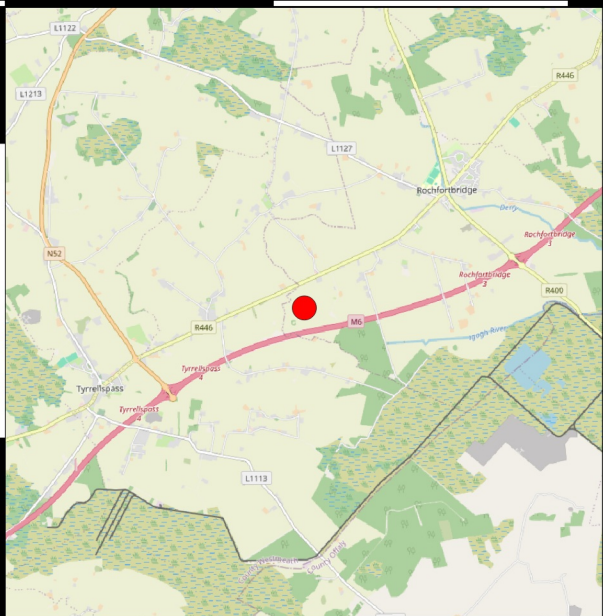
740000N

739600N

739200N

738800N

738400N



741000N  
738000N  
735000N



642000E 645000E 648000E

643200E

643600E

644000E

644400E

644800E

645200E

- Site Location
- Indicative Site Boundary



Client:



Project Code:

14331-11-24

Project Title:

Castlelost

Drawing Title:

Figure 1 Site Location



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0 16 32 48 64 80 m




Drawn By:  
AD

Date:  
26/03/2025

643950E 644100E 644250E 644400E 644550E 644700E 644850E

739350N  
739200N  
739050N  
738900N  
738750N  
738600N



-  Indicative Site Boundary
-  Rotary Borehole
-  Soakaway Pit



**Client:**  


**Project Code:**  
14311-11-24

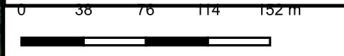
**Project Title:**  
Castlelost

**Drawing Title:**  
Figure 2 Site Investigation Points



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<b>Drawn By:</b> AD	<b>Date:</b> 27/03/2025
------------------------	----------------------------

643950E 644100E 644250E 644400E 644550E 644700E 644850E

## **APPENDIX 2 – Trial Pit Records**





<b>Machine :</b> 8 Tonne Excavator <b>Method :</b> Trial Pit	<b>Dimensions</b> L x W x D 1.10m x 0.40m x 1.80m	<b>Ground Level (mOD)</b> 109.60	<b>Client</b>	<b>Job Number</b> 14331-11-24
	<b>Location</b> 644253.8 E 739119.9 N	<b>Dates</b> 18/03/2025	<b>Engineer</b> Halston	<b>Sheet</b> 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.70	B			109.30	0.30	TOPSOIL		
					0.40	Firm brown slightly sandy gravelly CLAY with medium cobble content		
1.50	B			107.80	0.70	Grey slightly clayey sandy subangular to subrounded fine to coarse GRAVEL with medium cobble content and low boulder content		
					1.10			
					1.80	Complete at 1.80m		

<b>Plan</b> .	<b>Remarks</b> No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit complete at 1.80m BGL and backfilled upon completion.		
	<table border="1"> <tr> <td><b>Scale (approx)</b> 1:25</td> <td><b>Logged By</b> AD</td> <td><b>Figure No.</b> 14331-11-24.SA01</td> </tr> </table>	<b>Scale (approx)</b> 1:25	<b>Logged By</b> AD
<b>Scale (approx)</b> 1:25	<b>Logged By</b> AD	<b>Figure No.</b> 14331-11-24.SA01	



<b>Machine :</b> 8 Tonne Excavator <b>Method :</b> Trial Pit	<b>Dimensions</b> L x W x D 0.90m x 0.40m x 1.80m	<b>Ground Level (mOD)</b> 105.63	<b>Client</b>	<b>Job Number</b> 14331-11-24
	<b>Location</b> 644489.1 E 739232.6 N	<b>Dates</b> 18/03/2025	<b>Engineer</b> Halston	<b>Sheet</b> 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.80	B			105.33	(0.30)	TOPSOIL		
					0.30	Firm brown slightly sandy slightly gravelly CLAY with medium cobble content		
1.50	B			104.73	(0.60)			
					0.90	Soft brown mottled grey slightly sandy slightly gravelly CLAY		
				104.13	(0.30)	Firm brown slightly sandy slightly gravelly CLAY with medium cobble and boulder content		
				103.83	1.80	Complete at 1.80m		

<b>Plan</b> .	<b>Remarks</b> No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit complete at 1.80m BGL and backfilled upon completion.		
	<table border="1"> <tr> <td><b>Scale (approx)</b> 1:25</td> <td><b>Logged By</b> AD</td> <td><b>Figure No.</b> 14331-11-24.SA02</td> </tr> </table>	<b>Scale (approx)</b> 1:25	<b>Logged By</b> AD
<b>Scale (approx)</b> 1:25	<b>Logged By</b> AD	<b>Figure No.</b> 14331-11-24.SA02	



Machine : 8 Tonne Excavator Method : Trial Pit		Dimensions L x W x D 1.00m x 0.40m x 1.80m	Ground Level (mOD) 105.36	Client	Job Number 14331-11-24
		Location 644738.1 E 739195.7 N	Dates 18/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.00	B			105.06	0.30	TOPSOIL		
					(0.50)	Firm brown slightly sandy slightly gravelly CLAY		
				104.56	0.80	Firm brown slightly sandy gravelly CLAY with medium cobble content		
1.50	B			103.56	1.80	Complete at 1.80m		

<b>Plan</b> .	<b>Remarks</b>  No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit complete at 1.80m BGL and backfilled upon completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>AD</td> <td>14331-11-24.SA03</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	AD
Scale (approx)	Logged By	Figure No.				
1:25	AD	14331-11-24.SA03				



Machine : 8 Tonne Excavator Method : Trial Pit		Dimensions L x W x D 1.50m x 0.40m x 2.50m	Ground Level (mOD) 102.83	Client	Job Number 14331-11-24
		Location 644683.9 E 739078.4 N	Dates 18/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.00	B			102.53	(0.30) 0.30	TOPSOIL Firm brown slightly sandy gravelly CLAY		
2.00	B			101.23	(1.30) 1.60	Firm brown sandy gravelly CLAY with medium cobble content		
				100.33	(0.90) 2.50	Complete at 2.50m		

<b>Plan</b> .	<b>Remarks</b>  No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit complete at 2.50m BGL and backfilled upon completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>AD</td> <td>14331-11-24.SA04</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	AD
Scale (approx)	Logged By	Figure No.				
1:25	AD	14331-11-24.SA04				



Machine : 8 Tonne Excavator Method : Trial Pit		Dimensions L x W x D 1.20m x 0.40m x 2.10m	Ground Level (mOD) 103.67	Client	Job Number 14331-11-24
		Location 644611.2 E 738943.5 N	Dates 18/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.00	B			103.37	0.30	TOPSOIL		
					(0.70)	Firm brown slightly sandy slightly gravelly CLAY with medium cobble content		
1.50	B			102.67	1.00	Greyish brown slightly sandy clayey fine to coarse sub angular to sub rounded GRAVEL		
					(0.40)			
				102.27	1.40	Firm light brown slightly sandy slightly gravelly CLAY with medium cobble content		
				101.57	2.10	Terminated at 2.10m		

<b>Plan</b> .	<b>Remarks</b>  No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit terminated at 2.10m BGL due to obstruction: Large boulder. Trial pit backfilled upon completion.	
		<b>Scale (approx)</b> 1:25



Machine : 8 Tonne Excavator Method : Trial Pit		Dimensions L x W x D 1.60m x 0.40m x 2.50m	Ground Level (mOD) 107.39	Client	Job Number 14331-11-24
		Location 644540 E 738864.1 N	Dates 18/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
1.00	B			107.09	0.30	TOPSOIL		
					0.65	Firm brown slightly sandy slightly gravelly CLAY with medium cobble content		
2.00	B			106.44	0.95	Firm greyish brown sandy slightly gravelly CLAY with medium cobble content		
					1.05			
				105.39	2.00	Soft to firm light brown slightly sandy gravelly CLAY with medium cobble content		
					2.50	Complete at 2.50m		

<b>Plan</b> .	<b>Remarks</b>  No groundwater encountered. Trial pit stable. Soakaway test complete in trial pit in accordance with BRE Digest 365. Trial pit complete at 2.50m BGL and backfilled upon completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>AD</td> <td>14331-11-24.SA06</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	AD
Scale (approx)	Logged By	Figure No.				
1:25	AD	14331-11-24.SA06				

**Castlelost – Trial Pit Photographs**

**SA01**



**SA01**



**Castlelost – Trial Pit Photographs**

**SA01**



**SA01**



**Castlelost – Trial Pit Photographs**

**SA02**



**SA02**



**Castlelost – Trial Pit Photographs**

**SA02**



**SA02**



**Castlelost – Trial Pit Photographs**

**SA03**



**SA03**



Castlelost – Trial Pit Photographs

SA03



SA03



**Castlelost – Trial Pit Photographs**

**SA04**



**SA04**



**Castlelost – Trial Pit Photographs**

**SA04**



**SA04**



**Castlelost – Trial Pit Photographs**

**SA05**



**SA05**



Castlelost – Trial Pit Photographs

SA05



SA05



**Castlelost – Trial Pit Photographs**

**SA06**



**SA06**



**Castlelost – Trial Pit Photographs**

**SA06**



**SA06**



## **APPENDIX 3 – Soakaway Testing Records**





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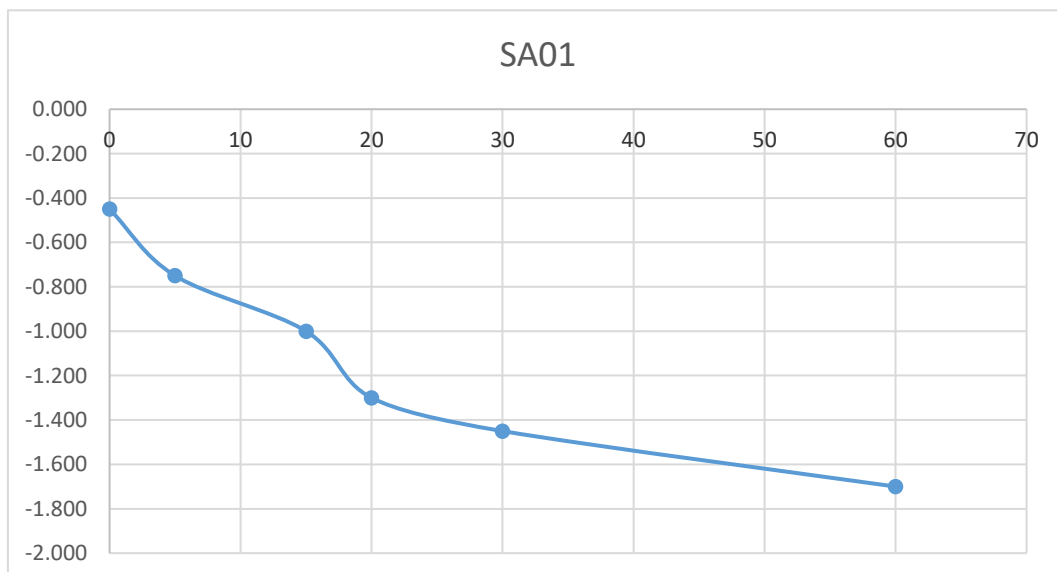
**SA01**

**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 1.10m x 0.40m 1.80m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.450
18/03/2025	5	-0.750
18/03/2025	15	-1.000
18/03/2025	20	-1.300
18/03/2025	30	-1.450
18/03/2025	60	-1.700

<b>Start depth</b> 0.45	<b>Depth of Pit</b> 1.800	<b>Diff</b> 1.350	<b>75% full</b> 0.7875	<b>25%full</b> 1.4625
Length of pit (m)	Width of pit (m)		75-25Ht (m)	Vp75-25 (m3)
1.100	0.400		0.675	0.30
Tp75-25 (from graph) (s)	<b>1080</b>		50% Eff Depth	ap50 (m2)
<b>f =</b>	<b>1.116E-04</b>	<b>m/s</b>	0.675	2.465





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**SA02**

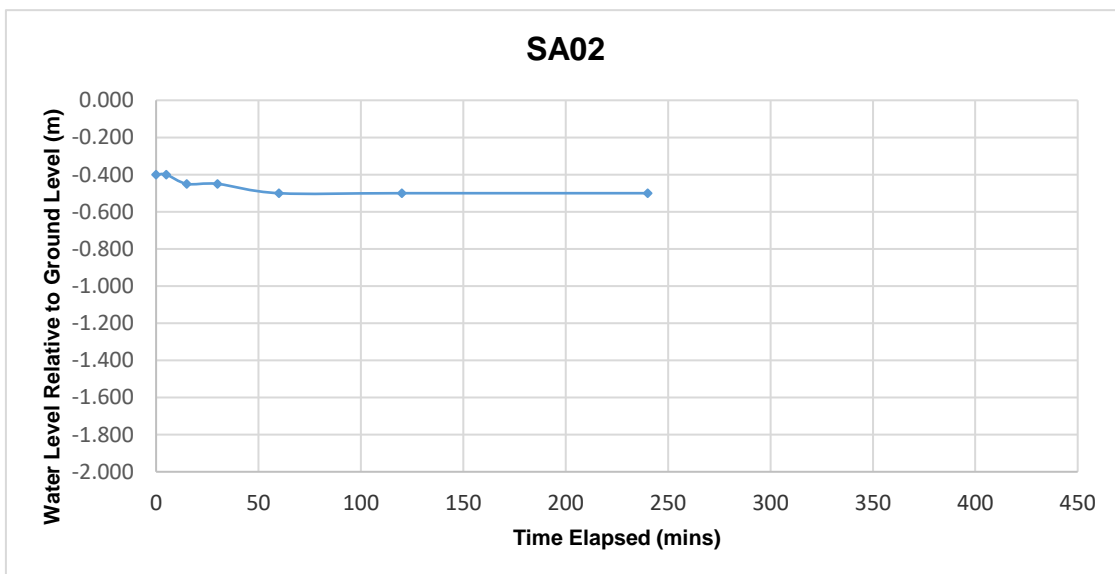
**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 0.90m x 0.40m x 1.80m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.400
18/03/2025	5	-0.400
18/03/2025	15	-0.450
18/03/2025	30	-0.450
18/03/2025	60	-0.500
18/03/2025	120	-0.500
18/03/2025	240	-0.500

**\*Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.40	1.800	1.400	0.75	1.45





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**SA03**

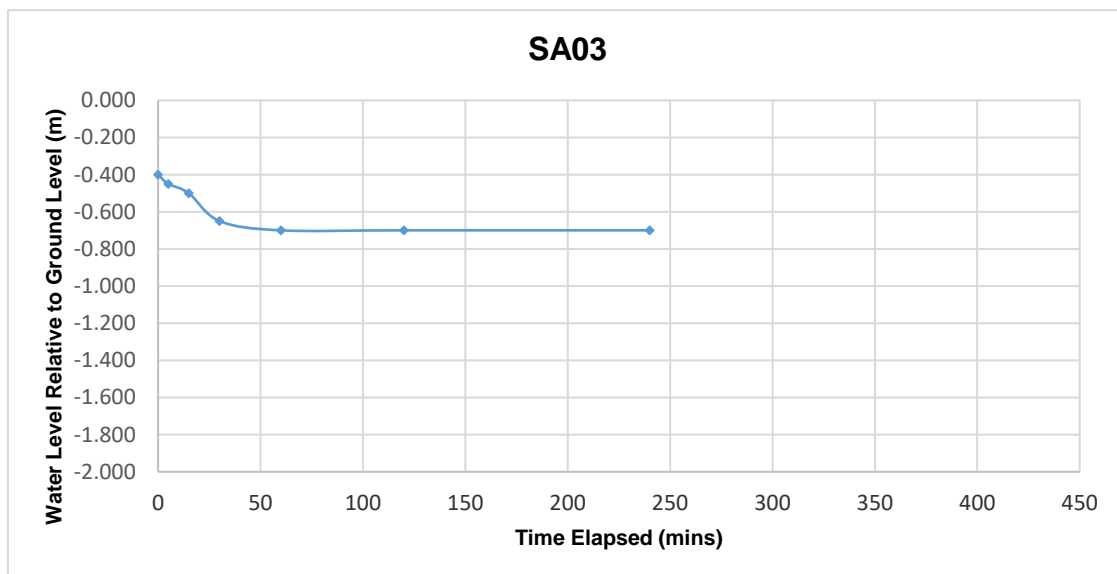
**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 1.00m x 0.40m x 1.80m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.400
18/03/2025	5	-0.450
18/03/2025	15	-0.500
18/03/2025	30	-0.650
18/03/2025	60	-0.700
18/03/2025	120	-0.700
18/03/2025	240	-0.700

**\*Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.40	1.800	1.400	0.75	1.45





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**SA04**

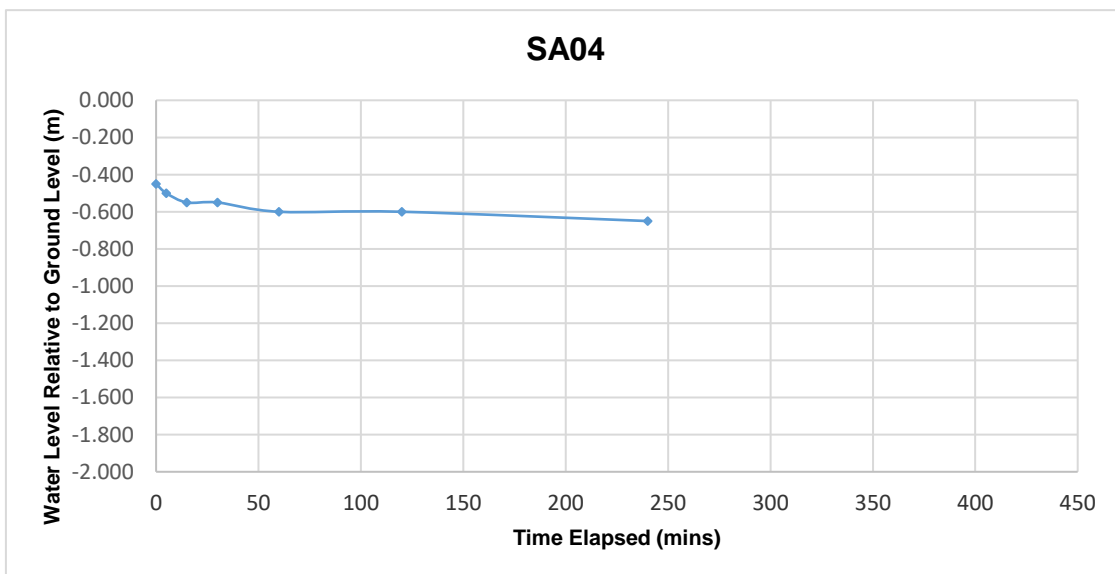
**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 1.50m x 0.40m x 2.50m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.450
18/03/2025	5	-0.500
18/03/2025	15	-0.550
18/03/2025	30	-0.550
18/03/2025	60	-0.600
18/03/2025	120	-0.600
18/03/2025	240	-0.650

**\*Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.45	2.500	2.050	0.9625	1.9875





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**SA05**

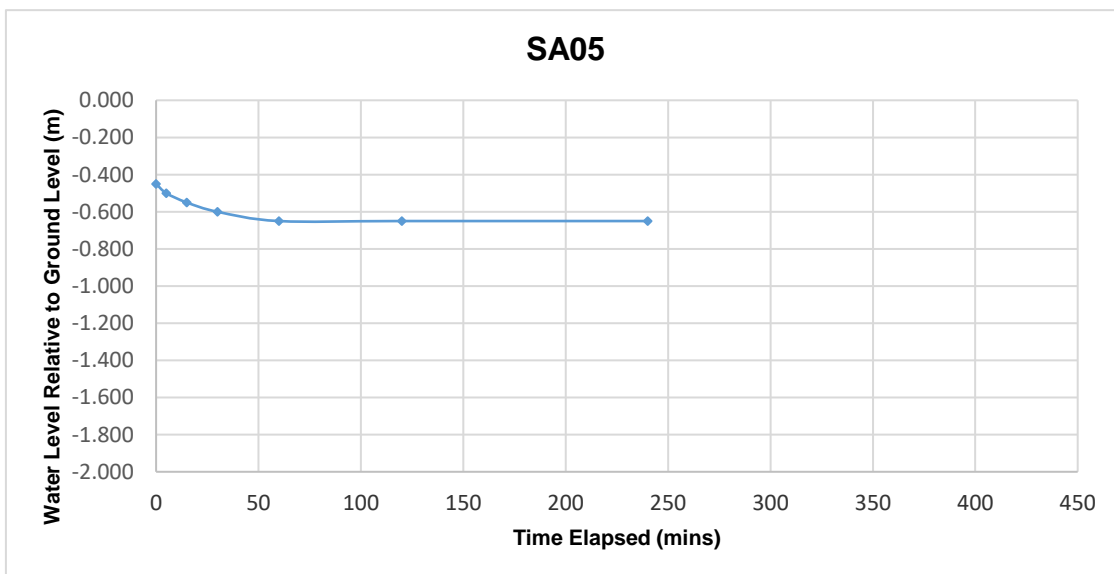
**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 1.20m x 0.40m x 2.10m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.450
18/03/2025	5	-0.500
18/03/2025	15	-0.550
18/03/2025	30	-0.600
18/03/2025	60	-0.650
18/03/2025	120	-0.650
18/03/2025	240	-0.650

**\*Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.45	2.100	1.650	0.8625	1.6875





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**SA06**

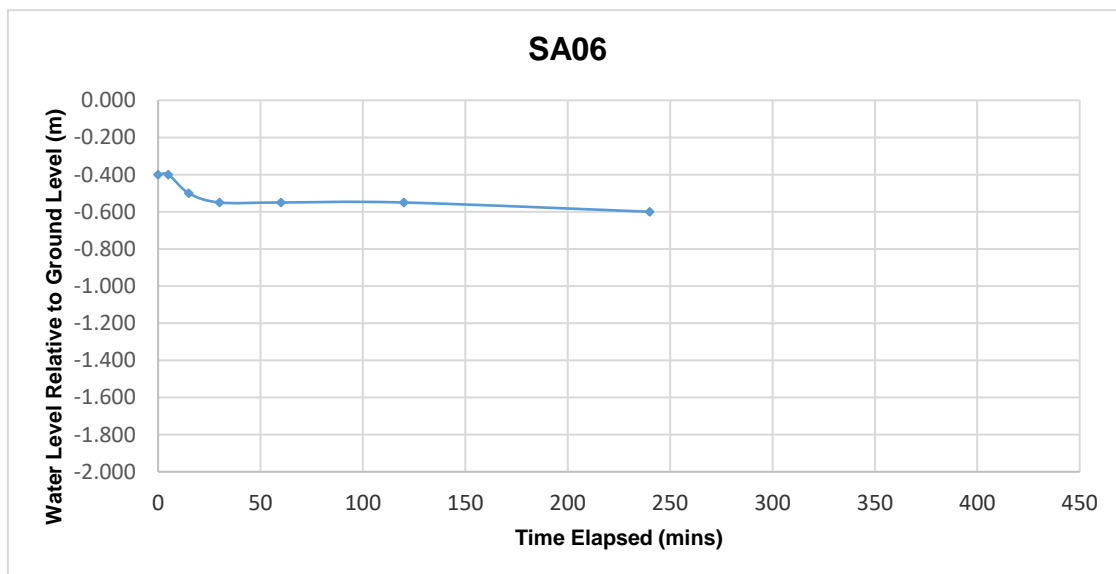
**Soakaway Test to BRE Digest 365**

**Trial Pit Dimensions: 1.60m x 0.40m x 2.50m (L x W x D)**

Date	Time	Water level (m bgl)
18/03/2025	0	-0.400
18/03/2025	5	-0.400
18/03/2025	15	-0.500
18/03/2025	30	-0.550
18/03/2025	60	-0.550
18/03/2025	120	-0.550
18/03/2025	240	-0.600

**\*Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.40	2.500	2.100	0.925	1.975



## **APPENDIX 4 - Rotary Borehole Records**





Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 113.53		Client		Job Number 14331-11-24	
Flush : Water		Location 644132.1 E 739143.3 N		Dates 26/03/2025- 27/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
1.10	68	15	7			112.43	(1.10)	Recovery consists of brown slightly sandy slightly gravelly CLAY. Driller notes: Brown Clay			
2.20				NI			(1.70)	Very weak to medium strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Slightly to moderately weathered. 1.10m to 2.80m BGL: Mostly non intact with clay infill of fractures			
2.70	100	100	100	4		110.73	2.80 (0.90)	Medium strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh 2.80m to 3.70m BGL: Two fracture sets. F1: One 70 to 90 degree fracture undulating rough. F2: 0 to 20 degrees closely spaced undulating rough			
3.70						109.83	3.70	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh			
6.30	100	90	90	5			(6.00)	3.70m to 6.30m BGL: Three fracture sets. F1: 0 to 20 degrees widely spaced undulating rough. F2: 70 to 90 degrees widely spaced undulating rough. F3: 20 to 40 degrees close to medium spaced undulating rough			
8.20	100	100	100	2				6.30m to 8.20m BGL: Two fracture sets. F1: One 70 to 90 degree fracture undulating rough. F2: 0 to 20 degrees medium spaced undulating to planar rough			
8.90				8				8.20m to 8.90m BGL: One fracture set. F1: 0 to 20 degrees closely spaced undulating rough			
9.70	100	100	100	1		103.83	9.70	8.90m to 9.70m BGL. One fracture: F1: 0 to 20 degrees undulating rough Complete at 9.70m			

**Remarks**  
Borehole complete at 9.70m BGL.  
50mm slotted standpipe with pea gravel surround installed from 9.70m to 2.00m BGL. 50mm plain standpipe with bentonite seal installed from 2.00m to GL with a raised cover.

Scale (approx)  
1:50

Logged By  
AD

Figure No.  
14331-11-24.BH02



Machine : Baretta T-44 Flush : Water Core Dia: 63.5 mm Method : Rotary Cored	Casing Diameter 96mm cased to 9.70m	Ground Level (mOD) 108.29	Client	Job Number 14331-11-24
	Location 644313.4 E 739222.3 N	Dates 24/03/2025- 25/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
2.20	40				2,2/2,3,3,4 SPT(C) N=12	107.99	(0.30) 0.30	TOPSOIL Recovery consists of grey slightly sandy clayey subangular to subrounded fine to coarse Gravel. Driller notes brown CLAY onto sand and gravel.		
2.20-2.65						106.09	2.20	Recovery consists of brown/grey clayey sandy Gravel. Driller notes sandy GRAVEL (medium dense)		
3.70-4.15	54				2,3/4,4,6,6 SPT(C) N=20	104.59	3.70	Recovery consists of grey/brown sandy gravelly CLAY with medium cobble and boulder content. Driller notes sandy boulder CLAY (Stiff)		
5.20-5.25						102.39	5.90	Medium strong to strong medium massive fine to coarse grained light grey fossiliferous LIMESTONE with occasional calcite veins. Fresh to slightly weathered with clay infill. 5.90m to 9.70m BGL: One fracture sets: F1: 10 to 30 degrees medium to close spaced undulating rough.		
5.90	50	43	35							
6.70	100	85	60	7			(2.50)			
8.80						99.89	8.40	Medium strong to strong massive fine to coarse grained light grey fossiliferous LIMESTONE with occasional calcite veins. Fresh to slightly weathered.		
	100	100	72				(1.30)			
9.70						98.59	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion.	Scale (approx)	Logged By
	1:50	AD
	<b>Figure No.</b> 14331-11-24.BH02	



Machine : Beretta T-44 Flush : Water Core Dia: 63.5 mm Method : Rotary Cored	Casing Diameter 96mm cased to 9.70m	Ground Level (mOD) 107.32	Client	Job Number 14331-11-24
	Location 644377.5 E 739252.5 N	Dates 25/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
2.20	45				6,9/13,17 SPT(C) 30/150	107.02	(0.30) 0.30	TOPSOIL		
2.20-2.50						105.12	2.20	Recovery consists of brown slightly sandy gravelly Clay with low cobble content. Driller notes brown CLAY onto boulder CLAY.		
3.70	80				8,17/26 SPT(C) 26/50	103.42	3.90	Recovery consists of grey slightly clayey sandy subangular to subrounded fine to coarse Gravel with medium cobble content. Driller notes SAND and GRAVEL with cobbles and pockets of clay (dense)		
3.70-3.90						103.42	3.90	Medium strong to strong medium to thickly bedded dark grey fine grained fossiliferous LIMESTONE with clay bands. Fresh to moderately weathered with frequent calcite veins		
4.60	100	33		NI				3.90m to 5.70m BGL - Mostly non intact		
5.20	100	41	33					(2.80)		
5.70	100	60	46							
6.70	100	100	100	3		100.62	6.70	Medium strong to strong medium to thickly bedded dark grey fine grained fossiliferous LIMESTONE. Fresh to slightly weathered with frequent calcite veins		
7.40	100	100	81						5.70m to 9.70m BGL: 1 Fracture set: F1: 0 to 30 degrees medium spaced, undulating, rough.	
8.20	100	100	85				(3.00)			
9.70						97.62	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion.	Scale (approx)	Logged By
	1:50	AD
<b>Figure No.</b> 14331-11-24.BH03		



Machine : Beretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 105.67		Client		Job Number 14331-11-24	
Flush : Water		Location 644556.8 E 739323.4 N		Dates 26/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Coring									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown slightly sandy gravelly Clay. Driller notes: Brown CLAY onto sandy GRAVEL.		
2.20	25					103.67	(2.00)			
2.20-2.27					25/50 SPT(C) 25*/50	103.17	(0.50)	Recovery consists of dark grey sandy slightly clayey fine to coarse subangular to subrounded Gravel. Driller notes sandy GRAVEL (dense)		
2.50	93	86	64		50/20		2.50	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to slightly weathered with rare calcite veins		
3.70	100	100	86							
5.20	93	93	46	4			(7.20)	(2.50-9.70m BGL) Two fracture sets. F1: 0-30 degrees, medium spaced undulating rough. F2: 70-90 degrees, medium to widely spaced undulating rough		
6.70	93	93	76							
8.20	100	100	63							
9.70						95.97	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL Borehole backfilled upon completion	Scale (approx)	Logged By
	1:50	
	<b>Figure No.</b> 14331-11-24.BH04	



Machine : Baretta T-44		Casing Diameter 96mm cased to 8.20m		Ground Level (mOD) 112.39		Client		Job Number 14331-11-24	
Flush : Water		Location 644186.8 E 739035.9 N		Dates 27/03/2025- 28/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.70	100	73	36	7		111.69	0.70	Brown slightly sandy slightly gravelly CLAY		
2.20								Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh with calcite veins		
2.35				NI				0.70m to 2.35m BGL: Three fracture sets. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 20 to 40 degrees closely spaced undulating to stepped, rough. F3: 70 to 90 degrees widely spaced undulating rough		
2.70	100	100	67							
3.70	100	100	100				(7.50)	2.70m to 5.50m BGL: One fracture set. F1: 0 to 30 degrees closely spaced undulating to stepped, rough		
5.20	100	100	73	4						
6.70	90	90	54					5.50m to 8.20m BGL: Three fracture sets. F1: 0 to 20 degrees closely spaced undulating to planar rough to smooth. F2: 30 to 50 degrees closely spaced undulating rough. F3: 60 to 90 degrees widely spaced undulating rough		
8.20						104.19	8.20	Complete at 8.20m		

<b>Remarks</b> Borehole complete at 8.20m BGL. Borehole backfilled upon completion								<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
								<b>Figure No.</b> 14331-11-24.BH05	



<b>Machine :</b> Baretta T-44 <b>Flush :</b> Water <b>Core Dia:</b> 63.5 mm <b>Method :</b> Rotary Cored		<b>Casing Diameter</b> 96mm cased to 9.70m	<b>Ground Level (mOD)</b> 107.30	<b>Client</b> Halston	<b>Job Number</b> 14331-11-24
		<b>Location</b> 644362.3 E 739121.6 N	<b>Dates</b> 31/03/2025	<b>Engineer</b> Halston	<b>Sheet</b> 1/1

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown slightly sandy slightly gravelly Clay. Driller notes brown sandy CLAY onto brown gravelly boulder CLAY.		
2.10	19					105.20	(2.10)			
2.10-2.15					25/50 SPT(C) 25*/50 50/0		2.10	Recovery consists of grey sandy clayey fine to coarse subangular to subrounded Gravel with medium cobble content. Driller notes sandy GRAVEL with cobbles. (medium dense)		
	82						(1.60)			
3.70					1,2/3,2,2,3 SPT(C) N=10	103.60	3.70	Recovery consists of brown Clay with cobbles. Driller notes sandy CLAY with gravel. (firm)		
3.70-4.15							(1.50)			
	100									
5.20					13,19/24,26 SPT(C) 50/100	102.10	5.20	Very stiff brown sandy gravelly CLAY with low cobble and boulder content		
5.20-5.45							(1.40)			
	100									
6.60					25/50 SPT(C) 25*/50 50/20	100.70	6.60	Very weak to moderately weak massive light grey fine grained fossiliferous brecciated LIMESTONE. Moderately to highly weathered.		
6.70	100	45	20				(1.60)			
6.70-6.77										
				8						
8.20						99.10	8.20	Moderately weak to medium strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to moderately weathered 6.60m to 9.70m BGL: Two fracture sets. F1: 0 to 20 degrees closely spaced undulating rough. F2: 20 to 40 degrees closely spaced undulating rough		
	100	85	67				(1.50)			
9.70						97.60	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion	<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
	<b>Figure No.</b> 14331-11-24.BH06	



Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 106.23		Client		Job Number 14331-11-24	
Flush : Water		Location 644420.9 E 739150.1 N		Dates 21/03/2025- 24/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of sandy Clay and sandy Gravel. Driller notes brown sandy CLAY with gravels and cobbles.		
2.20-2.65	19				2,3/3,3,4,6 SPT(C) N=16	104.03	2.20	Recovery consists of Sand and Gravel. Driller notes sandy GRAVEL with cobbles (medium dense)		
3.70-4.15					2,2/3,4,4,5 SPT(C) N=16	102.53	3.70	Recovery consists of sandy Clay onto Gravel. Driller notes silty SAND with gravel and cobbles. (stiff / medium dense)		
5.20 5.20-5.65	57				3,3/3,5,6,6 SPT(C) N=20	101.03	5.20	Recovery consists of brown/grey sandy clayey fine to coarse subangular to subrounded Gravel. Driller notes SAND and GRAVEL (Dense).		
6.60	80	70	55	11		99.63	6.60	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to slightly weathered		
7.60	100	100	42	4		98.63	7.60	6.60m to 7.60m BGL: One fracture set. F1: 0 to 40 degrees medium spaced undulating rough Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh		
8.20	93	33	27	11			(2.10)	7.60m to 8.20m BGL: Two fracture sets: F1: 0 to 30 degrees closely spaced undulating rough. F2: 70 to 90 degrees widely spaced undulating rough		
9.70						96.53	9.70	8.20m to 9.70m BGL: Two fracture sets: F1: 0 to 30 degrees widely spaced undulating rough. F2: 60 to 90 degrees medium to widely spaced undulating rough Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion								<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
								<b>Figure No.</b> 14331-11-24.BH07	



Machine : Beretta T-44 Flush : Core Dia: 63.5 mm Method : Rotary Cored	Casing Diameter 96mm cased to 9.70m	Ground Level (mOD) 105.46	Client	Job Number 14331-11-24
	Location 644588.5 E 739211.4 N	Dates 25/03/2025	Engineer Halston	Sheet 1/1

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
2.20-2.65	27				5,6/6,7,7,9 SPT(C) N=29	105.16	(0.30) 0.30	TOPSOIL Recovery consists of brown slightly sandy gravelly Clay. Driller notes brown CLAY.			
2.50						103.26	2.20	Recovery consists of brown Clay with high cobble content. Driller notes brown boulder CLAY.			
3.40	38					102.06	3.40	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Slightly to moderately weathered with occasional calcite veins.			
4.80	100	50	35	9				3.40m to 9.70m BGL - Two fracture sets. F1: 0-30 degrees, medium spaced undulating rough. F2: 70-90 degrees, medium to widely spaced undulating rough			
5.20	100	85	50								
6.80	100	88	88				(6.30)				
8.20	100	100	100	3							
9.70										95.76	9.70

**Remarks**  
Borehole complete at 9.70m BGL.  
50mm slotted standpipe with pea gravel surround installed from 9.70m to 1.50m BGL. 50mm plain standpipe with bentonite seal installed from 1.50m to GL with a raised cover.

Scale (approx)  
1:50

Logged By  
AD

Figure No.  
14331-11-24.BH08



Machine : Beretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 116.07		Client		Job Number 14331-11-24	
Flush : Water		Location 644227.9 E 738887 N		Dates 28/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown slightly sandy slightly gravelly CLAY. Driller notes Brown gravelly CLAY.		
1.30	60	41		NI		114.77	1.30 (0.90)	Medium strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to slightly weathered with occasional clay infill 1.30m to 2.20m BGL: Mostly non intact		
2.20			77			113.87	2.20	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to slightly weathered		
3.70	100	100	100	5				2.20m to 6.50m BGL: Three fracture sets. F1: 0 to 20 degrees closely to widely spaced undulating rough. F2: 20 to 40 degrees closely spaced undulating rough. F3: 70 to 90 degrees widely spaced undulating rough		
5.20	100	100	45				(7.50)			
6.50										
6.70	100	100	83							
8.20				4				6.50m to 9.70m BGL: Two fracture sets. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 20 to 40 degrees medium spaced undulating to planar rough		
9.70	100	100	93			106.37	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion								<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
								<b>Figure No.</b> 14331-11-24.BH08	



Machine : Beretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 109.00		Client		Job Number 14331-11-24	
Flush : Water		Location 644326.2 E 738980 N		Dates 31/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown slightly sandy slightly gravelly Clay onto Gravel. Drillers notes brown sandy CLAY onto GRAVEL with cobbles.		
1.30	80	43	23			107.70	(1.30)			
2.20				8			1.30	Medium strong to strong massive light grey medium to coarse grained fossiliferous LIMESTONE. Fresh with rare calcite veins		
3.40	100	100	39					1.30m to 3.40m BGL: Two fracture sets. F1: 0 to 20 degrees closely spaced undulating rough. F2: 20 to 40 degrees closely to widely spaced undulating rough.		
3.70				NI						
5.20	100	100	63							
6.20				3						
6.70	100	100	71				(8.40)	3.70m to 6.20m BGL: One fracture set. F1: 0 to 30 degrees closely to medium spaced undulating rough.		
8.20				6						
8.70	100	100	93					6.20m to 9.70m BGL: Two fracture sets. F1: 70 to 90 degrees closely spaced undulating rough. F2: 0 to 20 degrees closely to medium spaced undulating rough		
9.70						99.30	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion								<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
								<b>Figure No.</b> 14331-11-24.BH10	



Machine : Beretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 105.16		Client		Job Number 14331-11-24	
Flush : Water		Location 644493.4 E 739062.3 N		Dates 31/03/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown sandy slightly gravelly Clay onto sandy Gravel. Driller notes Brown sandy CLAY onto sandy GRAVEL with cobbles.		
2.20	52				4,4/4,5,6,6 SPT(C) N=21	102.96	2.20	Recovery consists of grey sandy slightly clayey fine to coarse subangular to subrounded Gravel. Driller notes sandy GRAVEL. (medium dense)		
2.20-2.65						102.06	3.10	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE with rare calcite veins. Fresh		
3.10				NI						
3.60					8			3.10m to 5.60m BGL: Three fracture sets. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 20 to 40 degrees closely to medium spaced undulating rough. F3: One 70 to 90 degree fracture undulating rough		
3.70	100	100	69			99.56	5.60	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE with frequent calcite veins. Fresh		
5.20					3			5.60m to 9.70m BGL: One fracture set. F1: 0 to 20 degrees closely to widely spaced undulating rough.		
5.60	93	93	69							
6.70										
8.20	100	100	100							
9.70	100	100	80			95.46	9.70	Complete at 9.70m		

<b>Remarks</b> Borehole complete at 9.70m BGL. Borehole backfilled upon completion								<b>Scale (approx)</b> 1:50	<b>Logged By</b> AD
								<b>Figure No.</b> 14331-11-24.BH11	



Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 111.30		Client		Job Number 14331-11-24	
Flush : Water		Location 644413.6 E 738835.6 N		Dates 01/04/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.00								Recovery consists of brown slightly sandy slightly gravelly Clay onto sandy Gravel. Driller Notes: Brown CLAY onto sandy GRAVEL.			
2.20	22					109.10	(2.20)				
2.20-2.65	60	13			2,2/3,3,3,4 SPT(C) N=13		2.20	Recovery consists of grey sandy fine to coarse angular to subangular Gravel. Driller notes sandy GRAVEL. (medium dense)			
3.50						107.80	3.50	Medium strong to strong massive grey fine to coarse grained fossiliferous LIMESTONE. Fresh with rare calcite veins and occasional clay infill.			
3.70				14							
4.20	100	100	71					3.50m to 4.20m BGL: Two fracture sets. F1: 0 to 20 degrees closely spaced undulating rough. F2: 70 to 90 degrees medium spaced undulating rough.			
5.20	100	100	88	4							
6.70	100	100	85				(6.20)	4.20m to 8.10m BGL: One fracture set. F1: 0 to 20 degrees closely spaced undulating rough			
8.10											
8.20	100	100	100	3							
9.70						101.60	9.70	8.10m to 9.70m BGL: One fracture set. F1: 0 to 30 degrees closely to widely spaced undulating rough			
								Complete at 9.70m			

<b>Remarks</b> Borehole complete at 9.70m BGL. 50mm slotted standpipe with pea gravel surround installed from 9.70m BGL to 1.50m BGL. 50mm plain standpipe with bentonite seal installed from 1.50m BGL to GL with raised cover.									Scale (approx) 1:50	Logged By AD
									Figure No. 14331-11-24.BH12	



Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 107.12		Client		Job Number 14331-11-24	
Flush : Water		Location 644619.6 E 738809.3 N		Dates 02/04/2025- 03/04/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.00								Recovery consists of brown CLAY onto light brown CLAY. Driller notes Brown CLAY.			
2.20	61					104.92	2.20	Weak to medium strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Reduced recovery with drillers noting clay infill being washed away.			
2.20-2.65					25/50 SPT(C) N=50			2.20m to 3.50m BGL: Mostly non intact with reduced recovery.			
3.50	73	73	8	NI			(1.30)				
3.70						103.62	3.50	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE. Fresh to slightly weathered with rare calcite veins and occasional clay infill.			
5.20											
5.40				NI							
5.80	90	74	33	5				3.50m to 6.50m BGL: Three fracture sets. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 20 to 40 degrees closely spaced undulating rough. F3: 70 to 90 degrees closely spaced undulating rough			
6.50				NI							
6.70	100	90	57				(6.20)				
8.20				8							
	100	90	40					6.70m to 9.70m BGL: Three fracture set. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 20 to 40 degrees medium spaced undulating rough. F3: 70 to 90 degrees closely spaced undulating rough			
9.70						97.42	9.70	Complete at 9.70m			

<b>Remarks</b> Borehole complete at 9.70m BGL. 50mm slotted standpipe with pea gravel surround installed from 9.70m BGL to 1.50m BGL. 50mm plain standpipe with bentonite seal installed from 1.50m BGL to GL with raised cover.									Scale (approx) 1:50	Logged By AD
									Figure No. 14331-11-24.BH13	



Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 104.56		Client		Job Number 14331-11-24	
Flush : Water		Location 644696.7 E 738890.5 N		Dates 01/04/2025		Engineer Halston		Sheet 1/2	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00								Recovery consists of brown slightly sandy slightly gravelly Clay onto dark grey gravelly Sand. Driller notes brown CLAY onto		
2.20	45				1,1/1,1,2,2 SPT(C) N=6	102.36	2.20	Recovery consists of dark grey slightly clayey slightly gravelly fine to coarse Sand onto Gravel with cobbles. (soft / loose)		
2.20-2.65	67	13					(1.50)			
3.70					2,3/4,7,7,9 SPT(C) N=27	100.86	3.70	Recovery consists of broken cobbles and a Boulder. Driller notes COBBLES and BOULDERS (Dense)		
3.70-4.15	27	27					(2.00)			
5.20					12,17/17,33 SPT(C) 50/140					
5.20-5.49										
5.70	93	93	27	7		98.86	5.70	Medium strong massive light brownish pink medium to coarse grained dolomitised LIMESTONE with vugs and occasional clay and sand infill. Slightly to moderately weathered		
6.70								5.70m to 7.10m BGL: Two fracture sets. F1: 0 to 20 degrees closely to medium spaced undulating rough. F2: 70 to 90 degrees medium spaced undulating rough.		
7.10	80	73	42							
8.20				3				7.10m to 9.10m BGL: One fracture set. F1: 0 to 30 degrees closely to medium spaced undulating rough		
9.10	100	100	57				(6.60)			
9.70										

<b>Remarks</b> Borehole complete at 14.20m BGL. Borehole backfilled upon completion	Scale (approx)	Logged By
	1:50	AD
	<b>Figure No.</b> 14331-11-24.BH14	



Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 104.56		Client		Job Number 14331-11-24	
Flush : Water		Location 644696.7 E 738890.5 N		Dates 01/04/2025		Engineer Halston		Sheet 2/2	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
11.20	80	80	31	6				9.10m to 12.30m BGL: Two fracture sets. F1: 0 to 30 degrees closely spaced undulating to stepped, rough. F2: One 70 to 90 degree fracture. undulating rough		
12.30	100	100	93			92.26	12.30	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE with calcite veins. Fresh		
12.70				3			(1.90)	12.30m to 14.20m BGL: Two fracture sets. F1: 0 to 20 degrees medium spaced undulating rough. F2: 20 to 40 degrees widely spaced undulating rough		
14.20	100	100	90			90.36	14.20	Complete at 14.20m		

Remarks	Scale (approx)	Logged By
	1:50	AD
	Figure No. 14331-11-24.BH14	



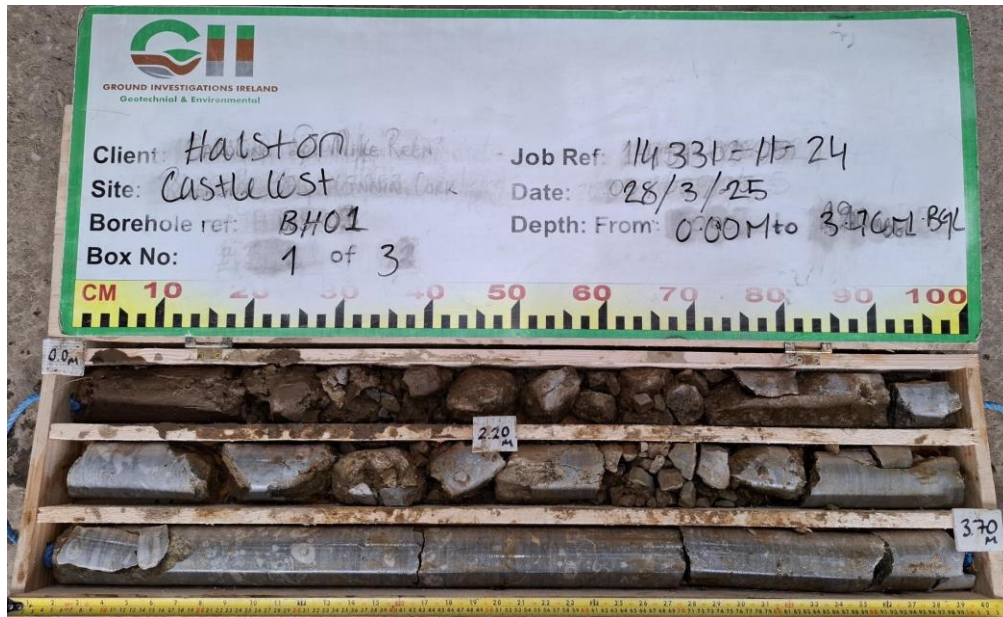
Machine : Baretta T-44		Casing Diameter 96mm cased to 9.70m		Ground Level (mOD) 103.26		Client		Job Number 14331-11-24	
Flush : Water		Location 644813.5 E 739081 N		Dates 03/04/2025		Engineer Halston		Sheet 1/1	
Core Dia: 63.5 mm									
Method : Rotary Cored									

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.00								Recovery consists of brown slightly sandy slightly gravelly Clay onto Gravel. . Driller notes brown CLAY onto possible weathered rock			
2.20	54					101.06	(2.20)				
2.20-2.65					25/50 SPT(C) N=50		2.20	Possible weathered bedrock recovered as grey slightly sandy fine to coarse angular to subangular GRAVEL with low cobble content			
2.80	90	67	21			100.46	2.80	Medium strong to strong massive light grey fine to coarse grained fossiliferous LIMESTONE with rare calcite veins. Fresh to slightly weathered			
3.70				8				2.80m to 4.00m BGL: Two fracture sets. F1: 0 to 20 degrees closely spaced undulating rough. F2: 70 to 90 degrees medium spaced undulating rough.			
4.00	100	100	93								
5.20				8				4.00m to 6.70m BGL: Two fracture set. F1: 0 to 10 degrees closely to medium spaced undulating to stepped, rough. F2: 20 to 50 degrees medium spaced undulating rough.			
6.70	100	100	67				(6.90)				
8.20				7				6.70m to 9.70m BGL: Three fracture sets. F1: 0 to 20 degrees closely spaced undulating rough. F2: 40 to 60 degrees medium spaced undulating to stepped, rough. F3: 70 to 90 degrees widely spaced undulating rough			
9.70	100	100	80			93.56	9.70	Complete at 9.70m			

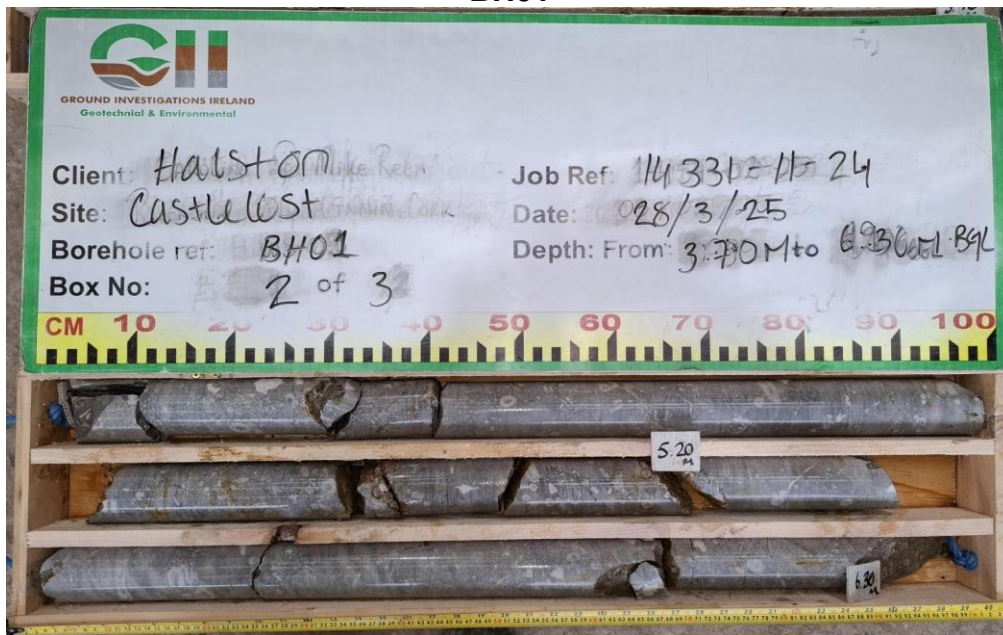
<b>Remarks</b> Borehole complete at 9.70m BGL. 50mm slotted standpipe with pea gravel surround installed from 9.70m BGL to 1.50m BGL. 50mm plain standpipe with bentonite seal installed from 1.50m BGL to GL with raised cover.									Scale (approx)	Logged By
									1:50	AD
									<b>Figure No.</b> 14331-11-24.BH15	

# Castlelost – RC Borehole Photos

## BH01

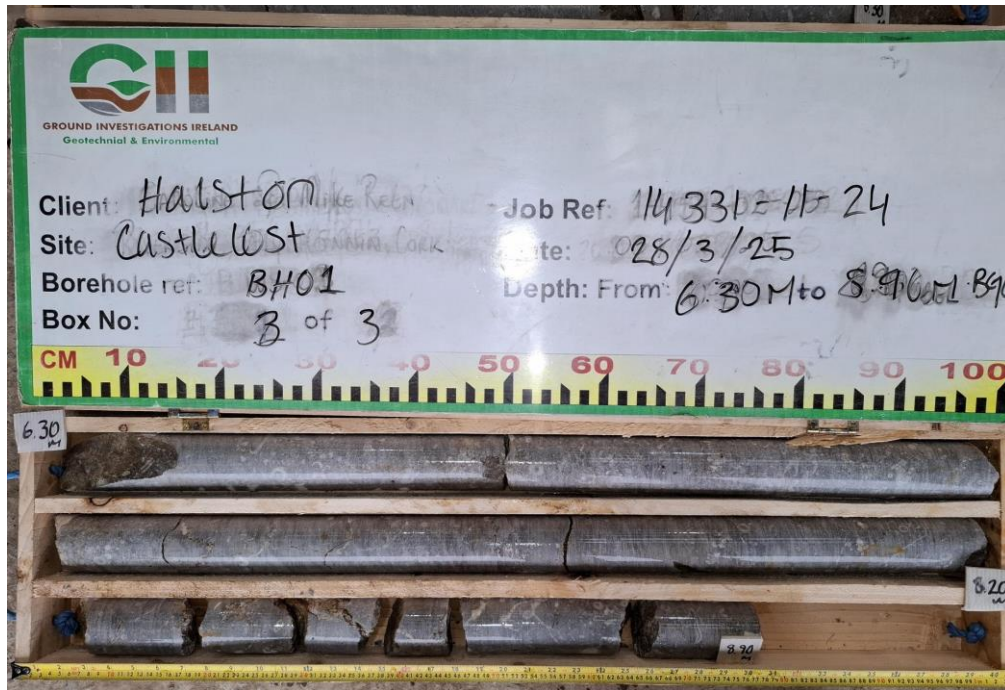


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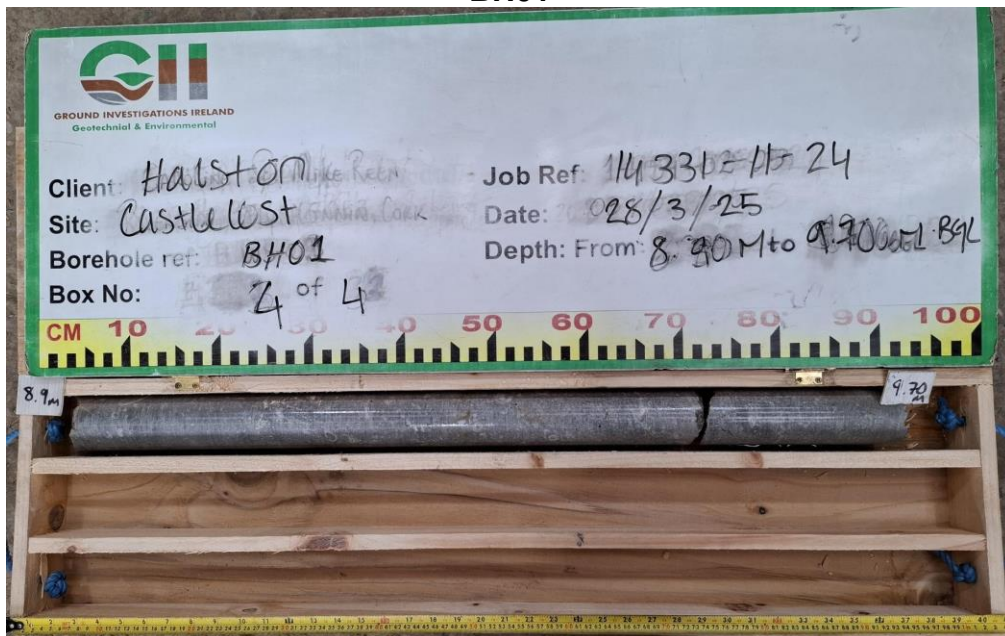


# Castlelost – RC Borehole Photos

## BH01

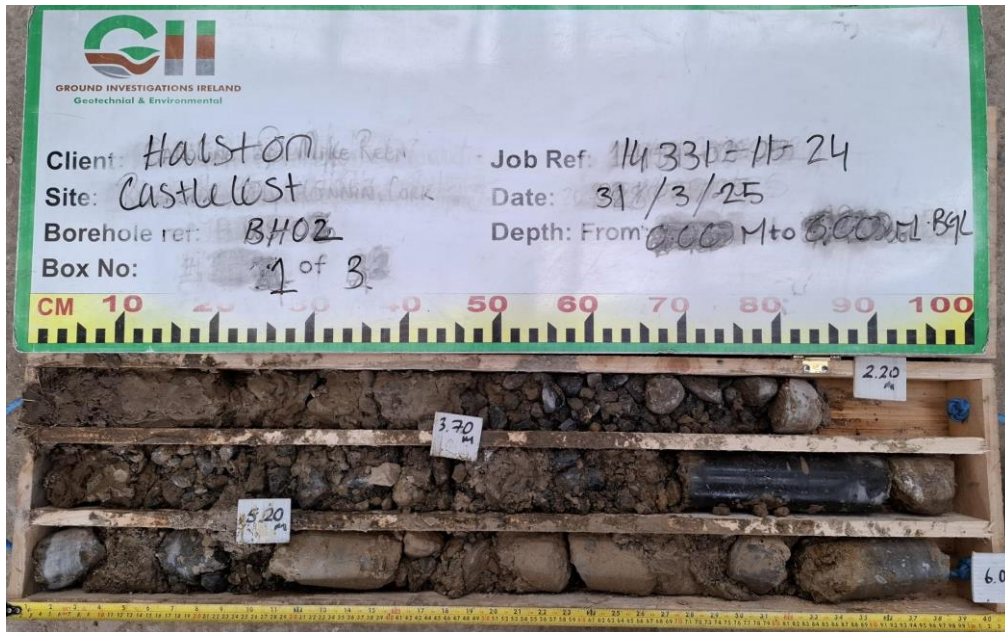


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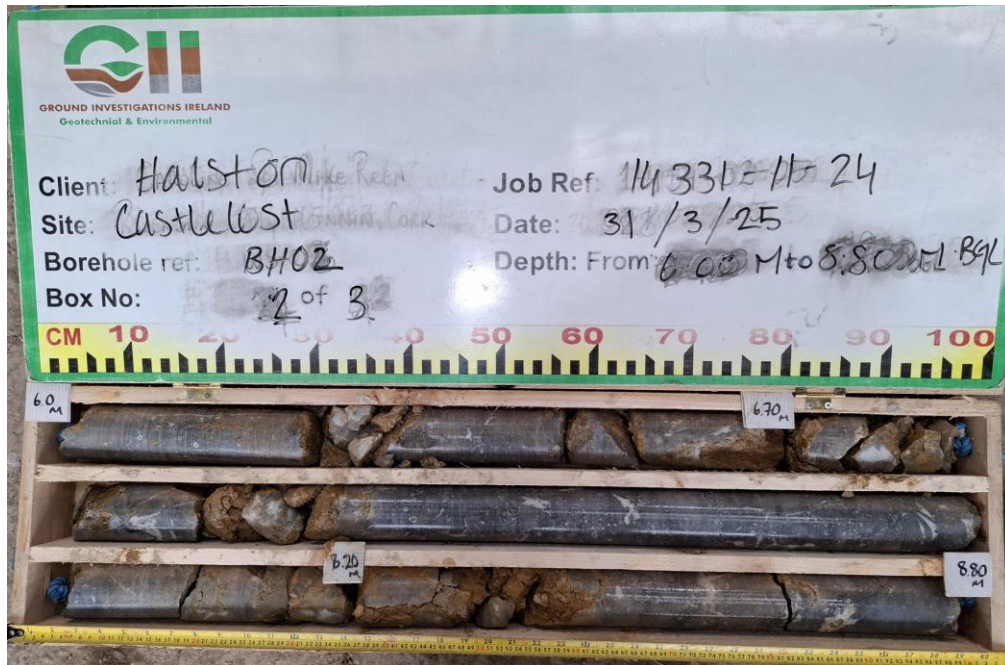


# Castlelost – RC Borehole Photos

## BH02

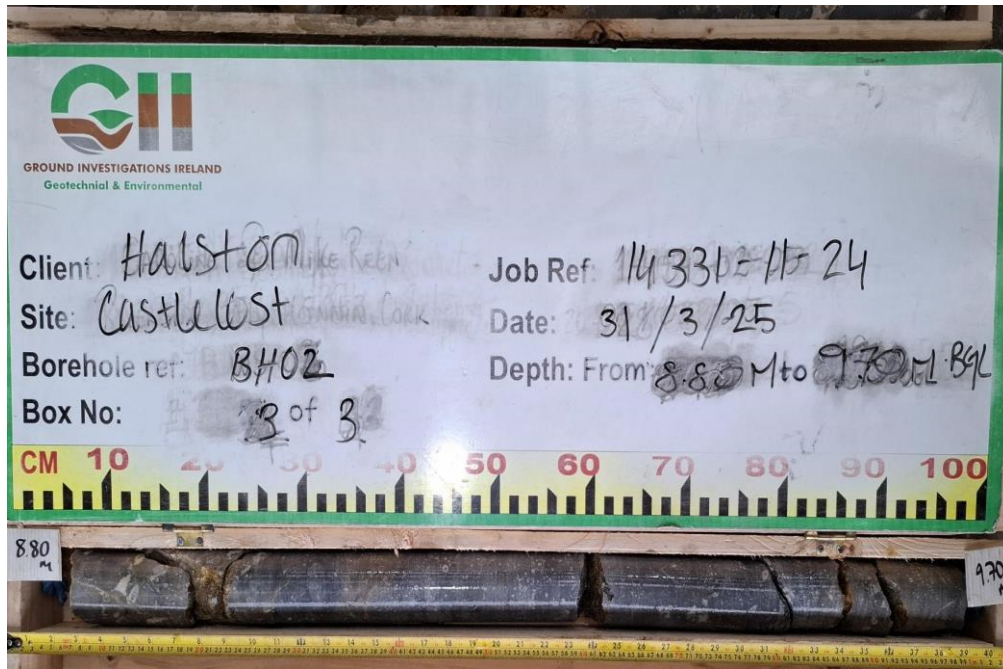


## BH02



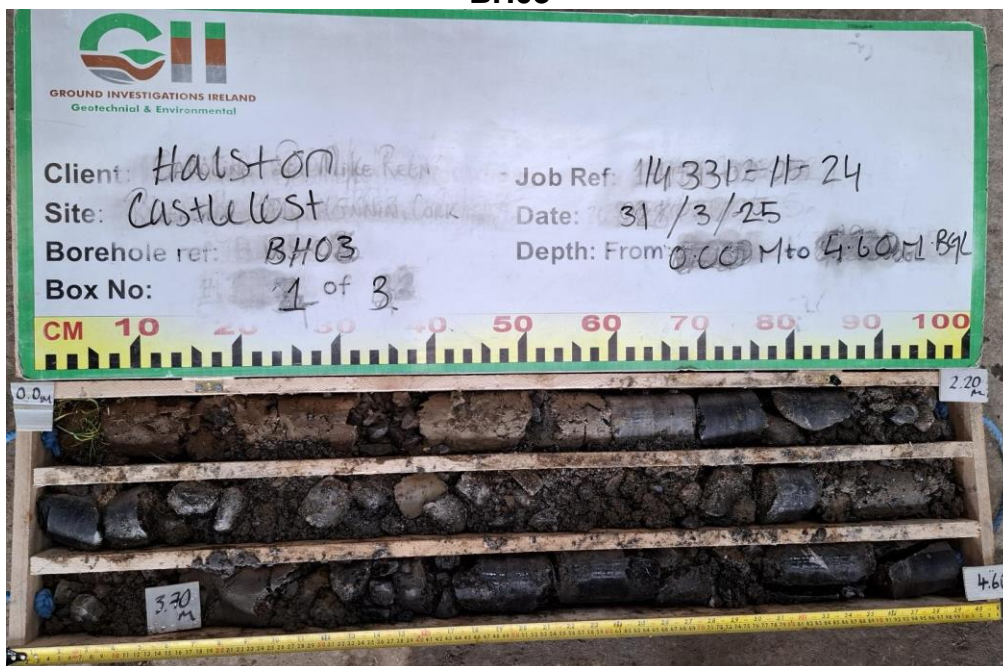
# Castlelost – RC Borehole Photos

## BH02

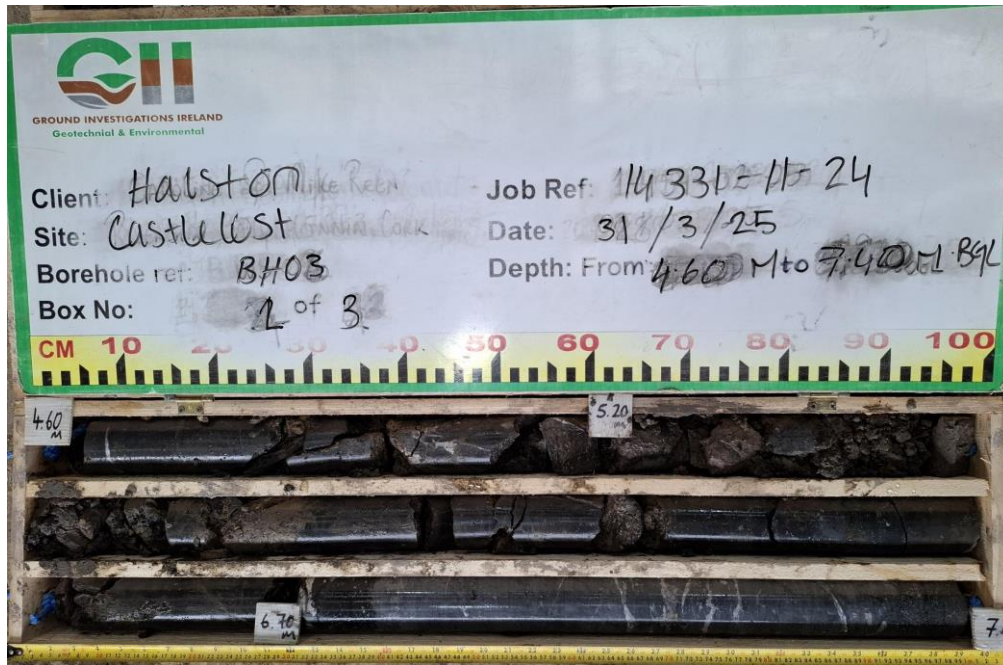


# Castlelost – RC Borehole Photos

## BH03

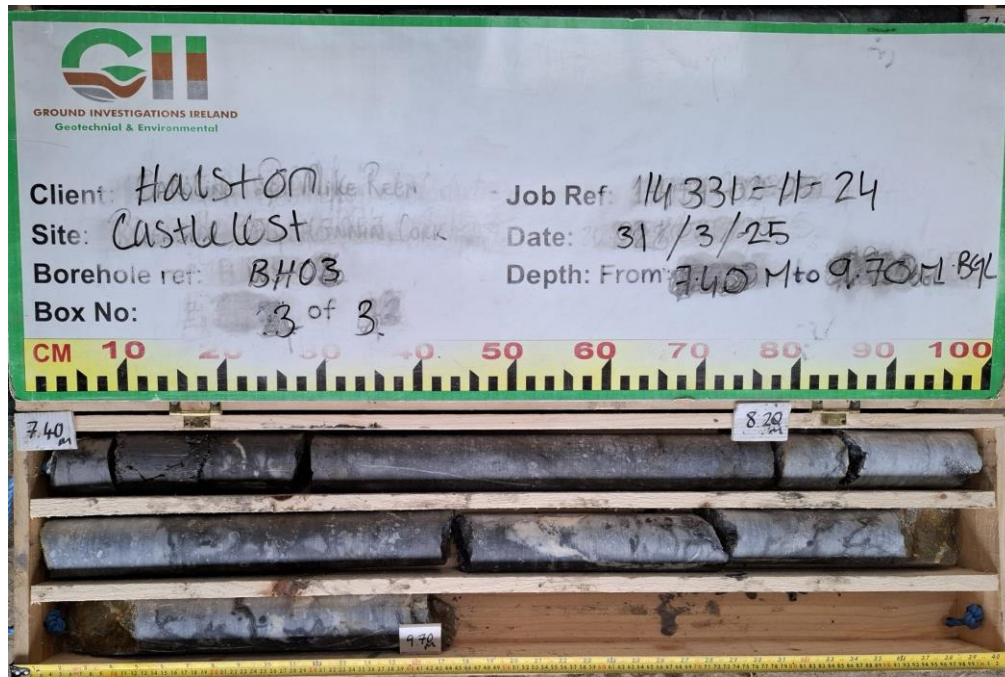


## BH03



# Castlelost – RC Borehole Photos

## BH03



# Castlelost – RC Borehole Photos

## BH04

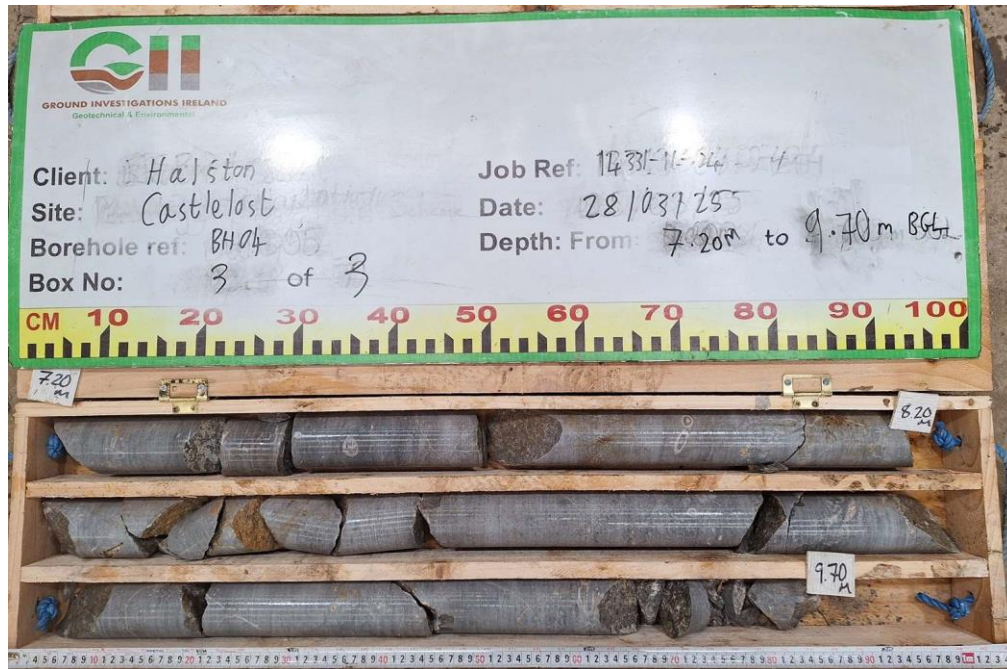


## BH04



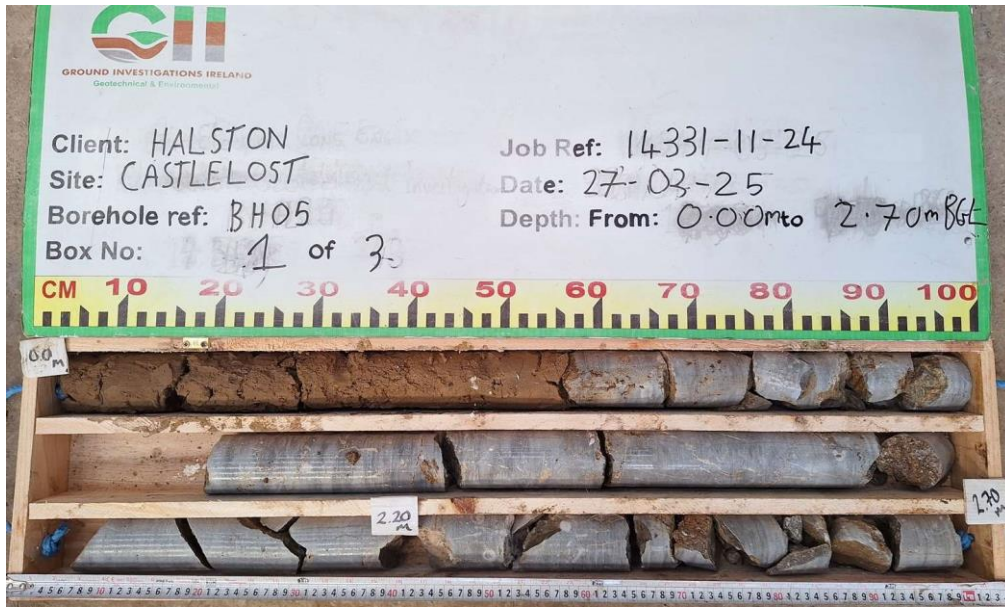
# Castlelost – RC Borehole Photos

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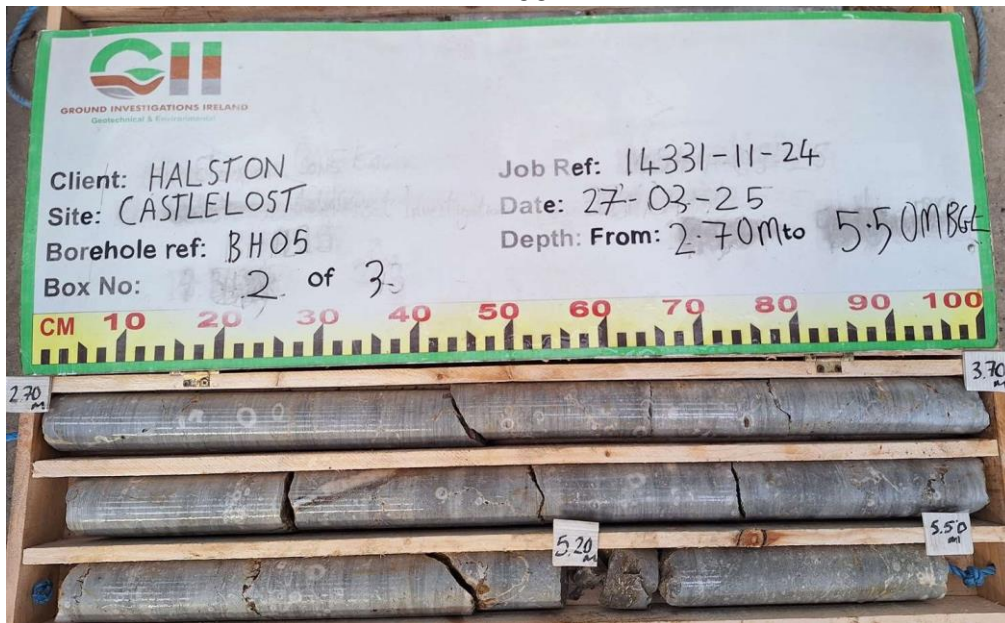


# Castlelost – RC Borehole Photos

## BH05

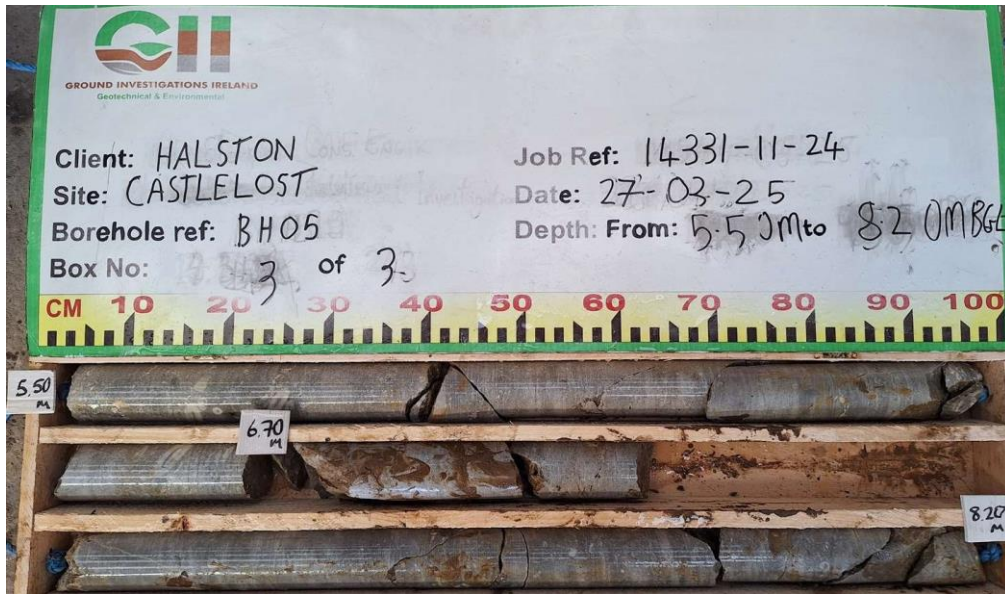


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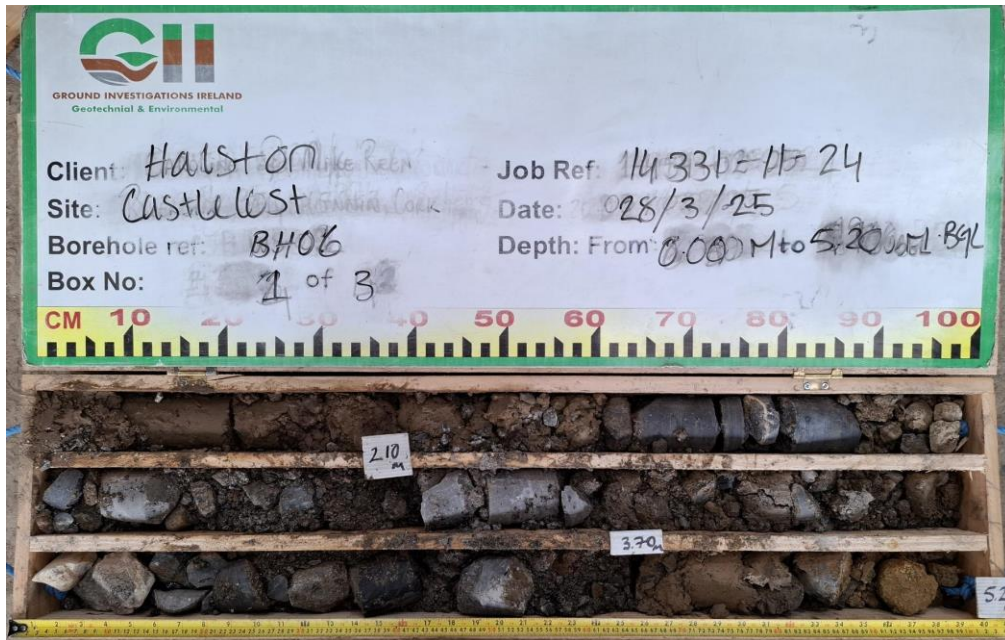
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## BH05



# Castlelost – RC Borehole Photos

## BH06

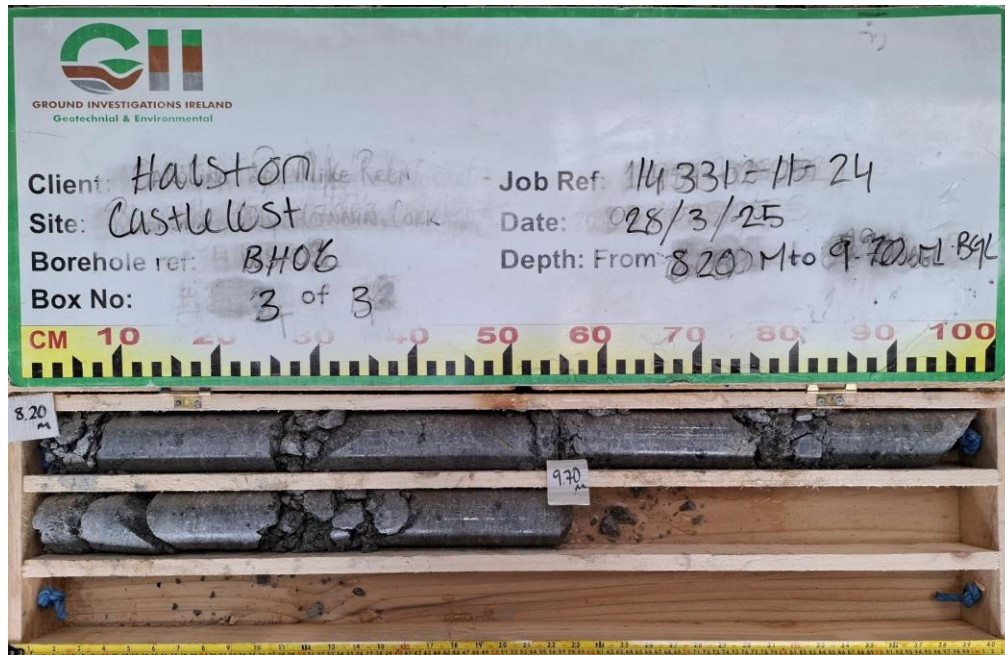


## BH06



# Castlelost – RC Borehole Photos

## BH06

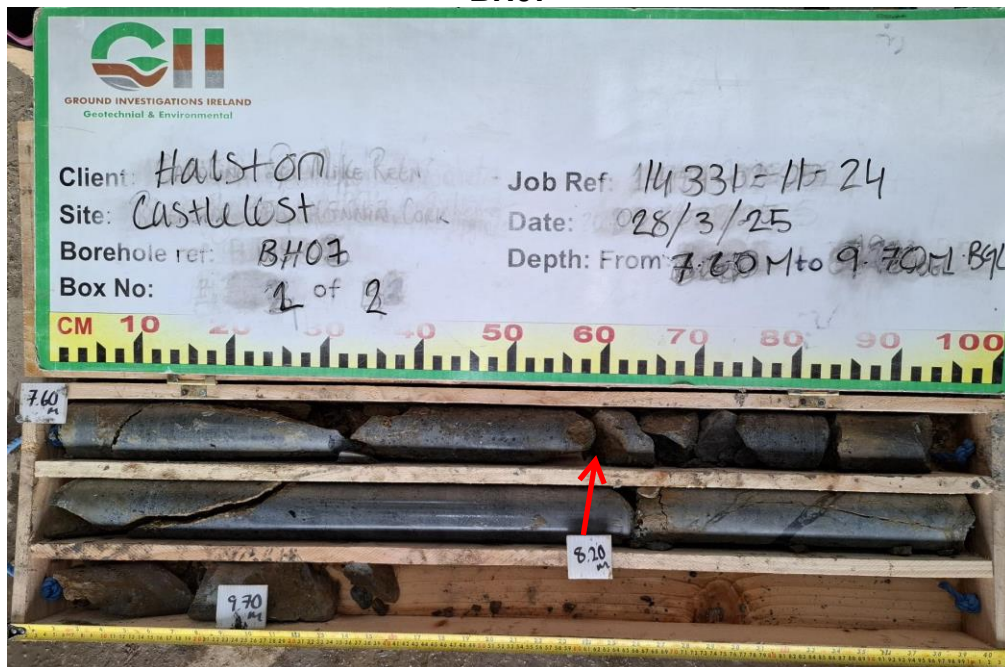


# Castlelost – RC Borehole Photos

## BH07

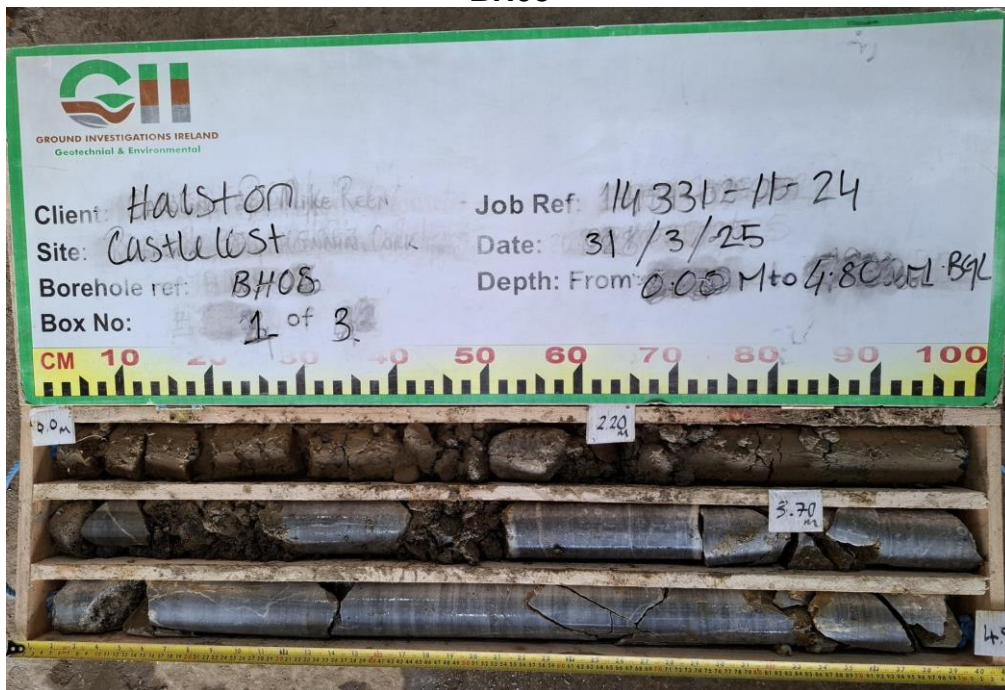


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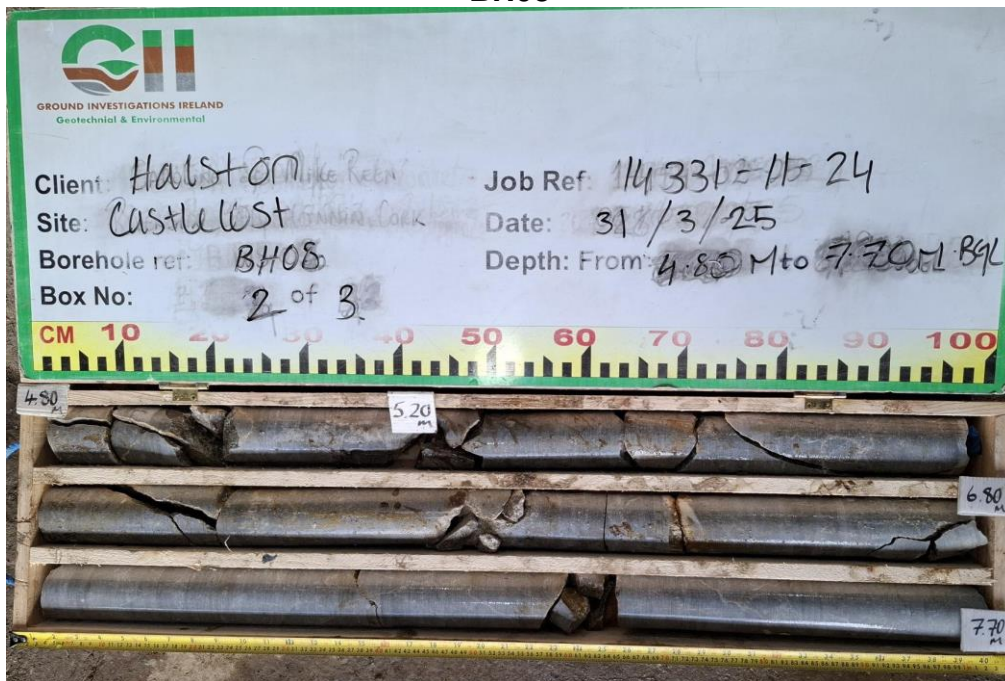


# Castlelost – RC Borehole Photos

## BH08

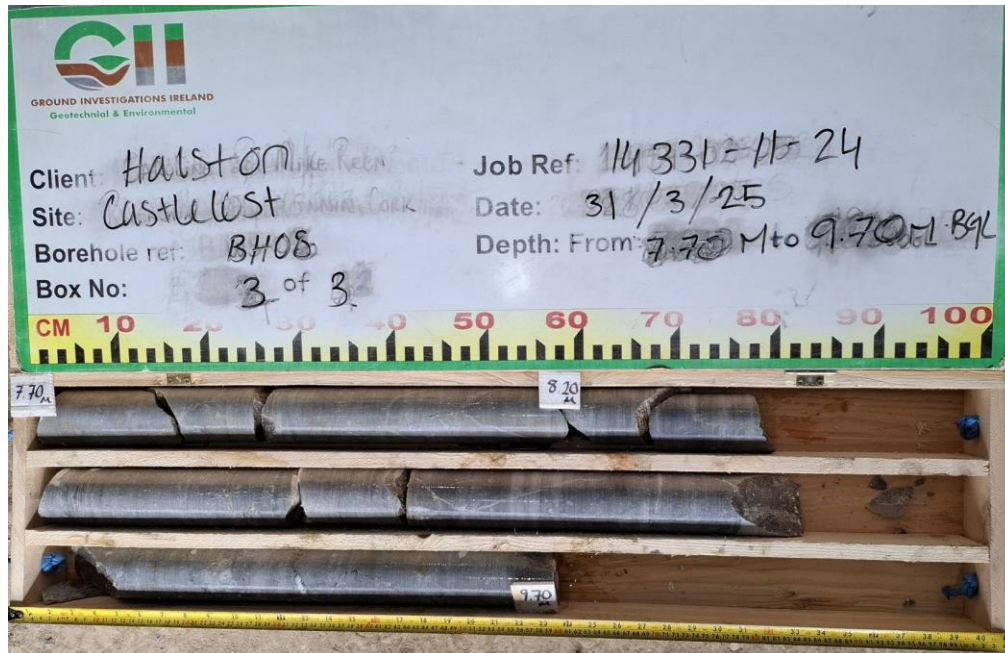


## BH08



# Castlelost – RC Borehole Photos

## BH08





# Castlelost – RC Borehole Photos

## BH09

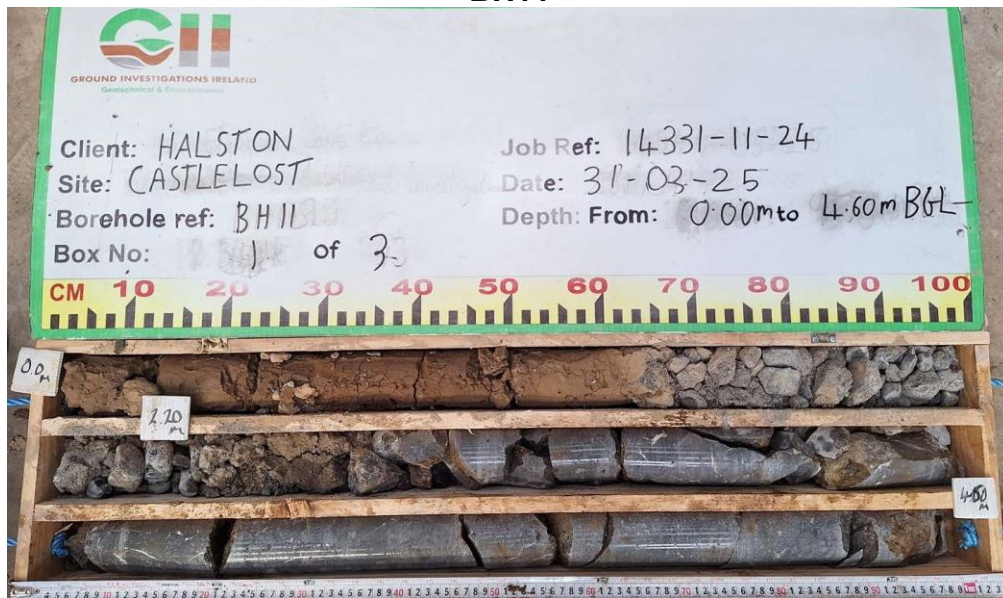




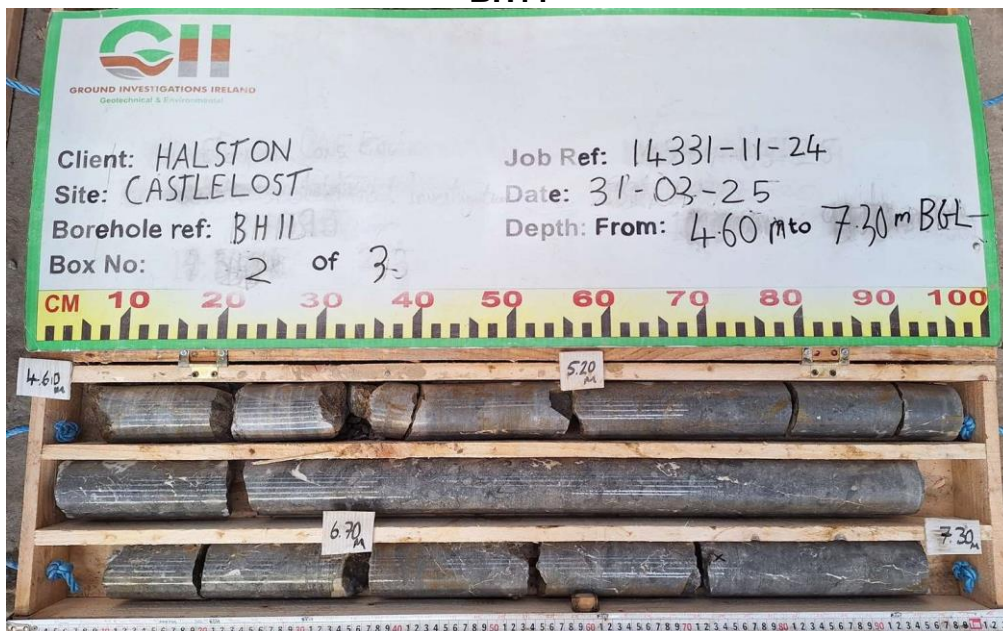


# Castlelost – RC Borehole Photos

## BH11

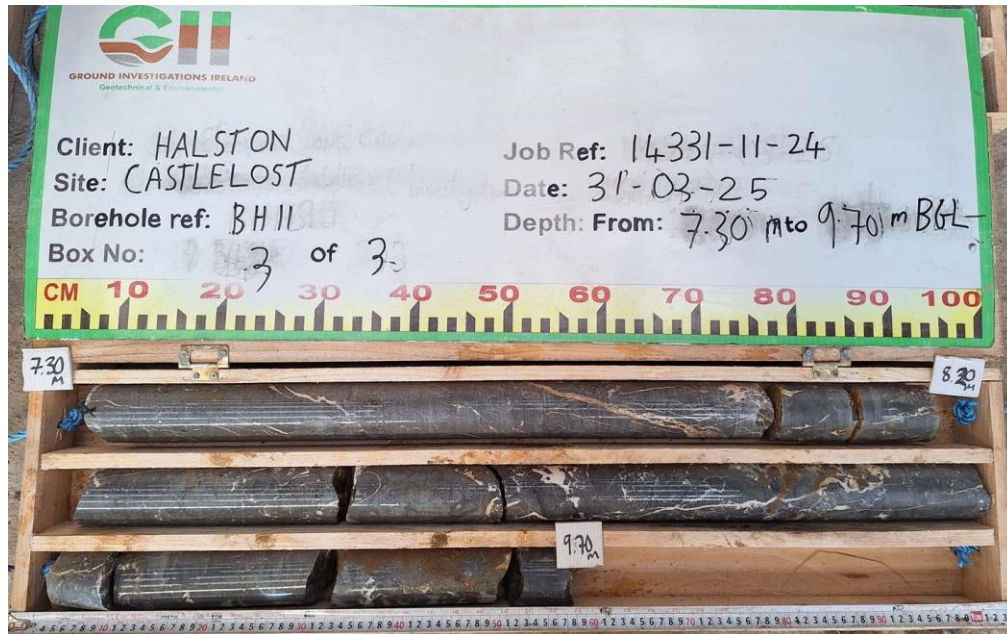


## BH11



# Castlelost – RC Borehole Photos

## BH11



# Castlelost – RC Borehole Photos

## BH12

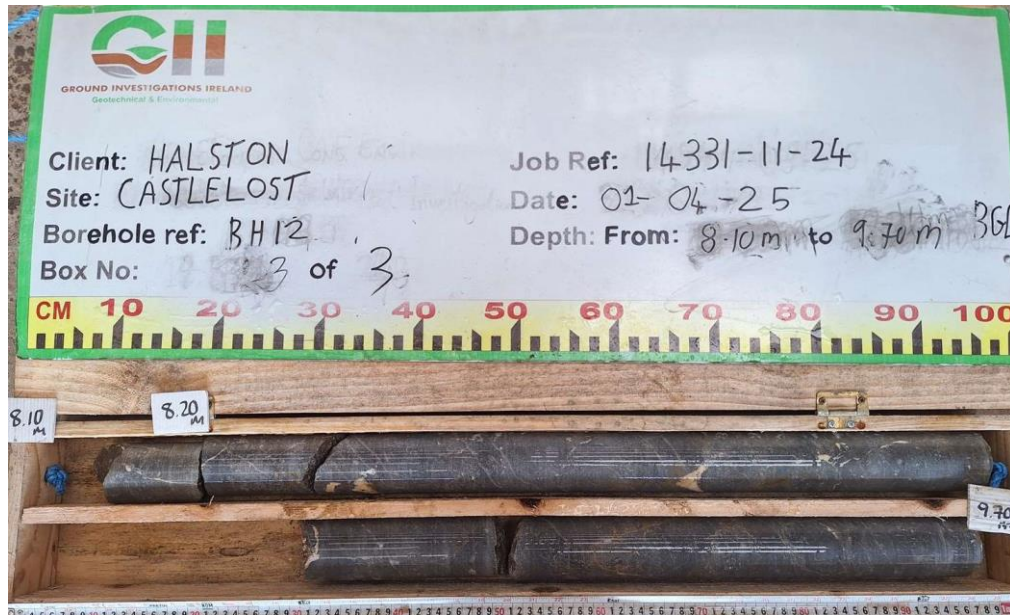


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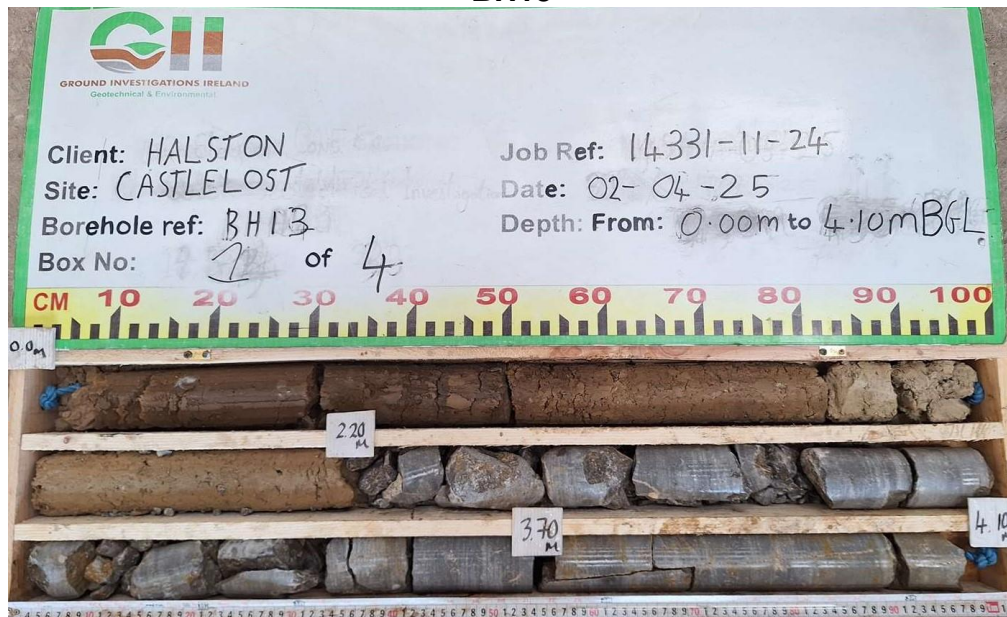
# Castlelost – RC Borehole Photos

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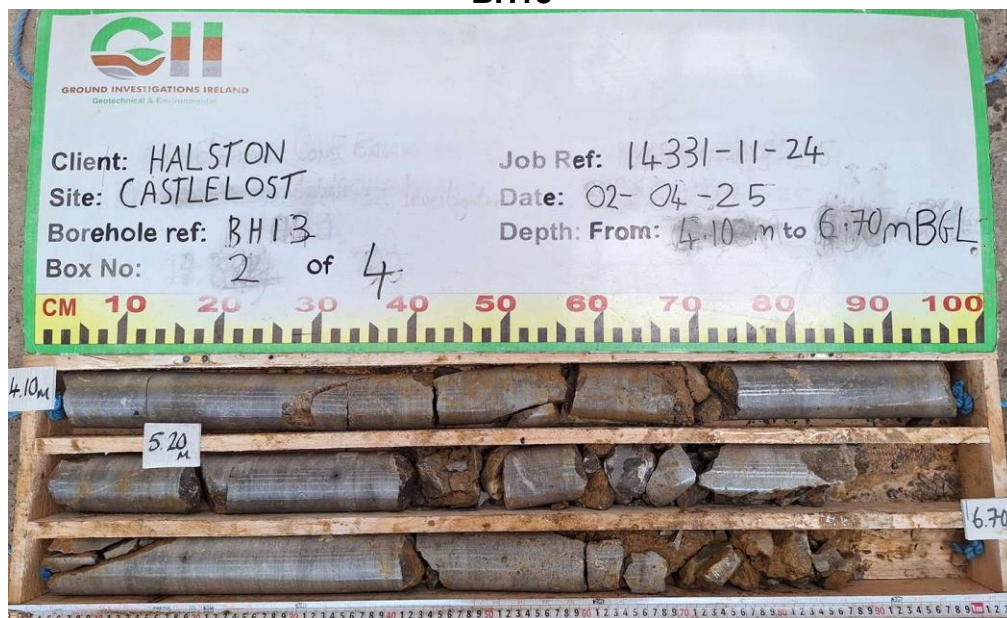


# Castlelost – RC Borehole Photos

## BH13

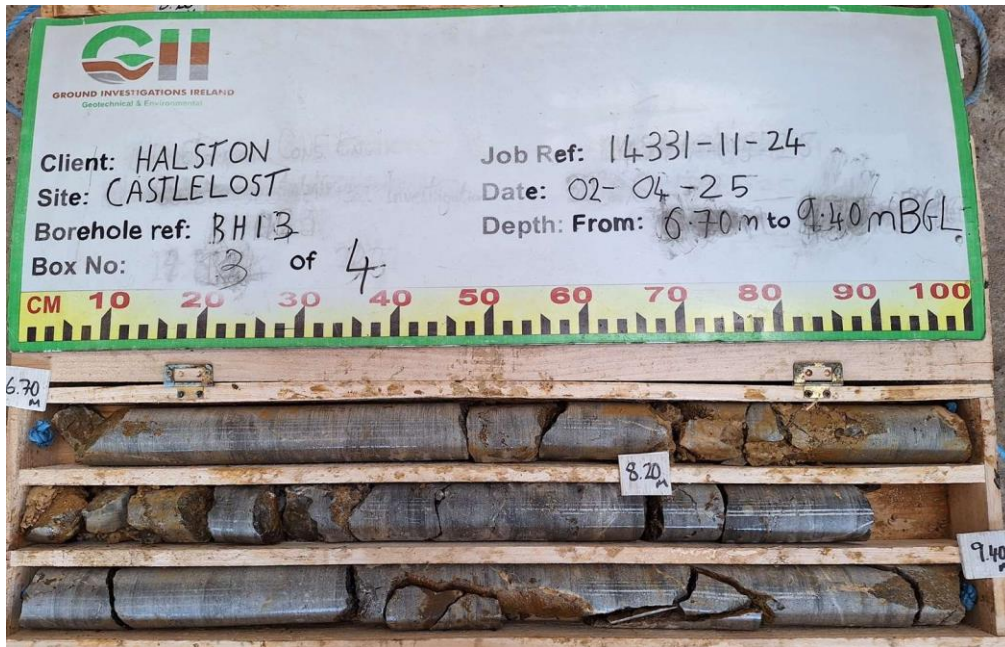


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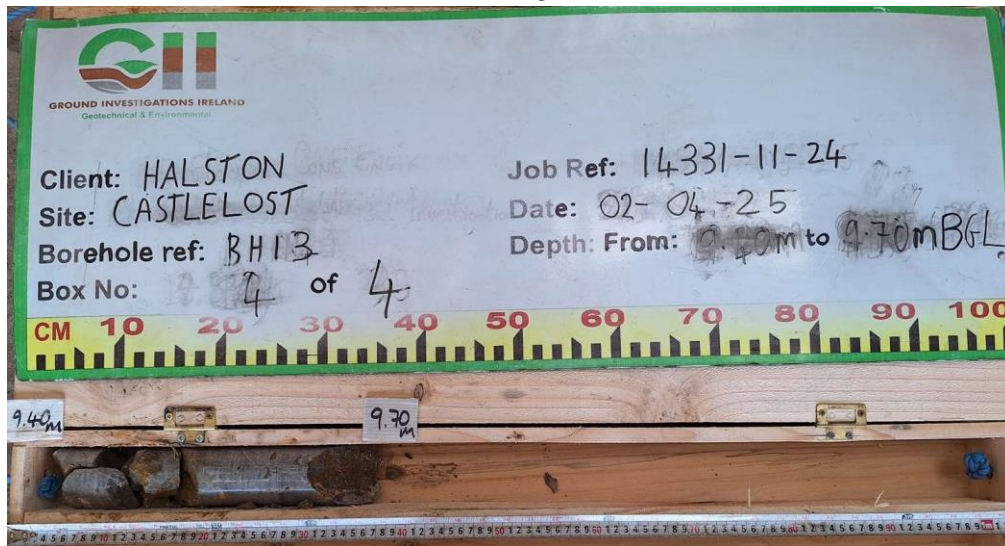


# Castlelost – RC Borehole Photos

## BH13

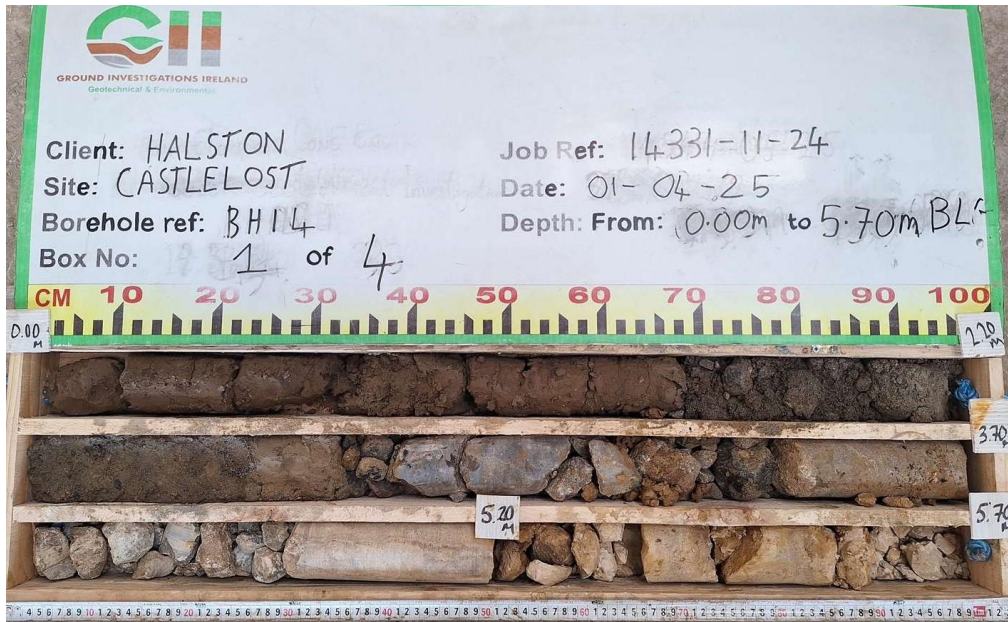


## BH13



# Castlelost – RC Borehole Photos

## BH14



## BH14

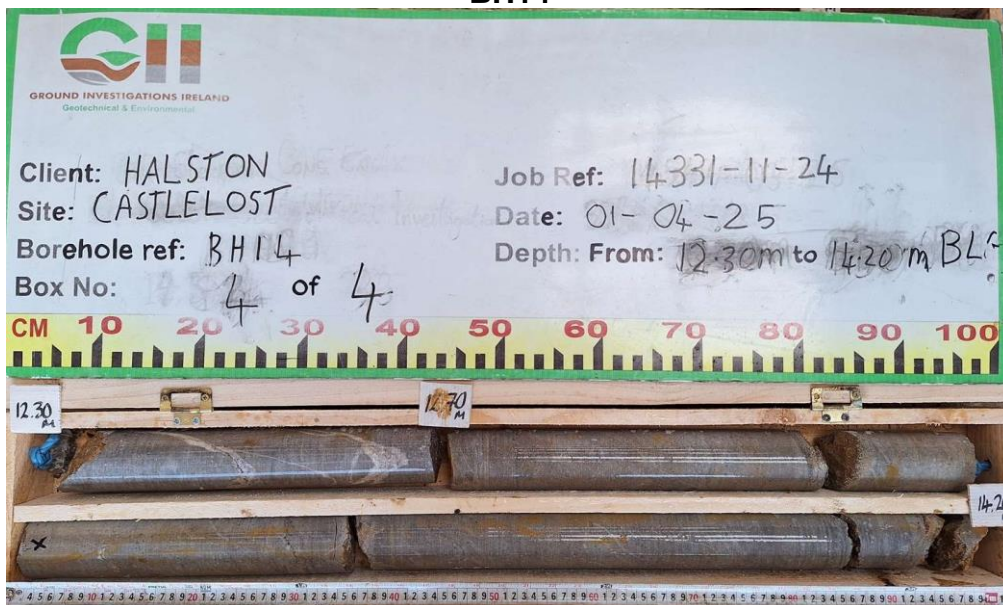


# Castlelost – RC Borehole Photos

## BH14



## BH14



# Castlelost – RC Borehole Photos

## BH15



## BH15

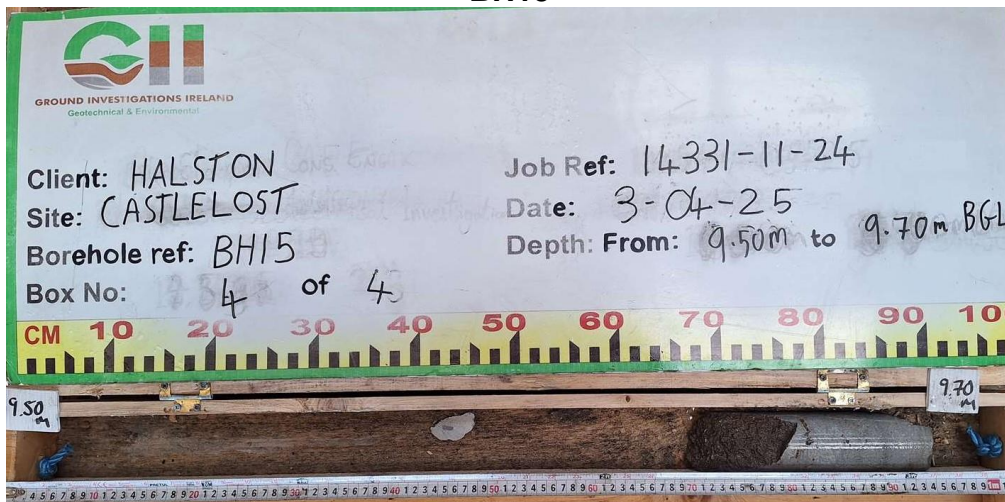


# Castlelost – RC Borehole Photos

## BH15



## BH15





## APPENDIX 8.1

(Superseded by Appendix 8.2)



## **APPENDIX 8.2**



# Revised Stage 3 Flood Risk Assessment

## Version 2

**LOCATION:** Kiltotan and Collinstown, Oldtown, Gneevebane, Farthingstown, Co. Westmeath

**PREPARED FOR:** Halston Environmental & Planning Ltd.

**PREPARED BY:** Cian O'Sullivan MEngSc (Hydrology)

**REVIEWD BY:** Colin O'Reilly PhD (Hydrology)

**DATE:** 10th June 2025

**REFERENCE:** 3151

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## 1 INTRODUCTION

The following flood risk assessment has been prepared by Cian O’Sullivan MEngSc (Hydrology) and reviewed by Colin O’Reilly PhD (Hydrology) of Envirologic Ltd. on behalf of Halston Environmental & Planning Ltd.

This report is intended to satisfy the requirements of Meath County Council, relating to a proposed development in the townland of Robinstown and Mullingar Town Centre, Co. Westmeath. The applicant is ORS and the proposed development, which is being referred to as ‘’, is to consist of:

As per the Flood Risk Management Guidelines (2009), where flood risk may be an issue for any proposed development, a flood risk assessment (FRA) should be carried out that is appropriate to the scale and nature of the development and the risks arising. The flood risk assessment outlined herein is intended to be sufficiently detailed to quantify the risks and effects of any flooding, necessary mitigation measures, together with recommendations on how to best manage any residual risks. As per the document ‘The Planning System and Flood Risk Management (2009)’ the flood risk assessment will consist of the following sections:

- Site description
- Site layout
- S-P-R model; sequential approach; justification test
- Determination of flood level
- Mitigation measures
- Conclusions

A site walkover and surveying of local hydrology was performed by Envirologic throughout April and May 2025.

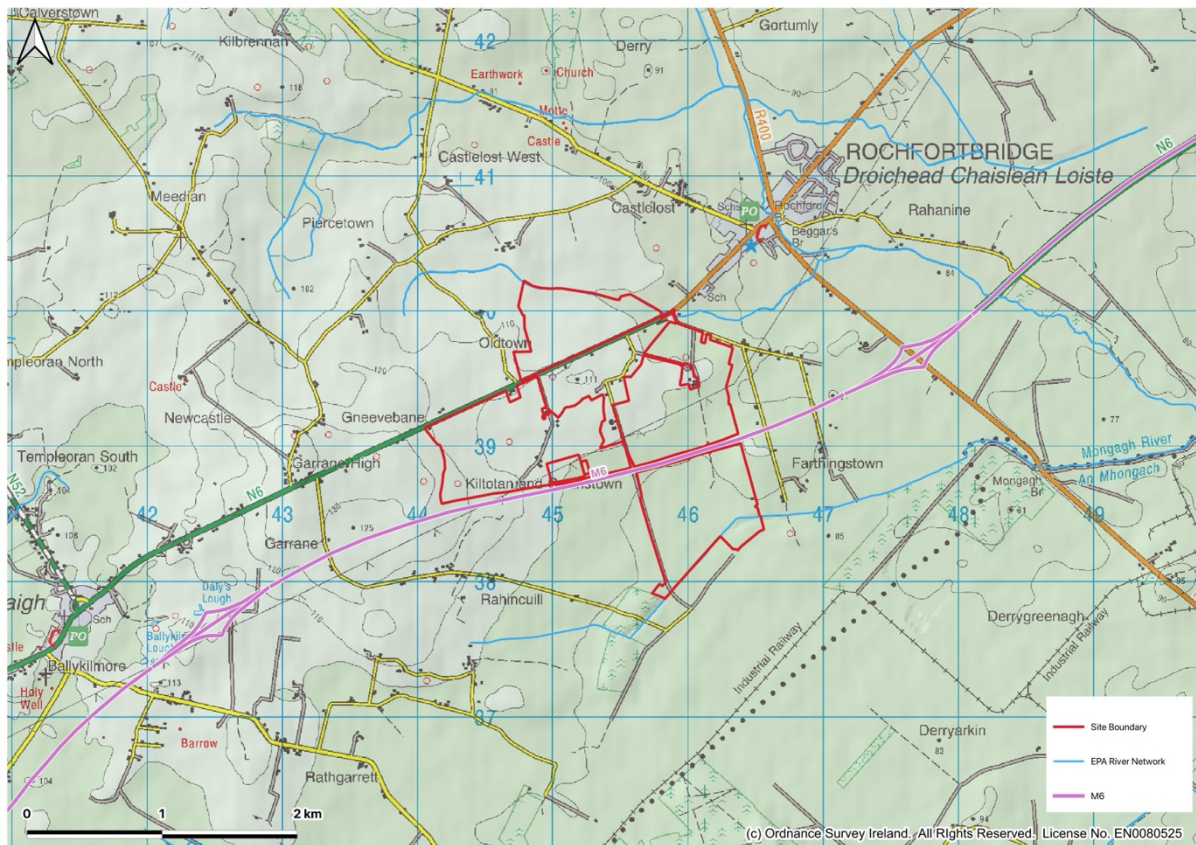
## 2 SITE DESCRIPTION

### 2.1 SITE LOCATION

The subject site is located in the townlands of Oldtown, Gneevebane, Farthingstown, Kiltotan and Collinstown, between the towns of Tyrellspass and Rochfortbridge (Figure 1). The M6 Galway to Dublin motorway and the N6 national road divides the site boundary into three discrete areas which will be henceforth referred to as the northern, central and southern portions.

Regional topography is considered to be undulating. There is a general gradient through the site from a local hill at Garrane High (140 mOD), 1 km to the west, in an east-southeast direction towards the Mongagh River. The 1:50,000 OS Discovery map shows that the 120 mOD contour line passes through the western site boundary and the 90 mOD contour line passes through the eastern site boundary. A 111 mOD spot height is found inside the northern portion of the site boundary, whilst a 90 mOD spot height is located 770 m to the east of the site boundary. The surrounding landscape is dominated by moderate intensity grassland agriculture with some tracts of forestry plantation on the southern side of the M6.

Figure 1 - Site Location and Topography



## 2.2 SITE LAYOUT

The proposed development site has an area of 240 ha (Figure 2). The site can be described as having an irregular shape comprised of:

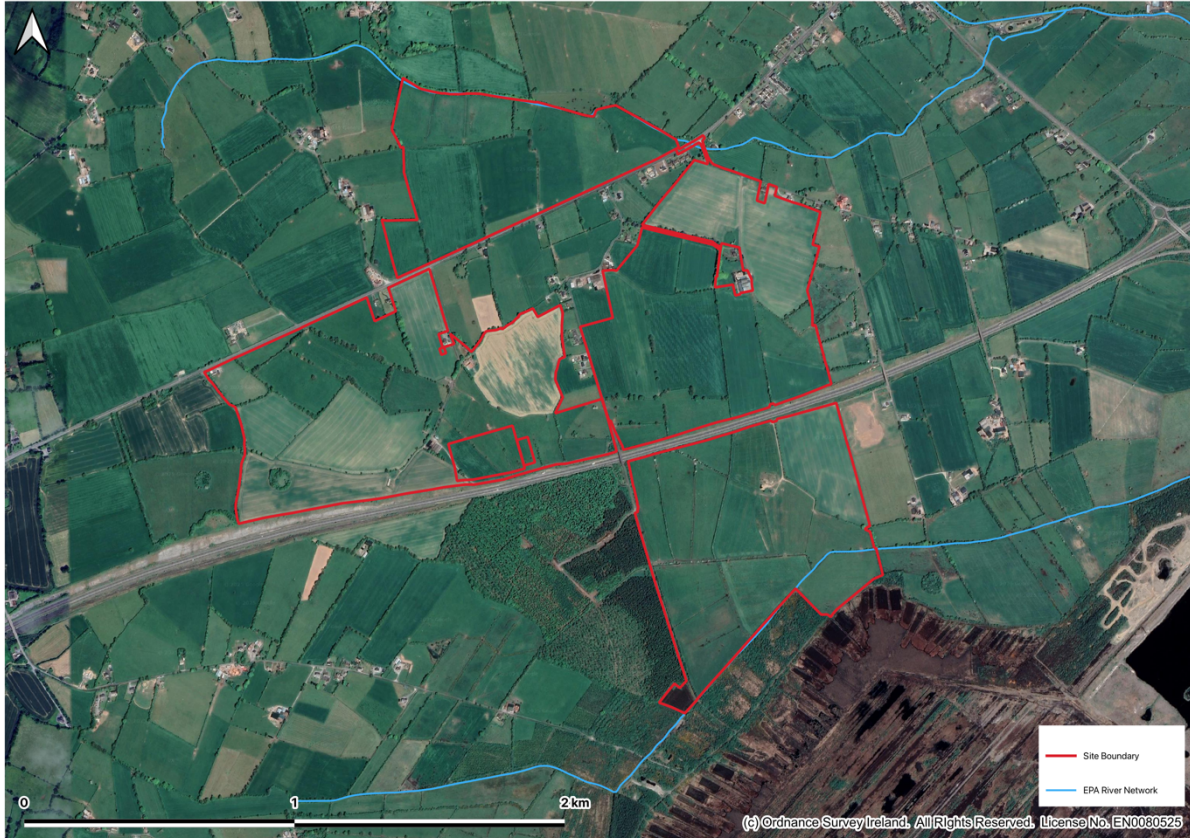
- i. The northern portion which is bounded to the south by the N6 and to the north by the Castlejordan River. This portion is entirely in greenfield condition, consisting moderate intensity grasslands.
- ii. The central portion which is bounded by the N6 to the north and the M6 to the south. This area contains the primary development features and has an east-west width of approximately 2,300 m and a north-south length of 2,500 m. Areas containing ribbon developments and one-off houses are excluded.
- iii. The southern portion which is south of the M6. This portion is entirely in greenfield condition, consisting moderate intensity grasslands. Forestry plantation to the west of this portion with cutaway noted to the south.

Energy-related infrastructure (permitted under PI. Ref. 21/515, 21/532, 23/60442, 24/60053) is in place in the southern part of the central portion and consists briefly of:

- Five open cycle gas turbine electrical generating units;
- 220 kV gas insulated switchgear electrical substation;
- Open area battery storage system compound.

To facilitate the proposed development works and provide access within the site boundary, two new bridge crossings are proposed across watercourses in the southern portion of the site.

Figure 2 – Site boundaries with EPA river network overlain



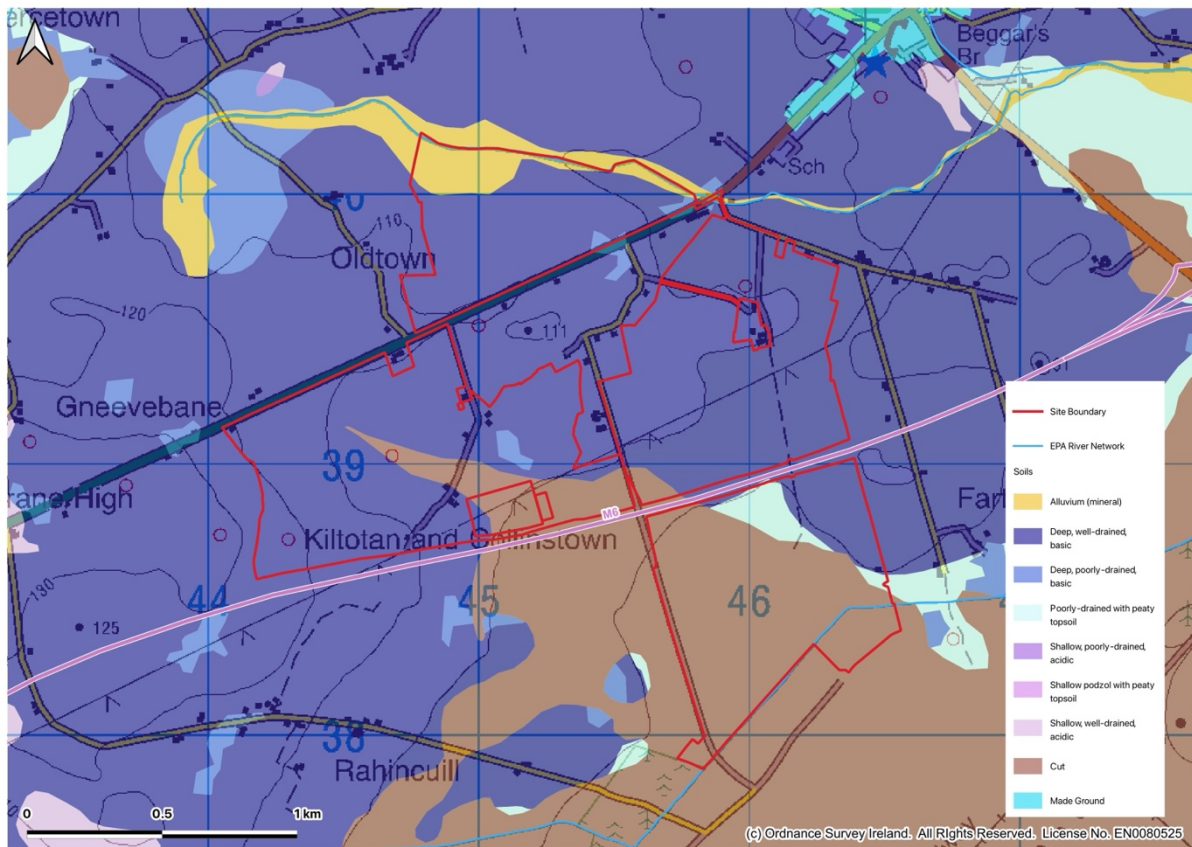
## 2.3 SOILS & GEOLOGY

### 2.3.1 Soils

Teagasc soil maps indicate that the soil types within the application boundary vary (Figure 3). Deep, well-drained soils dominate the northern and central portions of the site, with alluvium deposits underlying and flanking the Castlejordan River. A linear band of peat deposits extend into the southern area of the central portion.

The southern portion of the site is underlain by peat, with podzols mapped along the margins. It was noted during the site walkover that the southern site portion has undergone land improvement works which involved raising of ground levels, presumably by means of infill deposition to facilitate motorway construction.

Figure 3 - General Soil Classification

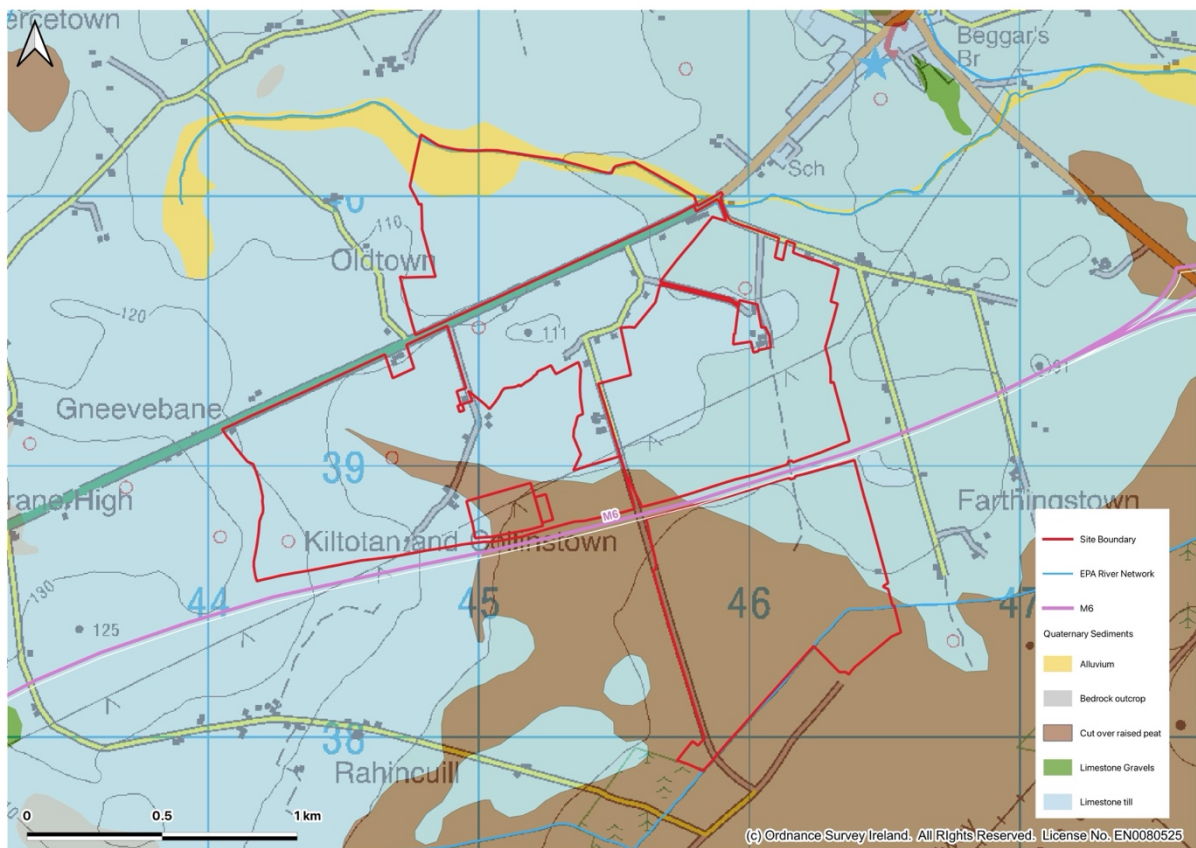


### 2.3.2 Quaternary Deposits

The quaternary period encompasses the last 1.6 million years and deals with the subsoils and sediments that were deposited over the bedrock described below. The Pleistocene (1.6 million years – 10,000 years ago) is commonly known as the last Ice Age, which was a period of intense glaciation separated by warmer inter-glacial periods, and it is during this period that the quaternary sediments seen today were deposited. Large amounts of ponded water were present at this stage resulting in considerable fluvio-glacial sedimentation.

The quaternary deposits map shows that the site is predominantly underlain by limestone till (Figure 4). This combination of deposit type is characteristic of sub-glacial regimes. There are no significant sand and gravel or esker deposits in the area.

Figure 4 - Quaternary Deposits



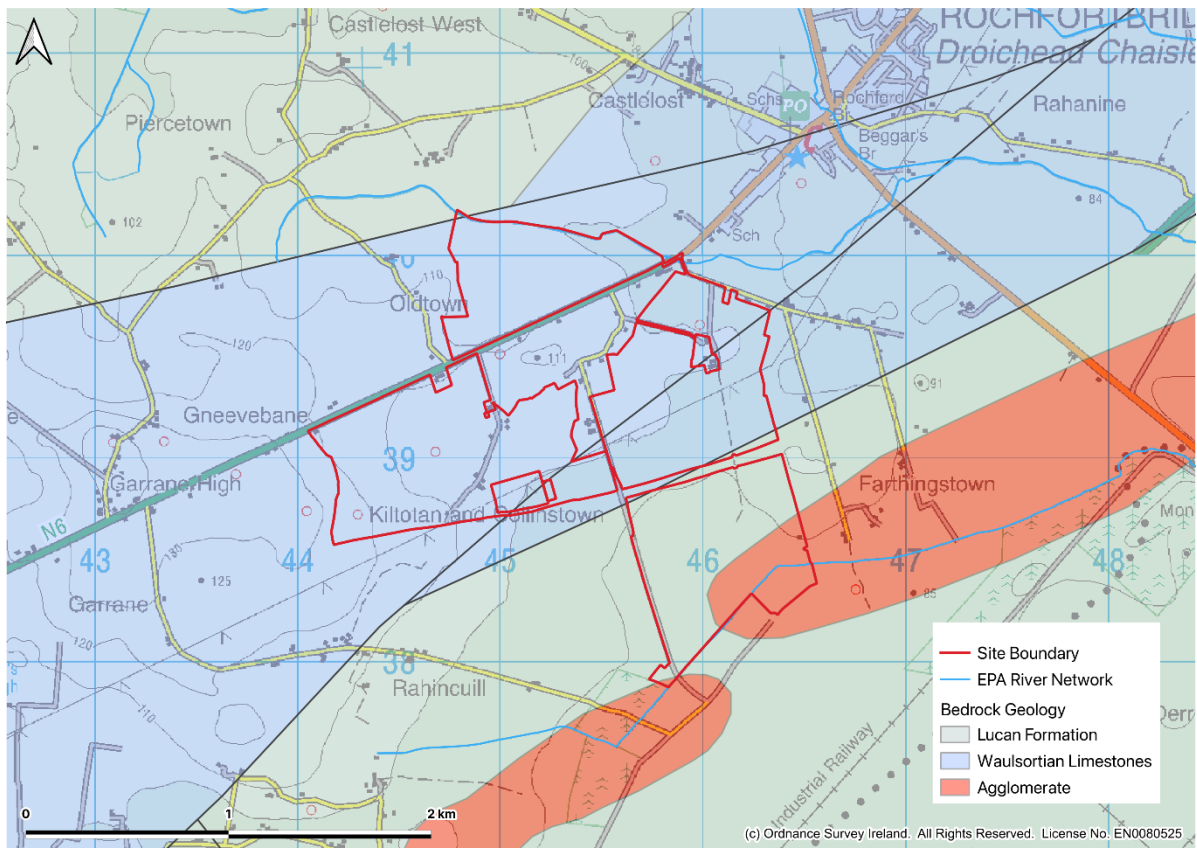
### 2.3.3 Bedrock & Structural Geology

The southern portion of the site is underlain by the Lucan Formation. This formation consists of impure bedded limestone with shale and/or clay impurities. The northern and central portions of the site are underlain by Waulsortian Limestone, which are characterised by massive, unbedded lime and mudstone deposits.

There are numerous structural geological features such as structural faulting mapped throughout the site boundary, as demonstrated in Figure 5.

The limestone formation is well exposed in a roadside cutting on the M6 southwest of the application site.

Figure 5 – Bedrock & Structural Geology



## 2.4 HYDROGEOLOGY

### 2.4.1 Aquifer Classification

The Waulsortian limestones underlying the site typically have a low-moderate permeability depending on presence or otherwise of karstification. No karst features or springs are mapped proximal to the site boundary. Figure 6 highlights that the bedrock aquifer underlying the site is locally important and moderately productive only in local zones (LI), with a small portion of the south east corner of the site described as being generally moderately productive (Lm).

### 2.4.2 Groundwater Vulnerability

Groundwater vulnerability across the site is classed by the GSI as varying from High to Moderate (Figure 7). In the northwest portion of the site, groundwater has been classified as being of High vulnerability. The remainder, and majority of the site, is classified as having Moderate groundwater vulnerability, representing moderately permeable till deposits greater than 10 m depth.

Figure 6 – Aquifer Classification

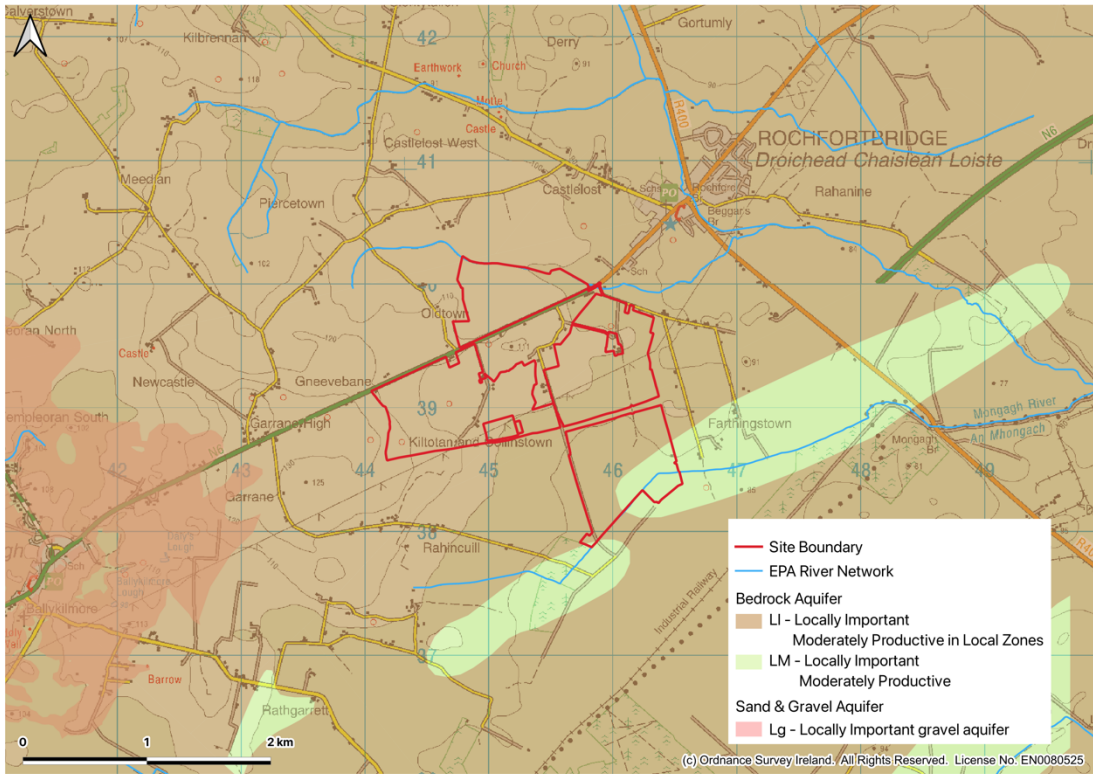
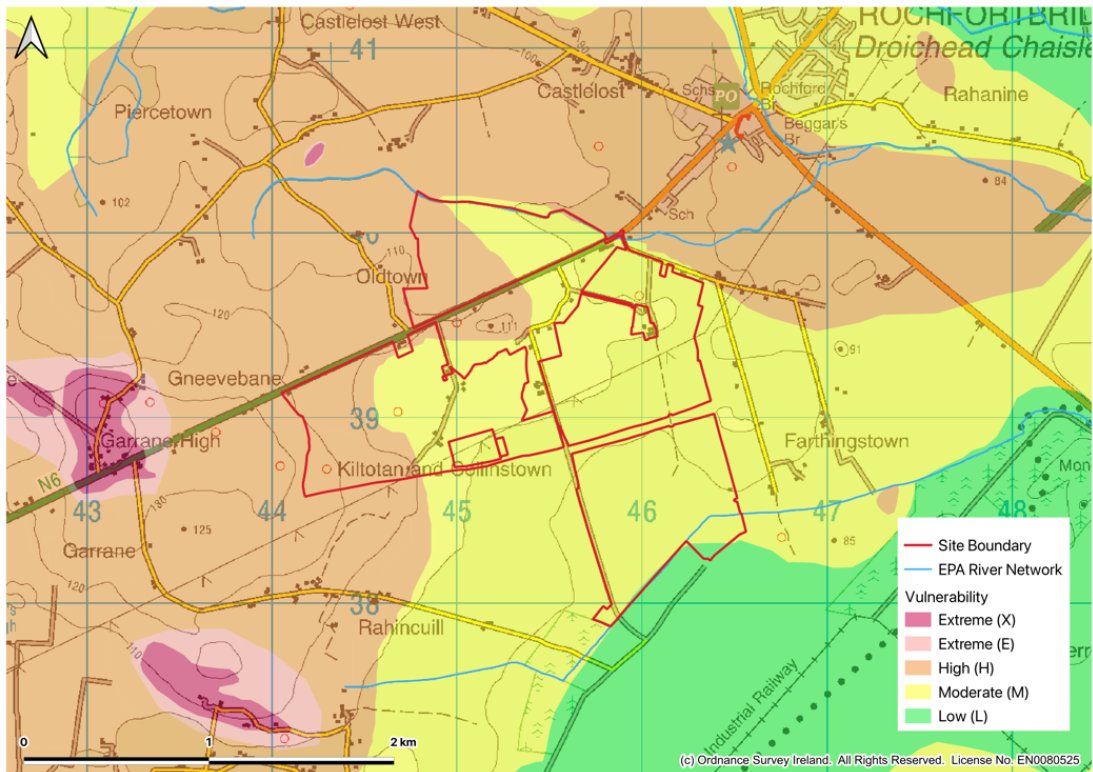


Figure 7 – Groundwater Vulnerability



### 2.4.3 [Hydrogeology and its Influence on Hydrology](#)

In general the aquifer is mapped as consisting of moderately permeable till deposits, however there may be localised areas where permeability and storativity in the aquifer is high. In a more permeable setting, and where the water table lies below the local river network it is likely that some stream water may pass into the aquifer. Where the water table is above the river stage, groundwater will leave the aquifer as baseflow. At lower elevations and depressions, groundwater seepage may occur as springs. Discharge of baseflow from the aquifer to the stream networks within the site boundary is not flashy and therefore likely to be sustained through drier periods of the year. During flooding the inverse occurs, and the aquifer offers large storage potential for flowing water to seep into it. When the flooding and associated high river flows subside, the hydraulic gradient is reversed and water will flow from the aquifer back into the river. This phenomenon is known as bank storage and is indicative of a highly interactive surface water groundwater system. It also accounts for the fact that streams bounded by permeable deposits exhibit less flashy flooding and higher baseflow in periods of dry weather.

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## 2.5 HYDROLOGY

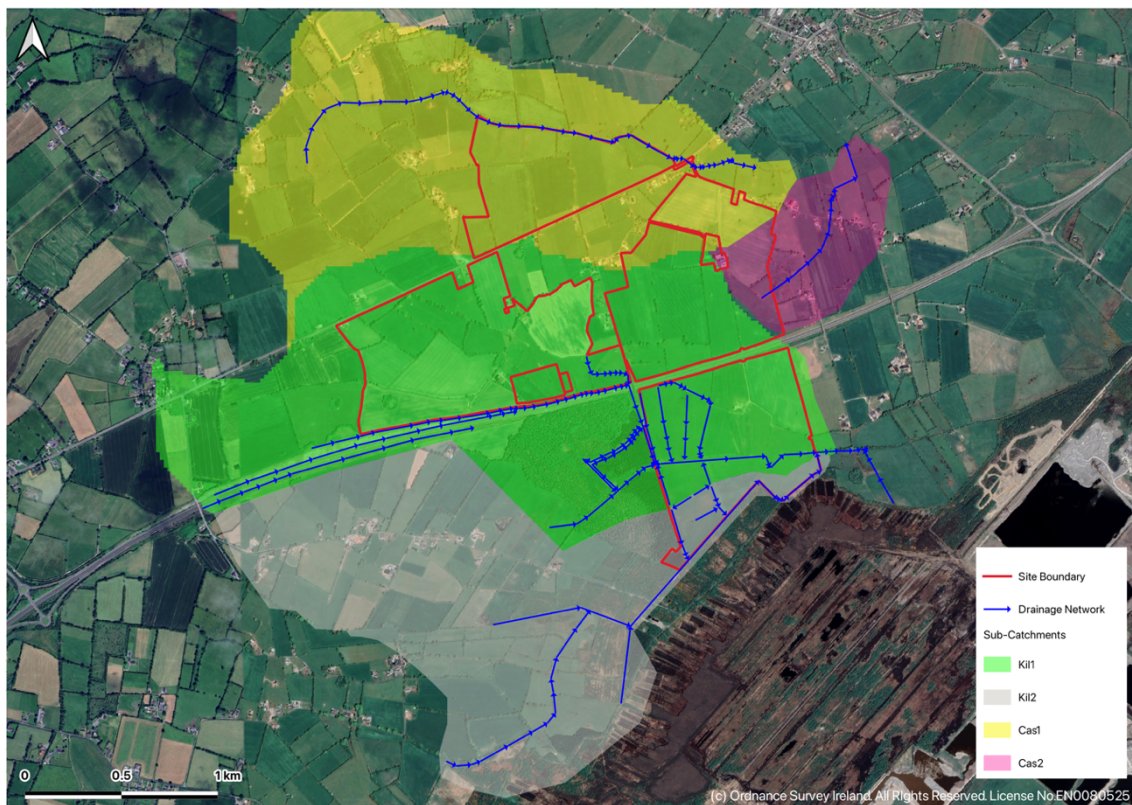
### 2.5.1 [Catchment Description](#)

The application site is located in the upper reaches of the Boyne Catchment (Hydrometric Area 07). Two mapped sub-catchments bisect the site boundary, the Castlejordan to the north (07\_1400) and the Kiltotan and Collinstown to the south (07\_564). These rivers drain to the east where they outfall to the Yellow River, which itself joins the main River Boyne channel 14 km east of the site boundary.

The EPA River Network database suggests that the divide between the Castlejordan and Kiltotan and Collinstown river catchments lies within the site boundary, broadly tracking along the N6 road and along elevated lands in the central portion of the site.

Subsequent ground truthing revealed there are four distinct sub-catchments within the site boundary (Figure 8). Natural flow pathways may have been disrupted through agricultural drainage and recent development works, the primary example of this being the M6 and its associated drainage system. The most significant flow pathways associated with each catchment are also highlighted.

Figure 8 – Sub-catchments associated with the site boundary



### 2.5.2 [Sub-catchment description: Kil1](#)

Kil1 is characterised by a relatively dense network of field drains from agricultural lands and culverts. Crucially, the main channel is considered to be that which directs water under the M6. This sub-catchment has an area of 3.47 km<sup>2</sup>. A detailed description of the flow network as surveyed is illustrated in Figure 9. The main channel, Kil1, rises in the centre of the catchment as a small field drain with an invert elevation of 110 mOD. It was noted across multiple site visits in May 2025 that the channel was dry at this elevation. Kil1 flows eastwards before being culverted southwards beneath the M6 motorway (Kil1\_01). Water was observed in the channel at an elevation of 92.73 mOD and a small flow was noted to be entering the culvert (approx. 0.5 l/s). A field drain which joins Kil1 at the inlet of the M6 culvert Kil1\_01 was noted as being dry for its entirety. A 450 mm culvert connects FD01 to Kil1\_01 where it enters the TII culvert network.

Two open drainage channels are present alongside the M6 (M6 North & M6 South), to the west of Kil1\_01, with 450 mm culverts connecting road runoff to the TII drainage network. The 450 mm culvert serving the M6 North channel was noted to be orientated in a south-east direction as it passes underneath the M6. The 450 mm culvert servicing the M6 South channel was oriented due east. Following an extensive walkover no outfall for either of these two culverts was identified in the forestry and agricultural lands south of the M6. A short salt tracing exercise was attempted to confirm the presence or otherwise of hydraulic connections between the M6 North and M6 South culvert inlets and the Kil1\_01 culvert outlet. This test yielded no detectable results but it was observed that water entering the M6 North and South culverts outfall to a sedimentation tank which would significantly dilute the salt introduced. This also confirms that these culverts are part of a constructed drainage network. Without additional drainage network maps it has been assumed that these culvert inlets connect at subsurface junctions and outfall

to Kil1\_01 culvert outlet (900 mm). In addition French drains track along both sides of the M6 (Figure 10) and slope towards Kil1\_01 culvert outlet.

Downstream of the M6 motorway, the Kil1 channel is fed by multiple field drains. These drains are not hydraulically connected to any sources upgradient (north) of the M6. It has been assumed that these were installed during raising of lands during motorway construction. The presence of standing water observed in FD02, FD03, FD04 and FD05 reinforces this. Surveyed water elevations confirm a general flow direction south towards Kil1. The channels would benefit from drainage maintenance works to remove vegetation and silt that has accumulated in places. Similarly FD06, FD07, FD08 and FD09 contained standing water, but surveyed water elevations implied an easterly flow direction towards Kil1.

**Figure 9 – Kil1 detailed drainage network**



### 2.5.3 Sub-catchment description: Kil2

Kil2 is comprised of three channels maintained by the OPW as part of the Boyne East Arterial Drainage Scheme (C1/64/1, C1/64/1/16 and C1/64/1/18). This sub-catchment has an area of 2.59 km<sup>2</sup> and acts as a tributary to the main Kil1 channel. The confluence of these two watercourses is at the southeast corner of the site boundary. The main channel is known as the Kiltotan and Collinstown (EPA code: 07K04) and is characterised by steep banks as a result of regular OPW maintenance. Contrary to the mapped EPA River Network and OPW Drainage Network databases, the walkover confirmed that this channel runs alongside the southern site boundary (Figure 8) and does not cut across the south east corner as is mapped in Figure 2. No major inflows to the channel were noted during site visits.

Figure 10 – French drains and their flow direction along the M6 towards Kil1



#### 2.5.4 [Sub-catchment description: Cas1](#)

Cas1 is the northernmost catchment that interacts with the application site, flowing alongside the northern site boundary. The channel is named the Castlejordan Stream (EPA code: 07C04) and has an area of 2.59 km<sup>2</sup>. It is characterised by steep banks following regular drainage maintenance (C1/64/1/13/4). There are multiple field drains that direct surface water into the main channel, but none contained water during multiple site visits through May 2025. There were no other major inflows to the channel as it passes through the site boundary. The channel is culverted under the R446, where it continues downstream before joining the Rochfortbridge Stream, approximately 1.4 km east of the site boundary.

#### 2.5.5 [Sub-catchment description: Cas2](#)

Cas2 is the easternmost catchment and only interacts with a very small part of the application site. It has an area of 0.52 km<sup>2</sup>, of which only 0.1 km<sup>2</sup> lies within the site boundary. It is essentially a field drain within the eastern portion of the site which directs surface water north towards the Castlejordan stream. The catchment is within agricultural lands. In a manner consistent with Kil2 and Cas1, the channel banks are steep following drainage works aimed at containing water within the channel.

## 2.5.6 [Designated Areas](#)

Designated areas within the area are presented in Table 1. The River Boyne and River Blackwater SPA and SAC are hydraulically connected to the site via downstream drainage 24 km to the east. A number of other ecological designated areas are proximal to the site boundary

**Table 1 – Summary of Designated Sites Within a 15 km Radius of the Site**

Ecological Designated Sites	Site Code	Location at Closest Point to the Proposed Project
Cloncrow Bog NHA	000677	3 km west
Lough Ennell SAC & pNHA	000685	6 km north west
Raheenmore Bog SAC & pNHA	000582	6 km south
Milltownpass Bog NHA	002323	7 km north east
Black Castle Bog NHA	000570	12 km south east
River Boyne and River Blackwater SPA & SAC	004232	24 km east

## 2.5.7 [Flooding History](#)

### 2.5.7.1 [Historical OSI Maps](#)

The historical 6" OSI maps (1830 - 1930) show no evidence of historical flooding at the application site (Plate 1). It is noted from the historical 6" maps that field drainage networks have since been disrupted by infrastructure projects such as the M6 motorway. Channels associated with the Kil1, Kil2 and Cas1 catchments are largely shown as being present on historical maps.

### 2.5.7.2 [OPW Flood Hazard Mapping](#)

Consultation of the OPW flood hazard mapping tool shows that one flood event was recorded within 5 km of the site boundary (Plate 2). This flood event was recorded in 2005 and refers to recurring flooding in low-lying spots on the roads in the area of Piercetown. No previous flooding events have been recorded with respect to the watercourses that flow through the site boundary.

Plate 1 - Historical 6" OSi maps (1830 - 1930)

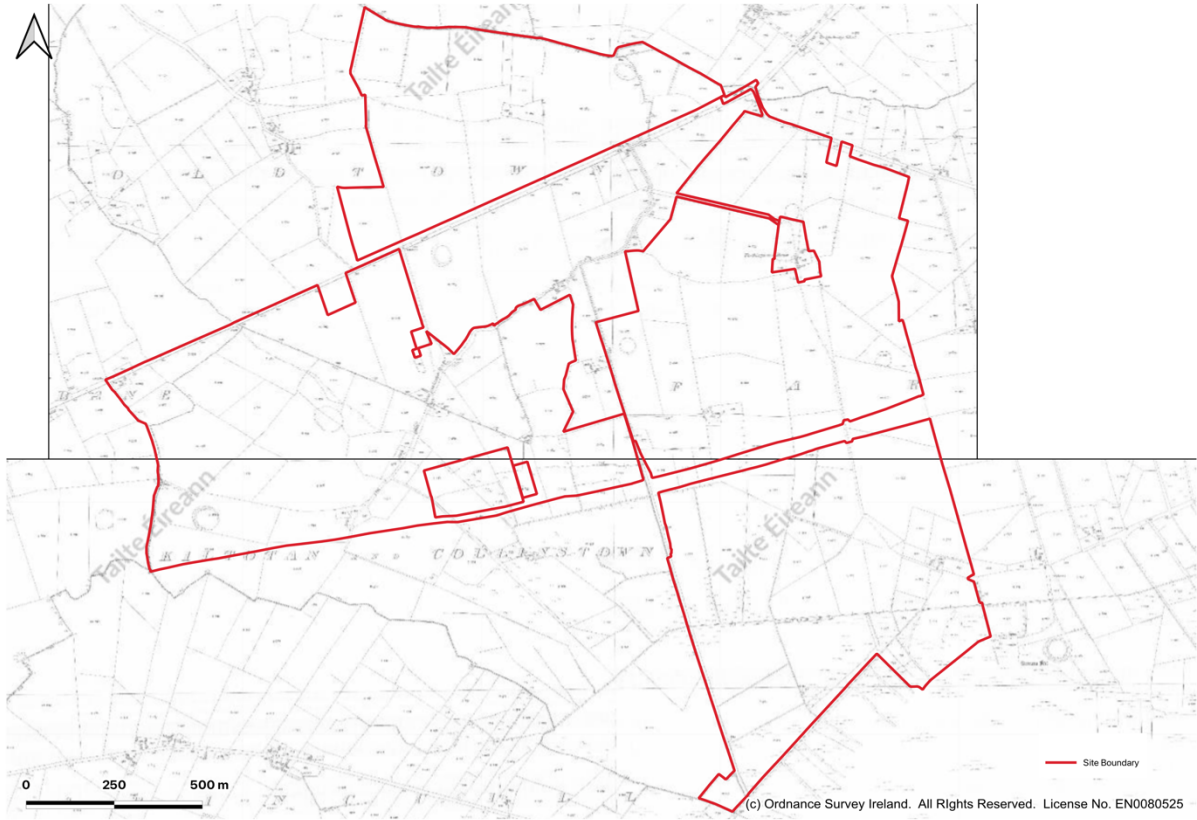


Plate 2 - OPW Historical Flood Events Map



## 2.5.8 [Flood Risk Indicators](#)

### 2.5.8.1 National Indicative Fluvial Mapping (NIFM)

The margins flanking the Kiltotan and Collinstown stream are covered by OPW National Indicative Fluvial Mapping (NIFM), which infers flood risk on the margins of the cutaway bog south of the site boundary (Plate 3). Predicted flood waters appear to encroach only marginally on these lands at the southern site boundary. No other channels associated with the application site exhibit flooding according to the NIFM.

**Plate 3 – OPW National Indicative Fluvial Mapping flood extents**



## 2.5.9 [CFRAM](#)

The OPW FloodInfo resource shows that the channels within the site boundary have not been covered by detailed CFRAM hydraulic modelling or CFRAM Indicative flood mapping.

## 2.5.10 [Benefitting Lands](#)

Plate 4 shows that a large portion of the site boundary lies within benefitting lands, tracking along the watercourses associated with the Kil1, Kil2 and Cas1 catchments. These maps were prepared to identify areas that would benefit from land drainage schemes and typically indicate low lying land near watercourses that would be prone to flooding.

The emphasis of these schemes was the improvement of agricultural land. With respect to the site boundary, Plate 4 confirms that there are multiple channels which are maintained as part of the Boyne Arterial Drainage Scheme.

It is noted that the OPW Drainage Map also corresponds with the drainage network layout that was groundtruthed as part of the site walkover, with respect to the Kil2 channel. This is further evidence that the EPA river network map is incorrect in the southern portion of the application site.

**Plate 4 - Drainage Channels and Benefitting lands**



### 3 SEQUENTIAL TEST & VULNERABILITY MATRIX

#### 3.1 SEQUENTIAL APPROACH

The 'Planning System and Flood Risk Management Guidelines for Planning Authorities (2009)' require the planning system at national, regional, and local levels to:

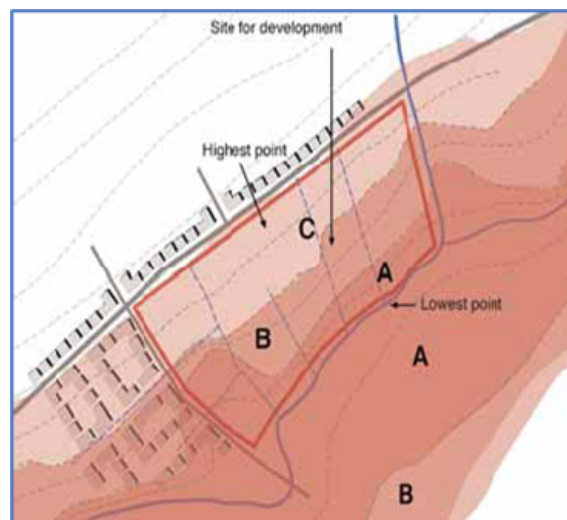
- Avoid development in areas at risk of flooding by not permitting development in flood risk areas, particularly floodplains, unless where it is fully justified that there are wider sustainability grounds for appropriate development and unless the flood risk can be managed to an acceptable level without increasing flood risk elsewhere and where possible, reducing flood risk overall.
- Adopt a sequential approach to flood risk management based on avoidance, reduction and then mitigation of flood risk as the overall framework for assessing the location of new development in the development planning processes; and

- Incorporate flood risk assessment into the process of making decisions on planning applications and planning appeals.

The sequential approach is used to assess flood risk at the site and, where there is variability, to assign appropriate zones in accordance with the Guidelines (DoEHLG, 2009). As shown in Plate 5, Zone A, applied to areas with a high probability of flooding, defines areas with the highest risk of flooding from rivers (i.e. more than 1% probability or more than 1 in 100). Development in this zone should be avoided and/or only considered in exceptional circumstances. Development should only be permitted in areas at risk of flooding when there are no alternative, reasonable sites available in areas at lower risk that also meet the objectives of proper planning and sustainable development. Zone B is applied to areas with a moderate probability of flooding from rivers. (i.e. a 0.1% to 1% probability or between 1 in 1000 and 1 in 100), with Zone C having a low probability of flooding.

With respect to coastal flooding Zone A is applied to areas with the highest risk of coastal flooding (i.e. more than 0.5% probability or more than 1 in 200 year return period). Development in this zone should be avoided and/or only considered in specified circumstances. Zone B is applied to areas with a moderate probability of coastal flooding (between 1 in 200 and 1 in 1000), with Zone C having a low probability of coastal flooding (less than 0.1% or 1 in 1000). The Flood Risk Assessment will clarify within which zone the site lies.

**Plate 5 – Schematic map showing use of the Sequential Approach to assign Flood Risk Zones (DoEHLG, 2009)**



### 3.2 VULNERABILITY MATRIX

Clause 2.16 of the Flood Management Guidelines (OPW, 2009) states: 'The classification of different land uses and types of development as highly vulnerable, less vulnerable and water-compatible is influenced primarily by the ability to manage the safety of people in flood events and the long-term implications for recovery of the function and structure of buildings.'

The Planning System and Flood Risk Management guidelines provide three vulnerability categories based on the development type. The proposed works fall into the following vulnerability categories as follows:

- **Highly vulnerable** = residential, hospitals, schools, **essential infrastructure**, emergency service facilities.

- **Less vulnerable** = buildings used for retail, warehousing, commercial, **industrial** and non-residential institutions.
- Water-compatible development = amenity open space, outdoor sport and recreation.

Different types of development are appropriate in each of the Flood Zones, based on their vulnerability to flood risk. Hence:

- **Highly vulnerable: requires Justification test in Flood Zone A and Flood Zone B, appropriate in Flood Zone C;**
- **Less vulnerable: requires Justification test in Flood Zone A; appropriate in Flood Zone B and Flood Zone C;**
- Water-compatible: appropriate in Flood Zones A, B and C.

Highly vulnerable development should only be considered in zones A and B if adequate lands or sites are not available in Zone C and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to and from the development can or will adequately be managed at the site.

The development works proposed in the central portion of the site are considered to be ‘essential infrastructure’ and therefore comes under ‘highly vulnerable development’. The solar farm has been designed to be a water compatible land use, due to all solar panels being raised above maximum predicted flood level, hence the solar panels are deemed appropriate to progress in Flood Zones A, B and C.

Based on desktop information collected to this point the majority of the site is deemed to be within Flood Zone C. Based on the NIFM database a small area in the southern portion of the application site may be in Flood Zone A. The hydraulic capacity of the proposed bridges will also be investigated as part of the modelling exercise.

A conservative approach is being applied and the assessment will proceed to quantitative determination of flood levels in watercourses adjacent to the site. Unless the quantitative assessment shows the site to be in Flood Zone A or Flood Zone B then a Justification Test is not required.

### 3.3 S-P-R MODEL

The flood risk assessment is carried out using the source-pathway-receptor (S-P-R) model, as outlined below. The S-P-R model is used to identify the sources of flood water, the people and assets affected by potential flooding, and the pathways by which the flood water reaches those receptors.

Consideration will be given to the predominant sources, pathways and receptors in terms of the influence they have on site flooding, or the manner in which they may be impacted. The primary water sources on site are as follows:

Sources	Pathways	Receptors
Extreme rainfall event (1 in 100 year)	Pluvial Flooding	Proposed Site
Channels within site boundary	Fluvial Flooding	Proposed Site Infrastructure
Runoff from upgradient lands	Road Runoff	Local Road & M6
Drainage/throughflow from upgradient lands	Field Drains	Third Party Lands and Property

The risk of pluvial flooding is considered to be low. No significant enclosed topographical depressions were noted on the site topographical survey. The topographical gradients and the dense surface water drainage network means that there is low probability of rainfall accumulating within the application site.

Based on the findings of the desktop assessment fluvial flooding is considered to be the primary flood mechanism. Fluvial flooding mechanisms will be looked at in more detail to quantify flood risk from the various catchments within the site boundary. Quantification of this risk will be achieved by firstly determining flood flows in the watercourses as they flow through/past the site.

A hydraulic model will then be compiled to facilitate estimation of flood levels within, and adjacent to, the site when these peak flows are passed through a series of surveyed cross sections. Mitigation measures will then be applied as appropriate.

## 4 SUBJECT SITE FLUVIAL FLOOD FLOW CALCULATIONS

### 4.1 OPW ADVICE

In selecting appropriate formulae reference has been made to an advisory response from OPW Hydrology Section and Work Package 4.2:

- For catchments between 5 km<sup>2</sup> and 25 km<sup>2</sup> the preferred equation is the 'FSU small catchments' equation. When using the small catchment equation, we generally advocate not using a pivotal site adjustment seeing as there is a very small pool of other small catchments from which to source a pivotal site.
- For catchments less than 25 km<sup>2</sup> we would always say that at least three methods should be explored and that the choice of the flow to be used is up to the practitioner.
- The WP4.2 report is intended to provide a further methodology for small catchment flood estimation. As far as we are concerned, it is the preferred method.
- For catchments less than 5 km<sup>2</sup> there is no FSU method applicable. For such 'small' catchments we would suggest that maybe the rational method or modified rational method could be used.

The OPW FSU method alone may therefore be deemed unsuitable for the calculation of potential flood flows in this instance.

Flood flow calculations for each sub-catchment are presented below.

### 4.2 FLOOD FLOW CALCULATIONS: KIL1

#### 4.2.1 [OPW FSU - 7 Variable Equation](#)

The ungauged method can be used to determine flood flows at the site using catchment characteristics, which are then corrected using a correlation against descriptors for gauged catchments. The median annual maximum flood magnitude (QMED), as outlined in the Flood Studies Update (FSU) (Nicholson & Bree 2013) is now preferred over the mean annual flood flow rate ( $Q_{\text{bar}}$ ) parameter described in the Flood Studies Report (FSR) (NERC 1975). The

preferred median method is less sensitive to large extreme floods and to flood measurement error in general. The estimation method for ungauged locations is based on a regression analysis relating observed QMED to physical catchment descriptors (PCDs) at gauged locations in Ireland, given by the following equation:

$$QMED_{rural} = 1.237 \times 10^{-5} \cdot AREA^{0.937} \cdot BFI_{soil}^{-0.922} \cdot SAAR^{1.306} \cdot FARL^{2.217} \cdot DRAIN^{0.341} \cdot S^{0.185} \cdot (1 + ARTDRAIN2)^{0.408}$$

The PCDs applicable to the Kil1 catchment are shown in Table 2.

**Table 2 - Physical Catchment Descriptors Applicable to the Kil1 catchment**

PCD	Description	Units	Value
AREA	Catchment area	km <sup>2</sup>	3.47
SAAR	Average annual rainfall	mm	901.14
BFIsoil	Baseflow index derived from soils data		0.727
FARL	Flood attenuation from reservoirs and lakes		1
DRAIN	Ratio of river network to catchment area	no./km <sup>2</sup>	0.507
S <sub>1085</sub>	Slope of the main stream between the 10 and 85 percentiles	m/km <sup>2</sup>	5.559
ARTDRAIN2	Proportion of river network included in drainage schemes		0.802
URBEXT			0
QMED <sub>rural</sub>		m <sup>3</sup> /s	0.534
QMED <sub>urban</sub>		m <sup>3</sup> /s	0.534

A principal of the FSU is the concept of a pivotal site, however no pivotal sites were considered suitable for application to such a small catchment. The return-period flood flow (Q<sub>T</sub>) is determined by an index flood method, whereby a growth factor as determined from an EV1 distribution plot is applied. In this case:

$$Q_t = QMED \times 2.55$$

$$Q_{100} = 0.534 \text{ m}^3/\text{s} \times 2.55$$

$$Q_{100} = 1.36 \text{ m}^3/\text{s}$$

Finally, a climate change growth factor of 20 % is applied:

$$Q_{100} = 1.36 \times 1.2$$

$$Q_{100} = 1.63 \text{ m}^3/\text{s}$$

Using the standard OPW FSU approach the climate adjusted Q<sub>1000</sub> flow in the watercourse as it passes the site is equal to:

$$Q_{1000} = QMED \times 3.33$$

$$Q_{1000} = 0.534 \text{ m}^3/\text{s} \times 3.33$$

$$Q_{1000} = 1.81 \text{ m}^3/\text{s}$$

#### 4.2.2 OPW FSU – Small Catchments

The updated Flood Studies Update (Nicholson and Bree, 2013) presents the formula suited to catchments less than 25 km<sup>2</sup>:

$$Q_{MED_{rural}} = 2.0951 \times 10^{-5} \cdot AREA^{0.9245} \cdot BFI_{soil}^{-0.9030} \cdot SAAR^{1.2695} \cdot FARL^{2.3163} \cdot S^{0.2513}$$

The same PCDs shown in Table 2 are again applied. This equation yields a  $Q_{MED}$  value of 0.32 m<sup>3</sup>/s. As per the OPW Guidelines a pivotal site adjustment factor is not being applied to the outcome of the small catchments equation.

In this case the  $Q_{100}$  flood flow is determined as follows:

$$Q_T = Q_{MED} \times \text{growth factor}$$

$$Q_{100} = 0.324 \text{ m}^3/\text{s} \times 2.55$$

$$Q_{100} = 0.825 \text{ m}^3/\text{s}$$

Finally, a climate change growth factor of 20% is applied:

$$Q_{100} = 0.825 \times 1.2$$

$$\mathbf{Q_{100} = 0.99 \text{ m}^3/\text{s}}$$

In this case the  $Q_{1000}$  flood flow is determined as follows:

$$Q_{1000} = Q_{MED} \times 3.33$$

$$Q_{1000} = 0.324 \text{ m}^3/\text{s} \times 3.33$$

$$\mathbf{Q_{1000} = 1.1 \text{ m}^3/\text{s}}$$

#### 4.2.3 OPW FSU – 3 Variable Method

The FSU 3-variable equation was developed as part of the FSU. It was developed as a 'short cut' equation for the estimation of flow in ungauged catchments:

$$Q_{MED} = 0.000302 \cdot AREA^{0.829} \cdot SAAR^{0.898} \cdot BFI^{1.539}$$

$$Q_{MED} = 0.23 \text{ m}^3/\text{s}$$

Application of the relevant growth factors as per above results in:

$$\mathbf{Q_{100+cc} = 0.715 \text{ m}^3/\text{s}}$$

$$\mathbf{Q_{1000} = 0.794 \text{ m}^3/\text{s}}$$

4.2.4 [Flood Studies Report, FSR \(NERC 1974\)](#)

This is the original FSR method, with the regression coefficient for Ireland. Estimates from this equation should be treated with extreme caution. Growth factor of 1.96 was applied to determine Q<sub>100</sub>. It is recommended that these equations should be used only for preliminary flood estimates.

$$Q_{BAR} = 0.0172 \cdot AREA^{0.94} \cdot STMFRQ^{0.27} \cdot S_{1085}^{0.16} \cdot SOIL^{1.23} \cdot RSMD^{1.03} \cdot (1 + LAKE)^{-0.85}$$

**Table 3 - Calculations of Q<sub>100</sub> – FSR Ungauged Catchments**

Area, km <sup>2</sup>	STMFRQ, jn/km <sup>2</sup>	S <sub>1085</sub> , m/km	SOIL	RSMD	LAKE	Q <sub>BAR</sub> m <sup>3</sup> /s	Q <sub>BAR</sub> x 1.96 gf m <sup>3</sup> /s	Q <sub>100</sub> x 1.47 sfe m <sup>3</sup> /s	Q <sub>100</sub> x x cc (1.2), m <sup>3</sup> /s
3.47	0.287	5.559	0.35	34.44	0	0.548	1.075	1.581	<b>1.90</b>

Using a growth factor of 2.6 to convert from Q<sub>BAR</sub> to Q<sub>1000</sub>, the resulting Q<sub>1000</sub> flow is estimated as **2.09** m<sup>3</sup>/s.

4.2.5 [Institute of Hydrology Report \(IH\)124 \(1994\)](#)

Report No. 124 derives an equation to estimate flood flows for small rural catchments (less than 25 km<sup>2</sup>). The equation has a standard factorial error (SFE) of 1.65.

$$Q_{bar_{rural}} = 0.00108 (AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17})$$

**Table 4 - Calculations of Q<sub>100</sub> – IH124**

Area, km <sup>2</sup>	SAAR	SOIL	Q <sub>BAR</sub> m <sup>3</sup> /s	Q <sub>BAR</sub> x 1.96 gf m <sup>3</sup> /s	Q <sub>100</sub> x 1.65 sfe m <sup>3</sup> /s	Q <sub>100</sub> x x cc (1.2), m <sup>3</sup> /s
3.47	901.14	0.35	0.96	1.88	3.11	<b>3.72</b>

Without implementing the SFE (1.65), the Q<sub>100</sub> rate plus 20% climate change factor was:

$$Q_{100} = 1.88 \text{ m}^3/\text{s} \times 1.2 = 2.25 \text{ m}^3/\text{s}$$

Using a growth factor of 2.59 to convert from Q<sub>BAR</sub> to Q<sub>1000</sub>, the resulting Q<sub>1000</sub> flow is estimated as **4.1** m<sup>3</sup>/s.

This method was developed for small catchments (< 25 km<sup>2</sup>) in the UK. Its derivation did not include any Irish catchments. The equation tends to overestimate Q<sub>BAR</sub> for the smallest of the UK catchments used. This value is not comparable to results derived from other formulae.

4.2.6 [Modified IH 124 \(Cawley & Cunnane 2003\)](#)

Irish researchers at NUIG (Cawley & Cunnane 2003) developed a Modified Institute of Hydrology 124 methodology and formula as follows:

$$Q_{bar_{rural}} = 0.000036 (AREA^{0.94} \times SAAR^{1.58} \times SOIL^{1.87})$$

**Table 5 - Calculations of Q<sub>100</sub> – Modified IH124**

Area, km <sup>2</sup>	SAAR	SOIL	Q <sub>BAR</sub> m <sup>3</sup> /s	Q <sub>BAR</sub> x 1.96 gf m <sup>3</sup> /s	Q <sub>100</sub> x 1.65 sfe m <sup>3</sup> /s	Q <sub>100</sub> x x cc (1.2), m <sup>3</sup> /s
3.47	901.14	0.35	0.759	1.488	2.456	<b>2.94</b>

Using a growth factor of 2.59 to convert from Q<sub>BAR</sub> to Q<sub>1000</sub>, the resulting Q<sub>1000</sub> flow is estimated as **3.24 m<sup>3</sup>/s**.

4.2.7 [Modified Rational Method](#)

FSU Work Package 4.2 shows that the UK only apply the Rational Method to catchments from 2 to 4 km<sup>2</sup>. In Ireland this method is more commonly used to determine stormwater attenuation requirements. It is calculated using the formula:

$$QT = 2.78 \times C_v \times C_r \times I \times A$$

where:

Q<sub>T</sub> = design peak flow, l s<sup>-1</sup>

T = return period in years = 21.2 mm/hr

C<sub>v</sub> = runoff coefficient = 0.84 (winter)

C<sub>r</sub> = peaking/routing factor = 1.3 (arbitrary value)

A = 3.47 km<sup>2</sup>

Hence:

$$Q_{100} = 2.78 \times 0.84 \times 1.3 \times 0.0212 \times 3.473$$

$$Q_{100} = 0.223 \text{ m}^3/\text{s}$$

$$Q_{100} + 20\% \text{ cc} = 0.525 \text{ m}^3/\text{s}$$

$$Q_{1000} = \mathbf{0.578 \text{ m}^3/\text{s}}$$

4.2.8 [Summary of Flood Flow Calculations](#)

Results from the various flood estimation methods are summarised below in Table 6. In taking a conservative approach, the flood flow values selected for use in the hydraulic model were those calculated using the Modified IH124 method, as this method was developed using Irish catchment characteristics. The values derived using this

method are 65% greater than average taken across all formulae. The respective  $Q_{100+cc}$  and  $Q_{1000}$  values being equal to 2.94 m<sup>3</sup>/s and 3.24 m<sup>3</sup>/s, respectively.

**Table 6 - Summary of Calculated Flood Flows for the Kil1 catchment**

Methodology	$Q_{100} + 20\% cc$ (m <sup>3</sup> /s)	$Q_{1000}$ (m <sup>3</sup> /s)
FSU Standard	1.63	1.81
FSU small catchments	0.99	1.10
FSU – 3 variable	0.72	0.79
FSR 6 – including SFE	1.90	2.09
IH124 – including SFE	3.72	4.10
<b>Modified IH124 – including SFE</b>	<b>2.94</b>	<b>3.24</b>
Modified rational method	0.53	0.58
Minimum	0.53	0.58
Maximum	3.72	4.10
Average (n = 7)	1.78	1.96

#### 4.3 FLOOD FLOW CALCULATIONS: KIL2

The physical catchment descriptors applicable to the Kil2 catchment are shown in Table 7.

**Table 7 - Physical Catchment Descriptors Applicable to the Kil2 catchment**

PCD	Description	Units	Value
AREA	Catchment area	km <sup>2</sup>	2.59
SAAR	Average annual rainfall	mm	902
BFIsol	Baseflow index derived from soils data		0.726
FARL	Flood attenuation from reservoirs and lakes		1
DRAIN	Ratio of river network to catchment area	no./km <sup>2</sup>	0.736
S <sub>1085</sub>	Slope of the main stream between the 10 and 85 percentiles	m/km <sup>2</sup>	9.0587
ARTDRAIN2	Proportion of river network included in drainage schemes		0.6847
URBEXT			0
QMED <sub>rural</sub>		m <sup>3</sup> /s	0.492
QMED <sub>urban</sub>		m <sup>3</sup> /s	0.492

Results from the various flood estimation methods are summarised below in Table 8. In taking a conservative approach, the flood flow values selected for use in the hydraulic model were those calculated using the Modified IH124 method, as this method was developed using Irish catchment characteristics. The values derived using this method are 58% greater than average taken across all formulae. The respective  $Q_{100+cc}$  and  $Q_{1000}$  values being equal to 2.24 m<sup>3</sup>/s and 2.47 m<sup>3</sup>/s, respectively.

**Table 8 - Summary of Calculated Flood Flows for the Kil2 catchment**

Methodology	Q <sub>100</sub> + 20% cc (m <sup>3</sup> /s)	Q <sub>1000</sub> (m <sup>3</sup> /s)
FSU Standard	1.51	1.67
FSU small catchments	0.67	0.75
FSU – 3 variable	0.56	0.62
FSR 6 – including SFE	1.68	1.87
IH124 – including SFE	2.87	3.16
<b>Modified IH124 – including SFE</b>	<b>2.24</b>	<b>2.47</b>
Modified rational method	0.39	0.43
Minimum	0.39	0.43
Maximum	2.87	3.16
Average (n = 7)	1.42	1.51

#### 4.4 FLOOD FLOW CALCULATIONS: CAS1

The physical catchment descriptors applicable to the Cas1 catchment are shown in Table 9.

**Table 9 - Physical Catchment Descriptors Applicable to the Cas1 catchment**

PCD	Description	Units	Value
AREA	Catchment area	km <sup>2</sup>	2.59
SAAR	Average annual rainfall	mm	907.14
BFIs <sub>soil</sub>	Baseflow index derived from soils data		0.714
FARL	Flood attenuation from reservoirs and lakes		1
DRAIND	Ratio of river network to catchment area	no./km <sup>2</sup>	1.069
S <sub>1085</sub>	Slope of the main stream between the 10 and 85 percentiles	m/km <sup>2</sup>	5.47
ARTDRAIN2	Proportion of river network included in drainage schemes		1
URBEXT			0.0138
QMED <sub>rural</sub>		m <sup>3</sup> /s	0.559
QMED <sub>urban</sub>		m <sup>3</sup> /s	0.559

Results from the various flood estimation methods are summarised below in Table 10. In taking a conservative approach, the flood flow values selected for use in the hydraulic model were those calculated using the Modified IH124 method, as this method was developed using Irish catchment characteristics. The values derived using this method are 56% greater than average taken across all formulae. The respective Q<sub>100+cc</sub> and Q<sub>1000</sub> values being equal to 2.26 m<sup>3</sup>/s and 2.99 m<sup>3</sup>/s, respectively.

**Table 10 - Summary of Calculated Flood Flows for the Cas1 catchment**

Methodology	Q <sub>100</sub> + 20% cc (m <sup>3</sup> /s)	Q <sub>1000</sub> (m <sup>3</sup> /s)
FSU Standard	1.71	1.90
FSU small catchments	0.78	0.87
FSU – 3 variable	0.55	0.61
FSR 6 – including SFE	1.57	1.73
IH124 – including SFE	2.89	3.82
<b>Modified IH124 – including SFE</b>	<b>2.26</b>	<b>2.99</b>
Modified rational method	0.39	0.43
Minimum	0.39	0.43
Maximum	2.89	3.82
Average (n = 7)	1.45	1.76

#### 4.5 FLOOD FLOW CALCULATIONS: CAS2

The physical catchment descriptors applicable to the Cas2 catchment are shown in Table 11.

**Table 11 - Physical Catchment Descriptors Applicable to the Cas1 catchment**

PCD	Description	Units	Value
AREA	Catchment area	km <sup>2</sup>	0.52
SAAR	Average annual rainfall	mm	907.1
BFIssoil	Baseflow index derived from soils data		0.714
FARL	Flood attenuation from reservoirs and lakes		1
DRAIN	Ratio of river network to catchment area	no./km <sup>2</sup>	1.069
S <sub>1085</sub>	Slope of the main stream between the 10 and 85 percentiles	m/km <sup>2</sup>	5.47
ARTDRAIN2	Proportion of river network included in drainage schemes		1
URBEXT			0.0138
QMED <sub>rural</sub>		m <sup>3</sup> /s	0.124
QMED <sub>urban</sub>		m <sup>3</sup> /s	0.124

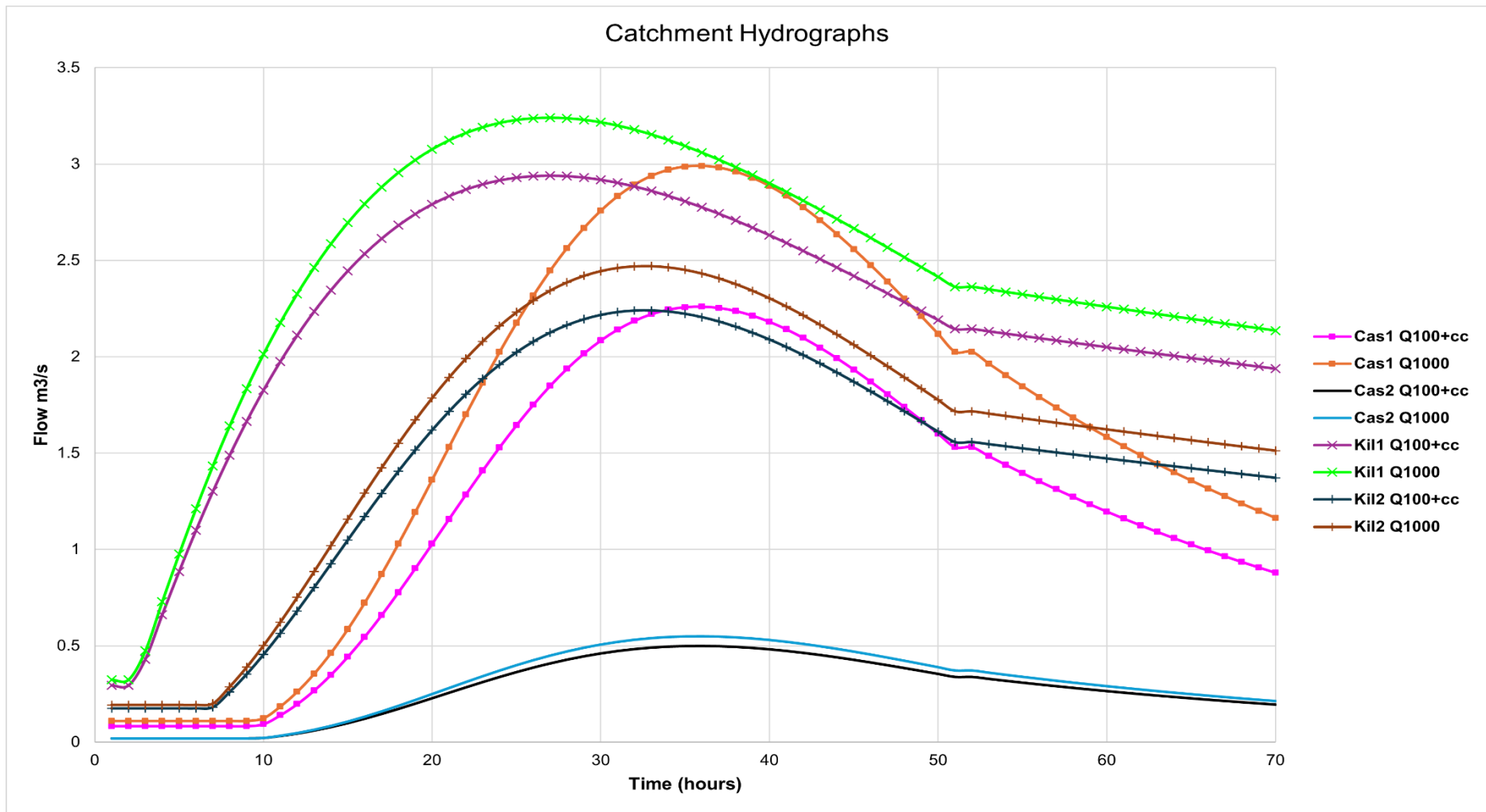
Results from the various flood estimation methods are summarised below in Table 12. In taking a conservative approach, the flood flow values selected for use in the hydraulic model were those calculated using the Modified IH124 method, as this method was developed using Irish catchment characteristics. The values derived using this method are 39% greater than average taken across all formulae. The respective Q<sub>100+cc</sub> and Q<sub>1000</sub> values being equal to 0.50 m<sup>3</sup>/s and 0.55 m<sup>3</sup>/s, respectively.

**Table 12 - Summary of Calculated Flood Flows for the Cas2 catchment**

Methodology	Q <sub>100</sub> + 20% cc (m <sup>3</sup> /s)	Q <sub>1000</sub> (m <sup>3</sup> /s)
FSU Standard	0.38	0.42
FSU small catchments	0.18	0.20
FSU – 3 variable	0.15	0.19
FSR 6 – including SFE	0.56	0.59
IH124 – including SFE	0.69	0.76
<b>Modified IH124 – including SFE</b>	<b>0.50</b>	<b>0.55</b>
Modified rational method	0.07	0.08
Minimum	0.07	0.08
Maximum	0.69	0.76
Average (n = 7)	0.36	0.40

Seventy hour hydrographs for each catchment and flood flow scenario are shown in Graph 1. Time to peak characteristics have been derived from the FSU portal and are representative of how 'flashy' the rainfall-runoff response is in each catchment.

Graph 1 – Hydrographs for each catchment and flood flow scenario



## 5 HYDRAULIC MODEL

### 5.1 MODEL CONCEPT

A site-specific hydraulic model was constructed using Flood Modeller (version 6.1), an industry standard hydraulic modelling software package for which Envirollogic maintains a full license. This software package is designed to perform one dimensional (1D) hydraulic simulations for networks of natural or constructed water channels. In addition to the one-dimensional hydraulic solver the software also utilises a two-dimensional solver (2D) which models water flow and depth in situations where flood levels overtop the bank-full capacity of the surveyed channels and spill onto the adjoining floodplain. Construction of the 1D–2D linked model relies on four primary inputs summarised as follows:

- Geometric Data: Surveyed cross-sectional data of the main channel through the site boundary;
- Geometric Data: A georeferenced digital elevation model of the site and surrounding landscape to cover potential adjoining flood plain upstream and downstream of the site location;
- Upstream Boundary Conditions -  $Q_{100}$  &  $Q_{1000}$  flood flow volumes for the upstream catchment of the site;
- Inclusion of Manning Roughness Coefficient values, used to calculate frictional forces within the flood model.

### 5.2 MODEL BUILD – EXISTING DRAINAGE REGIME

#### 5.2.1 [Cross Sections](#)

The 1D model was compiled using evenly spaced cross sections along watercourses within the site boundary. These sections were surveyed manually using Trimble RTK VRS technique. Cross section locations for each channel are shown in Figure 11 and Figure 12. Sixty five cross sections were surveyed across four separate channels (see Table 13). In each catchment the cross sections extended beyond the downstream end of the site boundary.

**Table 13 – Survey Details**

Channel	Number of Cross Sections	Modelled Reach Length
Kil1	36	1,830 m
Kil2	11	1,515 m
Cas1	15	1,750 m
Cas2	3	600 m

Figure 11 - Cross Section Locations: Kil1 & Kil2

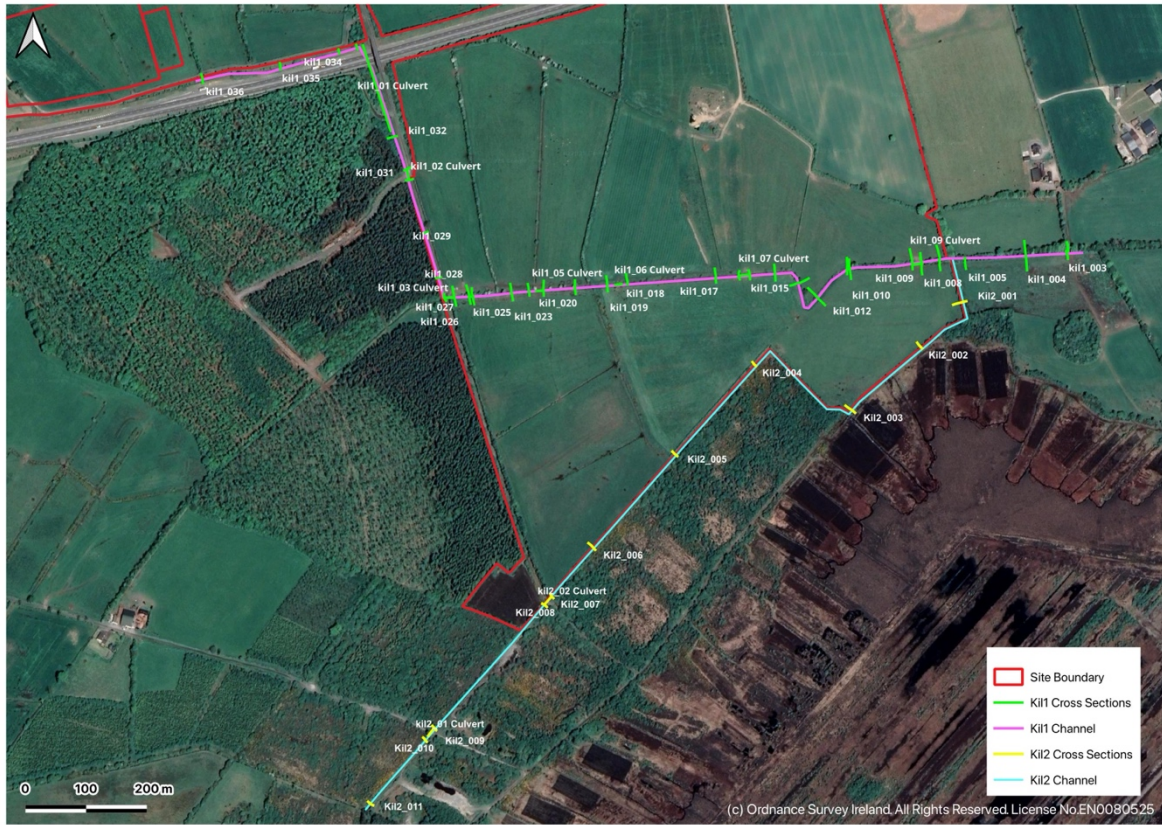
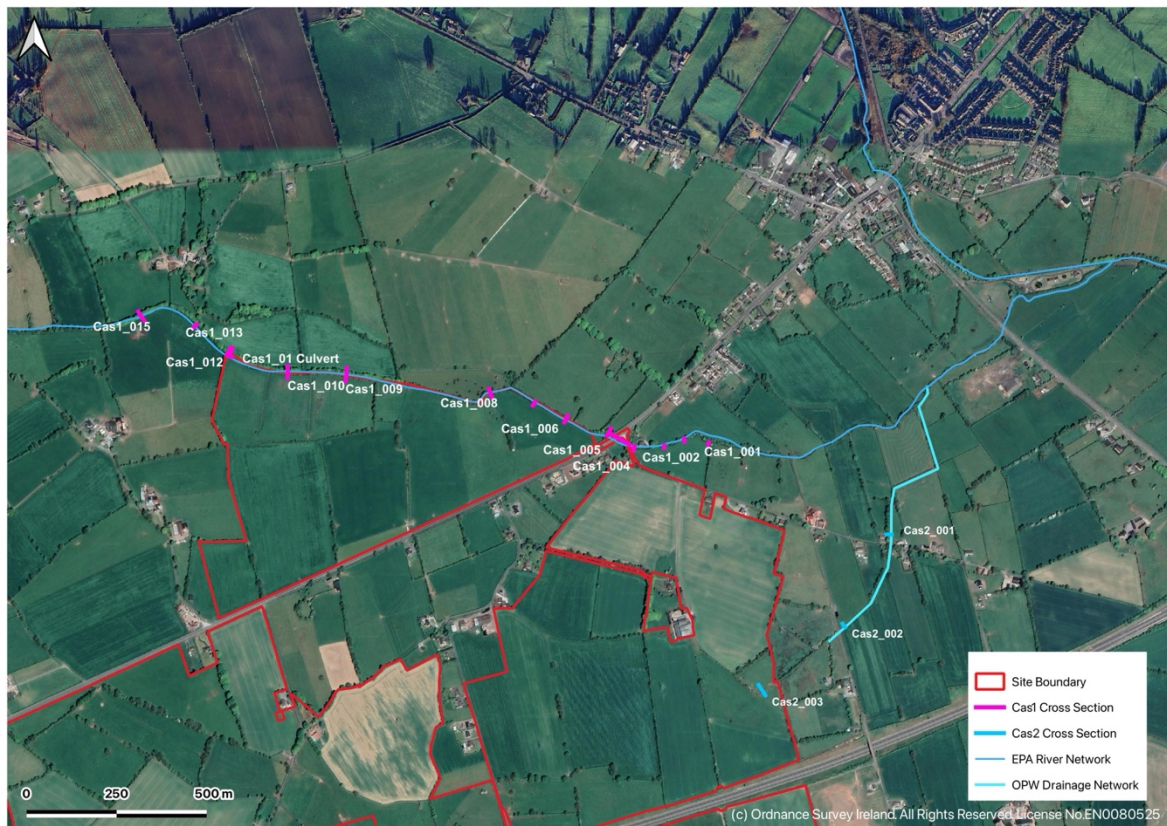


Figure 12 - Cross Section Locations: Cas1 & Cas2



### 5.2.2 [Flow Boundaries](#)

The  $Q_{100+cc}$  and  $Q_{1000}$  flow rates calculated above using Modified IH124 method were selected as the design flood flows through each channel. For catchments Kil2, Cas1 and Cas2 these flow rates apply to the catchment area at the downstream site boundary. In taking a conservative approach these flows were introduced as the upstream flow boundary, i.e. the start of the modelled reach.

Only in the case of Kil1 was this flow split to better represent flow gains through the catchment. Upstream of the motorway, the catchment which feeds into the culvert Kil1\_01US represents 27% of the overall catchment area, resulting in  $Q_{100+cc}$  and  $Q_{1000}$  flow values of  $0.79 \text{ m}^3/\text{s}$  and  $0.87 \text{ m}^3/\text{s}$  respectively. The remainder was introduced at the culvert outlet (Kil1\_01DS) resulting in a combined flow of  $2.94 \text{ m}^3/\text{s}$  and  $3.24 \text{ m}^3/\text{s}$  throughout the remainder of the modelled reach.

### 5.2.3 [Roughness Coefficients & Channel Geometry](#)

A Manning's roughness coefficient of 0.03 was applied to open river channel bed sections (noted as silty/gravelly) and a value of 0.04 applied to riverbanks. The Kil1, Kil2 and Cas1 channels are noted on the OPW drainage network database as being maintained as part of the Boyne arterial drainage district. It was observed during the site visit that the channel profiles generally have steep banks and channel beds with a low-gradient.

### 5.2.4 [Existing Structures](#)

Specifications of the key hydraulic structures on each of the surveyed watercourses are summarised below in Table 14.

**Table 14 – Summary Details of Existing Hydraulic Structures**

Culvert Ref	Location	Culvert Invert U/S mOD	Culvert Crown U/S mOD	Culvert Invert D/S (mOD)	Culvert Crown D/S (mOD)	Culvert Diameter (mm)	Culvert Length (m)
Kil1_01	TII M6 Motorway	90.56	91.09	86.37	87.27	530 U/S 900 D/S	160
Kil1_02	Forest Access Road	85.96	85.87	85.78	86.68	900	18.5
Kil1_03	Forest Access Road	83.94	84.94	83.93	84.93	1000	4.5
Kil1_04	Field Culvert	83.64	84.64	83.62	84.62	1000	4.5
Kil1_05	Field Culvert	83.26	84.26	83.26	84.26	1000	4.5
Kil1_06	Field Culvert	82.99	83.99	82.97	83.97	1000	7
Kil1_07	Field Culvert	82.31	83.61	82.29	83.59	1300	16.5
Kil1_08	Field Box Culvert	82.2	83.7	82.2	83.70	1500 x1500	3.5

Kil1_09	Field Culvert	81.82	83.42	81.79	83.39	1600	15.5
Kil2_01	Forest Access Road	82.518	83.518	82.51	83.51	1000	6
Kil2_02	Forest Access Road	82.113	83.113	82.05	83.05	1000	4.5
Cas1_01	Field Culvert	97.9	98.9	97.7	98.70	1000	5.5
Cas1_02	R446 Culvert	92.5	93.5	92.294	93.294	1000	60

### 5.3 SIMULATION: FLOOD FLOWS & FLOOD EXTENTS

The conveyance capacity of all surveyed cross sections along the existing stream were assessed for suitability to transmit  $Q_{100}$  and  $Q_{100+cc}$  flood flows. The design flows are presented in Table 15.

**Table 15 – Modelled  $Q_{100}$  and  $Q_{100+cc}$  flood flows for each channel**

Channel	$Q_{100+cc}$ Flow (m <sup>3</sup> /s)	$Q_{1000}$ Flow (m <sup>3</sup> /s)
Kil1 (036 – 032)	0.79	0.88
Kil1 (032-003)	2.94	3.24
Kil2	2.24	2.47
Cas1	2.26	2.99
Cas2	0.50	0.55

#### 5.3.1 Simulation Results: Kil1

The predicted peak surface water elevations from the Flood Modeller 1D simulation during unsteady-state conditions are presented in Table 16.

**Table 16 - Predicted surface water elevations for  $Q_{100}$  and  $Q_{100+cc}$  flood flows: Kil1**

Cross Section	Kil1			
	$Q_{100+cc}$ Flow (m <sup>3</sup> /s)	$Q_{100+cc}$ fluvial flood levels (mOD)	$Q_{1000}$ Flow (m <sup>3</sup> /s)	$Q_{1000}$ fluvial flood levels (mOD)
Kil1_036	0.79	92.95	0.87	93.00
Kil1_035	0.79	92.51	0.87	92.91
Kil1_034	0.79	92.50	0.87	92.91
Kil1_033	0.79	92.50	0.87	92.91
Kil1_01US	0.79	91.00	0.87	91.00
Kil1_01DS	0.79	87.31	0.87	87.49
Kil1_032	2.94	87.37	3.24	87.39
Kil1_031	2.94	87.30	3.24	87.32

Cross Section	Kil1			
	Q <sub>100+cc</sub> Flow (m <sup>3</sup> /s)	Q <sub>100+cc</sub> fluvial flood levels (mOD)	Q <sub>1000</sub> Flow (m <sup>3</sup> /s)	Q <sub>1000</sub> fluvial flood levels (mOD)
Kil1_02US	2.94	86.97	3.24	87.09
Kil1_02DS	2.94	86.88	3.24	87.00
Kil1_030	2.94	86.61	3.24	86.71
Kil1_029	2.94	86.45	3.24	86.62
Kil1_028	2.94	86.40	3.24	86.55
Kil1_027	2.94	86.38	3.24	86.53
Kil1_03US	2.94	86.15	3.24	86.30
Kil1_03DS	2.94	86.12	3.24	86.26
Kil1_026	2.94	85.67	3.24	85.81
Kil1_025	2.94	85.66	3.24	85.80
Kil1_04US	2.94	85.51	3.24	85.70
Kil1_04DS	2.94	85.49	3.24	85.68
Kil1_024	2.94	85.18	3.24	85.49
Kil1_023	2.94	85.18	3.24	85.49
Kil1_022	2.94	85.18	3.24	85.48
Kil1_05US	2.94	85.10	3.24	85.39
Kil1_05DS	2.94	85.09	3.24	85.38
Kil1_021	2.94	84.93	3.24	85.19
Kil1_020	2.94	84.93	3.24	85.18
Kil1_019	2.94	84.92	3.24	85.18
Kil1_06US	2.94	84.13	3.24	84.60
Kil1_06DS	2.94	84.08	3.24	84.54
Kil1_018	2.94	83.67	3.24	83.98
Kil1_017	2.94	83.64	3.24	83.97
Kil1_016	2.94	83.62	3.24	83.95
Kil1_07US	2.94	83.61	3.24	83.94
Kil1_07DS	2.94	83.58	3.24	83.89
Kil1_015	2.94	83.466	3.24	83.65
Kil1_014	2.94	83.38	3.24	83.60
Kil1_013	2.94	83.34	3.24	83.56
Kil1_012	2.94	83.31	3.24	83.54
Kil1_011	2.94	83.27	3.24	83.50
Kil1_08US	2.94	83.19	3.24	83.41
Kil1_08DS	2.94	83.18	3.24	83.40
Kil1_010	2.94	83.08	3.24	83.29

Cross Section	Kil1			
	Q <sub>100+cc</sub> Flow (m <sup>3</sup> /s)	Q <sub>100+cc</sub> fluvial flood levels (mOD)	Q <sub>1000</sub> Flow (m <sup>3</sup> /s)	Q <sub>1000</sub> fluvial flood levels (mOD)
Kil1_009	2.94	82.97	3.24	83.20
Kil1_09US	2.94	82.66	3.24	82.83
Kil1_09DS	2.94	82.62	3.24	82.79
Kil1_008	2.94	82.41	3.24	82.55
Kil1_007	2.94	82.38	3.24	82.53
Kil1_006	2.94	82.35	3.24	82.51
Kil1_005	2.94	82.06	3.24	82.19
Kil1_004	2.94	81.72	3.24	81.84

The results show that there is surcharging upstream of the culvert Kil1\_02 (southwest of the southern site boundary and outside the application site) and upstream of Kil1\_04 resulting in out of bank flooding.

The fate of surcharged flood waters was examined with a combined 1D-2D model. The 2D model confirms floodwaters overtop the left bank of Kil1\_02 and across the southern portion of the application site in a southerly direction. Floodwaters flow back into the Kil1 channel at various points. Floodwaters at Kil1\_04 exceed both banks. On the right bank, floodwaters flow in a southerly direction across the southern portion of the application site. The floodwaters continue to flow across the southern portion of the application site, along a field drain, before re-entering Kil2, in the vicinity of Kil2\_006. The flood extents as generated by the 1D-2D model have been mapped in Figure 13. The maximum depth of flooding is 0.61 m in the southeast corner of the site, as floodwaters enter Kil2.

Figure 13 – Flood Extents emanating from Kil1



### 5.3.2 Simulation Results: Kil2

The predicted peak surface water elevations from the 1D unsteady state simulation for Kil2 are presented in Table 17. The results showed that there is surcharging upstream of the culverts Kil2\_01 (southwest of the southern site boundary and outside the application site) and Kil2\_02 (beneath the end of the laneway at the southwestern end of the southern portion of the application site), resulting in out of bank flooding.

The fate of surcharged flood waters was examined with a combined 1D-2D model. The 2D model confirms minor flooding upstream of Kil2\_01, with these waters being outside the application site. The surcharge upstream of Kil2\_02 was also minor, resulting in a floodplain of only 126 m<sup>2</sup>, to maximum depths of 0.19 m and 0.42 m for the Q<sub>100</sub> and Q<sub>1000+cc</sub> simulations, respectively (Figure 14).

Progressing downstream of these culverts, flood waters are maintained within the remainder of the channel, as shown in the Longitudinal Profile: Kil2 (see Appendix A).

**Table 17 – Predicted surface water elevations for Q<sub>100</sub> and Q<sub>1000+cc</sub> flood flows: Kil2**

Cross Section	2.24 m <sup>3</sup> /s	2.27 m <sup>3</sup> /s
	Q <sub>100+cc</sub> fluvial flood levels (mOD)	Q <sub>1000</sub> fluvial flood levels (mOD)
Kil2_011	84.60	84.93
Kil2_010	84.58	84.91
Kil2_01US	84.37	84.66
Kil2_01DS	84.33	84.65
Kil2_009	83.93	84.13
Kil2_008	83.84	84.06
Kil2_02US	83.58	83.73
Kil2_02DS	83.55	83.70
Kil2_007	83.16	83.22
Kil2_006	83.06	83.12
Kil2_005	82.93	82.99
Kil2_004	82.72	82.76
Kil2_003	82.37	82.44
Kil2_002	82.16	82.21
Kil2_001	81.96	82.01

Figure 14 – Surcharging and Flood Zones adjacent to Kil2 Channel



### 5.3.3 Simulation Results: Cas1

The predicted surface water elevations from the 1D unsteady state simulation for Cas1 are presented in Table 18. The results showed that there is surcharging upstream of the culvert Cas1\_02 (crossing under R446 at northeastern site corner), in both the  $Q_{100+cc}$  and  $Q_{1000}$  flood scenarios. However, this only occurs during the  $Q_{1000}$  flood scenario. The fate of these surcharge flood waters was examined with a combined 1D-2D model. The 2D model confirms that surcharged waters do not encroach on any part of the site boundary. They do however, spillover the R446, where the road has an elevation of 94.70 mOD. The flood waters continue south-east through a field and re-enter the Cas1 channel (Figure 15). Flood depths as the waters cross the R446 do not exceed a depth of 0.09 m (Table 18). Flood extents and depths were identical for the  $Q_{1000}$  simulation. Further downstream of this culvert, flood waters are maintained within the channel (Longitudinal Profile: Cas1; see Appendix A).

**Table 18 – Predicted surface water elevations for  $Q_{100+cc}$  and  $Q_{1000}$  flood flows: Cas1**

Cross Section	2.26 m <sup>3</sup> /s	2.99 m <sup>3</sup> /s
	$Q_{100+cc}$ fluvial flood levels (mOD)	$Q_{1000}$ fluvial flood levels (mOD)
Cas1_015	100.12	100.248
Cas1_014	99.93	100.072
Cas1_013	99.70	99.85
Cas1_012	99.63	99.78
Cas1_01US	98.68	98.81
Cas1_01DS	98.65	98.78
Cas1_011	98.32	98.40
Cas1_010	98.06	98.06
Cas1_009	98.07	98.07
Cas1_008	95.43	95.50
Cas1_007	94.65	95.09
Cas1_006	94.34	95.06
Cas1_005	94.25	95.05
Cas1_02US	93.69	94.37
Cas1_02DS	93.31	93.71
Cas1_004	92.94	93.03
Cas1_003	92.38	92.50
Cas1_002	92.16	92.30
Cas1_001	91.67	91.79

Figure 15 – Predicted Q<sub>1000</sub> Flood Extents & Depths adjacent to Cas1 Channel



### 5.3.4 Simulation Results: Cas2

The predicted surface water elevations from the 1D unsteady state simulation for Cas2 are presented in Table 19. The results showed that there is no out of bank flooding. The associated longitudinal profile is illustrated in Appendix A).

Table 19 - Predicted surface water elevations for Q<sub>100+cc</sub> and Q<sub>1000</sub> flood flows: Cas2

Cross Section	0.50	0.55
	Q <sub>100+cc</sub> fluvial flood levels (mOD)	Q <sub>1000</sub> fluvial flood levels (mOD)
Cas2_003	90.60	90.61
Cas2_002	87.26	87.29
Cas2_001	86.85	86.88

## 5.4 PROPOSED BRIDGE CROSSINGS

Two new bridges are proposed to facilitate new internal access roads; these are to be installed along the Kil1 channel at locations as shown in Figure 16.

For new river crossing structures OPW guidelines (2013) advise that:

- *A bridge or culvert must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100-year flow without significantly changing the hydraulic characteristics of the watercourse.*
- *A bridge must be capable of operating under the above design conditions while maintaining a freeboard of at least 300 mm.*
- *A culvert diameter, height and width must not be less than 900 mm to facilitate maintenance access and reduce the likelihood of debris blockage.*

Envirologic have sized the proposed bridge crossings to ensure conveyance of  $Q_{100}$  flood flows, as calculated using the IH124 method. In addition, a further 20% allowance has been made for climate change. As per OPW Section 50 requirements a drainage factor of 1.6 has also been applied given the Kil1 channel is part of an OPW maintained arterial drainage scheme. The OPW requirements are satisfied as follows:

- Design flood flow as per OPW requirements =  $3.72 \text{ m}^3/\text{s} \times 1.6 = 5.95 \text{ m}^3/\text{s}$

Each bridge structure shall consist of a precast concrete deck. Stone gabions will act as a foundation to the concrete base of the deck level, which will be set back approximately 1m from the top of the channel bank. There will be a minimum clearance of 400 mm from the top of the channel bank to the bridge soffit. A schematic of the bridge crossing design is illustration in Plate 6.

### 5.4.1 Br1

- Coordinates = 645,902 m Easting / 738,458 Northing;
- Design flood level = 85.35 mOD;
- Channel bank elevation = 86.79 mOD (left), 85.96 mOD (right);
- Soffit elevation = 87.20 mOD;
- Spring elevation = 86.79 mOD = left bank ground elevation;
- Bridge deck level = 87.70 mOD;
- Bridge Width = 6 m;
- Bridge Span = 28 m;
- Freeboard = 1.85 m;
- OPW criteria for culvert design satisfied

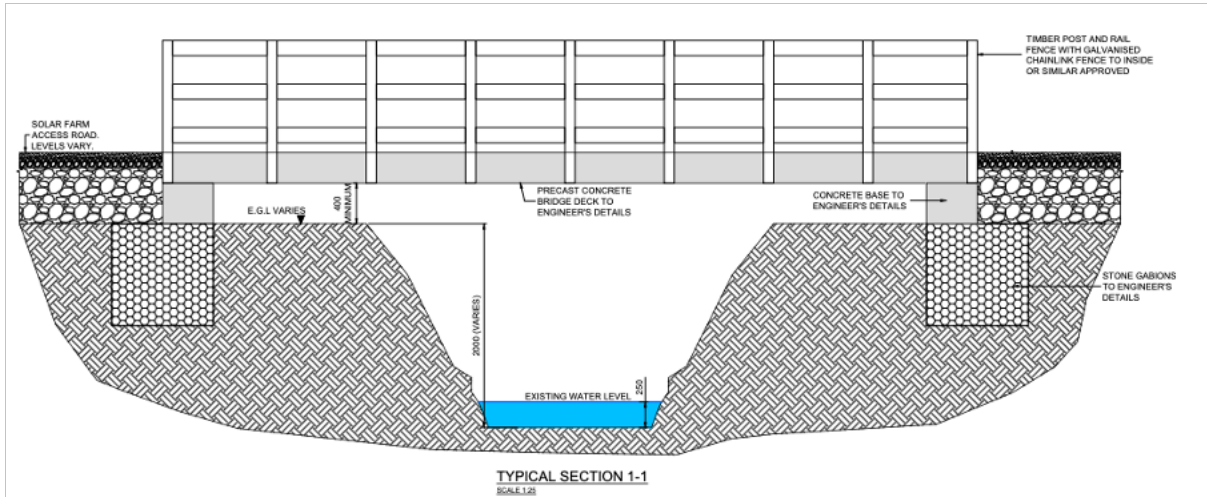
### 5.4.2 Br2

- Coordinates = 646,259 m Easting / 738,439 m Northing;
- Design flood level = 84.09 mOD;
- Channel bank elevation = 84.46 mOD (left), 85.92 mOD (right);
- Soffit elevation = 86.32 mOD;
- Spring elevation = 84.46 mOD = left bank ground elevation;
- Bridge deck level = 86.82 mOD;
- Bridge Width = 6 m;
- Bridge Span = 23 m;
- Freeboard = 2.23 m;
- OPW criteria for culvert design satisfied

**Figure 16 - Location of Proposed Bridges**



Plate 6 – Proposed Bridge Design

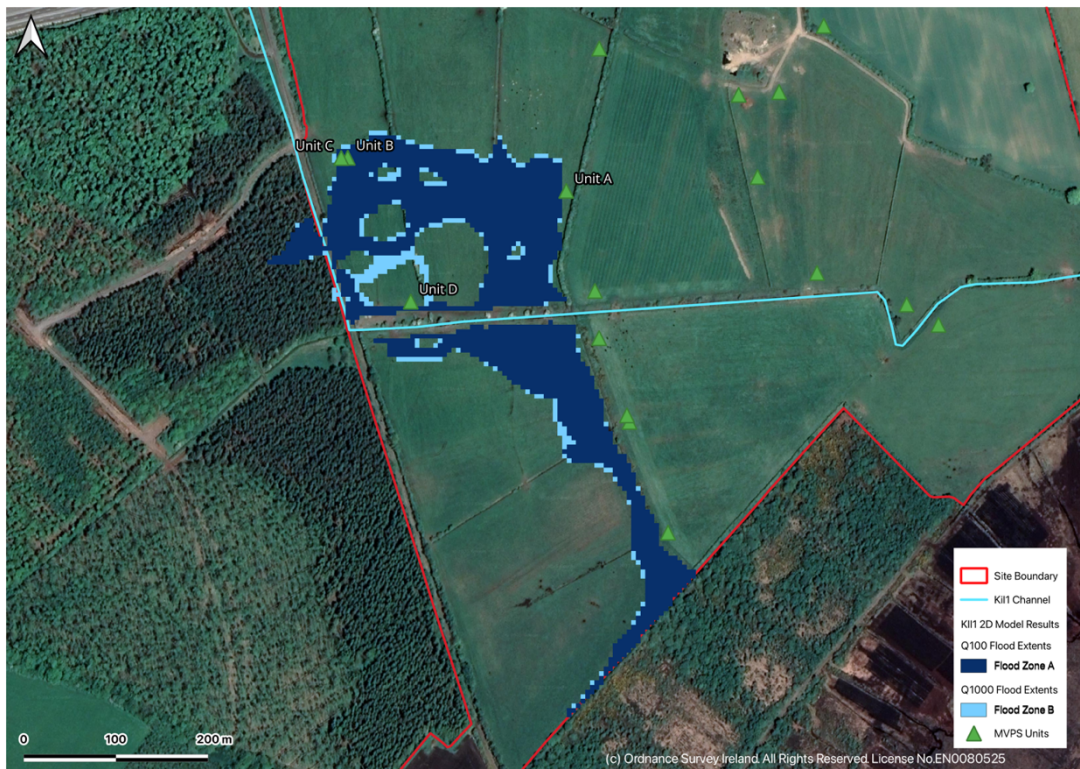


## 6 MITIGATION

### 6.1 MVPS UNITS

When the flood extent polygon for the Kil1 channel is overlain onto the site layout map it becomes apparent that 4 of the proposed MVPS units are potentially at risk of flooding. These MVPSs are referred to as Unit A, Unit B, Unit C and Unit D and are located in the southern portion of the site.

Figure 17 - Location of Proposed MVPS units in Southern Site Portion



Summary details are included in Table 20. Results show that maximum flood depths during a  $Q_{100+cc}$  and  $Q_{1000}$  will not exceed 0.11 m depth.

**Table 20 - Predicted surface water elevations at Potentially Affected MVPS units**

MVPS unit	Easting, m	Northing, m	GL, mOD	$Q_{100}$ , mOD	$Q_{1000}$ , mOD	Max. Flood Depth, m	Recommended Minimum FFL, mOD	Proposed FFL, mOD
Unit A	645,882	738,594	85.01	85.10	85.12	0.11	85.42	85.61
Unit B	645,646	738,628	85.90	85.92	85.94	0.04	86.24	86.5
Unit C	645,637	738,627	85.91	85.93	85.94	0.03	86.24	86.51
Unit D	645,713	738,473	85.54	85.65	85.65	0.11	85.95	86.14

As per the Flood Risk Guidelines (2009) minimum recommended finished floor level of any MVPS units should be a minimum 300 mm above the predicted  $Q_{100}$  elevation, with a 20% allowance included for climate change. The minimum recommended finished floor level of all MVPS enclosures is set at 300 mm above  $Q_{1000}$ . The proposed FFL is 600 mm above ground level. Hence, the proposed FFL of each MVPS exceeds the minimum recommended FFL, satisfying the OPW criteria in design proposals.

The MVPS unit has dimensions 6 m x 2.4 m and sits on 3 concrete pads, akin to lintels. The loss of active floodplain lost by constructing MVPS units A – D within Flood Zone A/B will potentially < 1 m<sup>3</sup> of active floodplain storage in the area. This is considered negligible in terms of the overall flood plain area.

The flood model showed that the floodplain is functioning as a conveyance route. The conveyance of flood waters shall not be impeded by the construction of MVPS units A – D.

All other proposed MVPS units and buildings within the application site are in Flood Zone C and hence the site layout design is in accordance with the Flood Risk Guidelines (2009).

## 6.2 SOLAR PANELS

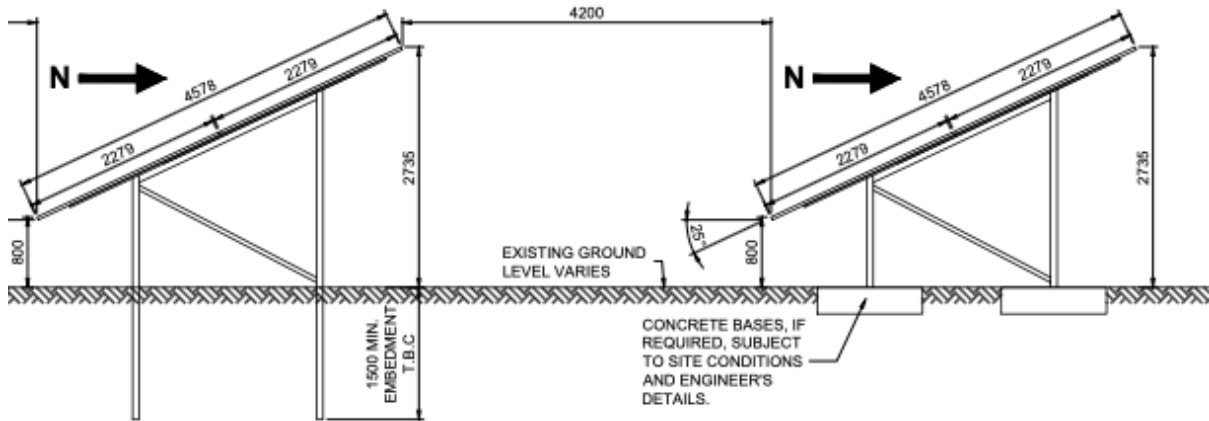
The solar panel modules will be fixed in position so there will be no moving parts. The panels use galvanised steel framing piles driven into the ground and the PV panels will be arranged in south facing rows ranging from 2 m to 6 m apart within existing field boundaries. The overall Solar PV contains full table solar panel arrays (29.98 m long x 4.6 m wide x 2.8 m high) and half table solar Panel arrays (14.98 m long x 4.58 m wide x 2.8 m high). The proposed Solar PV Solar Development will have a capacity of approximately 170 MWp thereby supplying approximately 140,000 MWh per annum of renewable power to the national grid which will assist in the secure supply of energy in the region and provide a valuable contribution to cutting greenhouse gas emissions.

Solar panels will be mounted on metal stakes that will be buried approximately 1,500 mm into the ground. The panels are mounted on the stakes at an angle such that the lower end sits 800 mm above ground and the upper end will be 2,735 mm above ground (Plate 7).

Solar panels will be mounted on a frame above ground level with no requirement to alter the existing topographical profile of the site. The lowest part of the panel will be 800 mm above ground, which exceeds the predicted

maximum flood depths at all locations across the site. Surface water runoff from the PV panels will fall directly onto the ground.

**Plate 7 – Cross Section of Solar Panel and Mounting Detail**



### 6.3 SITE LAYOUT

Other recommendations with regard to site layout are as follows:

- Maintain open drains, watercourses and culvert/bridge inlets in the immediate vicinity of the site.
- All underground cabling and ducting shall be watertight.
- There will be no significant earthworks hence no alteration in pluvial flood risk. Areas that currently flood shall be permitted to flood.
- The loss of floodplain storage due to the erection of the solar panel mounting legs is considered to be negligible.
- SuDS measures to be employed as proposed to dispose of roof and hardstanding runoff.

### 6.4 OPW SECTION 50

The two proposed bridge structures span a watercourse that is maintained as part of an arterial drainage scheme. Therefore permission must be sought from the OPW by way of a Section 50 license. This is typically implied as a Condition of Planning. The proposed bridge structures have been designed to satisfy OPW criteria, i.e. there is a minimum freeboard of 0.3 m above the  $Q_{100}$  level when adjusted for climate change (1.2) and arterial drainage channel (1.6).

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## 6.5 IN-STREAM WORKS METHOD STATEMENT

### 6.5.1 [Introduction](#)

The following method statement shall be made available to Westmeath County Council, National Parks and Wildlife Service, and Inland Fisheries Ireland for review prior to works commencing.

The method statement intends to describe programme of works relating to the construction of two bridges, outlining in broad terms the manner in which the different aspects of the work will be undertaken. These works are required to accommodate development works as part of Project Admiral.

The aim of this programme of works are as follows:

- a. Construction of two bridges along the Kil1 Channel
- b. Maximise potential for development of ecological habitat along all river channels within the site boundary. This will include suitability for fish passage, and provision of areas suitable for spawning;
- c. Minimise the amount of damage to existing habitat during construction of the two proposed bridges.

### 6.5.2 [Cleaning Original Channels](#)

There are certain sections of river bank and channel bed of the Kil1, Kil2 and Cas1 channel that are overgrown and require cleaning. Blockages of vegetation along the field drains previously mentioned will be also removed. This is necessary to ensure the cross-sectional area provides adequate conveyance capacity to transmit flood flows. All vegetation and excess silt in the channels will be removed using an excavator. It is acknowledged that there will be a temporary adverse impact to habitat associated with the removal of this vegetation. Once new vegetation is established, the longer-term impact will be positive.

### 6.5.3 [Mitigation Measures: Bridge Construction Phase](#)

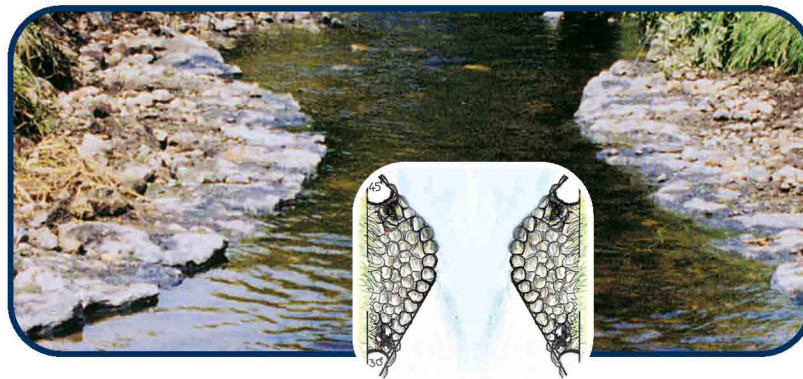
Any works involving the Kil1 channel and its banks will commence from the downstream end. It is deemed unnecessary and impractical to divert the flow in the Kil1 channel during the construction phase. A cofferdam should be placed 100 m downstream of each construction area to trap excess sediment and prevent it entering the watercourses downstream of the site. Straw bales can be placed at increments along the Kil1 channel to trap sediment. Sediment removal can occur periodically over the first number of weeks following completion of the construction phase.

### 6.5.4 [General Channel Modifications](#)

The gradient across the Kil1 channel route is moderate to high which means there is potential for introducing oxygen to the stream by way of cascades and turbulent zones. Velocity, and turbulence, can be increased slightly at minor narrowed sections in a low flow channel, as per Plate 8.

Rows of larger stones/boulders will be placed on the stream bed in flatter sections to create riffles. Where possible, the channel will be deepened on the outer side of any bends to create pools.

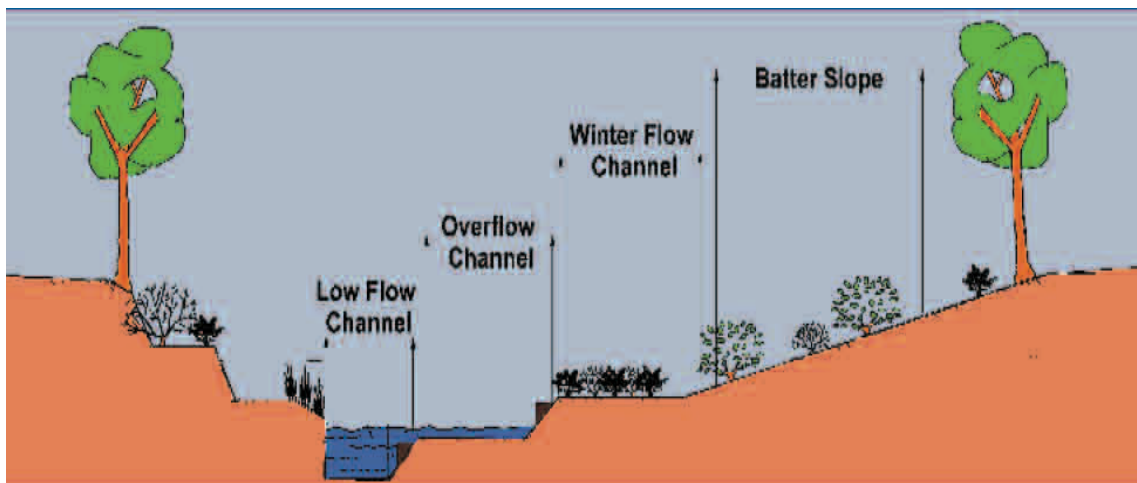
Plate 8 – Narrow river channel in low flow (IFI & OPW, 2010)



### 6.5.5 [Channel Cross Sections](#)

In the event that any unforeseen channel modifications are required during the bridge construction phase the following will be adhered to. The width of the river channel will be reduced from the river bed to a height of 300 mm. This reduced width will be around 0.5 – 1.0 m. This has the effect of maintaining higher velocities in the wetted channel during normal and low flow regimes. The upper section of the profile will be wider, to provide a conveyance capacity capable of transmitting flood flows. A schematic is presented in Plate 9. The inside of any channel bends will be landscaped with sloping marginal benches, as shown in Plate 10.

Plate 9 - Schematic of stream cross sectional profile (ERFB, 2011)



**Plate 10 – Example of stepped bend of river bend**



#### 6.5.6 [Channel Bank Vegetation](#)

Any excavated soils will be stockpiled temporarily and used to cap the banks of the rehabilitated channel. This will promote establishment of vegetation. The rehabilitated channel bank will be planted with native species that can be controlled/maintained to ensure conveyance capacity of channel is not significantly reduced by overgrowth in future. Grass and juvenile, native trees are deemed suitable. Trees will provide cover to pooled sections of the river channel. Bank gradients should be such that no bank failure or slippages will occur in future.

#### 6.5.7 [Hydrocarbons](#)

Hydrocarbon spill kits will be on-site during works. Any fuels and lubricants will be stored in bunded compounds. Refuelling will be carried out safely and securely away from the river environs. Machinery will be fully inspected prior to, and during, the course of works for suitability. Support vehicles will remain on the tarmac / hard-core roadway.

#### 6.5.8 [Timing of Works](#)

All works within the river channel shall be carried out between the months of August to September, to coincide with low stream flows and to avoid interference with spawning runs. Bank maintenance works on existing sections, primarily involving the removal of scrub, should take place between October and March.

#### 6.5.9 [Invasive Species](#)

Standard precautionary measures to be practiced for protection against risk of invasive species. Any machinery, including excavator and dumper will be cleaned with a pressure washer prior to arriving on site, and upon leaving site.

**7 JUSTIFICATION TEST**

Based on the information above the proposed development works will take place within Fluvial Flood Zones A, B and C.

Revisiting the Planning System and Flood Risk Management Guidelines (2009) ‘energy infrastructure’ is considered highly vulnerable development and is considered appropriate in Flood Zone C. Solar farms can be considered as ‘less vulnerable’ or ‘water compatible’ given that they are essentially inert structures mounted 800 mm above ground. Less vulnerable development is considered appropriate in Flood Zone B and Flood Zone C, and requires a Justification Test in Flood Zone A. Water compatible development is considered appropriate in all Flood Zones. Nevertheless, in taking a conservative approach the Justification Test shall be applied.

**7.1 DEVELOPMENT MANAGEMENT JUSTIFICATION TEST**

The Development Management Justification Test is used at the planning stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

The Development Management Justification Test is an assessment of whether a development proposal within an area at risk of flooding meets specific criteria for proper planning and sustainable development and demonstrates that it will not be subject to unacceptable risk nor will it increase flood risk elsewhere. According to the County Westmeath Land Use Zonings Map for County Development Plan 2021 – 2027 the application area is not zoned.

In line with the Flood Risk Guidelines (DoEHLG, 2009) where a planning authority is considering proposals for new development in areas at a high or moderate risk of flooding that include types of development that are vulnerable to flooding and that would generally be inappropriate, the planning authority must be satisfied that the development satisfies all of the criteria of the Justification Test as it applies to development management outlined in Table 21.

All other proposed MVPS units and buildings within the application site are in Flood Zone C and hence the site layout design is in accordance with the Flood Risk Guidelines (2009).

**Table 21 - Requirements of Part 1 of the Justification Test**

Requirement	Site Specific Response
<b>Part 1</b>	
The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of the flood risk guidelines.	In accordance with the Westmeath County Development Plan 2021 – 2027 the application site is not zoned. Given energy infrastructure and solar farms are typically located in rural areas this lack of zoning is standard.  Planning permission for energy infrastructure in this area has been approved in the past.
<b>Part 2</b>	

(i)	<p>The development proposed will not increase flood risk elsewhere and, if possible, will reduce overall flood risk.</p>	<p>The flood risk assessment demonstrates that development can take place on the site without increasing flood risk elsewhere. The flood model showed that the floodplain is functioning as a conveyance route. The conveyance of flood waters shall not be impeded by the construction of MVPS units A – D. The loss of floodplain due to solar farm mounting legs is considered to be negligible.</p> <p>The MVPS unit has dimensions 6 m x 2.4 m and sits on 3 concrete pads, akin to lintels. The loss of active floodplain lost by constructing MVPS units A – D within Flood Zone A/B will potentially &lt; 1 m<sup>3</sup> of active floodplain storage in the area. This is considered negligible in terms of the overall flood plain area.</p>
(ii)	<p>The development proposal includes measures to minimise flood risk to people, property and the economy and the environment as far as reasonably possible.</p>	<p>The development proposal includes for construction of two new bridges. The design specifications are in compliance with OPW Section 50 guidelines and incorporate recommended freeboard.</p>
(iii)	<p>The development proposal includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures of the design, implementation and funding of any future flood risk management measures and provisions for emergency services access.</p>	<p>There will be no residual impacts in terms of flood risk as a result of the proposed development. All rainfall-runoff will leave the application site at greenfield runoff rates.</p>
(iv)	<p>The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.</p>	<p>As per the Westmeath County Council Development Plan 2021 – 2027 SFRA permitting the proposed development will avoid any unnecessary restriction of national, regional or local economic and social growth.</p>

Table 21 above is provided to demonstrate how the proposed development on the application site passes the Justification Test for Development Management. This has been informed by a Stage 3 flood risk assessment which has been carried out to the appropriate level of detail to demonstrate that flood risk to and from the development can or will adequately be managed at the site.

## 8 SUMMARY

Development works are proposed at a site in the townlands of Kiltotan and Collinstown, Oldtown, Gneevebane and Farthingstown, Co. Westmeath. The development consists of a data centre campus and a decentralised energy resource comprising of a Solid Oxide Fuel Cell (SOFC) power system, Battery Energy Storage System (BESS), Solar Photovoltaic (PV) installation and a grid connection to the high voltage (220 kV) electricity network.

Following groundtruthing it was confirmed that the proposed development site drains to two separate surface water catchments, these being the Castlejordan River to the north, and the Mongagh River (EPA Name: Kiltotan & Collinstown) to the south. For reporting purposes these two watercourses have been divided into two sub-catchments, referred to by Envirologic as Cas1 and Cas2, and Kil1 and Kil2.

The site slopes generally from west-east/northwest-southeast and is bisected by the east-west M6 Motorway. According to desktop resources soils in the area are relatively well-drained and underlain by limestone till and pure limestones, resulting in moderate recharge rates. Parts of the application site on the southern side of the M6 are underlain by cut peat.

The desktop study also showed that there are no obvious indicators of flood risk in the area with no evidence of flooding on historical maps, and no historical events on the OPW flood event database. Infill resulting from M6 motorway construction appears to have been deposited on the low-lying peat deposits such that ground elevations on some of the lands in the southern portion of the site are now higher than surrounding greenfield areas.

Some of the drainage channels are maintained as part of an OPW arterial drainage scheme and these were noted as being deep and steep-sided. The main Castlejordan River channel (Cas1) flows in a southeasterly direction adjacent to the northern site boundary. It is culverted beneath the R446 and continues towards the southern side of Rochfortbridge. It is fed by a small tributary on the eastern side of the site, and has a small catchment of 2.6 km<sup>2</sup> to its downstream surveyed extent.

The main Kiltotan Stream channel rises on the southern boundary of the central site area and flows eastwards for a short distance before being culverted beneath the M6. South of the M6 it flows adjacent to a minor access road before turning eastwards and flowing through the centre of the southern portion of the site. A tributary that runs along the southern site boundary outfalls to this main channel close to the southeastern corner of the site.

Envirologic carried out extensive channel and cross section survey works to compile 1D-2D linked hydraulic models for the drainage network. Off-site flooding was noted on the Castlejordan River where it is culverted underneath the R446. On-site flooding fluvial flooding is predicted in the southern portion of the site; this is due to Kil1 surcharging at a culvert beneath a forestry access point (Kil1\_02) and adjacent to a local access road (Kil1\_04). This flooding inundates lands in the southern portion of the application site, to a maximum depth of 0.61 m.

A number of mitigation measures have been recommended with a view to facilitating the development. There are no proposals to install flood defences or raise riverbanks as this would displace floodwaters elsewhere. Instead the hydrological regime of the site will not be altered in any way. Solar panels are all raised above flood levels by way of mounting legs. Proposed finished floor levels of all MVPS units shall be a minimum 300 mm above Q<sub>1000</sub> flood elevations.

Specifications have been presented elsewhere for SuDS devices which will facilitate disposal of rainfall-runoff generated on hardstanding areas.

The northern and central portions of the site are in Flood Zone C and highly vulnerable development is appropriate here. Part of the solar farm in the southern portion of the site will be in Flood Zone A. As the solar farm has been designed to be a water compatible land use, due to all solar panels being raised above maximum predicted flood level, this form of development is deemed appropriate to progress in Flood Zones A, B and C. The floodplain in this part of the site is functioning as a conveyance route and there will be no increase in flood risk due to these works.

In line with the Flood Risk Guidelines (DoEHLG, 2009), the flood risk assessment demonstrates that the site and proposed site activities satisfy Part 1 of the Justification Test. Hence the Justification Test can proceed to Part 2. The flood risk assessment, which was performed at an appropriate scale, has shown that the proposed site layout design is deemed to have passed Part 2 of the Justification Test.

It can be concluded that the proposed development will not have a negative impact, in terms of flood risk, on the local drainage network, on local private property, or to the surrounding environment and human health.

Subject to the proposed works being carried out in accordance with the specifications presented in this assessment, it can be concluded that the proposed development will not have a negative impact, in terms of flood risk, on the local drainage network, on local private property, or to the surrounding environment and human health.

Permission for the proposed bridges shall be sought from the OPW by way of Section 50 license applications.

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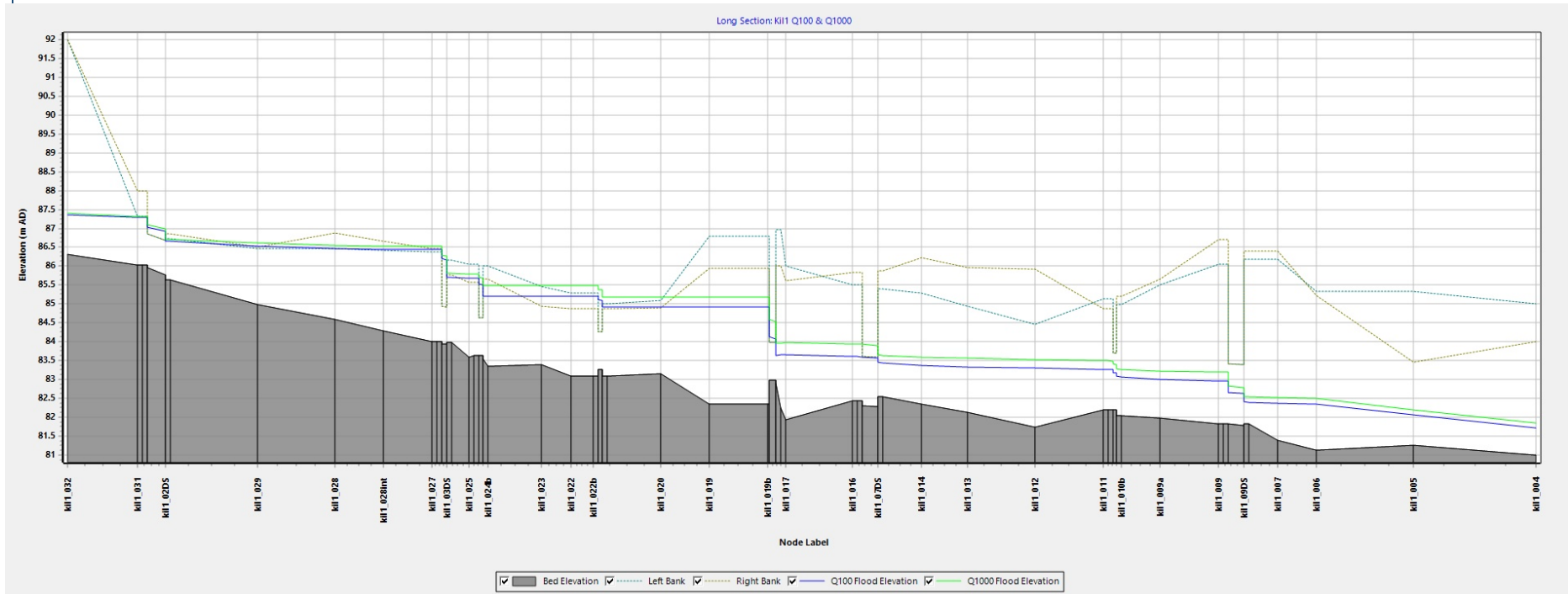
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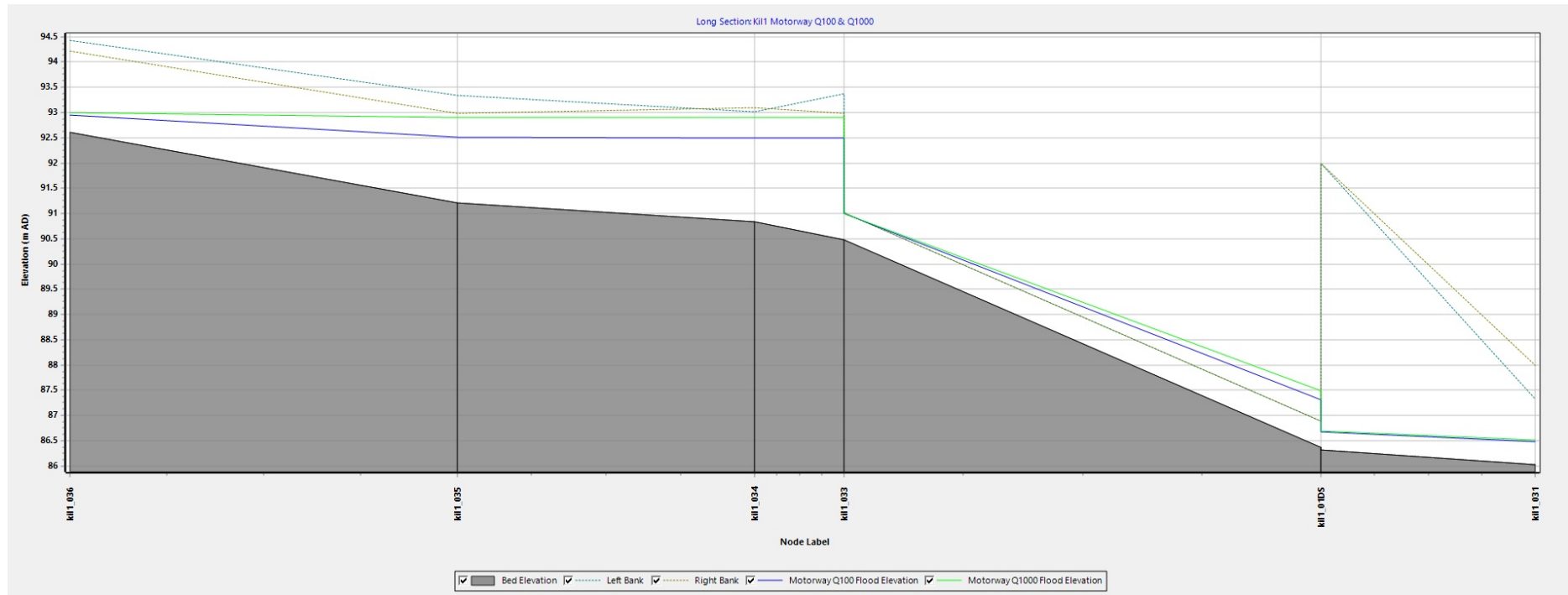
This report refers, within the limitations stated, to the condition of the site(s) at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the sites(s). The report is based on a visual site inspection and the physical investigation as detailed. Envirologic take no responsibility for conditions that have not been revealed due to lack of access. Whilst every effort has been made to interpret the conditions observed, such information is only indicative, and liability cannot be accepted for its lack of accuracy in representing geological/hydrological/hydrogeological conditions.

APPENDIX A

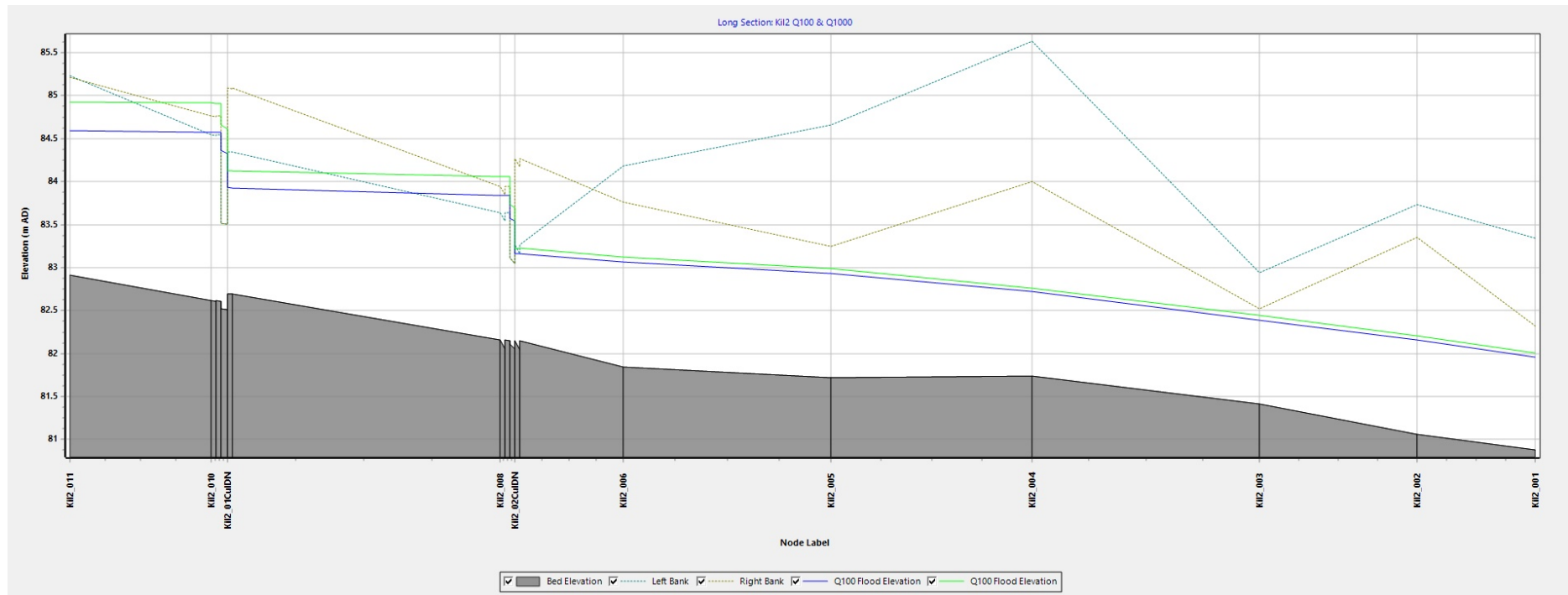
LONGITUDINAL PROFILE: KIL1 – DOWNSTREAM OF M6 CULVERT



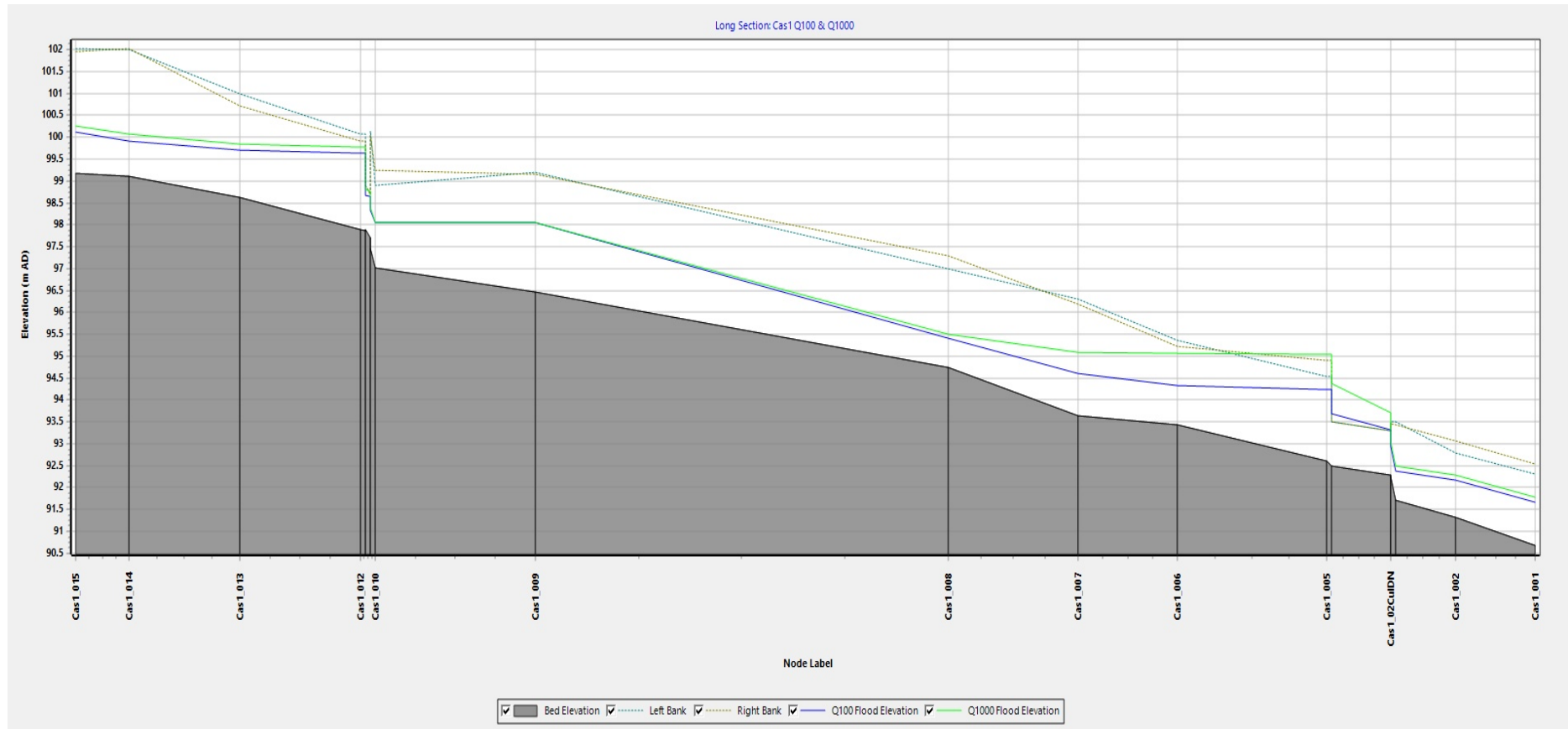
LONGITUDINAL PROFILE: KIL1 – UPSTREAM OF M6 CULVERT



LONGITUDINAL PROFILE: KIL2



LONGITUDINAL PROFILE: CAS1



LONGITUDINAL PROFILE: CAS2

