



Proposed New Lawn Cemetery, Old Dublin Road, Galway. Tier 2 Hydrogeological Risk Assessment



Report for:
Galway City Council

Date:
11th October 2022

Report No.:
BRE20007Rp01A01

BlueRock Environmental Limited
Suite 332, 48 Lower Salthill,
The Capel Building, H91 X856 Galway.
Mary's Abbey,
Dublin 7.

DOCUMENT INFORMATION

Project Title:	Hydrogeological Risk Assessment, Proposed New Lawn Cemetery Old Dublin Road Galway
Project No.:	BRE20007
Report Ref.:	BRE20007Rp01A01
Status:	Final
Date:	11 th October 2022
Client:	Galway City Council

Document Production / Approval Record

	Name	Signature	Date	Position
Prepared by (consultant)	Paul Cummins BSc. MSc.		11/10/22	Project Hydrogeologist
Approved by (consultant)	Niall Mitchell BE, MSc, CEng MIEI, PGeo		11/10/22	Hydrogeologist / Chartered Engineer

DISCLAIMER:

This report has been prepared by BlueRock Environmental Ltd (BREL) with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

Should any party wish to use or rely upon the contents of the report, written approval must be sought from BREL, a charge may be levied against such approval. BREL accepts no responsibility or liability for a) the consequences of this document being used for any purpose or project other than for which it was commissioned, and b) the consequences of this document to any third party with whom an agreement has not been executed.

BREL has prepared this report in accordance with the instructions and objectives of the within the terms of the instruction provided, and the performance of any related obligations. It should be noted that the instructions given may have limited the time and resource provisions utilised for the works and reporting, and they should not be considered to be exhaustive accordingly.

The conclusions and recommendations contained in this report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by BREL has not been independently verified by BREL, unless otherwise stated in the report. Where assessments of works or costs identified in this report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

BREL disclaim any undertaking or obligation to advise any person of any change in any matter affecting the report, which may come or be brought to BREL attention after the date of the report.

Any risk assessment and opinions provided, will have applied the Required Standard to take into consideration currently available guidance and available approaches in the generation of generic or site-specific assessment criteria or remedial target concentrations which relate to the assessment of risk in a specific land use scenario and risk posed to specific receptors. No liability can be accepted for the retrospective impact associated with any future changes or amendments to published assessment criteria, associated models, or associated guidance.

Certain statements made in the report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. BREL specifically does not guarantee or warrant any estimate or projections contained in this report.

Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this report.

BREL maintain intellectual copyright of the contents of this report and grant exclusive use of the material contained herein to the Client (or their appointed agent). No unauthorised distribution shall be made to any third parties without the prior consent of both BREL and the Client (or their appointed agent). No unauthorised reproduction, transmission, scanning, photocopying or storage in a retrieval system of any nature shall be made without the prior written consent of both BREL and the Client (or their appointed agent).

TABLE OF CONTENTS

1	INTRODUCTION	1
	1.1 GENERAL	1
	1.2 OBJECTIVE	1
	1.3 LEGISLATION & GUIDANCE.....	1
	1.4 RISK ASSESSMENT	3
	1.5 METHODOLOGY FOR TIER 2 ASSESSMENT	4
2	PHASE 1 DESK STUDY & SITE WALKOVER	6
3	BACKGROUND SITE INFORMATION.....	7
	3.1 SITE LOCATION	7
	3.2 TOPOGRAPHY	7
	3.3 SITE LAYOUT	8
	3.4 HISTORICAL LAND-USE AND ACTIVITIES	8
4	ENVIRONMENTAL DESCRIPTION.....	10
	4.1 REGIONAL GEOLOGY	10
	4.2 REGIONAL OVERBURDEN.....	10
	4.3 HYDROLOGY	12
	4.4 HYDROGEOLOGY	13
	4.4.1 Aquifer Classification	13
	4.4.2 Aquifer Vulnerability.....	13
	4.4.3 Groundwater WFD Status	15
	4.4.4 Groundwater Wells	15
	4.5 PROTECTED AREAS	16
	4.6 PREVIOUS INVESTIGATION	17
5	BREL SITE INVESTIGATION & MONITORING.....	19
	5.1.1 Ground Conditions.....	20
	5.1.2 Infiltration testing	20
	5.2 GROUNDWATER LEVELS.....	20
	5.3 GROUNDWATER FLOW INTERPRETATION	26
	5.4 WATER QUALITY SAMPLING.....	27
	5.5 WATER QUALITY GUIDELINES	28
	5.6 WATER QUALITY ANALYSIS	28
6	CONCEPTUAL SITE MODEL (CSM)	31
	6.1 IDENTIFICATION OF POTENTIAL SOURCES	31
	6.2 IDENTIFICATION OF POTENTIAL EXPOSURE PATHWAYS	31
	6.3 POTENTIAL RECEPTORS	32
	6.4 POTENTIAL POLLUTANT LINKAGES	32
7	CONCLUSIONS	37
8	RECOMMENDATIONS	39
9	REFERENCES	40

LIST OF FIGURES

Figure 1.1	Typical Stages of Risk Assessment	3
Figure 3.1	Site Location	7
Figure 3.2	Topographical Contours	8
Figure 4.1	Regional Geology	10
Figure 4.2	Topsoil Geology.....	11
Figure 4.3	Subsoil Geology.....	11
Figure 4.4	Regional Hydrology	12
Figure 4.5	Karst Features within 3km of site	13
Figure 4.6	Groundwater Vulnerability	14
Figure 4.7	Groundwater Wells within 5 km of the site	16
Figure 4.8	Natura 2000 Sites	17
Figure 4.9	2020 Trial Pit Locations	18
Figure 5.1	November 2020 Site Investigation Locations	19
Figure 5.2	Groundwater Levels (mOD).....	22
Figure 5.3	Automated Logger Monitoring (Nov 2020 to Feb 2021).....	23
Figure 5.4	Automated Logger Monitoring (Dec 2021 to March 2022)	23
Figure 5.5	Groundwater Contours and Flow Direction (11/01/2021).....	24
Figure 5.6	Groundwater Contours and Flow Direction (20/01/2021).....	25
Figure 5.7	Groundwater contours And Flow direction (10/02/2022).....	26

LIST OF TABLES

Table 3.1	Historical Land-use and Activities.....	9
Table 4.1	Vulnerability Mapping Guidelines	14
Table 4.2	Details of groundwater wells within 5 km of the site.....	16
Table 5.1	Groundwater Monitoring Well and Water Strike Details	20

Table 5.2	Water Level Data Logger.....	21
Table 5.3	Summary of Chemical Water Analysis	30
Table 6.1	Classification of Consequence	33
Table 6.2	Risk Categories	33
Table 6.3	Possible Pollutant Linkages.....	36

APPENDICES

Appendix A	2020 Trial Pit Logs
Appendix B	2021 Site Investigation Trial Pit & Borehole logs, PSD Certs and Infiltration Test results
Appendix C	Laboratory Certificates

1 INTRODUCTION

1.1 General

BlueRock Environmental Ltd (BREL) were requested by Galway City Council (GCC) to undertake a Tier 2 Hydrogeological Risk Assessment of a proposed New Lawn Cemetery at the Old Dublin Road, Galway city.

GCC are currently considering open lands along the Old Dublin Road for the development of a municipal cemetery to provide additional cemetery facilities for the city. As part of the consideration of this site, an assessment of potential risks posed by a proposed municipal cemetery to groundwater and other sensitive receptors was deemed necessary to determine the suitability of the site.

The proposed cemetery site comprises an area of 1.4 hectares and is located on the Old Dublin Road to the southwest of the Connacht Hotel. BREL understands that the development would comprise 1,900 graves with an approximate burial rate of 100 per year.

The human body is made up of a multitude of elements and complex organic substances. After death, these components return to the wider environment either through the natural processes of decay or through human intervention for example in cremation. The decaying process can potentially result in the discharge of hazardous substances and non-hazardous pollutants to groundwater.

As there are no dedicated graveyard guidance documents in Ireland for assessing proposed cemeteries, the UK R&D Technical Report P223 was utilised for this risk assessment to provide an initial conservative risk rating for the site based on background ground conditions and the scale of the proposed cemetery (i.e. number of burials per year). Based on a vulnerability rating of Moderate/High (Source: GSI¹ online mapping) and an expected average burial rate of approximately 100 per year, the site is assigned a High Risk to groundwater without more site-specific information to consider. It should be noted that this risk rating is a high-level rating only and enables the scoping of a site investigation and monitoring/assessment works to develop a site-specific risk assessment for the proposed cemetery.

1.2 Objective

The objective of this assessment is to gain an understanding of the environmental site setting and identify any potential risk or impacts that could result from the proposed graveyard on hydrological and or the hydrogeological environment within the general vicinity of the site.

1.3 Legislation & Guidance

There is currently no recent rules and regulations surrounding burials in graveyards in Ireland. The main document relates to the Regulation of Burial Grounds 1888, which was introduced under Section 181 of the Public Health of Ireland Act 1878. It consists of 13 no. rules which apply to all burial grounds. These rules govern the basic operation of burial ground groundwater regarding fencing, size, and depths of graves, general control of the graveyard and maintenance of proper records. It states that grave spaces must be at least nine feet long by four feet wide and at least six feet long by three feet wide in the case of children under twelve years of age. The first interment or burial

¹ Geological Survey of Ireland

in a grave space, should be sunk to a depth of at least eight feet or to a lesser extent as decided by the Medical Office of Health, if the sub-soil does not allow for a depth of eight feet.

There are a number of pieces of Irish legislation governing the pollution of water and impacts on sensitive receptors such drinking water supplies, human health and protected habitats. These are summarised below:

European Directives:

- Water Framework Directive (2000/60/EC);
- Groundwater Directive (2006/118/EC).

Irish Government Acts and Regulations:

- Local Government (Water Pollution) Acts 1977 to 1990;
- European Communities (Quality of Salmonid Waters) Regulations, 1988 (S.I. No. 293 of 1988);
- European Communities (Natural Habitats) Regulations, 1997 (S.I. No. 94 of 1997 as amended by S.I. No. 233 of 1998 and S.I. 378 of 2005);
- Environmental Protection Agency Acts, 1992 to 2011;
- Waste Management Acts, 1996 to 2011;
- European Communities (Water Policy) Regulations, 2003 (S.I. No. 722 of 2003);
- European Communities (Quality of Shellfish Waters) Regulations, 2006 (S.I. No. 268 of 2006);
- Water Services Act, 2007;
- European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007);
- Waste Water Discharge (Authorisation) Regulations 2007 and 2010 (S.I. No 684 of 2007 as amended by S.I. No. 231 of 2010);
- Bathing Water Quality Regulations, 2008 (S.I. No. 79 of 2008);
- European Communities Environmental Objectives (Surface Water) Regulations, 2009 (S.I. No. 272 of 2009);
- European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010); and,
- European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2010 (S.I. No. 610 of 2010).

In the absence of regulatory notes from the Environmental Protection Agency Ireland ('EPA'), the following relevant UK guidance has been considered as part of this assessment relating to Cemeteries, Burials and the Water Environment. This guidance is considered national and international best practice.

- The Environment Agency ('EA') guidance on assessing the groundwater pollution potential of cemetery developments². This guidance has since been withdrawn³ however some of its content remains useful and relevant, and,
- The Environment Agency Research and Development Report on the Pollution Potential of Cemeteries⁴.

The aforementioned guidance recommends that burial plots should be located:

- A minimum of 250m from a borehole, spring, or well used for the supply of drinking water and or bottling mineral water;

² Guidance: Cemeteries and burials: Prevent Groundwater Pollution (<https://www.gov.uk/guidance/cemeteries-and-burials-prevent-groundwater-pollution>) accessed 17th January 2019.

³ Assessing the Groundwater Pollution Potential of Cemetery Developments, Science Group: Air, Land & Water; Environment Agency April 2004 (Product Code SCH0040BGLA-E-P)

⁴ Pollution Potential of Cemeteries; Draft Guidance, R&D Technical Report P223, Young C.P, Blackmore K.M, Reynolds P, and Leavens A, 2002.

- A minimum of 50m from all other boreholes, springs, and wells (Private Water Supplies);
- A minimum of 50m from a river, canal, lake, wetland, or the coast;
- A minimum of 10m from field drains (to include old agricultural drainage systems);

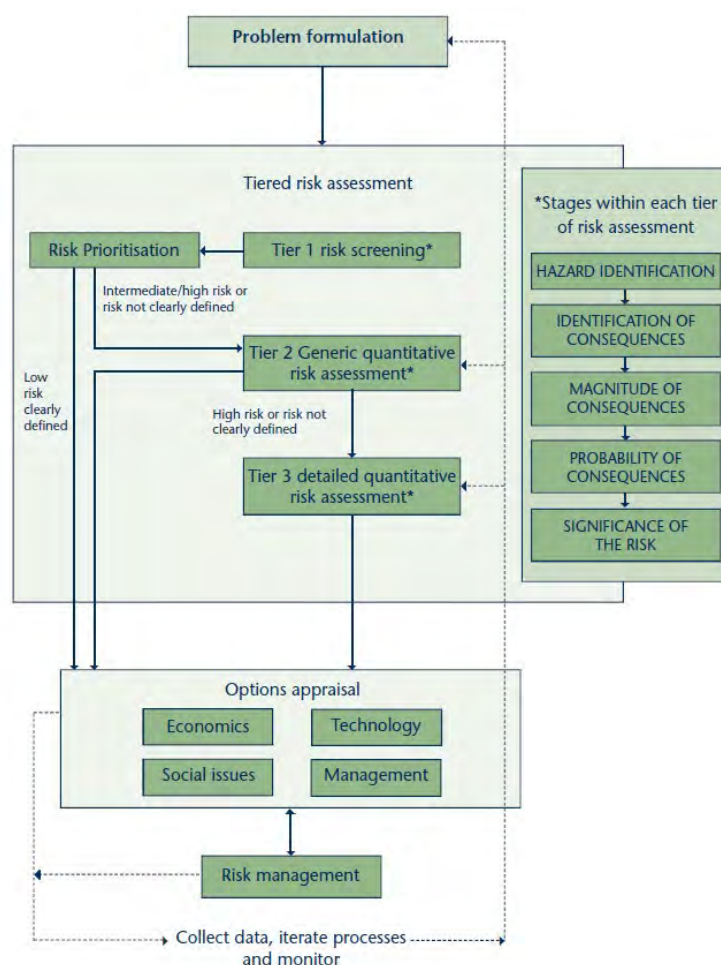
In addition to this:

- If bedrock is encountered in the trial pit, then this area should not be considered for burial plots; and,
- where standing water is present at the bottom of the trial pit when first dug, then this area of the site is not suitable for burials.

In the absence of guidance from the EPA, Northern Ireland Environment Agency Guidance recommends maintaining a minimum of 1m sub soil beneath a typical burial; thus requiring circa 2.8 metres of superficial cover to offer protection to the underlying aquifer. The guidance also discourages burials taking place below the water table.

1.4 Risk Assessment

A tiered assessment approach is typically utilised in order to determine the potential risk that would be posed by a cemetery. This report represents a Tier II Risk Assessment as outlined below in Figure 1.1.



(Source: EA, 2004)

Figure 1.1 Typical Stages of Risk Assessment

Tier 1: Detailed Desktop Survey and Risk Screening

This comprises the development of a preliminary site assessment using all readily available information including published maps and data (i.e. topographical, geological, hydrogeological including groundwater vulnerability maps) in addition to any historical investigations undertaken at the site. An assessment of the hazards is made, and potential pathways and receptors identified with a qualitative assessment undertaken of the significance of the risks posed.

On completion of the Tier 1 Risk Screening, the risks posed can be prioritised and considered further in an options appraisal exercise which may include reducing the hazard through new technology, burial procedures or mitigating the effects through improved environmental management techniques. A Tier 1 exercise is typically only sufficient for low-risk sites i.e. < 10 burials per year.

Tier 2: Preliminary Intrusive Site Investigation & Preliminary Risk Assessment

A Tier 2 assessment is typically undertaken for intermediate risk sites or where the risks are not clearly defined. This assessment involves the collation of more detailed site investigation data in conjunction with intrusive site investigation techniques (i.e. trial pitting or shallow borehole drilling, soil testing, water sampling etc.).

The data recorded facilitates simple pollutant flux and water balance calculations to determine the risk posed to sensitive receptors.

For any proposal to be acceptable, the assessment typically requires a demonstration that no impact on groundwater would occur or, at worst, that the impact would not amount to pollution as defined in the Groundwater Directive (i.e. no impact from hazardous, and ideally no impact from non-hazardous substances). If the proposed development is deemed acceptable, conditions that ensure pollution does not take place would typically need to be demonstrated.

Tier 3: Detailed Risk Assessment

If the risk is deemed to be high or is not clearly defined from the Tier 2 assessment, a Tier 3 assessment is typically required. This would involve a more detailed site investigation, risk assessment and on-going monitoring. The use of groundwater modelling techniques is often required.

Based on the moderate/high vulnerability of groundwater in the Old Dublin Road site and a proposed burial rate of approximately (100+ per year) a Tier 2 risk assessment was undertaken to assess the potential risk posed by the proposed cemetery with a view to completing a Tier 3 risk assessment should the Tier 2 assessment indicate favourable hydrogeological conditions and a low-level risk to sensitive receptors.

1.5 Methodology for Tier 2 Assessment

The scope of work was undertaken:

Phase 1	Desk Study & Site Visit
Phase 2	Trial Pitting (4 no.), Borehole drilling & Monitoring Well installations (4 no.), Soil & Groundwater Sampling & Groundwater level monitoring.
Phase 3	Tier 2 Interpretative Hydrogeological Reporting & Risk Assessment

This proposed scope is in accordance with the appropriate guidance documents as outlined below:

- ✓ Environment Agency (England and Wales) Guidance Document “Pollution Potential of Cemeteries Draft Guidance R&D Technical Report P223”

- ✓ Cemeteries and burials: prevent groundwater pollution & Cemeteries and burials: groundwater risk assessments (2017);
- ✓ European Communities Environmental Objectives (Groundwater) Regulations, 2010 – SI No. of 2010; and,
- ✓ EPA Guidance on the Authorisation of Discharges to Groundwater, 2011.

2 PHASE 1 DESK STUDY & SITE WALKOVER

An initial site walkover was undertaken by BREL on the 31st August 2020. This involved visual inspections of the existing site, the proposed cemetery extension site and the surrounding environs.

The following sources of publicly available information were consulted as part of the desk study:

- ✓ Ordnance Survey of Ireland, Discovery Series, Sheet 45;
- ✓ Ordnance survey of Ireland (OSI) online historical maps and aerial photographs;
- ✓ Geology of Galway Bay, Geological Survey of Ireland (GSI) (1:100,000), Sheet 14;
- ✓ GSI On-line Groundwater database. Aquifer Classification, Aquifer Vulnerability, Teagasc Soil Classification;
- ✓ GSI Clarinbridge (GWB) report;
- ✓ Soil Map of Ireland (Second Edition, 1980), national Soil Survey of Ireland, An Foras Talúntais.
- ✓ National Parks and Wildlife Service On-line database www.npws.ie;
- ✓ EPA Online Water Quality Mapping; <https://gis.epa.ie/>; and,
- ✓ OPW Hydro-Data (<http://www.floodinfo.ie/map/floodmaps/>).

The information outlined in Chapter 3 and Chapter 4 is sourced from the above sources of information and the site walkover.

In addition, a previous site investigation was undertaken by GCC on the 21st May 2022. This investigation comprised the excavation of 6 no. trial pits and are described in Section 4.6 below.

3 BACKGROUND SITE INFORMATION

3.1 Site Location

The site is located on the Old Dublin Road, located to the west of the Connaught hotel, within the eastern suburbs of Galway city (ITM 531749, 726058). The site is 2.3 km northeast of Galway city centre and <500m from Lough Atalia (Figure 3.1).



Source: Google Maps

Figure 3.1 Site Location

3.2 Topography

The topographical relief across the general area ranges between 15 mOD⁵ and 20 mOD and generally falls in a southwestern direction towards Lough Atalia (see Figure 3.2). The land surface is low lying and relatively flat.

⁵ Metres Ordnance Datum



Figure 3.2 Topographical Contours

3.3 Site Layout

The site comprises a football pitch and a rectangle of land to the south of the pitch comprising open gravel area for carparking and a wastewater pumping station. Land use to the north and west is residential, to the east is the Connacht Hotel and to the south the old Dublin Road. The site comprises an area of approximately 1.4 ha.

3.4 Historical Land-Use and Activities

A summary of a review of historical maps for the site is provided below in Table 3.1.

Ordinance Survey Map Reference	On Site	Immediate Surroundings
OS 6 inch Colour (1837-1842)	The site was part of a large plot of agricultural land.	Renmore House and estate located across the road to the southeast of the site. Land use in general is agricultural.
OS 6 inch Cassini (1845)	The site is surrounded to the north and east by sports fields. It is unclear if it formed part of this parcel.	There is an increase in the number of buildings in the general area. Land use in the area is mapped as recreational and residential.
OS 25 inch (1888-1913)	The site now forms a large area within a plot with a boundary delineated by trees.	No change to note.

Aerial Map 1995	The site has reduced in size to accommodate residential developments that exist to the north and the west of the site.	Lands surrounding the site are now developed into residential and commercial properties with the exception of the playing fields to the north of the present day Connaught Hotel.
Aerial Map 2000	No Change	No Change
Aerial Map 2005	No Change	No Change
Aerial Map 2005 - 2012	No Change	No Change

Table 3.1 Historical Land-use and Activities

4 ENVIRONMENTAL DESCRIPTION

4.1 Regional Geology

The geology underlying the site is mapped by the Geological Survey of Ireland (GSI) as the Burren Formation (Figure 4.1). This formation is typified by pale grey packstones and wackestones, but also contains intervals of dark cherty limestones, often associated with oolitic grainstones.

A northwest-southeast trending fault line is mapped to the southeast of the site. A small area of bedrock outcrop or subcrop is mapped to the southeast of the site.

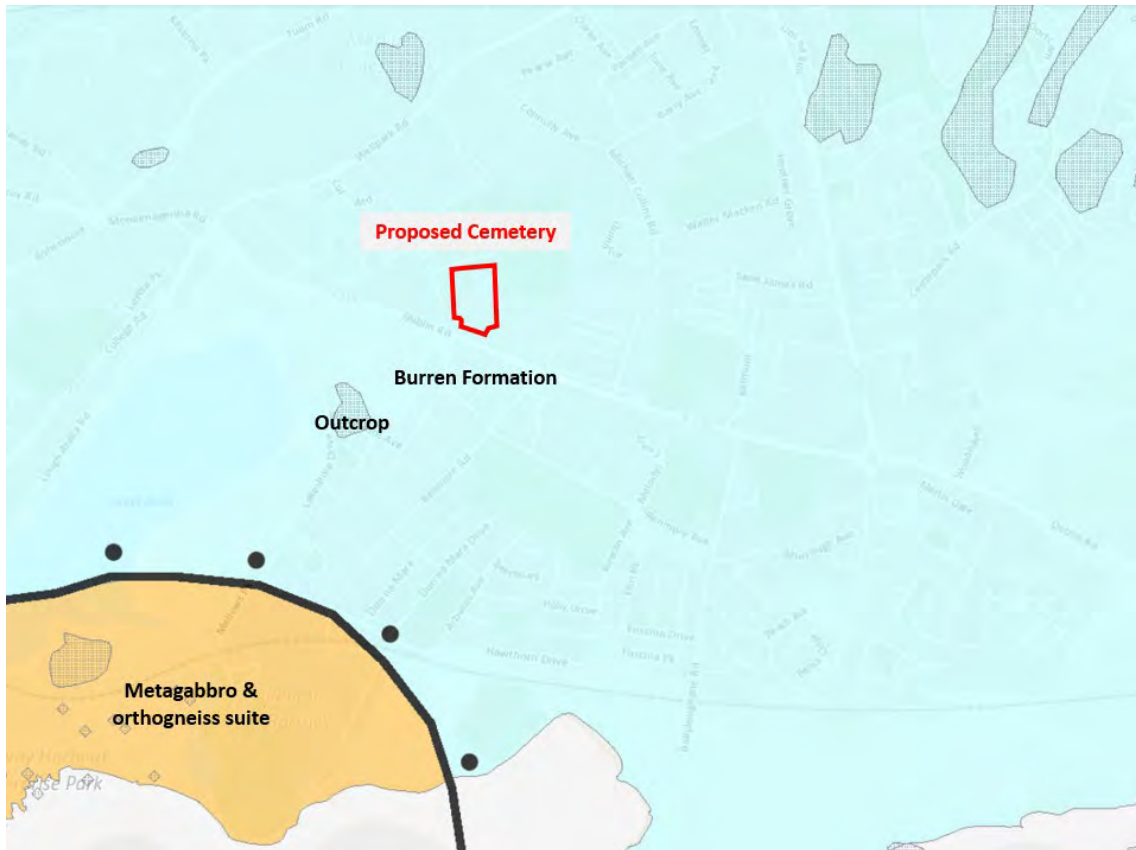


Figure 4.1 Regional Geology

4.2 Regional Overburden

Topsoil at the site is mapped as deep well drained mineral soil (BminDW), derived from limestone parent material (Figure 4.2). Topsoil outside of the site and adjacent playing fields area is mapped as Made Ground (MG). The subsoils across the site are mapped as Till (TLs) derived from limestone (Figure 4.3).

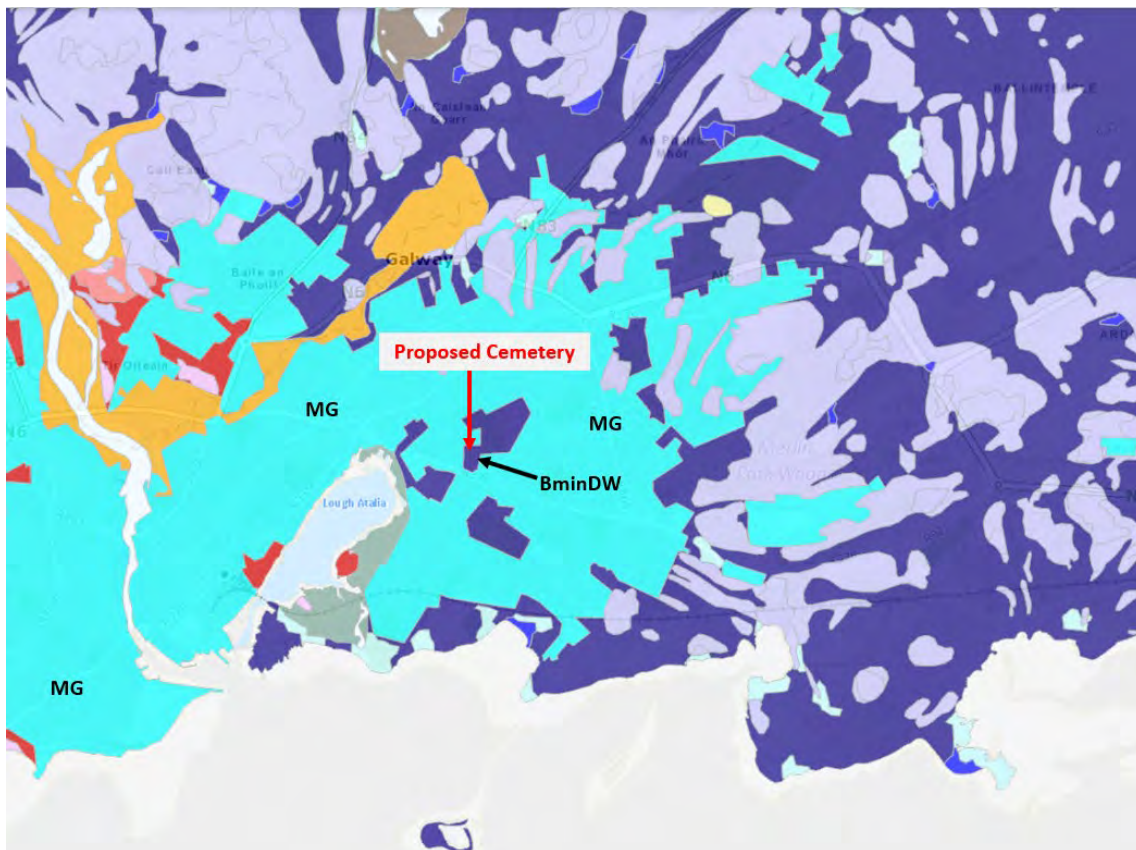


Figure 4.2 Topsoil Geology

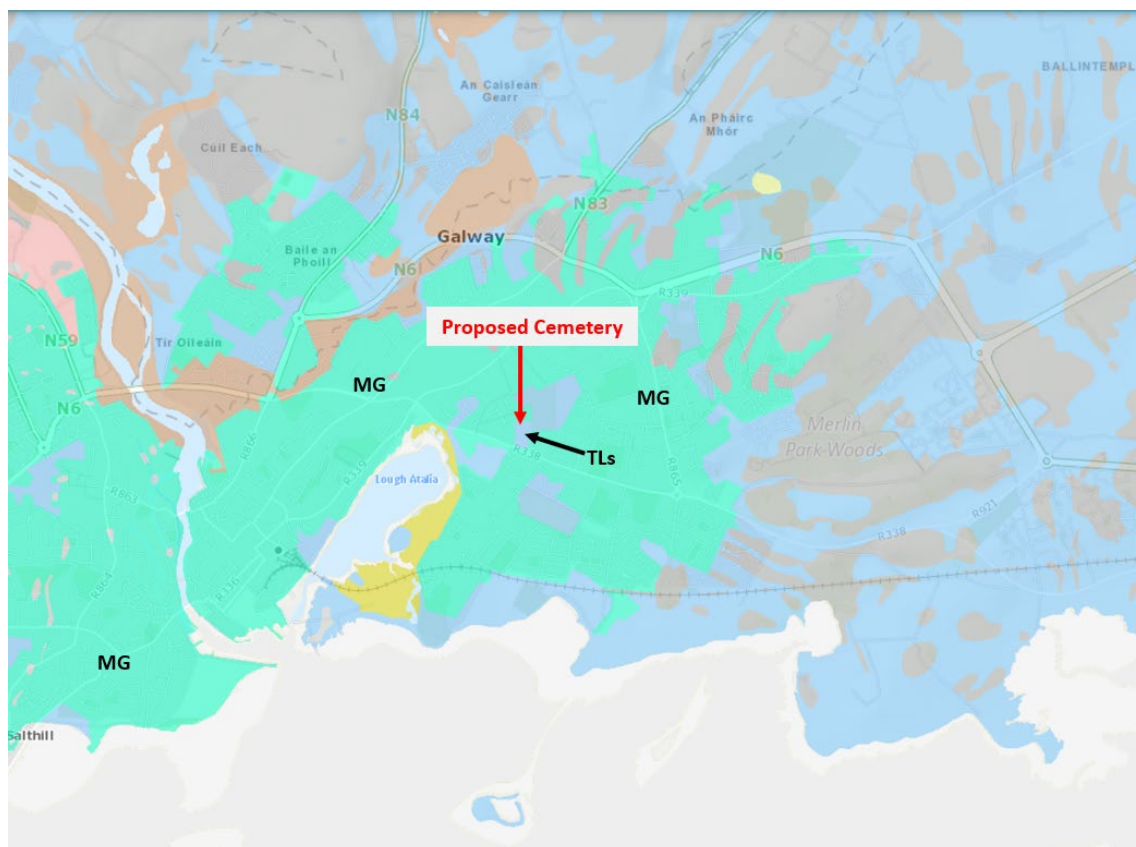


Figure 4.3 Subsoil Geology

4.3 Hydrology

Regionally the site is located within the Western River Basin District (WRBD) in hydrometric area 29. Locally the site is within the Carrowmoneash (Oranmore_SC_010_29_6). The site is located about 1km from the nearest surface water body the Terryland (EPA designation; Terryland_010) river. It also lies in close proximity to the larger Corrib (EPA designation; corrib_020) river. Both of these rivers are located within a different catchment area despite their proximity to the subject site.

The closest coastal water body is located at Lough Atalia which is approximately 450 metres southwest and downgradient of the site.

- The Carrowmoneash River (IE_WE_29C050400) is located 6.3km to the east and flows into Galway Bay at Oranmore. This river body is not designated a status under the Water Framework Directive (WFD) but the river is at risk from an Industrial area (<https://gis.epa.ie/EPAMaps/Water>).
- Ballyloughane Beach (IEWEBWT170_0700_0200) is located 1.2 km to the south of the site, the bathing water quality was classified as 'Poor' in 2019 (<https://gis.epa.ie/EPAMaps/Water>).
- Transitional Waterbody IE_WE_170_0500 is unassigned under the WFD;
- Transitional Waterbody WFD Status 2013-2018 IE_WE_170_0700 was classified as 'Good';
- There are no flood hazards mapped in the vicinity of the site (www.floodinfo.ie/map/floodmaps/).

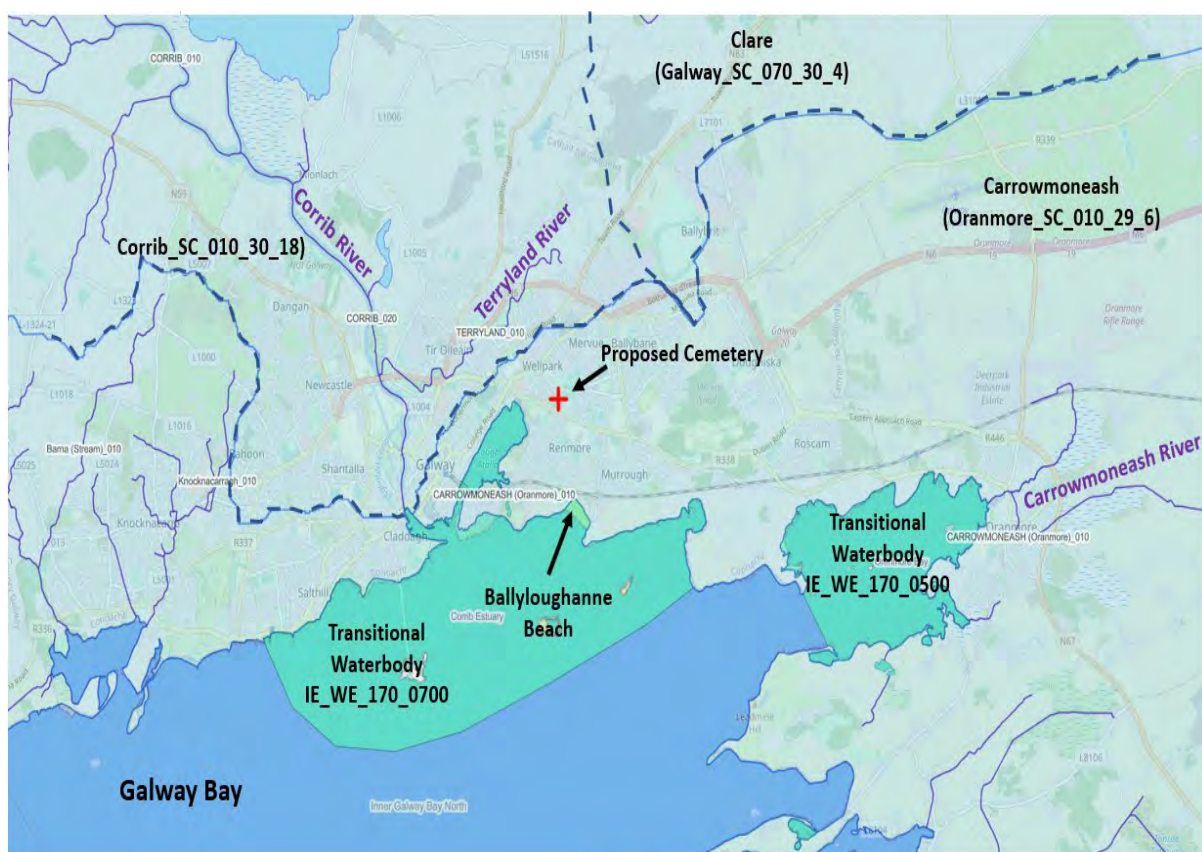


Figure 4.4 Regional Hydrology

4.4 Hydrogeology

4.4.1 Aquifer Classification

The GSI describes the bedrock in the area as a Regionally Important Aquifer - Karstified (conduit) (Rkc). The site is located within the Clarinbridge GWB. Karstification is widespread and it is considered that many features are not mapped or identified. GSI maps indicate a swallow hole at Merlin Park Hospital and two springs and a cave in the townland of Murroogh approximately <2km to the east-southeast of the site (Figure 4.5). Also mapped are two springs, a karst cave and two Karst swallow holes between 1 and 2 km to the north. There are no group water schemes or public supply source protection areas within 2km of the site. Abstraction wells mapped by the GSI in the general Galway city area are listed in Table 4.2. All are located at least 2 km and upgradient of the subject site.

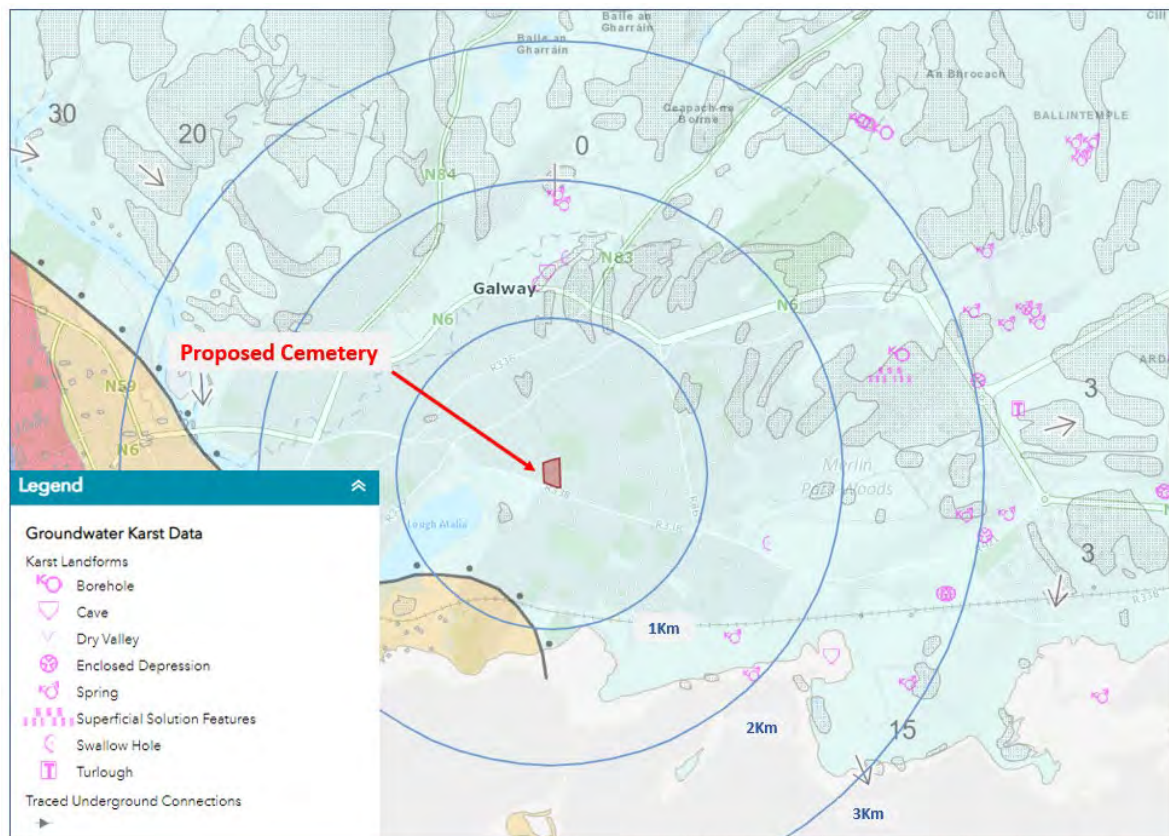


Figure 4.5 Karst Features within 3km of site

Most groundwater flux is expected to be in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 35m below this. Overall, flow directions are expected to be to the west, with groundwater discharging to littoral and intertidal springs. Locally, groundwater flow directions are expected to follow regional topography and are anticipated to flow towards Lough Atalia.

4.4.2 Aquifer Vulnerability

The Geological Survey of Ireland (GSI) has produced a groundwater vulnerability classification system to assess the vulnerability of groundwater across the country.

The classification system takes into account subsoil permeability, thickness of drift deposits, unsaturated zone thickness and recharge type; such that areas with thin (*i.e.* 0-2m) high permeability drift cover is considered the most vulnerable (an “Extreme” vulnerability rating being given), whilst areas with thick (*i.e.* > 8 m) low permeability drift cover are considered the least vulnerable (a “Low” vulnerability rating being given). The groundwater vulnerability matrix is provided below in Error! Reference source not found..

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	> 3.0m	3.0 - 10.0m	3.0 - 5.0m	> 3.0m	N/A
Moderate (M)	N/A	> 10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	> 10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
 (2) Precise permeability values cannot be given at present.
 (3) Release point of contaminants is assumed to be 1-2 m below ground surface.

Source: Geological Survey of Ireland

Table 4.1 Vulnerability Mapping Guidelines

The site is mapped by the GSI as Moderate (M) Vulnerability in the southern region of the site and High (H) Vulnerability in the northern region of the site (Figure 4.6).

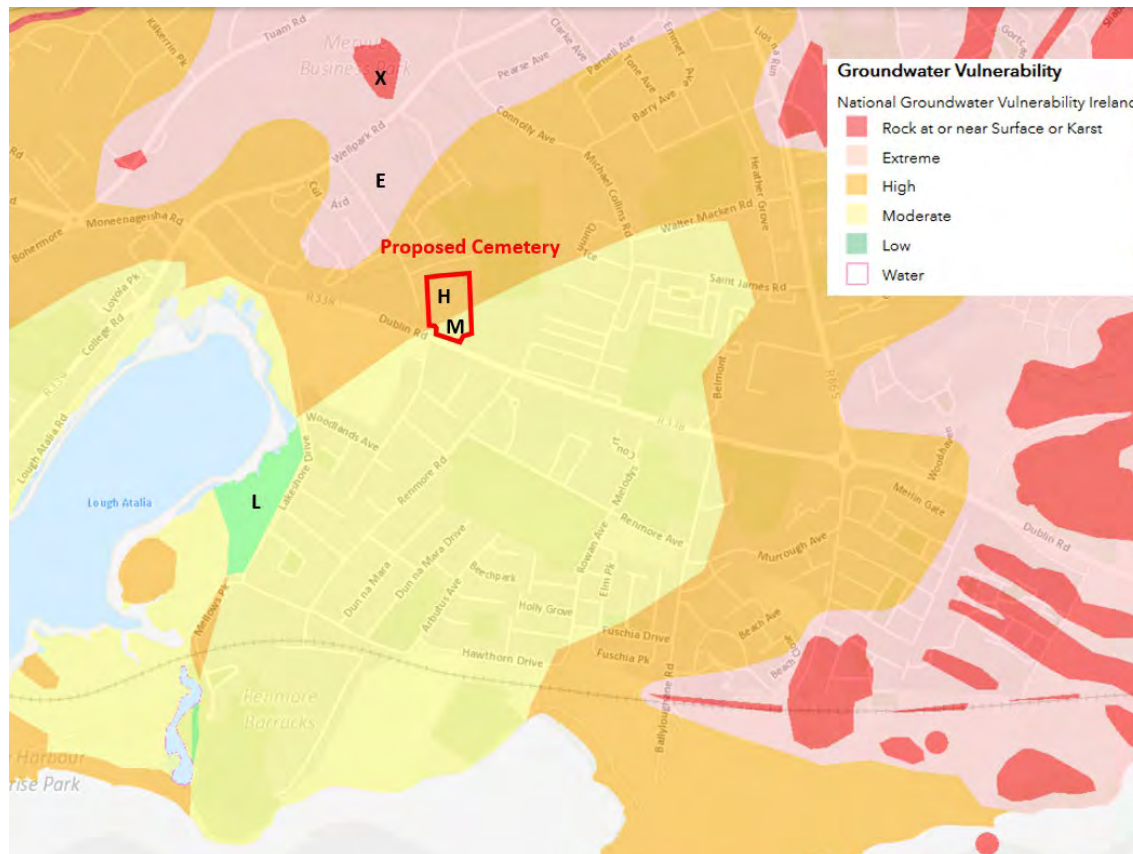


Figure 4.6 Groundwater Vulnerability

4.4.3 Groundwater WFD Status

The Clarinbridge GWB (IE_WE_G_0008) has a Groundwater WFD Status of 'Good' and a WFD Risk Score of 'at risk'.

4.4.4 Groundwater Wells

Several groundwater wells are mapped by the GSI within 5 km of the site. The details of these wells are outlined in Table 4.2 and their locations presented on Figure 4.7.

There is a groundwater abstraction well within the grounds of the Connaught Hotel located in close proximity to the eastern site boundary of the site. Information sourced from the planning files and from direct consultations with the hotel confirmed the following:

- ✓ The abstraction well was drilled on 8th March 2011 to a total depth of 54.86 mbgl⁶.
- ✓ Bedrock was encountered at a depth of 6.1 mbgl.
- ✓ A 200mm steel casing was installed to a depth of 12.2 mbgl with the annulus cemented with grout, and a PVC casing was installed to the base of the borehole.
- ✓ The estimated yield range was calculated to between 437 to 545 m³/day.
- ✓ Current water usage reported by the hotel is approximately 900 m³/week.
- ✓ The abstracted water is treated on site by filtration, Ultraviolet radiation and chlorination before being used for non-potable use. All drinking water and water used in the kitchens etc is sourced from Galway City Council mains water supply.

There are other known groundwater abstractions supplying water the Bon Secours Hospital (located approximately 390 metres southeast of the site), Flannerys Hotel (located approximately 545 metres southeast of the site), and the Huntsman Inn (located approximately 610 metres west of the site). The yields and uses of these wells are currently unknown. However, they are not understood to be used for potable use.

GSI Name	Well Type	Depth	Depth to Rock	Location / Well Use	Yield (m ³ /d)
1121NEW005	Borehole	42.7	Unknown	Ballinfoyle Group Scheme / Domestic (>2km northwest of site)	141.8
1121NEW027	Unknown	3	Unknown	Ballyloughaun / Other	Unknown
1121NEW019	Dug Well	9.8	Unknown	Murrough House Well / Agri & Domestic	Unknown
1121NEW001	Unknown	19.8	Unknown	Murrough / Agri & Domestic	Unknown
1211NEW018	Borehole	Unknown	Unknown	Merlin / Unknown	Unknown
1121NEW025	Borehole	4.3	Unknown	Mervue / Other	Unknown
1121NEW026	Dug Well	4.5	4.5	Mervue / Other	Unknown
1121NEW024	Borehole	33.2	Unknown	Brockagh / Group Scheme (>4km northeast of site)	130.9

⁶ mbgl = metres below ground level

1121NEW006	Borehole	38.1	0.3	Ballindoooley / Group Scheme Domestic use only	141.8
1121NEW032	Borehole	76.2	Unknown	Ballybane / Unknown	654
121NEW004	Borehole	76.2	0.3	Ballybrit / Domestic	654.6

Table 4.2 Details of groundwater wells within 5 km of the site

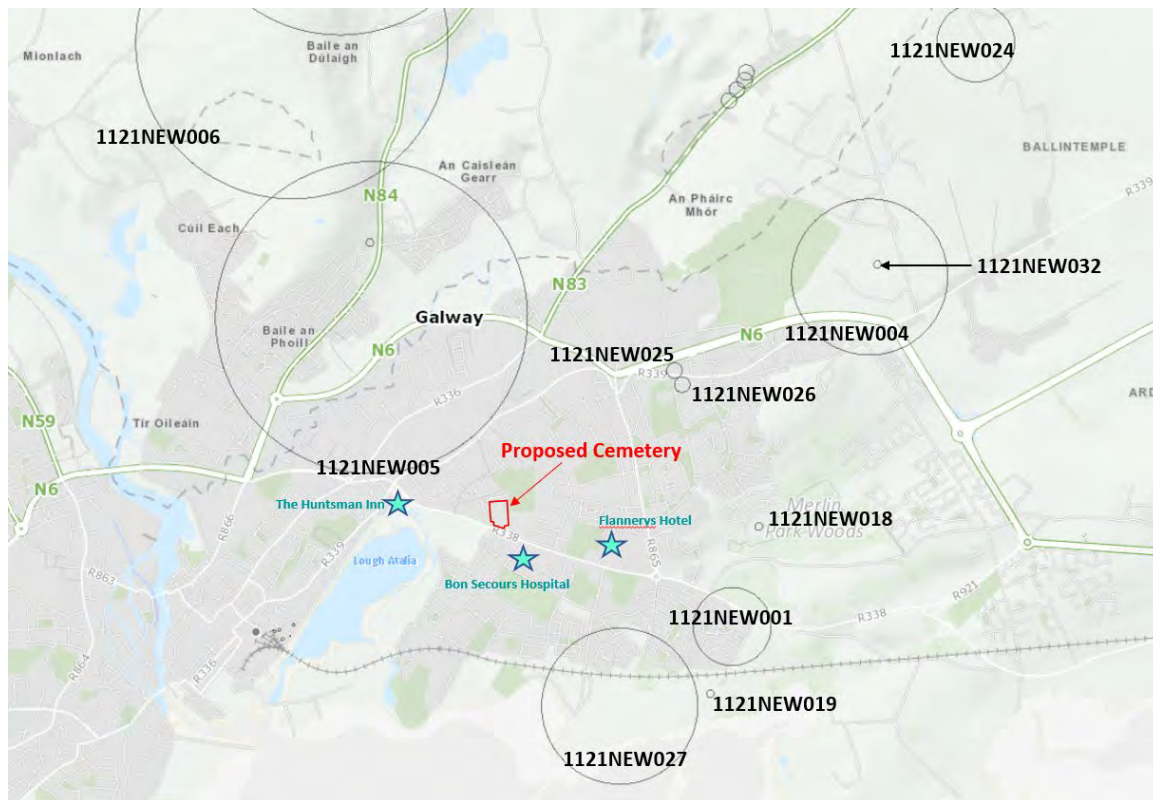


Figure 4.7 Groundwater Wells within 5 km of the site

4.5 Protected Areas

As mentioned previously, there are no groundwater group schemes or public supply source protection areas within the surrounding area.

The Galway Bay Complex and Lough Corrib Special Areas of Conservation (SAC), Inner Galway Bay Specially Protected Areas (SPA) and the Galway Bay Complex Proposed Natural Heritage Areas (pNHA) are mapped within 3km of the site (Figure 4.8).

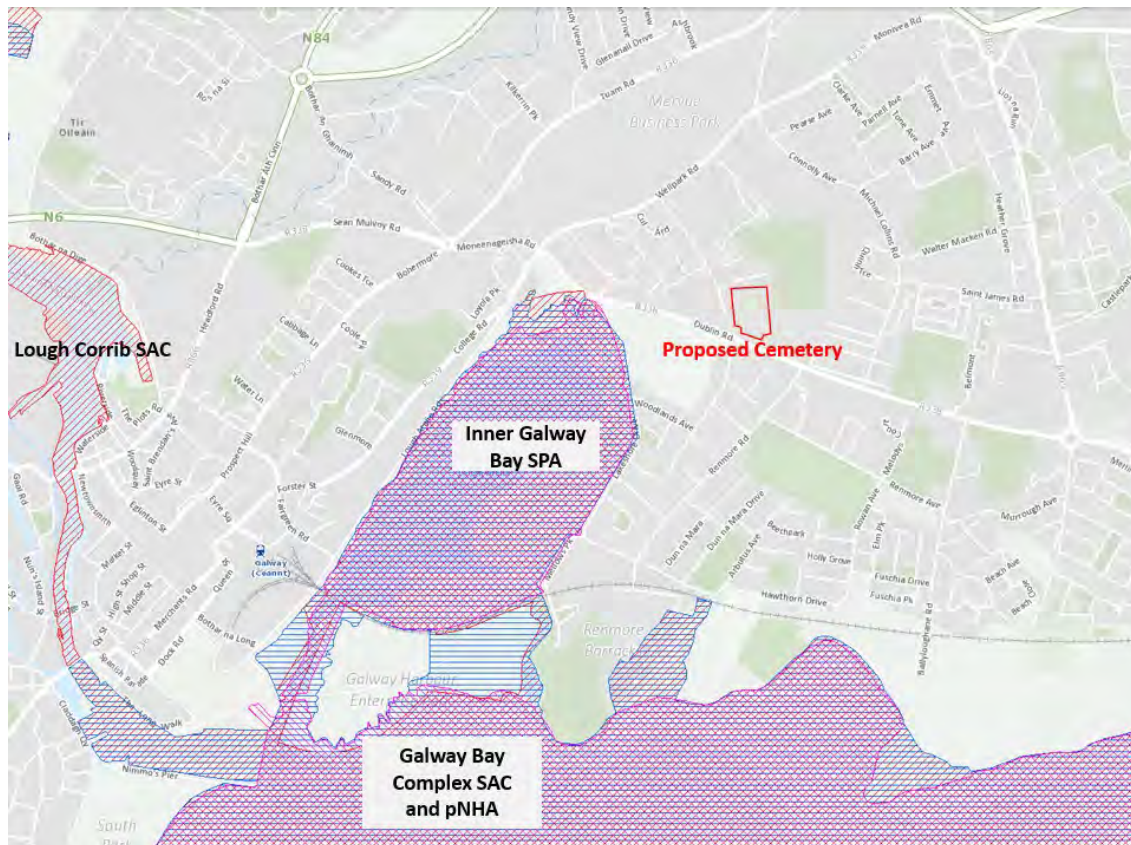


Figure 4.8 Natura 2000 Sites

4.6 Previous Investigation

Galway City Council (GCC) excavated 6 no. trial pits (i.e. TP1 to TP6) at the site using an 8-tonne excavator on the 21st May 2020. The trial pit locations are presented on Figure 4.9.

The total depth of the trial pits ranged between 2.0 and 3.0m. The ground conditions generally comprised 0.15 to 0.2m of topsoil overlying silty sandy gravelly clay with occasional cobbles and infrequent boulders. Organic material was recorded within dark brown sandy silty clay below the topsoil in TP1, TP3, TP4 and TP5 at depths ranging between 0.5 and 0.8m. The subsoil thickness ranged between 1.6 and 2.85m.

All 5 no. trial pits terminated in 'hard' material which the trial pit photographs suggest as comprising of stiff grey boulder clay. Possible weathered limestone bedrock was recorded in TP2 from 1.75 to 2.0m and this trial pit terminated on possible limestone bedrock at 2.0m. Bedrock was not confirmed, but rather suggested, based on the inability of the 8-tonne excavator to excavate further.

Groundwater was not encountered in any of the trial pits. All site investigation logs are presented in Appendix A.



Figure 4.9 **2020 Trial Pit Locations**

5 BREL SITE INVESTIGATION & MONITORING

An intrusive site investigation was undertaken by Causeway Geotech site investigation contractors between the 3rd and 17th November 2020. The works were supervised by a BREL hydrogeologist, who also undertook on-going monitoring at the site. The scope of the works comprised the following:

- ☒ Drilling of 4 no. boreholes (i.e. BH01 to BH04) to depths ranging between 10 and 15 mbgl.
- ☒ Installation of groundwater monitoring wells within each borehole screened within the limestone bedrock.
- ☒ The excavation of 5 no. trial pits (i.e. TP01 to TP04),
- ☒ infiltration/percolation testing within the trial pits,
- ☒ Groundwater sampling and laboratory testing; and,
- ☒ Automated groundwater level monitoring over time.

All 2020 site investigation locations are presented on Figure 5.1. All borehole and trial pit logs are presented in Appendix B.



Figure 5.1 November 2020 Site Investigation Locations

The boreholes were drilled by rotary drilling techniques using a Hanjin D8 tracked drilling rig to depths of between 10 and 15 mbgl. Each borehole was installed with a 50 mm diameter monitoring well to facilitate groundwater sampling and groundwater level monitoring.

The trial pits were excavated using a 13-tonne excavator to depths ranging between 1.85 and 2.85 mbgl. The trial pits were logged and photographed, and a particle size distribution (PSD) sample was taken at depths of between 2.0 and 2.5 mbgl.

5.1.1 Ground Conditions

The ground conditions generally comprised a layer of topsoil overlying made ground consisting of sandy gravelly clay. The made ground covered the extent of the playing field and was found to be present up to a depth of 0.75m. Topsoil was identified around the edges of the playing area with no evidence of made ground. The made ground and topsoils were logged as being underlain by natural subsoils comprising sandy gravelly silty clay with low limestone cobble content and fine to coarse subrounded limestone gravels. The subsoils were identified to be stiffer with depth and the trial pits were terminated on refusal. No groundwater was encountered.

The boreholes recorded a layer of topsoil overlying natural subsoils comprising, sandy gravelly clay, gravelly sandy silt, or gravelly silty sand. These natural subsoils were recorded to depths ranging between 2.0 and 5.7 mbgl and were shallowest along the eastern site boundary.

Weathered rock was recorded at depths ranging between 2.0 and 3.8 mbgl and competent bedrock was encountered at depths ranging between 4.0 and 5.7 mbgl. PSD test results are presented in Appendix B.

5.1.2 Infiltration testing

Infiltration testing in accordance with BRE Digest 365 was undertaken within trial pits TP01 (5th November 2020), and TP02A, TP03 and TP04 (17th November 2020). The objective of the testing was to assess the permeability of the overburden at the base of the burial lair. The tests failed within all pits with drawdowns < 100mm in each pit indicating very low permeability conditions within the lower subsoils. All infiltration test results are presented in Appendix B.

5.2 Groundwater Levels

The monitoring well and water strike information is outlined in Table 5.1 and indicates that groundwater strikes predominantly occurred within the upper horizons of the bedrock. Groundwater strikes all rose by between 1.3 and 3.8m after 20 minutes.

Borehole	Ground Level (mOD)	Depth (mbgl) ¹	Weathered rock / Competent Rock (mbgl)	Water Strike (mbgl / mOD)	Screened Horizon (mbgl)	Water strikes
BH01	16.58	15	5.7	6.5 / 10.1	6.0 - 15.0	Strong flow at 6.5m in the bedrock, rose to 2.7m after 20 minutes.
BH02	15.09	12	3.7 / 4.1	5.5 / 9.6	4.0 - 10.0	Strong flow at 5.5m in the bedrock, rose to 2.75m after 20 minutes.
BH03	17.73	10	3.8 / 4.1	3.8 / 13.9	4.0 - 8.0	Strong flow at 3.8m on top of the weathered rock, rose to 2.5m after 20 minutes.
BH04	18.18	10	2.0 / 4.0	4.5 / 13.7	3.0 - 10.0	Strong flow at 4.5m in the bedrock, rose to 3.0m after 20 minutes.

Table 5.1 Groundwater Monitoring Well and Water Strike Details

Groundwater data loggers were installed within the 4 no. monitoring wells between the 18th November 2020 and 16th February 2021 and again between the 21st December 2021 and the 1st March 2022.

A time-series hydrograph is presented on Figure 5.2, 5.4 and 5.5. Manual dip water levels recorded on 23rd March 2021 and 21st May 2021 encountered BH3 as dry.

BH	Ground Level (mOD)	Drilled depth of BH (mbgl)	Diver Minimum (mbgl) ^A	Diver Minimum (mOD) ^A	Diver Maximum (mbgl) ^B	Diver Maximum (mOD) ^B	Water level variation (m)
BH01	16.08	15.0	2.91	9.89	6.69	13.67	3.78
BH02	14.63	12.0	2.51	8.63	6.46	12.58	3.95
BH03	17.21	10.0	2.39	9.14	8.59	15.34	6.2
BH04	17.78	10.0	2.46	9.31	8.87	15.72	6.41

Table 5.2 Water Level Data Logger

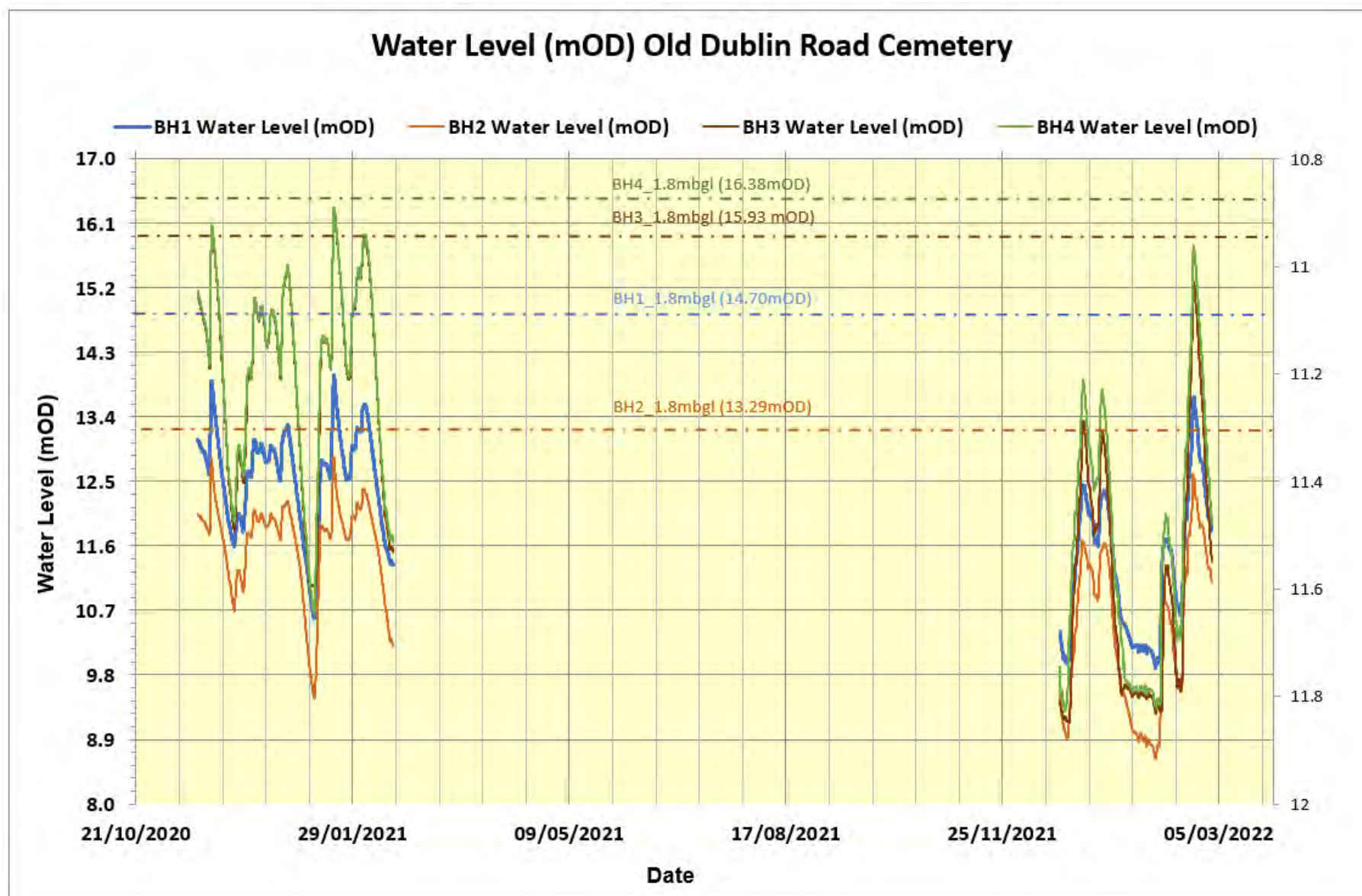


Figure 5.2 Groundwater Levels (mOD)

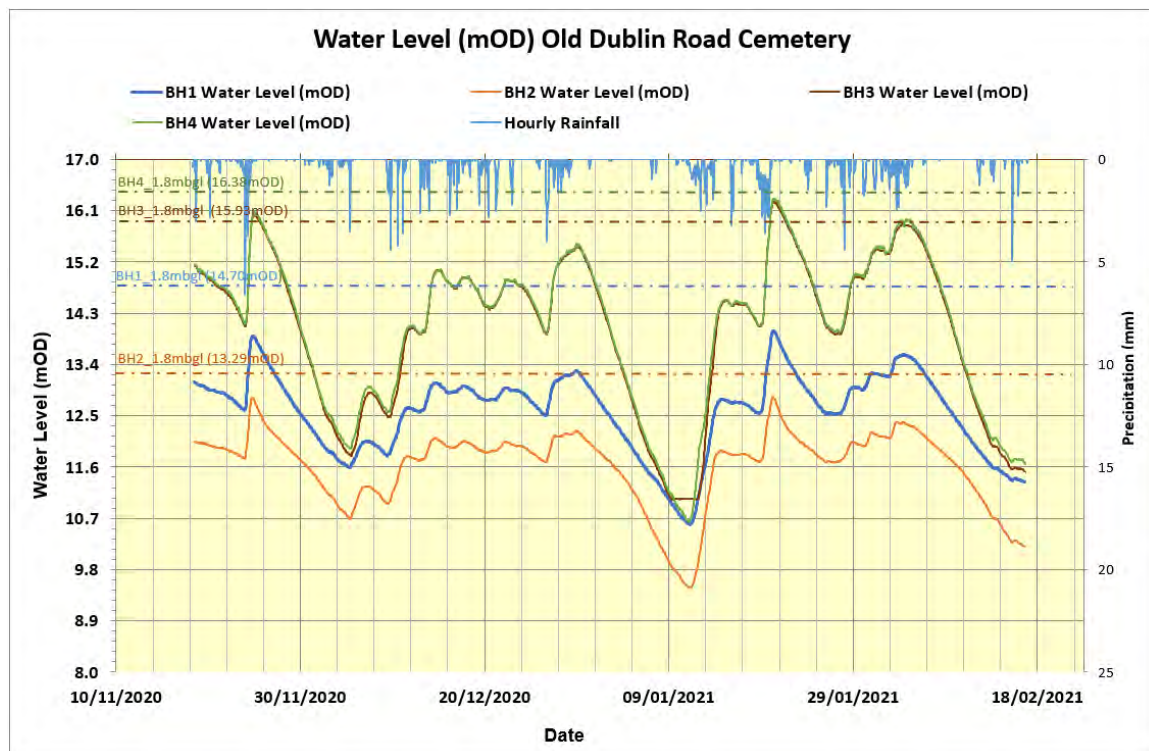


Figure 5.3 Automated Logger Monitoring (Nov 2020 to Feb 2021)

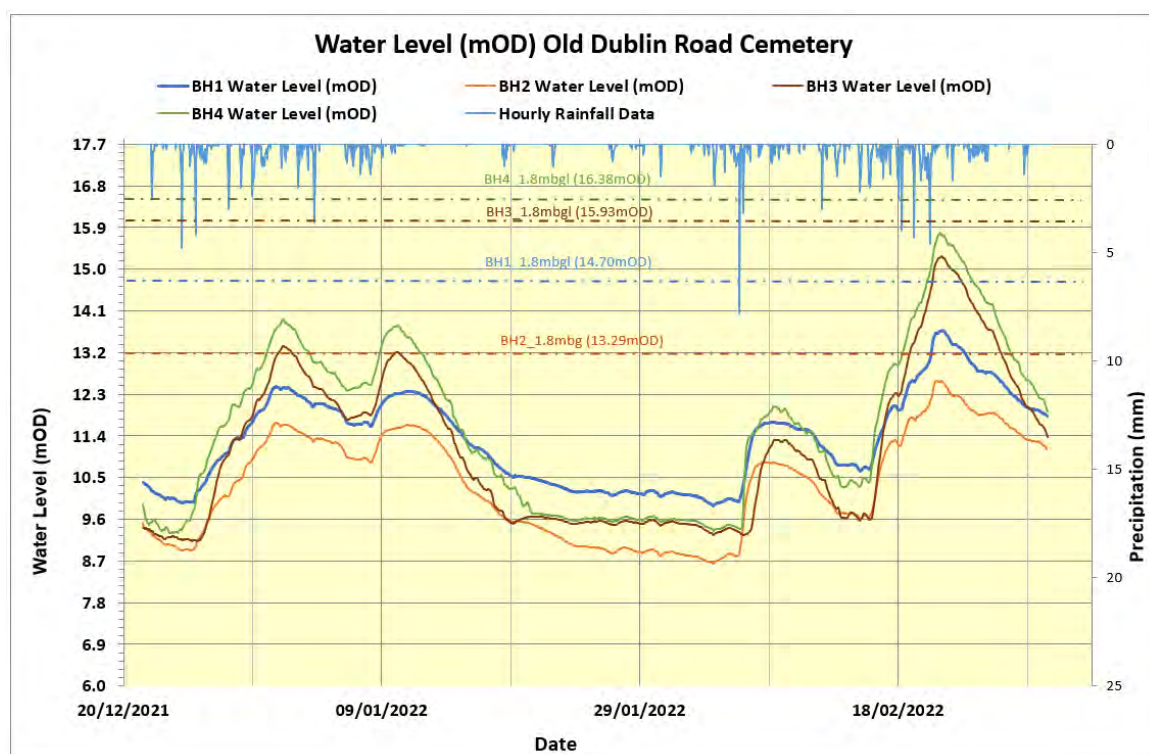


Figure 5.4 Automated Logger Monitoring (Dec 2021 to March 2022)

A number of groundwater contour plots were developed representing high water levels, low water levels and periods immediately after notable rainfall events (Figure 5.5, 5.6 and 5.7).

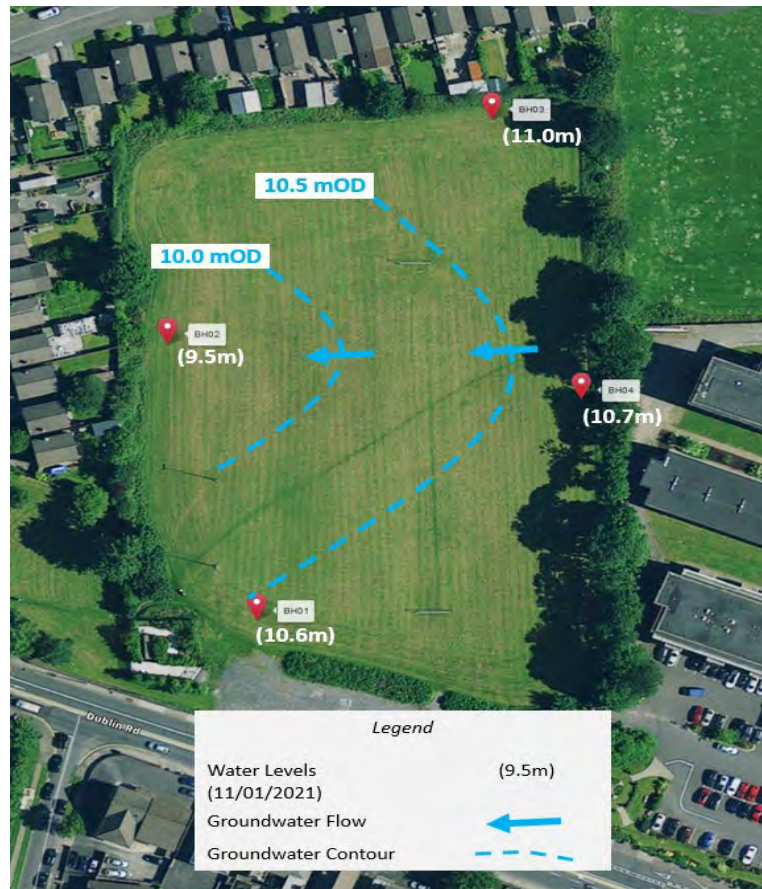


Figure 5.5 Groundwater Contours and Flow Direction (11/01/2021)



Figure 5.6 Groundwater Contours and Flow Direction (20/01/2021)

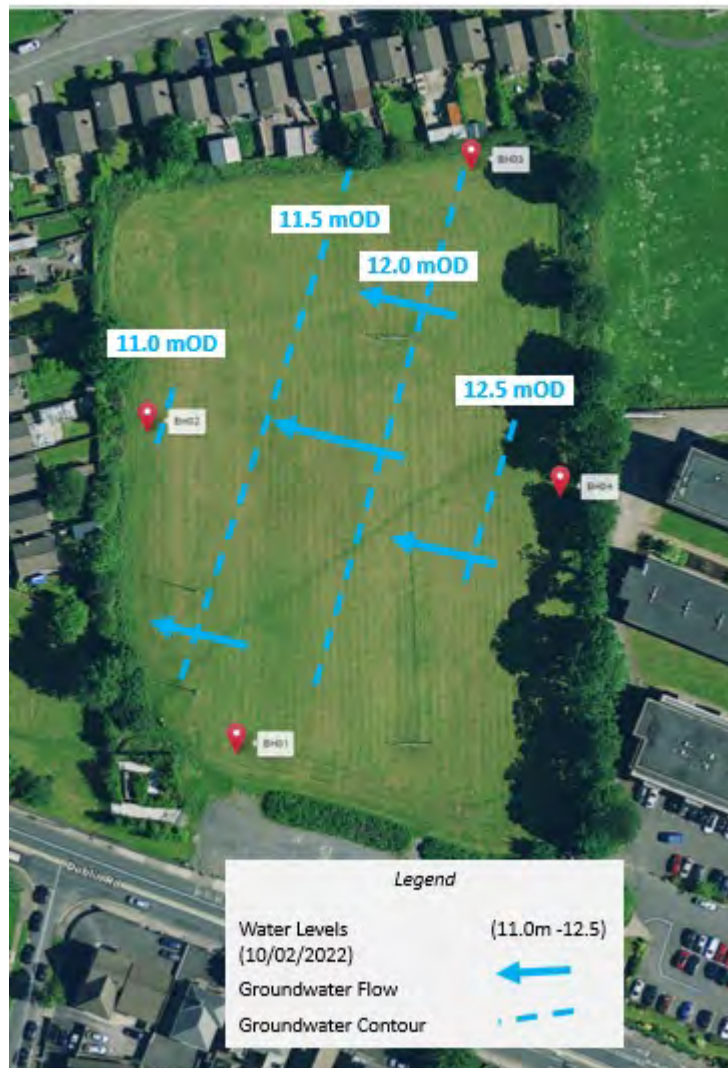


Figure 5.7 Groundwater contours And Flow direction (10/02/2022)

5.3 Groundwater Flow Interpretation

Based on the groundwater level data recorded, the following was noted:

1. The lowest groundwater level was recorded within BH02 at 8.63 mOD (i.e. 6.46 mbgl) on the 3rd February 2022 and the highest groundwater level was recorded within BH04 at 15.72mOD (2.46 mbgl) on the 20th January 2022. The greatest water level variation occurred within BH04 (6.41 m) located along the eastern and upgradient side of the site.
2. Groundwater flow directions were interpreted to be consistently flowing in a southwest/west/northwesterly direction across site.
3. Groundwater appears to be present across the site as a continuous and hydraulically connected body of water with similar signatures evident over time within each monitoring well.
4. The water strikes encountered within each borehole, while being drilled, and the associated noted increase in water levels in particular wells when the strike was encountered, suggests that groundwater is flowing both under both unconfined and potentially under slightly confined conditions. Unconfined aquifers are those where groundwater is in direct contact

with the atmosphere through the open pore spaces of the overlying soil or rock. They are directly recharged from rainfall and groundwater levels recorded in wells represent the actual groundwater level or water table in the subsurface. Confined aquifers are where thick or low permeability overburden deposits overly the groundwater aquifer within permeable subsoils or bedrock and are typically deeper than unconfined aquifers. The confining conditions results in groundwater flowing under pressure and groundwater levels recorded in wells. Groundwater in confined aquifers will rise up inside a borehole drilled into the aquifer. The level to which the water rises is called the potentiometric surface. An

5. The monitoring wells across the site were installed to depths ranging between 7.77 and 14.46 mbgl and installed within the upper horizons of the bedrock. The hotel abstraction well was drilled to a depth of 54.86 mbgl and screened within the rock between 12.19 and 54.86 mbgl. Bedrock was encountered at 6 mbgl. Given the depth of the abstraction well and its screened horizon, it is likely that there is a hydraulic connection between the abstraction well and groundwater monitored across the proposed cemetery site. However, without monitoring level data from the abstraction well, this has not been confirmed to date.
6. A review of the automated datalogger data did not identify any clear impact on groundwater levels by the abstraction well on groundwater levels in the monitoring wells over time. The most proximate monitoring well BH04 is located 15 metres southwest of the abstraction well and screened to a depth of 15 mbgl. The initial automated monitoring was undertaken during Covid lock-down periods in which the hotel was operating at significantly reduced capacity. The second monitoring period was undertaken at near full capacity of the hotel thereby representing maximum current use of the abstraction well.
7. Groundwater levels recorded across the site remained below the standard depth of a 1.8 metres grave with the exception of two (2 no.) occasions within BH03 in November 2020 and January 2021 where levels were recorded above the 1.8 metre level.
8. The recommended depth of 1.0 m of unsaturated soils below the base of a standard grave (i.e. 2.8 mbgl) was not maintained within all well locations on particular occasions throughout the monitoring period.

5.4 Water Quality Sampling

In-situ monitoring was undertaken by BREL personal on 23rd March 2021 and 21st May 2021. Groundwater levels were recorded in each well prior to sampling using an electronic water level probe. Field parameters i.e. Electrical Conductivity, pH, Temperature, and Dissolved Oxygen were recorded before and during the groundwater sampling.

Groundwater sampling was undertaken in accordance with the following recognised standards:

- ☒ ISO 5667-1:2006 - Guidance on the design of sampling programmes and sampling techniques;
- ☒ ISO 5667-3:2012 - Preservation and handling of water samples;
- ☒ ISO 5667-14:1998 - Guidance on quality assurance of environmental sampling & handling; and
- ☒ ISO 5667-11:2009 - Guidance on sampling groundwaters.

Groundwater samples were collected from each well using dedicated sterilised Waterra tubing and a non-return foot valve. Separate tubing and foot valves were used at each monitoring well to eliminate the possibility of cross contamination.

Groundwater resting in the monitoring well is generally not considered representative of equilibrium groundwater conditions in the underlying aquifer. To account for this, the monitoring well water was purged using a suction pump until the Electrical Conductivity (EC), pH and Temperature of the water stabilised. A stable conductivity reading over several readings is a strong indicator that equilibrium conditions have been achieved. In addition, a minimum of 3 times the water volume within each well was abstracted as per national and international best practice.

Upon reaching representative and stabilised conditions a groundwater sample was retrieved from each well using a dedicated sterilized bailer and laboratory supplied containers and cooler boxes. The laboratory was Eurofins-Chemtest who are a UKAS and MCERT accredited laboratory. Microbiological testing for each sample was undertaken locally by Complete Laboratory Solutions.

All samples were collected with dedicated laboratory supplied sample containers and transported within specialised designed cooler transport boxes and ice packs to ensure all samples were kept at a suitable cool temperature during transport. Samples were transported to the laboratory on the same day as collected and arrived in the UK laboratory within 24 hours and within the Galway laboratory within 3 hours.

5.5 Water Quality Guidelines

All groundwater sample results were compared with the following criteria:

- European Union (Drinking Water) Regulations 2014. Statutory Instrument No. 122 of 2014.
- European Communities Environmental Objectives (Groundwater) Regulations, 2010. Statutory Instrument No. 9 of 2010 (as amended S.I. 366 of 2016) – referred to as GTV's
- Environmental Protection Agency's Draft Interim Guideline Values (IGVs) for the Protection of Groundwater, 2003.
- Guidelines for Drinking-water Quality (4th Edition incl. the First Addendum). World Health Organisation. 2017.
- WHO, Petroleum Products in Drinking-Water. Background document for development of WHO Guidelines for Drinking-water Quality WHO/SDE/WSH/05.08/123, 2008.

5.6 Water Quality Analysis

Water samples were collected for analysis by BREL in March 2020 from 3 no. monitoring wells on-site. BH4 was not sampled as it was dry. A subsequent round of monitoring was undertaken on 21st June 2021 and BH3 and BH4 were not sampled as they were dry.

The borehole results were analysed against the groundwater regulations Interim EPA Guideline 2004 (IGV), the European Communities Environmental Objectives Groundwater Regulations 2010 and Amendment Regulations 2016 (GTV) and the World Health Organisation thresholds for Formaldehyde. The water quality results are summarised in Table 5.3 below, and laboratory certificates are presented in Appendix C.

All results were recorded below their respective guideline levels with the exception of Ammoniacal Nitrogen. The levels of Ammoniacal Nitrogen slightly exceeded the GTV of 0.175 µg/l in BH3 in March 2021 and in BH1 in June 2021 with levels of 0.26 and 0.29 µg/l recorded respectively.

Elevated levels of Manganese (490µg/l) were recorded within in BH03 during the March 2021 sampling event, and are above the IGV of 50µg/l. Unusually, it is noted that trace levels of Formaldehyde were detected in most of the wells (i.e. BH01, BH02 and BH03) ranging between 0.007 and 0.025 mg/l. The source of the Manganese is unclear but is potentially naturally occurring and was not consistent over both sampling events. The source of the positive detections of Formaldehyde recorded is unclear and unusual given the typically short half-life of formaldehyde in groundwater (i.e. 2 to 14 days). Its presence is most likely sourced from an upgradient location.

Determinand	Units	LOD ⁷	BH1	BH2	BH3	BH1	BH2	GTV ⁸	IGV ⁹	WHO ¹⁰
			23/3/21	23/3/21	23/3/21	21/6/21	21/6/21			
E. coli (Subcon)	cfu/100ml	N/A	10	0	2	<1	<1			
Total Coliforms (Subcon)	cfu/100ml	N/A	250	0	3	<1	<1			
Electrical Conductivity	µS/cm	1	-	-	-	770	720	1875	1000	
pH		N/A	8.3	8.1	8.2	8.4	7.6	-	6.5-9.5	
Alkalinity (Carbonate)	mg CaCO ₃ /l	10	< 10	< 10	< 10	230	360	-	-	
Chloride	mg/l	1	51	28	67	69	23	187.5	30	
Ammoniacal Nitrogen	mg/l	0.05	0.14	0.10	0.26	0.29	0.11	0.175	-	
Nitrite as N	mg/l	0.01	< 0.010	< 0.010	0.040	0.033	< 0.010	-	-	
Nitrite as N2	mg/l	0.01	< 0.010	< 0.010	0.13136	0.108372	< 0.010	0.375	-	
Nitrate as N	mg/l	0.5	1.4	0.84	1.0	1.1	0.52	-	-	
Nitrate as N03	mg/l	0.5	6.2	3.7	4.4	4.9	2.3	37.5	-	
Orthophosphate as PO4	mg/l	0.05	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	0.035	0.03	
Sulphate	mg/l	1	34	16	37	44	14	187.5	200	
Total Organic Nitrogen	mg/l	1	2.6	2.2	2.2	1.1	0.52	-	-	
Nitrogen (Total)	mg/l	5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	-	-	
Total Calcium	mg/l	5	94	110	99	94	120	-	200	
Total Potassium	mg/l	0.5	2.8	1.6	4.0	2.8	1.6	-	5	
Total Magnesium	mg/l	0.5	5.4	4.7	5.8	5.6	4.8	-	50	
Total Sodium	mg/l	0.5	31	18	53	36	16	150	150	
Hardness	mg/l	1	250	300	270	260	330	-	-	
Copper	µg/l	0.5	1.2	1.7	0.70	< 0.50	0.67	1500	30	
Iron	µg/l	5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	-	200	
Manganese	µg/l	0.5	1.7	6.0	490	33	2.1	-	50	
Nickel	µg/l	0.5	< 0.50	< 0.50	1.4	0.75	< 0.50	15	20	
Lead	µg/l	0.5	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	7.5	10	

⁷ Limit of Detection⁸ Groundwater Target Values⁹ EPA Interim Guideline Values¹⁰ World Health Organisation Guideline Values

Determinand	Units	LOD ⁷	BH1	BH2	BH3	BH1	BH2	GTV ⁸	IGV ⁹	WHO ¹⁰
			23/3/21	23/3/21	23/3/21	21/6/21	21/6/21			
Zinc	µg/l	3	< 3.0	3.6	< 3.0	< 2.5	< 2.5	75	100	
Total Organic Carbon	mg/l	2	18	< 2.0	3.4	2.4	2.2	-	-	
Total Petroleum Hydrocarbons	µg/l	10	< 10	< 10	< 10	< 10	< 10	7.5	10	
Formaldehyde	mg/l	0.005	0.021	0.025	0.007	0.024	< 0.005	-	-	2.6
Exceedances marked in BOLD										

Table 5.3 Summary of Chemical Water Analysis

6 CONCEPTUAL SITE MODEL (CSM)

The potential sources of contamination at the site and the implications with respect to risk to human health and to the environment have been interpreted in accordance with current government and EPA guidance on source-pathway-receptor risk assessment.

A conceptual model is an essential element of any site-specific environmental risk assessment. In this context, they are often simple representations of the hypothesised relationships between sources, pathways and receptors. For this report, a basic conceptual model has been developed based on the principles of LCRM¹¹ and interpretation of site information gathered during the site investigation activities. Thus, this allows the identification of potential pollutant linkages and whether these linkages have the potential to comprise significant harm and/or pollution of groundwater or surface water in relation to the site. Based on this interpretation, the implications for potential liability associated with soil or water contamination at the site can be evaluated.

The soil and groundwater conditions on the site, as identified through the environmental assessment, have been summarised into a Conceptual site Model (CSM), which defines the key sources, pathways and receptors that have been identified as being relevant to this site. The CSM concludes with potential pollutant linkages for the site given the current setting:

- ✓ SOURCES – the identification of contaminants within the soils and groundwater that represent potential pollution sources;
- ✓ PATHWAYS – the identification of the potential exposure mechanisms and migration pathways from the potential sources; and
- ✓ RECEPTORS – the identification of the potential receptors that could be sensitive to harm if exposed to these pollution sources.

Collectively, each of these scenarios would be considered a potential pollutant linkage that may require further assessment.

6.1 Identification of Potential Sources

Based on the investigation data recorded to date across the site, an updated summary of identified contaminant sources is provided below:

- ✓ Proposed municipal cemetery that has the potential to generate leachate through the natural process of decay of multiple burials over time.

6.2 Identification of Potential Exposure Pathways

Exposure pathways are the potential routes and mechanisms by which on-site sources could be linked to the identified potential receptors and thereby expose them to potential harm. Only plausible pathways need be considered. The following potential exposure pathways have been identified at the site:

- ✓ Migration of contaminants to on-site surface water drainage systems; and,
- ✓ Vertical/horizontal migration of contaminants (within the soil/groundwater).

¹¹ Land Contamination: Risk Management (LCRM), June 2019.

6.3 Potential Receptors

Based on the site's environmental setting and the proposed future end use of the site as a municipal cemetery, the following potential receptors have been considered:

- ✓ Groundwater;
- ✓ Drinking water abstraction wells;
- ✓ Groundwater abstractions
- ✓ Surface water

6.4 Potential Pollutant Linkages

For there to be a plausible pollutant linkage there must be a source, receptor and pathway and a feasible linkage between them (a so-called pollutant linkage). Consequently, even where a contaminant is identified, if there is no pathway for the contamination to reach a receptor, or no receptor then there can be no significant risk and remedial actions are not required.

Furthermore, even if there is a complete pollutant linkage, it is possible that the contaminant concentration that can pass along the linkage does not represent a significant risk to human health or the environment. Central to this risk assessment process is the development of a 'conceptual model'. This is a descriptive and/or pictorial representation of the area of potential contamination, the surrounding environment and the processes acting on the contaminants by which they can move and encounter receptors (e.g. by leaching and migration into groundwater).

Production of a conceptual model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, to assess risk both the likelihood and the consequences of an event must be considered. This report adopts the methodology for risk evaluation presented in the guidance document CIRIA C552 Contaminated Land Risk Assessment – A Guide to Good Practice¹². The method is qualitative and involves the classification of the magnitude of the potential severity or consequence of the risk occurring (Table 6.1).

Consequence	Definition
Severe	Short term (Acute) risk to human health likely to result in 'significant harm'. Long term risk of (significant) pollution of sensitive water resource. Catastrophic damage to building/property. Long-term risk to an ecosystem, or organism forming part of such ecosystem.
Medium	Chronic damage to human health (significant harm). Pollution of sensitive water resource. Significant change in ecosystem, or an organism forming part of such an ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures or the environment.
Minor	Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective

¹² Rudland, D. J., Lancefield, R. M. & Mayell, P. N., (2001). CIRIA C552: Contaminated Land Risk Assessment - A Guide to Good Practice

clothing etc.) Easily repairable effects on damage to buildings, structures and services.

Once the likelihood of an event occurring and its severity have been classified, a risk category can be assigned using Table 6.2.

Table 6.1 Classification of Consequence

		Consequence			
		Severe	Medium	Mild	Minor
Likelihood of Occurrence	High	Very High	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

Table 6.2 Risk Categories

The description of the classified risks and likely actions required, in accordance with CIRIA C552, are:

VERY HIGH RISK – There is a high probability that severe harm could arise to a designated receptor from an identified hazard OR, there is evidence that severe harm to a designated receptor is currently happening. This risk (if realised) is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.

HIGH RISK – Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.

MODERATE RISK – It is possible that harm could arise to a designated receptor from an identified hazard. However, if it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.

LOW RISK – It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.

VERY LOW RISK – There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

BREL has developed a conceptual model based on the information obtained to date through the desk-based study and the site investigations undertaken to-date and the proposed current use of the site as a municipal cemetery.

POSSIBLE POLLUTANT LINKAGE			Risk Characterisation
Potential Sources	Pathways	Receptors	
Mobile contaminants from burials	Vertical migration to groundwater	Groundwater Body	Low to Moderate Risk The ground conditions encountered across the site indicates that groundwater is unlikely to be present with dug graves across the majority of the site over a 12 month annual period with some isolated, occasional and slight water ingress at the base of a grave in the northern region of the site during the winter time. Based on the volume of water anticipated to be present within the karst bedrock aquifer and the background quality of groundwater in the area it is likely that there will be significant dilution capacity to facilitate a cemetery of the size proposed with limited impact to the regional groundwater body. It is acknowledged that some impact to groundwater quality will occur in the immediate vicinity of the site. In addition, variations in monitored groundwater levels were recorded above the base on a standard grave depth on 2 no. occasions in the north of the site and the standard 1.0 unsaturated zone guideline between the base of a grave and groundwater was not maintained across the site on a number of occasions. Therefore, although the downgradient impact to the west and southwest of the site is anticipated to be limited, this cannot be confirmed with more detailed groundwater modelling to confirm the assimilative capacity of the aquifer system and to demonstrate that the impact to groundwater is likely to be limited to the immediate vicinity of the proposed cemetery site. A Low to Moderate risk rating is assigned as a conservative measure.
		Water quality within Connacht Hotel abstraction well	High All recommended and legal separation distances for a proposed cemetery to sensitive water receptors are adhered to with the exception of the 50 m distance to a boreholes, springs and or private water supply wells. The Connacht hotel abstraction well is located within 10

POSSIBLE POLLUTANT LINKAGE			Risk Characterisation
Potential Sources	Pathways	Receptors	
			metres of the proposed cemetery boundary. It is noted that the Connacht Hotel well is located upgradient of the proposed cemetery and the abstracted water is treated at source and used for non-potable use only. It is also noted that the recommended depth of 1.0 m of unsaturated soils below the base of a standard grave (i.e. 2.8 mbgl) is not maintained in the eastern region of the site at particular times of the year. Based on the data recorded, groundwater across the site is likely to be hydraulically connected with water being abstracted from the Connacht hotel. However, no evidence of any impact on groundwater levels from the abstraction well within the 4 no. monitoring wells was observed over time. This could suggest that: (a) the abstraction from the hotel's well (i.e. 900 m³/week) is not significant relative to the body of water present in the bedrock aquifer; and/or (b) groundwater abstracted by the hotel well is sourced from depth and from a separate water body to that at shallow depth across the proposed cemetery site. However, given the proximity of the existing abstraction well used by the Connacht hotel to the proposed cemetery site, the lack of data in terms of abstraction rates and water levels within the abstraction well, and the capacity for future increases in abstraction rates over time, the potential risk posed to water quality within this well is conservatively assessed to be High.
	Vertical migration to groundwater and horizontal migration to surface water	Surface water	Low Risk The closest downgradient surface water body is Lough Atalia located approximately 450 metres southwest of the site. This water body is not considered to be sufficiently close to deem it at risk from the proposed cemetery based on the distance

POSSIBLE POLLUTANT LINKAGE			Risk Characterisation
Potential Sources	Pathways	Receptors	
			from the site, the large assimilative capacity present within the bedrock aquifer and the large assimilative capacity within the lough itself.

Table 6.3 Possible Pollutant Linkages

7 CONCLUSIONS

1. BlueRock Environmental Ltd (BREL) were requested by Galway City Council (GCC) to undertake a Tier 2 Hydrogeological Risk Assessment of a proposed New Lawn Cemetery at the Old Dublin Road, Galway city.
2. GCC are currently assessing open lands along the Old Dublin Road for a municipal city cemetery to provide additional cemetery space for the city. As part of the consideration of this site, the assessment of potential risks posed by the proposed cemetery to groundwater quality and other sensitive receptors was deemed necessary to determine the suitability of the site as a municipal cemetery.
3. The following activities were undertaken by BREL
 - Phase 1 Desk Study & Site Visit.
 - Phase 2 Trial Pitting (4 no.), Borehole drilling & Monitoring Well installations (4 no.), Soil & Groundwater Sampling & Groundwater level monitoring.
 - Phase 3 Tier 2 Hydrogeological Reporting & Risk Assessment.
4. Galway City Council (GCC) previously excavated 6 no. trial pits on the 21st May 2020.
5. Geological conditions encountered generally comprised a layer of topsoil overlying reworked made ground consisting of sandy gravelly clay. The reworked ground covers the extent of the playing field and is present to a depth of 0.75m. Topsoil was present around the edges of the playing area with no evidence of made ground. The made ground and topsoil were underlain by natural subsoils comprising sandy gravelly silty clay with low limestone cobble content and fine to coarse subrounded limestone gravels. The subsoils became stiffer with depth and ranged between 2.0 and 5.7 mbgl with the greatest depths in the western and southern regions of the site. No groundwater was encountered within the trial pits. Weathered rock was recorded in the boreholes at depths ranging between 2.0 and 3.8 mbgl and competent bedrock was encountered at depths ranging between 4.0 and 5.7 mbgl.
6. Groundwater data loggers were installed within the 4 no. monitoring wells between the 18th November 2020 and 16th February 2021 and again between the 21st December 2021 and the 1st March 2022. A time-series hydrograph was developed which indicated that all boreholes have a very similar water level signature suggesting all wells are installed within the same hydrogeological horizon and are hydraulically connected at shallow depth.
7. Groundwater flow directions were interpreted to be consistently flowing in a southwest/west/northwesterly direction across site.
8. The lowest groundwater level was recorded within BH02 at 8.63 mOD (i.e. 6.46 mbgl) and the highest groundwater level was recorded within BH04 at 15.72 mOD (i.e. 2.46 mbgl). The greatest vertical water level variation was recorded within BH04 (6.41 m variation) along the eastern and upgradient side of the site.
9. Bedrock was not encountered at depths less than 2.0 mbgl. No standing water was encountered within any trial pits.
10. The water strikes encountered within each borehole, while being drilled, and the associated noted increase in water levels in particular wells when the strike was encountered, suggests that groundwater is predominantly flowing under unconfined and potentially under slightly confined conditions in certain locations.
11. Based on the data recorded, groundwater across the site is likely to be hydraulically connected with water being abstracted from the Connacht hotel. However, no evidence of any impact on groundwater levels by abstractions from the abstraction well was observed. This suggests the abstraction from the hotel's well (i.e. 900 m³/week) is either not significant relative to the body of water present in the bedrock aquifer and/or is abstracted from groundwater at depth from a separate water body to that at shallow depth across the proposed cemetery site.
12. Groundwater levels recorded across the site remained below the standard depth of a 1.8 metres grave with the exception of two (2 no.) occasions within BH03 in November 2020 and January 2021 where levels were recorded above the 1.8 metre level. In addition, the recommended depth of 1.0

m of unsaturated soils below the base of a standard grave (i.e. 2.8 mbgl) within all well locations was not maintained on particular occasions throughout the monitoring period.

13. The ground conditions encountered across the site indicates that groundwater is unlikely to be present with dug graves across the majority of the site over a 12 month annual period with some isolated, occasional and slight water ingress at the base of a grave in the northern region of the site during the winter time.

Based on the volume of water anticipated to be present within the karst bedrock aquifer and the background quality of groundwater in the area it is likely that there will be significant dilution capacity to facilitate a cemetery of the size proposed with limited impact to the regional groundwater body.

It is acknowledged that some impact to groundwater quality will occur in the immediate vicinity of the site. In addition, variations in monitored groundwater levels were recorded above the base on a standard grave depth on 2 no. occasions in the north of the site and the standard 1.0 unsaturated zone guideline between the base of a grave and groundwater was not maintained across the site on a number of occasions. Therefore, although the downgradient impact to the west and southwest of the site is anticipated to be limited, this cannot be confirmed with more detailed groundwater modelling to confirm the assimilative capacity of the aquifer system and to demonstrate that the impact to groundwater is likely to be limited to the immediate vicinity of the proposed cemetery site.

14. Given the low permeability of the subsoils immediately above the bedrock in the area and the occasional occurrences of groundwater slightly above 2.8 mbgl, it is likely these soils provide a level of protection to the bedrock aquifer.
15. Standard separation distances to surface water features are maintained by the proposed cemetery.
16. As there are no known drinking water supplies within 250 m of the proposed cemetery, the recommended separation distances to drinking water supplies are maintained. BREL understands that all abstractions on 3rd party lands within 250 m are used for non-potable use only and are treated at source for on-going non-potable use.
17. The minimum recommended separation distance of 50 m to other boreholes, springs and/or private water supplies is not maintained in terms of the distance from the proposed cemetery to the Connacht Hotel abstraction well.
18. Laboratory test results suggests groundwater is generally of good quality with some occasionally elevated levels of Manganese and Ammoniacal nitrogen. Ecoli detections were recorded in BH1 which is potentially attributed to the proximate wastewater pumping station in the southern region of the site. It is noted that trace levels of Formaldehyde were detected in most of the wells. The source of these detections is unclear and unusual given the typically short half-life of formaldehyde in groundwater.
19. The Conceptual Site Model and risk assessment developed confirms that the main receptor at risk relating to the proposed cemetery is the Connacht Hotel groundwater abstraction well located <10m east of the eastern site boundary of the proposed site. Based on available data, there remains sufficient uncertainty as to the level of risk posed to water quality within this well over time. The High risk assigned is based on the lack of detailed information relating to the abstraction well itself, current and maximum abstraction rates and groundwater levels within the well, the radius of influence created by the abstraction well and whether the proposed site would be within this radius of influence, and the capacity for increased abstraction rates into the future from the abstraction well.
20. A Low to Moderate risk was assigned to the risk posed to groundwater quality downgradient of the site based on varying groundwater levels over time.
21. Measures, in attempt to reduce these risk ratings, are recommended in Section 8.0.

8 RECOMMENDATIONS

Based on the uncertainties outlined in Chapter 7 above, the following works are recommended are provided to address some of the data gaps identified to determine the true level of risk posed by the proposed cemetery to the Connacht Hotel abstraction well and to groundwater quality.

1. Undertake a detailed camera survey of the Connacht Hotel well to confirm the well installation.
2. Drill an additional 1-2 no. boreholes across the site to a similar depth as the Connacht Hotel abstraction well and install with a monitoring well installation at depth within the bedrock. The wells should be located in proximity to existing monitoring wells BH02 and BH04.
3. Undertake a detailed pump test within the Connacht Hotel abstraction well and record groundwater levels within the well and surrounding monitoring wells on the proposed cemetery site. Testing should be undertaken by a suitable experienced contractor over a minimum of 5-days and should comprise pump rates in excess of current abstraction rates in an effort to stress the well and consider future potential abstraction rates from the well. Groundwater sampling and chemical testing should be undertaken prior to, during and post completion of the pump test.
4. ON completion of the above, a Tier 3 Hydrogeological Risk Assessment should be undertaken including groundwater risk modelling to update the current CSM for the site and provide a more site-specific risk assessment for the proposed cemetery development.

9 REFERENCES

BS5930: 1999. *The code of practice for site investigations*. British Standards Institute.

DoELG, EPA, and GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government (DOELG), Environmental Protection Agency (EPA) and the Geological Survey of Ireland (GSI).

EPA (2010) Classification of Hazardous and Non-Hazardous Substances in Groundwater. Dr. Matthew Craig, Hydrometric and Groundwater Section, Aquatic Environment, Office of Environmental Assessment. Environmental Protection Agency, Wexford, Ireland.

EPA, 2011. *Guidance on the authorisation of discharges to groundwater*. Environmental Protection Agency.

C. W. Fetter, (1988), Applied Hydrogeology Fourth Edition, PHoward, H. Philip, et.al, Environmental Degradation Rates.1991. Lewis Publisher.

European Community Directive 2006/118/EC of the European Parliament and the Council of 12 December 2006 of the Protection of Groundwater against Pollution and Deterioration.

European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010).

Statutory Instrument 439/2000 European Communities (Drinking Water) Regulations 2000.

Statutory Instrument 378 of 2006 European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006.

Environment Agency Guidance document (2004) "Assessing the Groundwater Pollution Potential of Cemetery Developments".

Cemeteries and burials: prevent groundwater pollution & Cemeteries and burials: groundwater risk assessments (2017).

Appendix A
2020 Trial Pit Logs

Jez Pitches, Old Dublin Road – Preliminary Trial Pitting

May 2020



TRIAL PIT RECORDS

Proposed New Lawn Cemetery Old Dublin Road

Date of Trial Pits: 21st May 2020
Weather: Dry, sunny, 15-18 degrees
Method: 8 tonne excavator

Trial Pit 1

0 – 150	Topsoil
150 – 500	Dark brown sandy silty CLAY with organic material
500 – 1800	Light brown gravelly silty CLAY with occasional cobbles
1800 – 3000	Light grey silty CLAY with occasional cobbles and infrequent boulders
3.0m	Pit terminated in 'hard' material

Notes:

No Groundwater or water infiltration present

TP 1: Images



Trial Pit 2

0 – 150	Topsoil
150 – 550	Orange slightly silty fine SAND with occasional gravel
550 – 1750	Light brown sandy, silty GRAVEL with occasional cobbles & infrequent large boulders
1750 – 2000	Weathered grey limestone BEDROCK
2.0m	Pit terminated at BEDROCK shelf dipping from 1.7 to 2.0m

Notes:

No Groundwater or water infiltration present



Trial Pit 3

0 – 200	Topsoil
200 – 800	Dark brown sandy silty CLAY with organic material
800 – 2100	Light brown sandy, silty GRAVEL with occasional cobbles
2100 – 2700	Light grey gravelly CLAY with occasional cobbles and infrequent boulders
2.7 m	Pit terminated in 'hard' material

Notes:

No Groundwater or water infiltration present



Trial Pit 4

0 – 150	Topsoil
150 – 800	Dark brown sandy silty CLAY with organic material
800 – 2100	Light brown sandy, silty GRAVEL with occasional cobbles
2100 – 2700	Light grey gravelly CLAY with occasional cobbles and infrequent boulders
2.7 m	Pit terminated in 'hard' material

Notes:

No Groundwater or water infiltration present



Trial Pit 5

0 – 200	Topsoil with roots
200 – 700	Dark brown sandy silty CLAY with organic material and tree roots
800 – 1900	Light brown/orange gravelly CLAY with occasional cobbles
1900 – 2500	Light grey gravelly CLAY with occasional cobbles and infrequent boulders
2.5 m	Pit terminated in 'hard' material

Notes:

No Groundwater or water infiltration present. Large > 1cum boulder encountered (refer image below)

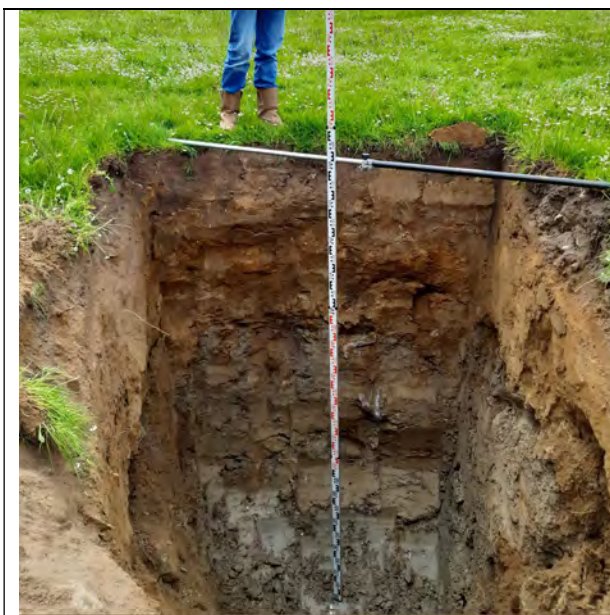


Trial Pit 6

0 – 150	Topsoil
150 – 900	Dark brown/orange sandy silty CLAY
800 – 1900	Light brown sandy gravelly CLAY with occasional cobbles
1900 – 2500	Light grey gravelly CLAY with occasional cobbles and infrequent boulders
2.8 m	Pit terminated in 'hard' material

Notes:

No Groundwater or water infiltration present.



Appendix B

**2021 Site Investigation Trial Pit & Borehole logs, PSD Certs and
Infiltration Test results**



CAUSEWAY
— GEOTECH

Old Dublin Road, Galway City – Tier 2 Hydrogeological Investigation

Client: Galway City Council

Client's Representative: Bluerock Environmental Ltd

Report No.: 20-0912

Date: December 2020

Status: Final for Issue

CONTENTS

Document Control Sheet

Note on: Methods of describing soils and rocks & abbreviations used on exploratory hole logs

1	AUTHORITY	4
2	SCOPE	4
3	DESCRIPTION OF SITE	4
4	SITE OPERATIONS.....	5
4.1	Summary of site works.....	5
4.2	Boreholes.....	5
4.3	Standpipe installations.....	5
4.4	Trial Pits.....	6
4.5	Infiltration tests.....	6
4.6	Surveying.....	6
4.7	Groundwater monitoring	6
5	LABORATORY WORK.....	7
5.1	Geotechnical laboratory testing of soils.....	7
6	GROUND CONDITIONS.....	7
6.1	General geology of the area	7
6.2	Ground types encountered during investigation of the site	7
6.3	Groundwater.....	8
7	REFERENCES	9

APPENDICES

Appendix A	Site and exploratory hole location plans
Appendix B	Borehole logs
Appendix C	Trial pit logs
Appendix D	Trial pit photographs
Appendix E	Infiltration test results
Appendix F	Geotechnical laboratory test results
Appendix G	SPT hammer energy measurement report

Document Control Sheet

Report No.:		20-0912			
Project Title:		Old Dublin Road, Galway City – Tier 2 Hydrogeological Investigation			
Client:		Galway City Council			
Client's Representative:		Bluerock Environmental Ltd			
Revision:	A00	Status:	Final for Issue	Issue Date:	15 th December 2020
Prepared by:		Reviewed by:		Approved by:	
 Sean Ross BSc MSc MIEI		 Colm Hurley BSc FGS PGeo		 Darren O'Mahony BSc MSc MIEI EurGeol PGeo	

The works were conducted in accordance with:

British Standards Institute (2015) BS 5930:2015+A1:2020, Code of practice for site investigations.

BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing.

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

Laboratory testing was conducted in accordance with:

British Standards Institute BS 1377:1990 parts 2, 4, 5, 7 and 9

METHODS OF DESCRIBING SOILS AND ROCKS

Soil and rock descriptions are based on the guidance in BS5930:2015, The Code of Practice for Site Investigation.

Abbreviations used on exploratory hole logs	
U	Nominal 100mm diameter undisturbed open tube sample (thick walled sampler).
UT	Nominal 100mm diameter undisturbed open tube sample (thin walled sampler).
P	Nominal 100mm diameter undisturbed piston sample.
B	Bulk disturbed sample.
LB	Large bulk disturbed sample.
D	Small disturbed sample.
C	Core sub-sample (displayed in the Field Records column on the logs).
L	Liner sample from dynamic sampled borehole.
W	Water sample.
ES / EW	Soil sample for environmental testing / Water sample for environmental testing.
SPT (s)	Standard penetration test using a split spoon sampler (small disturbed sample obtained).
SPT (c)	Standard penetration test using 60 degree solid cone.
(x,x/x,x,x,x)	Blows per increment during the standard penetration test. The initial two values relate to the seating drive (150mm) and the remaining four to the 75mm increments of the test length.
(Y for Z/ Y for Z)	Incomplete standard penetration test where the full test length was not achieved. The blows 'X' represent the total blows for the given seating or test length 'Z' (mm).
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm).
HVP / HVR	In situ hand vane test result (HVP) and vane test residual result (HVR). Results presented in kPa.
V VR	Shear vane test (borehole). Shear strength stated in kPa. V: undisturbed vane shear strength VR: remoulded vane shear strength
Soil consistency description	In cohesive soils, where samples are disturbed and there are no suitable laboratory tests, N values may be used to indicate consistency on borehole logs – a median relationship of $N \times 5 = C_u$ is used (as set out in Stroud & Butler 1975).
dd-mm-yyyy	Date at the end and start of shifts, shown at the relevant borehole depth. Corresponding casing and water depths shown in the adjacent columns.
▽	Water strike: initial depth of strike.
▼	Water strike: depth water rose to.
Abbreviations relating to rock core – reference Clause 36.4.4 of BS 5930: 2015	
TCR (%)	Total Core Recovery: Ratio of rock/soil core recovered (both solid and non-intact) to the total length of core run.
SCR (%)	Solid Core Recovery: Ratio of solid core to the total length of core run. Solid core has a full diameter, uninterrupted by natural discontinuities, but not necessarily a full circumference and is measured along the core axis between natural fractures.
RQD (%)	Rock Quality Designation: Ratio of total length of solid core pieces greater than 100mm to the total length of core run.
FI	Fracture Index: Number of natural discontinuities per metre over an indicated length of core of similar intensity of fracturing.
NI	Non Intact: Used where the rock material was recovered fragmented, for example as fine to coarse gravel size particles.
AZCL	Assessed zone of core loss: The estimated depth range where core was not recovered.
DIF	Drilling induced fracture: A fracture of non-geological origin brought about by the rock coring.
(xxx/xxx/xxx)	Spacing between discontinuities (minimum/average/maximum) measured in millimetres.

Old Dublin Road, Galway City – Tier 2 Hydrogeological Investigation

1 AUTHORITY

On the instructions of Bluerock Environmental Ltd., (“the Client’s Representative”), acting on the behalf of Galway City Council (“the Client”), a ground investigation was undertaken at the above location to provide geotechnical and environmental information for input to the design of a proposed cemetery.

This report details the work carried out both on site and in the geotechnical and chemical testing laboratories; it contains a description of the site and the works undertaken, the exploratory hole logs and the laboratory test results.

All information given in this report is based upon the ground conditions encountered during the site investigation works, and on the results of the laboratory and field tests performed. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those recorded during the investigation. No responsibility can be taken for conditions not encountered through the scope of work commissioned, for example between exploratory hole points, or beneath the termination depths achieved.

This report was prepared by Causeway Geotech Ltd for the use of the Client and the Client’s Representative in response to a particular set of instructions. Any other parties using the information contained in this report do so at their own risk and any duty of care to those parties is excluded.

2 SCOPE

The extent of the investigation, as instructed by the Client’s Representative, included boreholes, trial pits, soil sampling, groundwater monitoring in-situ and laboratory testing, and the preparation of a factual report on the findings.

3 DESCRIPTION OF SITE

As shown on the site location plan in Appendix A, the works were conducted on a playing field located on the Old Dublin Road, Galway. The site is bounded to the north and west by Wellpark Grove Housing Estate, to the east by the Connacht Hotel and to the south by Old Dublin Road. The site is comprising entirely of grasslands and falls in elevation from east to west across the site.

4 SITE OPERATIONS

4.1 Summary of site works

Site operations, which were conducted between 3rd and 17th November 2020, comprised:

- four boreholes by rotary drilling methods
- a standpipe installation in four boreholes
- five machine dug trial pits
- an infiltration test performed in four trial pits

The exploratory holes and in-situ tests were located as instructed by the Client's Representative, as shown on the exploratory hole location plan in Appendix A.

4.2 Boreholes

Four boreholes (BH01-BH04) were put to their completion by rotary drilling techniques only. The boreholes were completed using a Hanjin D8 tracked drilling rig.

Symmetrix-cased full hole rotary percussive drilling techniques were employed to advance the boreholes to completion.

SPTs were carried out at standard intervals throughout the overburden in accordance with BS EN 22476-3:2005+A1:2011 at standard depth intervals throughout the overburden using the split spoon sampler (SPT_(s)) or solid cone attachment (SPT_(c)). The penetrations are stated for those tests for which the full 150mm seating drive or 300mm test drive was not possible. The N-values provided on the borehole logs are uncorrected and no allowance has been made for energy ratio corrections. The SPT hammer energy measurement report is provided in Appendix G.

Appendix B presents the borehole logs.

4.3 Standpipe installations

A groundwater monitoring standpipe (50mm) was installed in BH01-BH04.

Details of the installations, including the depth range of the response zone, are provided in Appendix B on the individual borehole logs.

4.4 Trial Pits

Five trial pits (TP01, TP02, TP02A, TP03 and TP04) were excavated using a 3t or 13t tracked excavator fitted with a 600mm wide bucket, to a maximum depth of 2.85m. TP01, TP02A and TP03-TP05 were excavated to allow infiltration tests to be undertaken.

Disturbed (bulk bag) samples were taken at standard depth intervals and at change of strata.

Any water strikes encountered during excavation were recorded along with any changes in their levels as the excavation proceeded. The stability of the trial pit walls was noted on completion.

Appendix C presents the trial pit logs with photographs of the pits and arising provided in Appendix D.

4.5 Infiltration tests

An infiltration/soakaway test was carried out at four location (TP01, TP02, TP03 and TP04) in accordance with BRE Digest 365 - Soakaways (BRE, 2016). The tests were conducted in similarly numbered trial pits.

Appendix E presents the results and analysis of the infiltration test. The absence of the outflow from the pits precluded calculation of infiltration coefficients.

4.6 Surveying

The as-built exploratory hole positions were surveyed following completion of site operations by a Site Engineer from Causeway Geotech. Surveying was carried out using a Trimble R6 GPS system employing VRS and real time kinetic (RTK) techniques.

The plan coordinates (Irish Transverse Mercator) and ground elevation (mOD Malin (Irl)) at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A shows these as-built positions.

4.7 Groundwater monitoring

Following completion of site works, groundwater data loggers were installed in BH01-BH04 to monitor long term groundwater levels at hourly intervals.

Results of this will be issued in due course once the monitoring period has been completed.

5 LABORATORY WORK

Upon their receipt in the laboratory, all disturbed samples were carefully examined and accurately described and their descriptions incorporated into the borehole logs.

5.1 Geotechnical laboratory testing of soils

Laboratory testing of soils comprised:

- **soil classification:** moisture content measurement, Atterberg Limit tests and particle size distribution analysis.

Laboratory testing of soils samples was carried out in accordance with British Standards Institute: *BS 1377, Methods of test for soils for civil engineering purposes; Part 1 (2016), and Parts 2-9 (1990).*

The test results are presented in Appendix F.

6 GROUND CONDITIONS

6.1 General geology of the area

Published geological mapping indicate the superficial deposits underlying the site comprise Glacial Till or made ground. These deposits are underlain by limestones of the Burren Formation.

6.2 Ground types encountered during investigation of the site

A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- **Topsoil:** encountered across the site with a thickness range of 200-500mm.
- **Made Ground (fill):** reworked sandy gravelly clay/silt fill encountered in TP02A, TP03 and TP04 to a maximum depth of 0.75m in TP02A and TP04.
- **Fluvioglacial deposits:** typically medium dense sands and gravels interspersed with layers of sandy gravelly clay
- **Glacial Till:** sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth. BH01-BH04 encountered sand above rockhead, however based on the findings of trial pits in combination with laboratory test results this material is likely to be glacial till which has had its fine content washed out to the nature of the drilling

methods.

- **Bedrock (Limestone):** Rockhead (competent) was encountered at depths ranging from 4.10m in BH02 and BH03 to 5.70m in BH01. Weathered bedrock was encountered above these depths 0.4 to 2.00m in thickness.

6.3 Groundwater

Details of the individual groundwater strikes, along with any relative changes in levels as works proceeded, are presented on the exploratory hole logs for each location.

Groundwater was encountered during rotary drilling and trial pit excavation as shown in Table 1 below. Where encountered in boreholes it was generally coincident with rockhead level.

Table 1: Groundwater strike encountered during the ground investigation

GI Ref	Water Level (mbgl)	Comments
BH01	6.50	Rose to 2.70m after 20 mins
BH02	5.50	Rose to 2.75m after 20 mins
BH03	3.80	Rose to 2.50m after 20 mins
BH04	4.50	Rose to 3.00m after 20 mins
TP01	2.25	Slow seepage

However, it should be noted that the casing used in supporting the borehole walls during drilling may have sealed out any additional groundwater strikes and the possibility of encountering groundwater at other depths during excavation works should not be ruled out.

It should be noted that any groundwater strikes within bedrock may have been masked by the fluid used as the drilling flush medium.

Seasonal variation in groundwater levels should also be factored into design considerations and continued monitoring of the installed standpipes will give an indication of the seasonal variation.

7 REFERENCES

Geotechnical Society of Ireland (2016), Specification & Related Documents for Ground Investigation in Ireland

IS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. National Standards Authority of Ireland.

BS 5930: 2015+A1:2020: Code of practice for ground investigations. British Standards Institution.

BS EN ISO 14688-1:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 1 Identification and description.

BS EN ISO 14688-2:2018: Geotechnical investigation and testing. Identification and classification of soil. Part 2 Principles for a classification.

BS 1377: 1990: Methods of test for soils for civil engineering purposes. British Standards Institution.

BS EN ISO 14689-1:2018: Geotechnical investigation and testing. Identification and classification of rock. Identification and description.

BS EN ISO 22476-3:2005+A1:2011: Geotechnical investigation and testing. Field testing. Standard penetration test.

Building Research Establishment (2007), BRE Digest 365: Soakaways.



CAUSEWAY
— GEOTECH

APPENDIX A
SITE AND EXPLORATORY HOLE LOCATION PLAN





Project No.: 20-0912

Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Client: Galway City Council

Client's Representative: Bluerock Environmental Ltd

Legend Key



Title:
Site Location Plan

Last Revised:
15/12/2020

Scale:
1:10000



Project No.: 20-0912

Client: Galway City Council

Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Client's Representative: Bluerock Environmental Ltd

Legend Key

-  Locations By Type - RO
-  Locations By Type - TP



Title:
Exploratory Hole Location Plan

Last Revised:
15/12/2020

Scale:
1:1500

 Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation



CAUSEWAY
— GEOTECH

APPENDIX B
BOREHOLE LOGS



				Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation				Borehole ID BH01									
Method Rotary Drilling		Plant Used Hanjin D8		Top (m) 0.00		Base (m) 15.00		Coordinates 531725.03 E 726000.76 N		Final Depth: 15.00 m		Start Date: 03/11/2020		Driller: KW		Sheet 1 of 3 Scale: 1:40			
										Elevation: 16.58 mOD		End Date: 03/11/2020		Logger: RS		FINAL			
Depth (m)	Sample / Tests	Field Records				Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description					Water	Backfill		
		Strong flow at 6.50m						16.08	0.50		TOPSOIL								
								10.88	5.70		Dense light grey gravelly silty SAND with low cobble content. (Driller's description)								
											Grey LIMESTONE (Driller's description)								
Water Strikes				Remarks															
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Hand dug inspection pit excavated to 1.20m.															
6.50	6.50	20	2.70																
Casing Details				Water Added															
To (m)	Diam (mm)	From (m)	To (m)																
7.00	200																		
				Core Barrel	Flush Type	Termination Reason					Last Updated								
					Air	Terminated at scheduled depth.					15/12/2020								

 CAUSEWAY GEOTECH				Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation				Borehole ID BH01											
Method Rotary Drilling		Plant Used Hanjin D8		Top (m) 0.00		Base (m) 15.00		Coordinates 531725.03 E 726000.76 N		Final Depth: 15.00 m		Start Date: 03/11/2020		Driller: KW		Sheet 2 of 3 Scale: 1:40					
										Elevation: 16.58 mOD		End Date: 03/11/2020		Logger: RS		FINAL					
Depth (m)	Sample / Tests	Field Records				Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description						Water	Backfill			
											Grey LIMESTONE (Driller's description)										
																				7.5	
																				8.0	
																				8.5	
																				9.0	
																				9.5	
																				10.0	
																				10.5	
																				11.0	
																				11.5	
																				12.0	
																				12.5	
																				13.0	
																				13.5	
																				14.0	
																				14.5	
Water Strikes				Remarks																	
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Hand dug inspection pit excavated to 1.20m.																	
6.50	6.50	20	2.70																		
Casing Details				Water Added																	
To (m)	Diam (mm)	From (m)	To (m)																		
7.00	200																				
				Core Barrel	Flush Type	Termination Reason				Last Updated											
					Air	Terminated at scheduled depth.				15/12/2020											



Borehole ID
BH01

Sheet 3 of 3

Scale: 1:40

FINAL

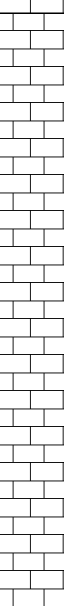
Backfill	
----------	--

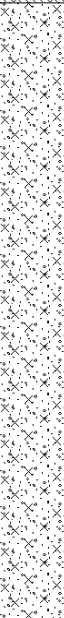
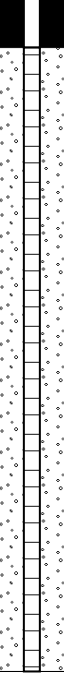
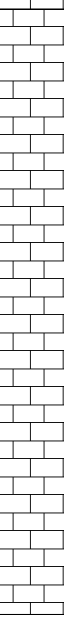
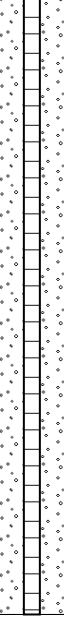
5.0 —

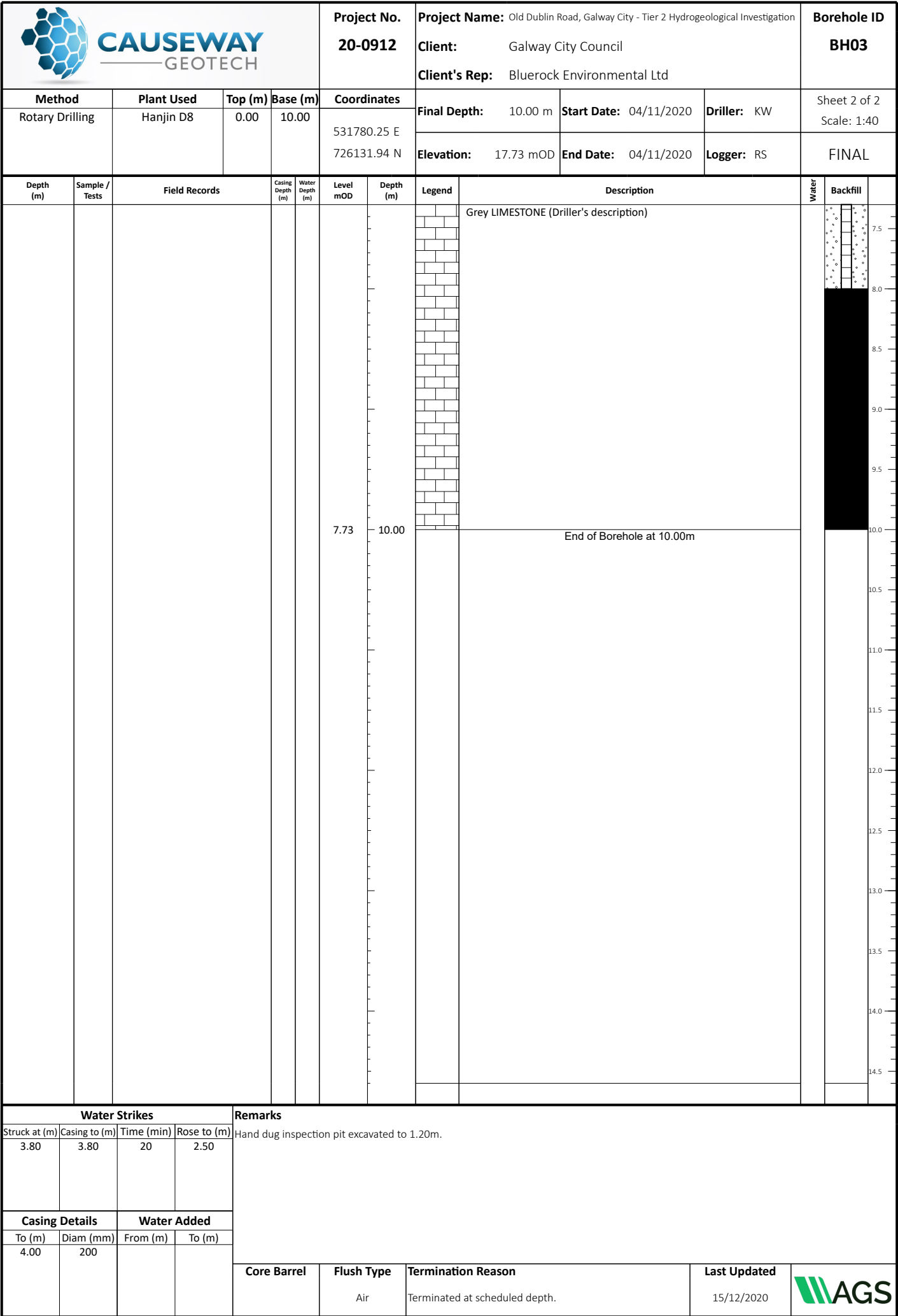
S

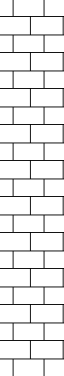
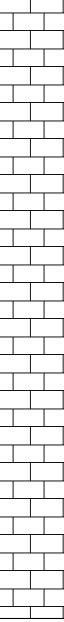
15/12/2020

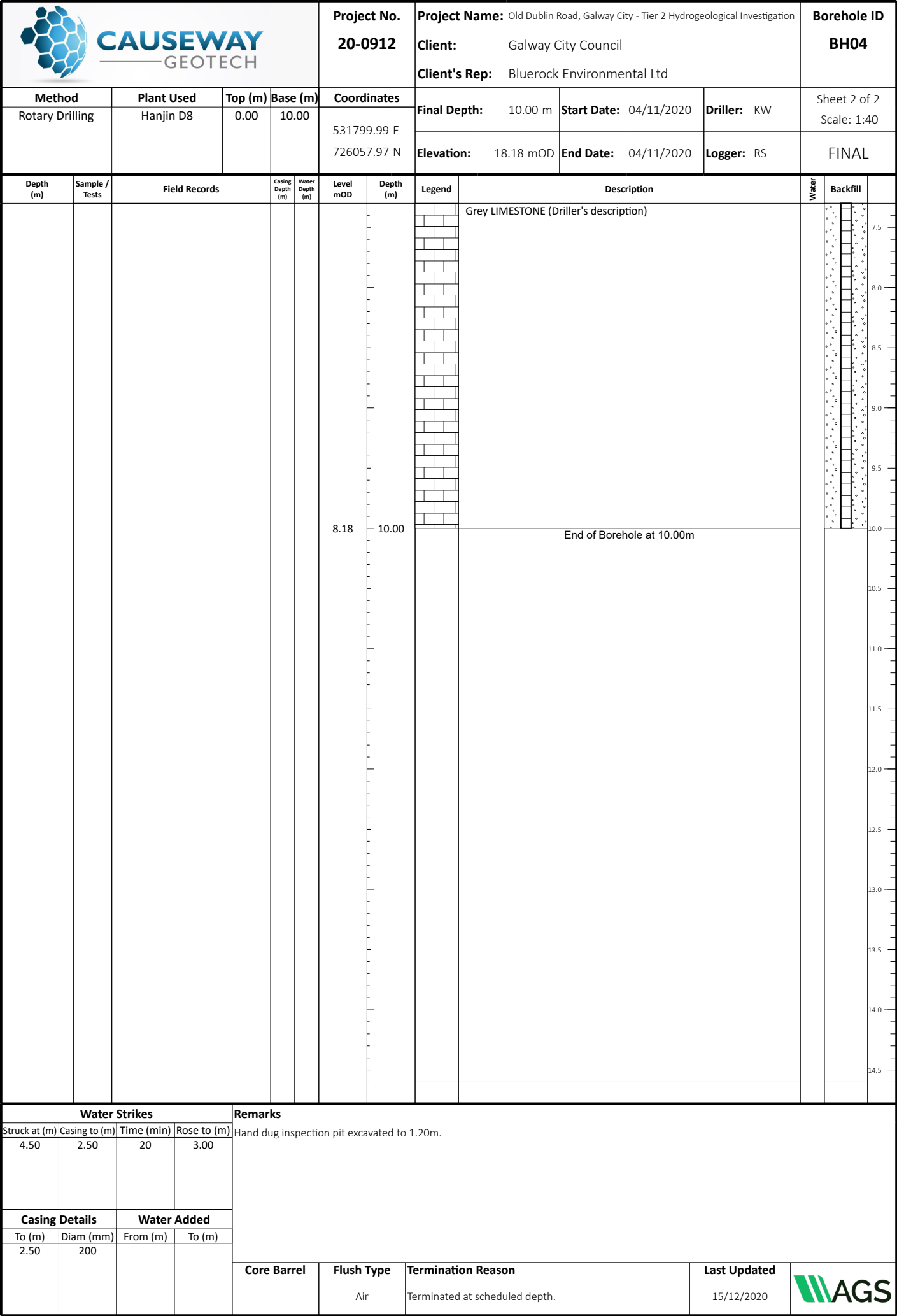


				Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation			Borehole ID BH02			
Method Rotary Drilling		Plant Used Hanjin D8	Top (m) 0.00	Base (m) 12.00	Coordinates 531706.96 E 726073.18 N		Final Depth: 12.00 m	Start Date: 03/11/2020	Driller: KW	Sheet 1 of 2 Scale: 1:40		
							Elevation: 15.09 mOD	End Date: 03/11/2020	Logger: RS	FINAL		
Depth (m)	Sample / Tests	Field Records		Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description		Water	Backfill
2.50 - 2.95	SPT (S)	N=17 (8,6/5,3,5,4) Hammer SN = 0210		2.50	Dry		14.59	0.50		TOPSOIL		
										Brown slightly gravelly sandy SILT. (Driller's description)		
							11.39	3.70		Grey weathered LIMESTONE (Driller's description)		
							10.99	4.10		Grey LIMESTONE (Driller's description)		
		Strong flow at 5.50m										
Water Strikes				Remarks								
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Hand dug inspection pit excavated to 1.20m.								
5.50	2.50	20	2.75									
Casing Details				Water Added								
To (m)	Diam (mm)	From (m)	To (m)									
4.00	200											
				Core Barrel	Flush Type	Termination Reason			Last Updated			
					Air	Terminated at scheduled depth.			15/12/2020			

 CAUSEWAY GEOTECH				Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation				Borehole ID BH03												
Method Rotary Drilling		Plant Used Hanjin D8		Top (m) 0.00		Base (m) 10.00		Coordinates 531780.25 E 726131.94 N		Final Depth: 10.00 m		Start Date: 04/11/2020		Driller: KW		Sheet 1 of 2 Scale: 1:40						
										Elevation: 17.73 mOD		End Date: 04/11/2020		Logger: RS		FINAL						
Depth (m)	Sample / Tests	Field Records				Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description					Water	Backfill					
		Strong flow at 3.80m						17.23	0.50		TOPSOIL											
														Dense greyish brown slightly gravelly silty SAND (Driller's description)								
																						
																						
								13.93	3.80		Grey weathered Limestone (Driller's description)											
								13.63	4.10		Grey Limestone (Driller's description)											
Water Strikes										Remarks												
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Hand dug inspection pit excavated to 1.20m.																		
3.80	3.80	20	2.50																			
Casing Details										Water Added												
To (m)	Diam (mm)	From (m)	To (m)																			
4.00	200																					
										Core Barrel	Flush Type	Termination Reason					Last Updated					
											Air	Terminated at scheduled depth.					15/12/2020					



				Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation				Borehole ID BH04			
Method Rotary Drilling		Plant Used Hanjin D8	Top (m) 0.00	Base (m) 10.00	Coordinates 531799.99 E 726057.97 N		Final Depth: 10.00 m		Start Date: 04/11/2020	Driller: KW	Sheet 1 of 2 Scale: 1:40		
							Elevation: 18.18 mOD		End Date: 04/11/2020	Logger: RS	FINAL		
Depth (m)	Sample / Tests	Field Records		Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description			Water	Backfill
						17.68	0.50		TOPSOIL				
									Brown gravelly silty SAND (Driller's description)				
						16.18	2.00		Grey weathered LIMESTONE (Driller's description)				
		Strong flow at 4.50m				14.18	4.00		Grey LIMESTONE (Driller's description)				
Water Strikes				Remarks									
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Hand dug inspection pit excavated to 1.20m.									
4.50	2.50	20	3.00										
Casing Details				Water Added									
To (m)	Diam (mm)	From (m)	To (m)										
2.50	200												
				Core Barrel	Flush Type	Termination Reason			Last Updated				
					Air	Terminated at scheduled depth.			15/12/2020				





CAUSEWAY
— GEOTECH

APPENDIX C
TRIAL PIT LOGS



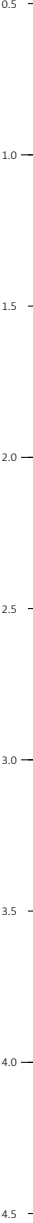
			Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation			Trial Pit ID TP01	
			Coordinates 531721.88 E 725996.24 N		Client: Galway City Council Client's Representative: Bluerock Environmental Ltd			Sheet 1 of 1 Scale: 1:25	
Method: Trial Pitting			Elevation 16.41 mOD		Date: 05/11/2020			Logger: RS	
Plant: 3T Tracked Excavator								FINAL	

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
2.20	B1	Slow seepage at 2.25m	16.11	0.30		TOPSOIL	
						Soft yellowish grey slightly sandy slightly gravelly silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse of limestone. Cobbles are subrounded of limestone.	
			14.11	2.30		End of trial pit at 2.30m	

Water Strikes		Depth: 2.30 Width: 0.60 Length: 2.60 Stability: Unstable	Remarks:
Struck at (m)	Remarks		
2.25	Slow seepage at 2.25m		
		Termination Reason: Terminated on refusal.	Last Updated 15/12/2020



			Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation			Trial Pit ID TP02	
			Coordinates 531703.02 E 726071.76 N		Client: Galway City Council Client's Representative: Bluerock Environmental Ltd			Sheet 1 of 1 Scale: 1:25	
Method: Trial Pitting			Elevation 14.77 mOD		Date: 05/11/2020			Logger: RS	
Plant: 3T Tracked Excavator								FINAL	

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
			14.57	0.20		TOPSOIL Firm brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of limestone.	
			14.22	0.55		Soft grey slightly gravelly sandy SILT with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse of limestone. Cobbles are subrounded of limestone.	
			12.92	1.85		End of trial pit at 1.85m	

Water Strikes		Depth: 1.85 Width: 0.60 Length: 2.40 Stability: Unstable	Remarks: No groundwater encountered.	
Struck at (m)	Remarks			
			Termination Reason: Terminated on refusal.	
			Last Updated 15/12/2020	



20-0912

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

TP02A

531703.02 E

Galway City Council

Bluerock Environmental Ltd

Sheet 1 of 1
Scale: 1:25

Trial Pitting

Plant:
13T Tracked Excavator

Elevation
mOD

17/11/2020

RS

FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
						TOPSOIL	
				0.30		MADE GROUND: Firm light brown slightly sandy slightly gravelly SILT. Sand is fine to coarse. Gravel is subrounded fine to coarse of mixed lithologies.	
				0.75		Soft grey slightly sandy slightly gravelly silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse of limestone. Cobbles are subrounded of limestone.	
2.50	B1						
				2.85		End of trial pit at 2.85m	

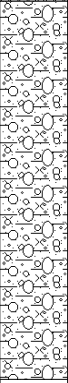
Water Strikes		Depth: 2.85 Width: 0.45 Length: 2.75	Remarks: No groundwater encountered.		
Struck at (m)	Remarks				
		Stability: Unstable	Termination Reason: Terminated on refusal.	Last Updated 15/12/2020	

			Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation			Trial Pit ID TP03	
			Coordinates 531785.93 E 726135.24 N		Client: Galway City Council Client's Representative: Bluerock Environmental Ltd			Sheet 1 of 1 Scale: 1:25	
Method: Trial Pitting			Elevation 18.06 mOD		Date: 17/11/2020			Logger: RS	
Plant: 13T Tracked Excavator								FINAL	

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
2.50	B1		17.76	0.30		TOPSOIL	
			17.36	0.70		MADE GROUND: Firm light brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subrounded fine to coarse of mixed lithologies.	
						Soft grey slightly sandy slightly gravelly silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse of limestone. Cobbles are subrounded of limestone.	
			15.46	2.60		End of trial pit at 2.60m	

Water Strikes		Depth: 2.60 Width: 0.45 Length: 3.30 Stability: Unstable	Remarks: No groundwater encountered.	
Struck at (m)	Remarks			
			Termination Reason: Terminated on refusal.	
			Last Updated 15/12/2020	

			Project No. 20-0912		Project Name: Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation			Trial Pit ID TP04	
			Coordinates 531803.08 E 726055.62 N		Client: Galway City Council Client's Representative: Bluerock Environmental Ltd			Sheet 1 of 1 Scale: 1:25	
Method: Trial Pitting			Elevation 18.21 mOD		Date: 17/11/2020			Logger: RS	
Plant: 13T Tracked Excavator								FINAL	

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
2.00	B1		17.46	0.75		MADE GROUND: Firm brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subrounded fine to coarse of mixed lithologies.	
			16.21	2.00		Soft grey slightly sandy slightly gravelly silty CLAY with low cobble and boulder content. Sand is fine to coarse. Gravel is subrounded fine to coarse of limestone. Cobbles and boulders are subrounded of limestone.	
						End of trial pit at 2.00m	

Water Strikes		Depth: 2.00 Width: 0.45 Length: 3.60 Stability: Unstable	Remarks: No groundwater encountered.	
Struck at (m)	Remarks			
			Termination Reason: Terminated on refusal.	
			Last Updated 15/12/2020	



CAUSEWAY
— GEOTECH

APPENDIX D
TRIAL PIT PHOTOGRAPHS





TP01



TP01



TP01



TP01



TP01



TP01



TP01



TP02



TP02



TP02



TP02



TP02



TP02



TP02A



TP02A



TP02A



TP02A



TP02A



TP02A



TP02A



TP03



TP03



TP03



TP03



TP03



TP03



TP03



TP04



TP04



TP04



TP04



TP04



TP04



TP04



CAUSEWAY
— GEOTECH

APPENDIX E
INFILTRATION TESTS



Soakaway Infiltration Test

Project No.: 20-0912
Site: Old Dublin Road Site, Galway
Test Location: TP01
Test Date: 05 November 2020



*Analysis using method as described in BRE Digest 365
and CIRIA Report C697-The SUDS Manual*

width (m) length (m)

test pit top dimensions 0.60 2.60

test pit base dimensions 0.60 1.40

test pit depth (m) 2.30

depth to groundwater before adding water (m) = 2.25

time (mins)	depth to water surface (m)	depth of water in pit (m)
0	1.29	1.01
1	1.29	1.01
2	1.29	1.01
4	1.29	1.01
6	1.29	1.01
8	1.29	1.01
10	1.30	1.00
15	1.32	0.98
20	1.33	0.97
30	1.34	0.97
45	1.35	0.95
60	1.36	0.94
90	1.38	0.92
120	1.40	0.90
150	1.41	0.89
180	1.43	0.87
210	1.45	0.85
240	1.45	0.85
255	1.46	0.84

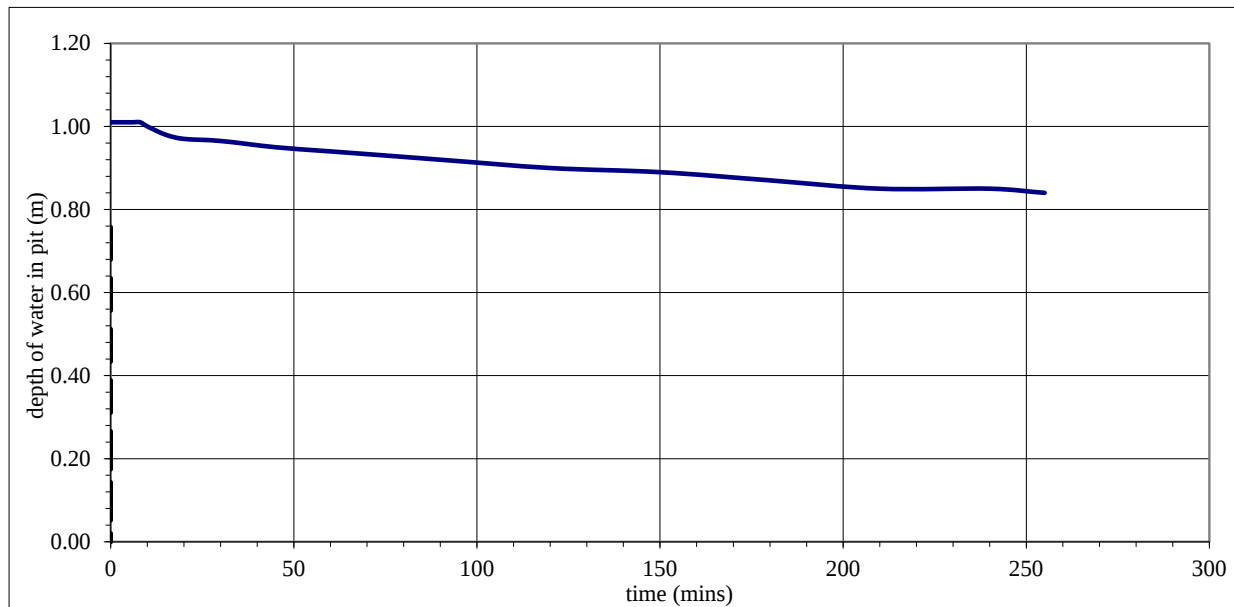
From graph below:

test start - 75% depth at
0.7575 m water depth
time is not determined

test end - 25% depth at
0.2525 m water depth
time is not determined

infiltration rate (q) is very low

time (mins)	depth to water (m)	depth of water in pit (m)	time elapsed (mins)	volume of water lost (m ³)	Area of walls and base at 50% drop (m ²)	q (m/min)	q (m/h)
	1.54	0.7575					
	2.05	0.2525					



Soakaway Infiltration Test

Project No.: 20-0912
Site: Old Dublin Road Site, Galway
Test Location: TP02A
Test Date: 17 November 2020



*Analysis using method as described in BRE Digest 365
and CIRIA Report C697-The SUDS Manual*

width (m) length (m)

test pit top dimensions 0.80 2.75

test pit base dimensions 0.45 1.30

test pit depth (m) 2.85

depth to groundwater before adding water (m) = Dry

time (mins)	depth to water surface (m)	depth of water in pit (m)
0	1.85	1.00
1	1.85	1.00
2	1.85	1.00
4	1.85	1.00
6	1.85	1.00
8	1.85	1.00
10	1.85	1.00
15	1.84	1.01
20	1.83	1.02
25	1.83	1.02
30	1.83	1.02
45	1.84	1.02
60	1.84	1.01

From graph below:

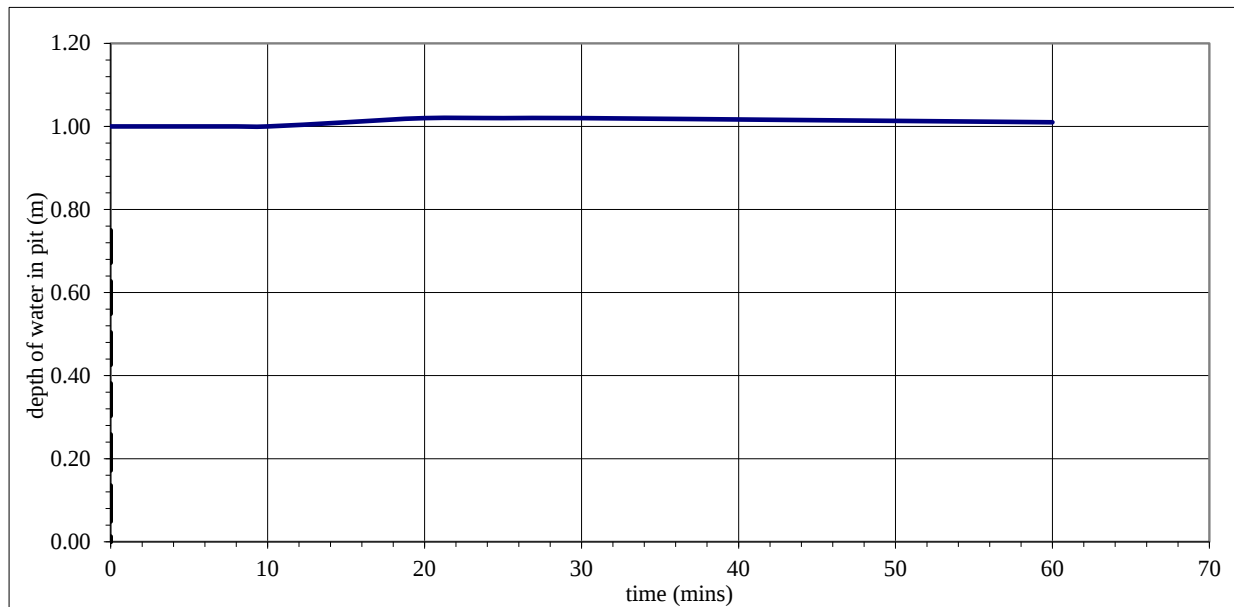
test start - 75% depth at
0.75 m water depth
time is not determined

test end - 25% depth at
0.25 m water depth
time is not determined

infiltration rate (q) is very low

**Rise in water level at 10 mins resulted
from side wall collapse**

time (mins)	depth to water (m)	depth of water in pit (m)	time elapsed (mins)	volume of water lost (m ³)	Area of walls and base at 50% drop (m ²)	q (m/min)	q (m/h)
	2.10	0.75					
	2.60	0.25					



Soakaway Infiltration Test

Project No.: 20-0912
Site: Old Dublin Road Site, Galway
Test Location: TP03
Test Date: 17 November 2020



*Analysis using method as described in BRE Digest 365
and CIRIA Report C697-The SUDS Manual*

width (m) length (m)

test pit top dimensions 0.80 3.30

test pit base dimensions 0.45 1.70

test pit depth (m) 2.60

depth to groundwater before adding water (m) = Dry

time (mins)	depth to water surface (m)	depth of water in pit (m)
0	1.58	1.02
1	1.58	1.02
2	1.58	1.02
4	1.58	1.02
6	1.58	1.02
8	1.58	1.02
10	1.58	1.02
15	1.59	1.02
20	1.59	1.01
25	1.59	1.01
30	1.59	1.01
45	1.59	1.01
60	1.59	1.01

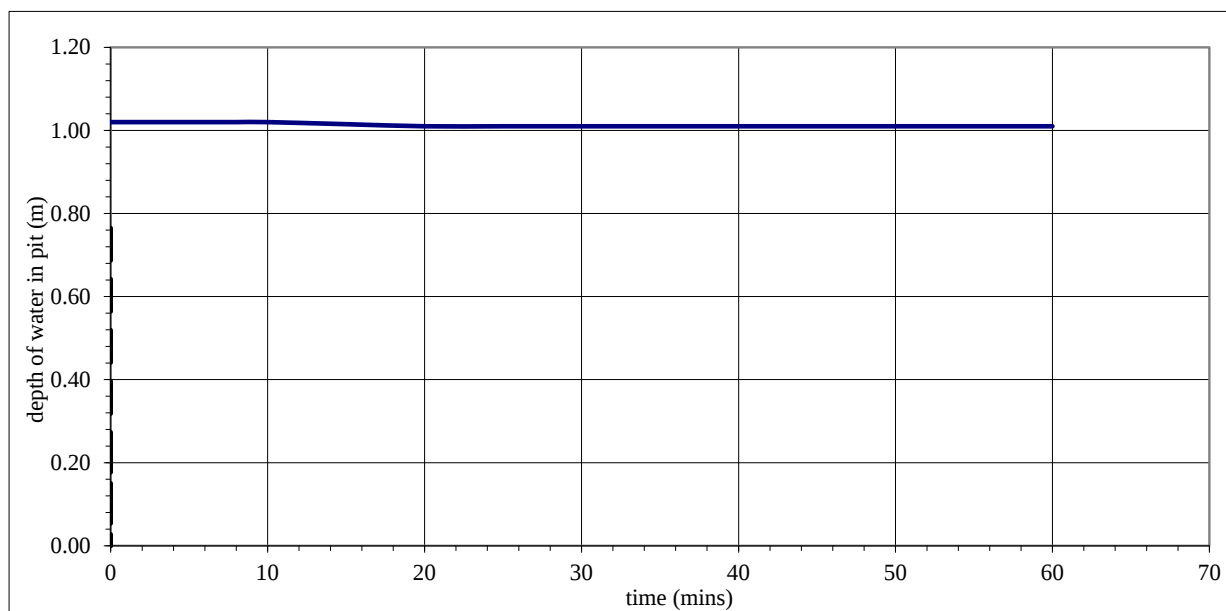
From graph below:

test start - 75% depth at
0.765 m water depth
time is not determined

test end - 25% depth at
0.255 m water depth
time is not determined

infiltration rate (q) is very low

time (mins)	depth to water (m)	depth of water in pit (m)	time elapsed (mins)	volume of water lost (m ³)	Area of walls and base at 50% drop (m ²)	q (m/min)	q (m/h)
	1.84	0.765					
	2.35	0.255					



Soakaway Infiltration Test

Project No.: 20-0912
Site: Old Dublin Road Site, Galway
Test Location: TP04
Test Date: 17 November 2020



*Analysis using method as described in BRE Digest 365
and CIRIA Report C697-The SUDS Manual*

width (m) length (m)
test pit top dimensions 0.60 3.60
test pit base dimensions 0.45 1.40
test pit depth (m) 2.00

depth to groundwater before adding water (m) = Dry

time (mins)	depth to water surface (m)	depth of water in pit (m)
0	1.23	0.77
1	1.23	0.77
2	1.23	0.77
4	1.23	0.77
6	1.23	0.77
8	1.23	0.77
10	1.23	0.77
15	1.21	0.79
20	1.21	0.79
25	1.22	0.79
30	1.22	0.79
45	1.22	0.79
60	1.22	0.79
90	1.23	0.78
120	1.24	0.76

From graph below:

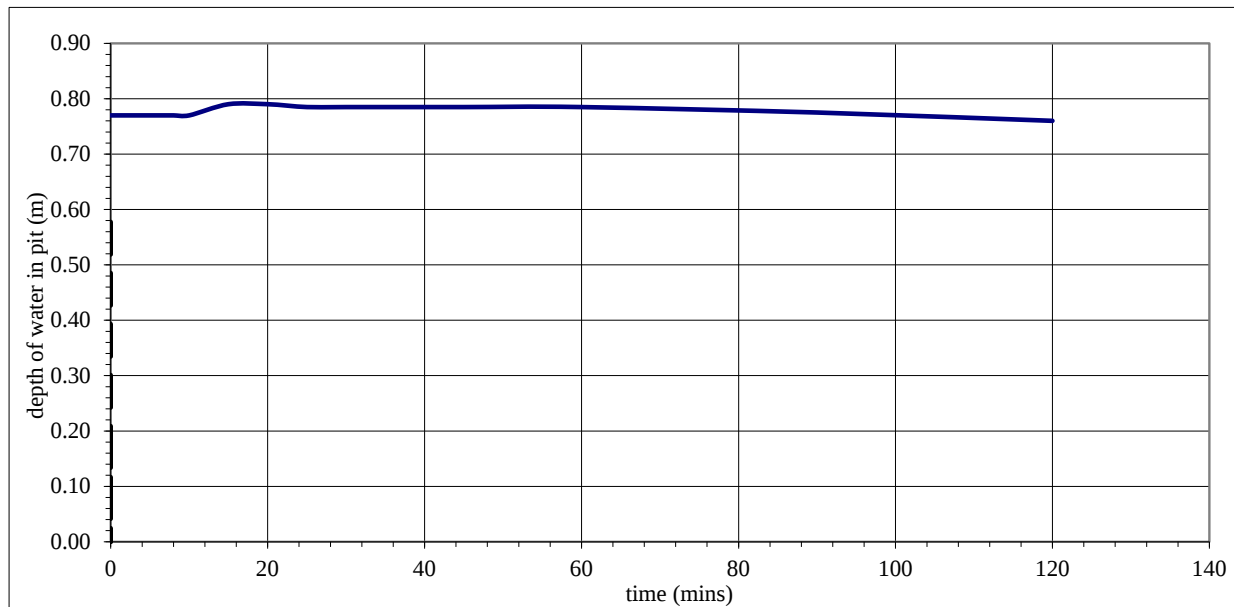
test start - 75% depth at
0.5775 m water depth
time is not determined

test end - 25% depth at
0.1925 m water depth
time is not determined

infiltration rate (q) is very low

**Rise in water level at 15 mins resulted
from side wall collapse**

time (mins)	depth to water (m)	depth of water in pit (m)	time elapsed (mins)	volume of water lost (m ³)	Area of walls and base at 50% drop (m ²)	q (m/min)	q (m/h)
	1.42	0.5775					
	1.81	0.1925					





CAUSEWAY
— GEOTECH

APPENDIX F
GEOTECHNICAL LABORATORY TEST RESULTS





CAUSEWAY
GEOTECH

HEAD OFFICE
Causeway Geotech Ltd
8 Drumahiskey Road, Ballymoney
Co. Antrim, N. Ireland, BT53 7QL
NI: +44 (0)28 276 66640
Registered in Northern Ireland.
Company Number: NI610766

REGIONAL OFFICE
Causeway Geotech (IRL) Ltd
Unit 3 Balbriggan Business Park, Balbriggan
Co Dublin, Ireland, K32 EH36
ROI: +353 (0)1 526 7465
Registered in Ireland.
Company Number: 633786

www.causewaygeotech.com

**SOIL AND ROCK SAMPLE ANALYSIS
LABORATORY TEST REPORT**

11 December
2020

Project Name:	Old Dublin Road, Galway City -Tier 2 Hydrogeological Investigation
Project No.:	20-0912
Client:	Galway City Council
Engineer:	Bluerock Environmental Ltd

We are pleased to attach the results of laboratory testing carried out for the above project. This memo and its attachments constitute a report of the results of tests as detailed in the Contents page(s).

The attached results complete the testing requested and we would therefore wish to confirm that samples will be retained without charge for a period of 28 days from the above date after which they will be appropriately disposed of unless we receive written instructions to the contrary prior to that date.

We trust our report meets with your approval but if you have any queries or require additional information, please do not hesitate to contact the undersigned.

Stephen Watson

Laboratory Manager

Signed for and on behalf of Causeway Geotech Ltd



Project Name: Old Dublin Road, Galway City -Tier 2 Hydrogeological Investigation

Report Reference: Schedule 1

The table below details the tests carried out, the specifications used, and the number of tests included in this report.

Tests marked with* in this report are not United Kingdom Accreditation Service (UKAS) accredited and are not included in Causeway Geotech Limited's scope of UKAS Accreditation Schedule of Tests. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	No. of results included in the report
SOIL	Moisture Content of Soil	BS 1377-2: 1990: Cl 3.2	4
SOIL	Liquid and Plastic Limits of soil-1 point cone penetrometer method	BS 1377-2: 1990: Cl 4.4, 5.3 & 5.4	4
SOIL	Particle size distribution - wet sieving	BS 1377-2: 1990: Cl 9.2	4
SOIL	Particle size distribution - sedimentation hydrometer method	BS 1377-2: 1990: Cl 9.5	4



Project Name

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

All tests performed in accordance with BS1377:1990 unless specified otherwise

10122



PARTICLE SIZE DISTRIBUTION

Job Ref

20-0912

Borehole/Pit No.

TP01

Site Name

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Sample No.

1

Soil Description

Brownish grey sandy gravelly silty CLAY.

Depth, m

2.20

Specimen Reference

6

Specimen
Depth

2.2

m

Sample Type

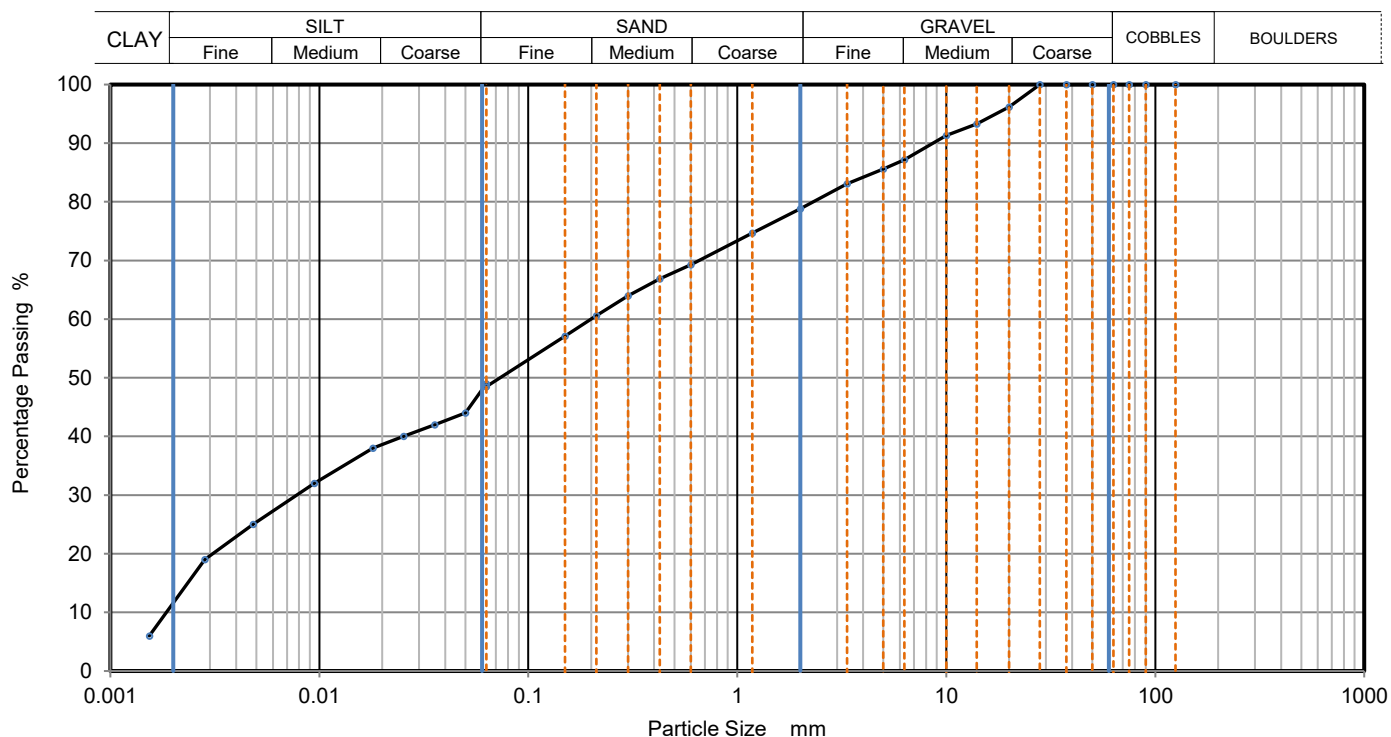
B

Test Method

BS1377:Part 2:1990, clauses 9.2 and 9.5

KeyLAB ID

Caus202012030



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.06300	49
90	100	0.05002	44
75	100	0.03559	42
63	100	0.02532	40
50	100	0.01802	38
37.5	100	0.00947	32
28	100	0.00482	25
20	96	0.00283	19
14	93	0.00154	6
10	91		
6.3	87		
5	86		
3.35	83		
2	79		
1.18	75		
0.6	69	Particle density (assumed) 2.65 Mg/m ³	
0.425	67		
0.3	64		
0.212	61		
0.15	57		
0.063	49		

Dry Mass of sample, g

2456

Sample Proportions	% dry mass
Cobbles	0.0
Gravel	21.2
Sand	30.3
Silt	36.7
Clay	11.8

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	110
Curvature Coefficient	0.17

Remarks

Preparation and testing in accordance with BS1377-2 :1990 unless noted below

Approved

Stephen.Watson

LAB 05R Version 4



10122



PARTICLE SIZE DISTRIBUTION

Job Ref

20-0912

Borehole/Pit No.

TP02A

Site Name

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Sample No.

1

Soil Description

Brownish grey sandy gravelly silty CLAY.

Depth, m

2.50

Specimen Reference

6

Specimen
Depth

2.5

m

Sample Type

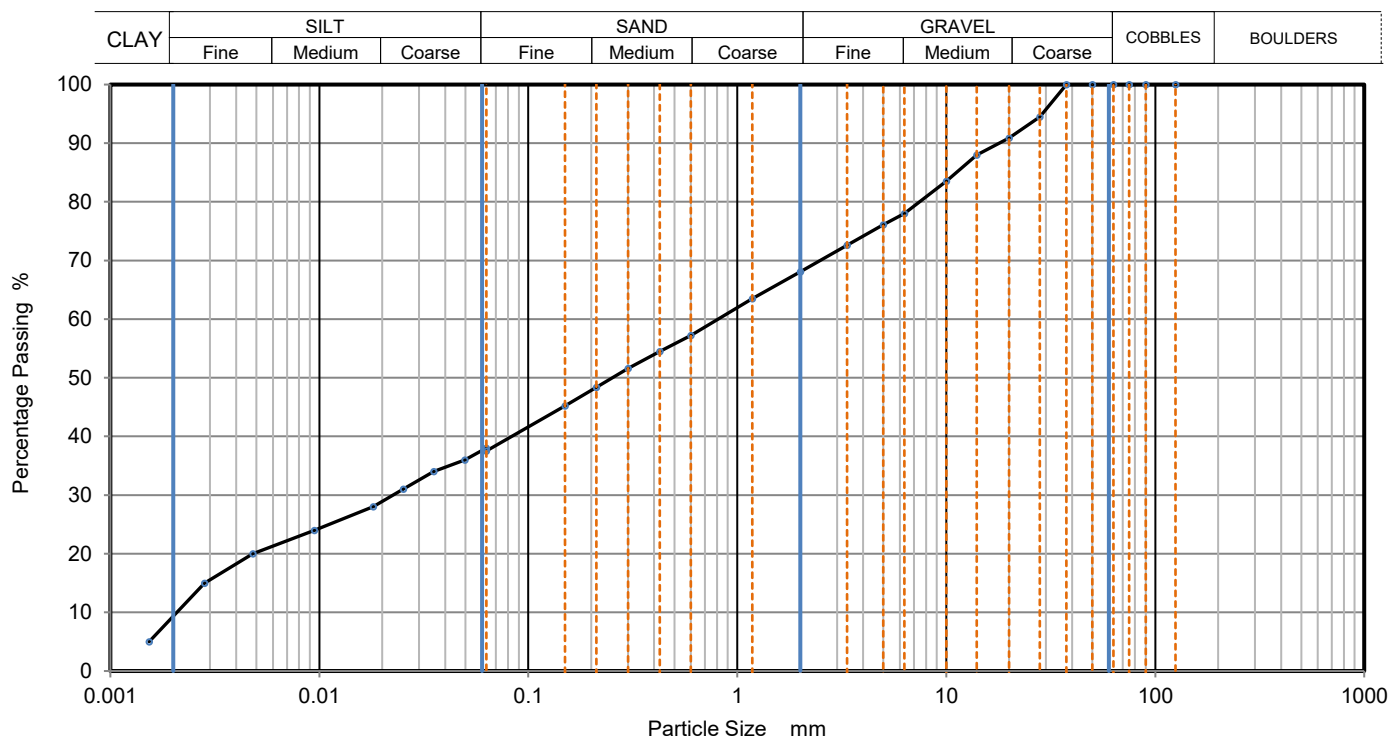
B

Test Method

BS1377:Part 2:1990, clauses 9.2 and 9.5

KeyLAB ID

Caus202012031



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.06300	38
90	100	0.04958	36
75	100	0.03528	34
63	100	0.02526	31
50	100	0.01808	28
37.5	100	0.00945	24
28	95	0.00481	20
20	91	0.00282	15
14	88	0.00153	5
10	84		
6.3	78		
5	76		
3.35	73		
2	68		
1.18	64		
0.6	57	Particle density (assumed) 2.65 Mg/m ³	
0.425	55		
0.3	52		
0.212	48		
0.15	45		
0.063	38		

Dry Mass of sample, g

2548

Sample Proportions	% dry mass
Cobbles	0.0
Gravel	31.9
Sand	30.6
Silt	28.3
Clay	9.2

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	380
Curvature Coefficient	0.31

Remarks

Preparation and testing in accordance with BS1377-2 :1990 unless noted below

Approved

Stephen.Watson

LAB 05R Version 4



10122



PARTICLE SIZE DISTRIBUTION

Job Ref

20-0912

Borehole/Pit No.

TP03

Site Name

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Sample No.

1

Soil Description

Brownish grey sandy gravelly silty CLAY.

Depth, m

2.50

Specimen Reference

6

Specimen
Depth

2.5

m

Sample Type

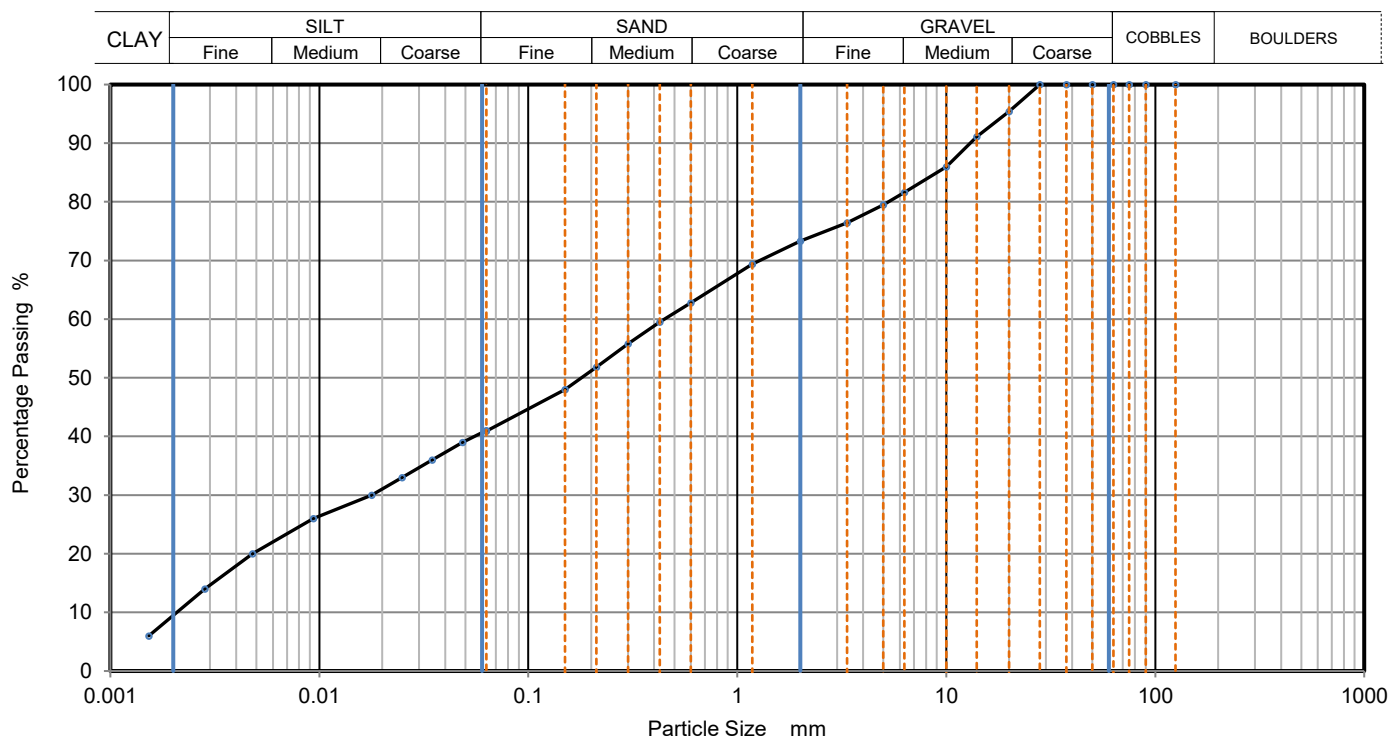
B

Test Method

BS1377:Part 2:1990, clauses 9.2 and 9.5

KeyLAB ID

Caus202012032



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.06300	41
90	100	0.04843	39
75	100	0.03470	36
63	100	0.02485	33
50	100	0.01780	30
37.5	100	0.00936	26
28	100	0.00479	20
20	95	0.00283	14
14	91	0.00153	6
10	86		
6.3	82		
5	80		
3.35	76		
2	73		
1.18	69		
0.6	63	Particle density (assumed) 2.65 Mg/m ³	
0.425	60		
0.3	56		
0.212	52		
0.15	48		
0.063	41		

Dry Mass of sample, g

2505

Sample Proportions	% dry mass
Cobbles	0.0
Gravel	26.7
Sand	32.4
Silt	31.5
Clay	9.4

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	210
Curvature Coefficient	0.31

Remarks

Preparation and testing in accordance with BS1377-2 :1990 unless noted below

Approved

Stephen.Watson

LAB 05R Version 4



10122



PARTICLE SIZE DISTRIBUTION

Job Ref

20-0912

Borehole/Pit No.

TP04

Site Name

Old Dublin Road, Galway City - Tier 2 Hydrogeological Investigation

Sample No.

1

Soil Description

Brownish grey sandy gravelly silty CLAY.

Depth, m

2.00

Specimen Reference

6

Specimen
Depth

2

m

Sample Type

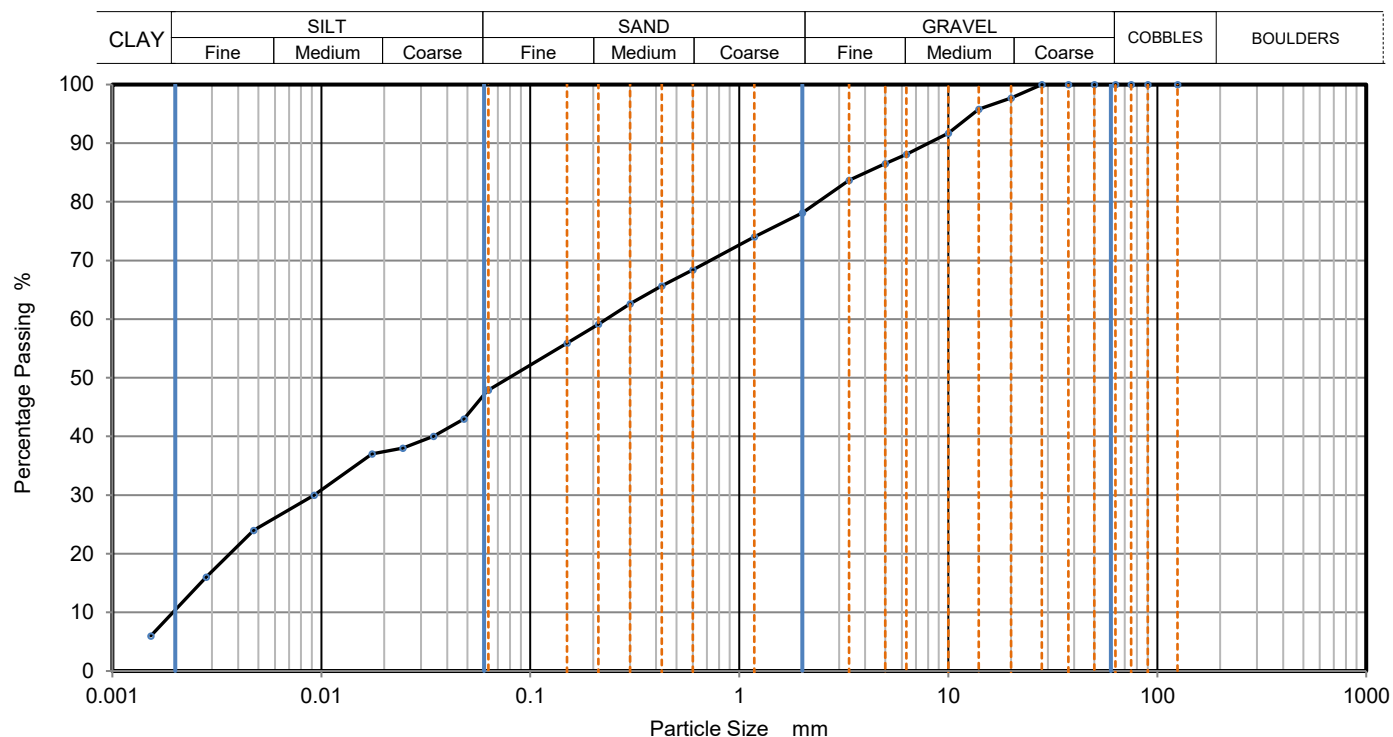
B

Test Method

BS1377:Part 2:1990, clauses 9.2 and 9.5

KeyLAB ID

Caus202012033



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.06300	48
90	100	0.04810	43
75	100	0.03447	40
63	100	0.02454	38
50	100	0.01746	37
37.5	100	0.00925	30
28	100	0.00474	24
20	98	0.00281	16
14	96	0.00153	6
10	92		
6.3	88		
5	87		
3.35	84		
2	78		
1.18	74		
0.6	68	Particle density (assumed) 2.65 Mg/m ³	
0.425	66		
0.3	63		
0.212	59		
0.15	56		
0.063	48		

Dry Mass of sample, g

2499

Sample Proportions	% dry mass
Cobbles	0.0
Gravel	21.9
Sand	30.2
Silt	37.3
Clay	10.6

Grading Analysis	
D100	mm
D60	mm
D30	mm
D10	mm
Uniformity Coefficient	120
Curvature Coefficient	0.18

Remarks

Preparation and testing in accordance with BS1377-2 :1990 unless noted below

Approved

Stephen.Watson

LAB 05R Version 4



10122



CAUSEWAY
— GEOTECH

APPENDIX G
SPT HAMMER ENERGY MEASUREMENT REPORT



Southern Testing
Keeble House
Stuart Way
East Grinstead
West Sussex
RH19 4QA

SPT Hammer Ref: 0210..
Test Date: 22/02/2020
Report Date: 03/03/2020
File Name: 0210...spt
Test Operator: NPB

Instrumented Rod Data

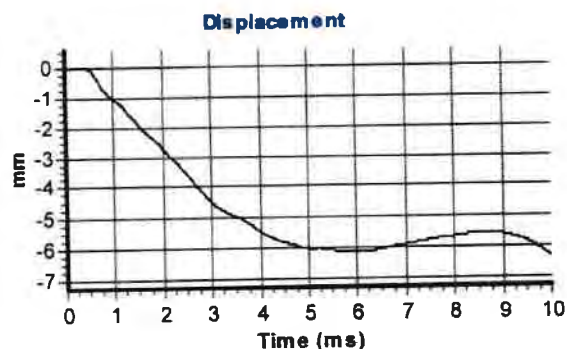
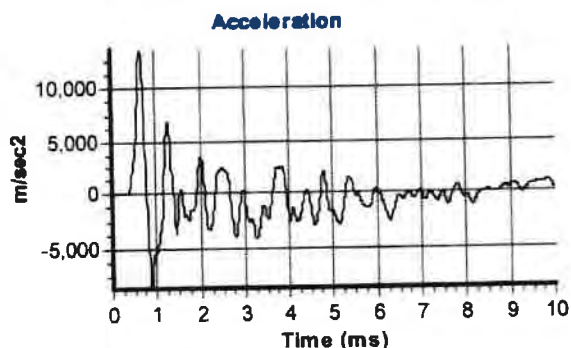
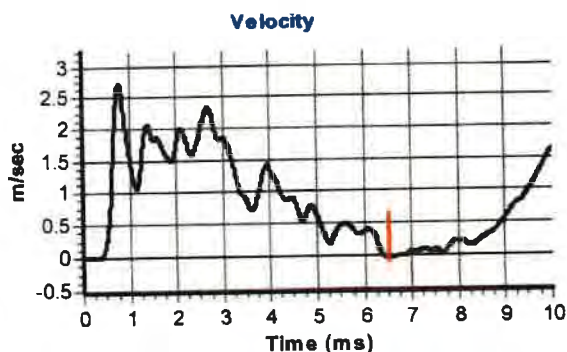
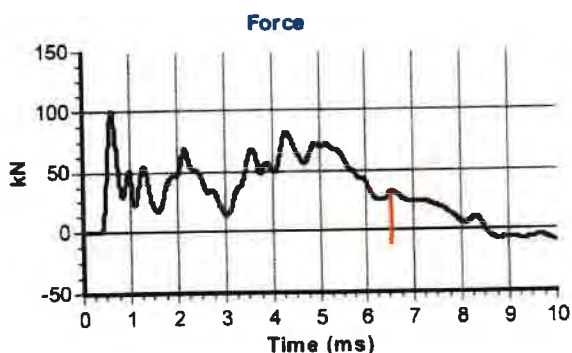
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.0
Assumed Modulus E_a (GPa): 200
Accelerometer No.1: 6458
Accelerometer No.2: 9607

SPT Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 10.0

Comments / Location

BALLEYMONEY



Calculations

Area of Rod A (mm^2): 905
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 297

Energy Ratio E_r (%)

63

Signed: Neil Burrows

Title: Field Operations Manager

The recommended calibration interval is 12 months

Appendix C

Laboratory Certificates



The Grove, Craven Arms, Shropshire. SY7 8DA.
Tel. 01588 672600 Fax. 01588 672880 Email: enquiries@scitech-labs.uk.com
CERTIFICATE OF ANALYSIS

Company Name and Address
Chemtest Limited
11 Depot Road, Newmarket, Suffolk, CB8 0AL

Farm/Premises Name and Address (if Different)
PO 21018

Type of Sample Ground Water
Sampled By Not Stated
Test method Used EIB 15

Sampled: 21/06/2021 at +N/S
Date Submitted: 23/06/2021
Received: 30/06/2021 at 10:54
Date Tested: 30/06/2021
Laboratory Reference Number: BAT2106300046
Page 1 of 2

Sci-Tech Reference No.	Customer Reference	E. Coli c.f.u. in 100ml*	Presumptive Coliforms c.f.u. in 100ml*
SMP2106300169	Job 21-21452 - 1227069 - GW BH1	<1	<1
SMP2106300170	Job 21-21452 - 1227070 - GW BH2	<1	<1

Date Reported 01/07/2021

All samples tested as received

*Not included in UKAS Schedule

+N/S = Time Not Stated

E=Estimated, <= less than, >= greater than. All customer results are obtained from samples sampled and delivered to the laboratory by the customer and all samples are tested as received. Opinions and interpretations expressed herein are outside the scope of our UKAS accreditation. This report is invalid unless signed by an authorised signatory. This report shall not be amended or reproduced (except in full) without the written approval of Sci-Tech Laboratories

Sci-Tech Laboratories, a trading division of Cawood Scientific Ltd

DEFRA approved laboratory, approval number AHZ2135

Signature

K Enefer
Laboratory Technician



The Grove, Craven Arms, Shropshire. SY7 8DA.
Tel. 01588 672600 Fax. 01588 672880 Email: enquiries@scitech-labs.uk.com

CERTIFICATE OF ANALYSIS

Company Name and Address
Chemtest Limited
11 Depot Road, Newmarket, Suffolk, CB8 0AL

Farm/Premises Name and Address (if Different)
PO 21018

Type of Sample
Ground Water

Sampled By
Not Stated

Test method Used
EIB 15

Sampled: 21/06/2021 at +N/S
Date Submitted: 23/06/2021
Received: 30/06/2021 at 10:54
Date Tested: 30/06/2021
Laboratory Reference Number: BAT2106300046
Page 2 of 2

This sample is outside the conditions of an accredited test, it has been tested after instruction from the client, and it is not admissible as an NCP/Lion code result.

Date Reported
01/07/2021

All samples tested as received

*Not included in UKAS Schedule

+N/S = Time Not Stated

E=Estimated, <= less than, >= greater than. All customer results are obtained from samples sampled and delivered to the laboratory by the customer and all samples are tested as received. Opinions and interpretations expressed herein are outside the scope of our UKAS accreditation. This report is invalid unless signed by an authorised signatory. This report shall not be amended or reproduced (except in full) without the written approval of Sci-Tech Laboratories

Sci-Tech Laboratories, a trading division of Cawood Scientific Ltd

DEFRA approved laboratory, approval number AHZ2135

Signature

K Enefer
Laboratory Technician

CERTIFICATE OF ANALYSIS

Client : Niall Mitchell
 Blue Rock Environmental
 33 Lower Salthill
 Galway City
 C/O Andrew McDermott

Report No. : 443724
 Date of Receipt : 23/03/2021
 Start Date of Analysis : 23/03/2021
 Date of Report : 30/03/2021
 Order Number :
 Sample taken by : CLS

Lab No	Sample Description	Test	Ref.	Result	Units
1160842	Water Sample: BH1	Total Coliforms (Filtration)	I,R	3	cfu/100ml
		Faecal Coliforms Filtration	I,R	2	cfu/100ml
1160843	Water Sample: BH2	Total Coliforms (Filtration)	I,R	0	cfu/100ml
		Faecal Coliforms Filtration	I,R	0	cfu/100ml
1160844	Water Sample: BH4	Total Coliforms (Filtration)	I,R	14	cfu/100ml
		Faecal Coliforms Filtration	I,R	5	cfu/100ml



Approved by:

Louise Quirke

Louise Quirke
Reporting Technician

See below for test specifications and accreditation status.

This report only relates to items tested and shall not be reproduced but in full with the permission of CLS.

0cfu is reported in waters, this refers to 'not detected in volume tested'

It is recommended that water samples requiring microbiological analysis should be tested within 24 hours of sampling. CLS will test food, water and swabs samples within 24 hours of receipt.

Where samples have been taken by the Client, results apply to the samples as received.

In-House Test	Specification	Measurement of Uncertainty	17025	GMP/FDA*	ISO**
Total Coliforms (Filtration)	CLS 16	+/- 0.10	Yes	No	Yes
Faecal Coliforms Filtration	CLS 16 based on The Microbiology of Recreational and Environmental Waters 2000	+/- 0.01	Yes	No	Yes

*Analysis carried out in a GMP approved, FDA inspected facility (MedPharma site only).

**Laboratory Analysis, Sampling, Food Safety Monitoring and Analysts on Contract are all ISO 9001 certified.

Lab No	Sample ID	Sample Condition on Receipt	Sampling Date
1160842	Water Sample: BH1	Good condition	23/03/2021
1160843	Water Sample: BH2	Good condition	23/03/2021
1160844	Water Sample: BH4	Good condition	23/03/2021



Final Report

Report No.: 21-09580-1
Initial Date of Issue: 01-Apr-2021
Client Causeway Geotech Ltd
Client Address: 8 Drumahiskey Road
Balnamore
Ballymoney
County Antrim
BT53 7QL
Contact(s): Carin Cornwall
Colm Hurley
Darren O'Mahony
Gabriella Horan
Joe Gervin
John Cameron
Lucy Newland
Martin Gardiner
Matthew Gilbert
Neil Haggan
Paul Dunlop
Sean Ross
Stephen Franey
Stephen Watson
Stuart Abraham
Thomas McAllister
Project OLD DUBLIN ROAD GALWAY
IRELAND

Quotation No.:	Date Received:	25-Mar-2021
Order No.:	Date Instructed:	25-Mar-2021
No. of Samples: 3		
Turnaround (Wkdays): 5	Results Due:	31-Mar-2021
Date Approved: 01-Apr-2021	Subcon Results Due:	19-Apr-2021

Approved By:

Details: Glynn Harvey, Technical Manager

Results - Water

Project: OLD DUBLIN ROAD GALWAY IRELAND

Client: Causeway Geotech Ltd	Chemtest Job No.:				21-09580	21-09580	21-09580
Quotation No.:	Chemtest Sample ID.:				1166887	1166888	1166889
Order No.:	Client Sample Ref.:				BH1	BH2	BH3
	Client Sample ID.:				BH1	BH2	BH3
	Sample Location:				BH1	BH2	BH4
	Sample Type:				WATER	WATER	WATER
	Date Sampled:				23-Mar-2021	23-Mar-2021	23-Mar-2021
Determinand	Accred.	SOP	Units	LOD			
pH	U	1010		N/A	8.3	8.1	8.2
Alkalinity (Carbonate)	U	1220	mg CaCO ₃ /l	10	< 10	< 10	< 10
Chloride	U	1220	mg/l	1.0	51	28	67
Ammonia (Free) as N	U	1220	mg/l	0.050	< 0.050	< 0.050	< 0.050
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.14	0.10	0.26
Nitrite as N	U	1220	mg/l	0.010	< 0.010	< 0.010	0.040
Nitrate as N	U	1220	mg/l	0.50	1.4	0.84	1.0
Orthophosphate as PO ₄	U	1220	mg/l	0.050	< 0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0	34	16	37
Total Organic Nitrogen	N	1340	mg/l	1.0	2.6	2.2	2.2
Nitrogen (Total)	N	1340	mg/l	5.0	< 5.0	< 5.0	< 5.0
Total Calcium	N	1455	mg/l	5.0	94	110	99
Total Potassium	N	1455	mg/l	0.50	2.8	1.6	4.0
Total Magnesium	N	1455	mg/l	0.50	5.4	4.7	5.8
Total Sodium	N	1455	mg/l	0.50	31	18	53
Hardness	N	1415	mg/l	1.0	250	300	270
Copper (Dissolved)	U	1455	µg/l	0.50	1.2	1.7	0.70
Iron (Dissolved)	N	1455	µg/l	5.0	< 5.0	< 5.0	< 5.0
Manganese (Dissolved)	U	1455	µg/l	0.50	1.7	6.0	490

Results - Water

Project: OLD DUBLIN ROAD GALWAY IRELAND

Client: Causeway Geotech Ltd	Chemtest Job No.:				21-09580	21-09580	21-09580
Quotation No.:	Chemtest Sample ID.:				1166887	1166888	1166889
Order No.:	Client Sample Ref.:				BH1	BH2	BH3
	Client Sample ID.:				BH1	BH2	BH3
	Sample Location:				BH1	BH2	BH4
	Sample Type:				WATER	WATER	WATER
	Date Sampled:				23-Mar-2021	23-Mar-2021	23-Mar-2021
Determinand	Accred.	SOP	Units	LOD			
Nickel (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50	1.4
Lead (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50	< 0.50
Zinc (Dissolved)	U	1455	µg/l	3.0	< 3.0	3.6	< 3.0
Total Organic Carbon	U	1610	mg/l	2.0	18	< 2.0	3.4
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10

Results - Water

Project: OLD DUBLIN ROAD GALWAY IRELAND

Client: Causeway Geotech Ltd	Chemtest Job No.:				21-09580	21-09580	21-09580
Quotation No.:	Chemtest Sample ID.:				1166887	1166888	1166889
Order No.:	Client Sample Ref.:				BH1	BH2	BH3
	Client Sample ID.:				BH1	BH2	BH3
	Sample Location:				BH1	BH2	BH4
	Sample Type:				WATER	WATER	WATER
	Date Sampled:				23-Mar-2021	23-Mar-2021	23-Mar-2021
Determinand	Accred.	SOP	Units	LOD			
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10	< 10
Methanal (Formaldehyde)	N		mg/l	0.0050	0.021	0.025	0.0070

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1340	Total Nitrogen in Waters	Total Nitrogen and organic Nitrogen	Persulphate digestion followed by colorimetry.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1455	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44 Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com



2183

Amended Report

Report No.:	21-21452-3		
Initial Date of Issue:	01-Jul-2021	Date of Re-Issue:	01-Jul-2021
Client	Causeway Geotech Ltd		
Client Address:	8 Drumahiskey Road Balnamore Ballymoney County Antrim BT53 7QL		
Contact(s):	Carin Cornwall Colm Hurley Darren O'Mahony Gabriella Horan Joe Gervin John Cameron Lucy Newland Martin Gardiner Matthew Gilbert Michelle Gaffney Neil Haggan Paul Dunlop Sean Ross Stephen Franey Stephen Watson Stuart Abraham Thomas McAllist		
Project	Old Dublin Road		
Quotation No.:	Q20-21333	Date Received:	23-Jun-2021
Order No.:		Date Instructed:	23-Jun-2021
No. of Samples:	2		
Turnaround (Wkdays):	5	Results Due:	29-Jun-2021
Date Approved:	01-Jul-2021	Subcon Results Due:	14-Jul-2021
Approved By:			
Details:	Glynn Harvey, Technical Manager		

Results - Water

Project: Old Dublin Road

Client: Causeway Geotech Ltd	Chemtest Job No.:				21-21452	21-21452
Quotation No.: Q20-21333	Chemtest Sample ID.:				1227069	1227070
	Client Sample ID.:				BH1	BH2
	Sample Type:				WATER	WATER
	Date Sampled:				21-Jun-2021	21-Jun-2021
Determinand	Accred.	SOP	Units	LOD		
E. coli (Subcon)	S		cfu/100ml	N/A	see attached	see attached
Total Coliforms (Subcon)	S		cfu/100ml	N/A	see attached	see attached
pH	U	1010		N/A	8.4	7.6
Electrical Conductivity	U	1020	µS/cm	1.0	770	720
Alkalinity (Total)	U	1220	mg/l	10	230	360
Chloride	U	1220	mg/l	1.0	69	23
Ammonia (Free) as N	N	1220	mg/l	0.050	< 0.050	< 0.050
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.29	0.11
Nitrite as N	U	1220	mg/l	0.010	0.033	< 0.010
Nitrate as N	U	1220	mg/l	0.50	1.1	0.52
Orthophosphate as PO4	U	1220	mg/l	0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0	44	14
Total Oxidised Nitrogen	U	1220	mg/l	0.20	1.1	0.52
Nitrogen (Total)	N	1340	mg/l	5.0	< 5.0	< 5.0
Calcium	U	1455	mg/l	2.00	94	120
Potassium	U	1455	mg/l	0.50	2.8	1.6
Magnesium	U	1455	mg/l	0.20	5.6	4.8
Sodium	U	1455	mg/l	1.50	36	16
Total Hardness as CaCO3	U	1270	mg/l	15	260	330
Copper (Dissolved)	U	1455	µg/l	0.50	< 0.50	0.67
Iron (Dissolved)	N	1455	µg/l	5.0	< 5.0	< 5.0
Manganese (Dissolved)	U	1455	µg/l	0.50	33	2.1
Nickel (Dissolved)	U	1455	µg/l	0.50	0.75	< 0.50
Lead (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50
Zinc (Dissolved)	U	1455	µg/l	2.5	< 2.5	< 2.5
Total Organic Carbon	U	1610	mg/l	2.0	2.4	2.2
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10

Results - Water

Project: Old Dublin Road

Client: Causeway Geotech Ltd	Chemtest Job No.:			21-21452	21-21452	
Quotation No.: Q20-21333	Chemtest Sample ID.:			1227069	1227070	
	Client Sample ID.:			BH1	BH2	
	Sample Type:			WATER	WATER	
	Date Sampled:			21-Jun-2021	21-Jun-2021	
Determinand	Accred.	SOP	Units	LOD		
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10
Methanal (Formaldehyde)	N		mg/l	0.0050	0.024	< 0.0050

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO ₃ equivalent.
1340	Total Nitrogen in Waters	Total Nitrogen and organic Nitrogen	Persulphate digestion followed by colorimetry.
1455	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 30 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com