FEHILY TIMONEY
30 YEARS

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX 5

Causeway Geotechnical Reports

Galway Historic Landfills – Tuam Ground Investigation

Client:	Galway County Council
Client's Representative:	Feehily Timoney
Report No.:	19-1465A
Date:	September 2020
Status:	Final for Issue

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Approved: ISO 9001 • ISO 14001 • OHSAS 18001

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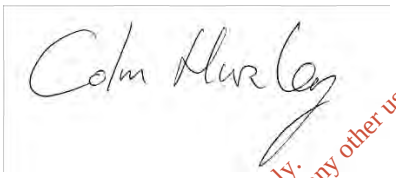
APPENDICES

Document Control Sheet

Report No.:		19-1465A			
Project Title:		Galway Historic Landfills –Tuam			
Client:		Galway County Council			
Client's Representative:		Feehily Timoney			
Revision:	A00	**Status:**	Final for Issue	**Issue Date:**	21 September 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, 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 Nx5=Cu 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.

Galway Historic Landfills – Tuam

1 AUTHORITY

On the instructions of Feehily Timoney Consulting Engineers, ("the Client's Representative"), acting on the behalf of Galway County Council ("the Client"), a ground investigation was undertaken at the above location to provide geotechnical and environmental information for input to the remediation of an historic landfill site in Galway.

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. A discussion on the recommendations for construction is also provided.

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, 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 site located 1km south east of Tuam town centre. The site is accessed off he R347 and is bounded by the R347 and the Tuam Civic Amenity Site to the east, and by agricultural lands to the north, south and west. Works were undertaken in an old landfill site immediately adjacent to the Civic Amenity Site and in the field to the south.

4 SITE OPERATIONS

4.1 Summary of site works

Site operations, which were conducted between 26th June and 18th September 2020, comprised:

- two boreholes by rotary drilling methods
- a standpipe installation in each borehole; and
- five machine dug 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

Two boreholes (GW01 and GW02) were put to their completion by rotary drilling techniques only. The boreholes were completed using a Hanjin 8D tracked drilling rig.

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

Appendix B presents the borehole logs.

4.3 Standpipe installations

A groundwater monitoring standpipe was installed in each borehole. Each borehole was also installed with waterra tubing and foot valve to allow future groundwater sampling.

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–TP05) were excavated using a 13t tracked excavator fitted with a 600mm wide bucket, to a maximum depth of 2.00m. TP01-TP03 and TP05 were undertaken to prove the depth to the existing clay liner.

Bulk samples were taken at depths specified by the Client's Representative.

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 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) at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A shows these as-built positions.

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.
- **shear strength** (total stress): unconsolidated undrained triaxial tests
- **compaction related:** Moisture Condition Value/moisture content relationship

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 peat and glacial till. These deposits are underlain by undifferentiated Visean Limestones.

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 50-400mm.
- **Paved surface:** 50mm of bitmac was encountered at a depth of 0.25mbgl in TP04.
- **Clay liner**: a geo-composite clay liner was encountered in all trial pits at depths of 0.20-0.40m.
- **Made Ground (fill):** sandy gravel or gravelly silty sand fill encountered beneath topsoil in TP04 and TP05.
- **Made Ground (landfill)**: reworked sandy gravel or gravelly silty sand or sandy gravelly silty clay encountered in TP04 to a depth of 2.00m. It should be noted that the trial pit was terminated at 2.00m and this stratum may extend beyond this. Fragments of timber, plastic, glass, steel, wire, clothing, brick and timber were encountered throughout the trial pit.
- **Recent deposits (peat):** peat was encountered in GW01 and GW02 to depths of 1.00m.
- **Glacial till:** sandy gravelly clay/silt with granular pockets were encountered in both boreholes to a depth of 6.40m in GW02. Extent was not proven in GW01 as the borehole terminated at 5.00m.
- **Bedrock (Limestone):** Limestone bedrock was encountered at a depth of 6.40m in GW02.

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 in GW02 at a depth of 5.00m. Groundwater was noted during drilling of GW01; however, groundwater was present at the bottom of the hole upon termination of the borehole.

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 should not be ruled out.

Groundwater was not noted during excavation of any of the trial pits.

Subsequent groundwater monitoring of the standpipe installations recorded water levels as shown in Table 1.

Table 1: Groundwater monitoring

Date	Water level (mbgl)	
	GW01	GW02
21/09/20	0.30	0.22

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

BS 5930: 2015: 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.

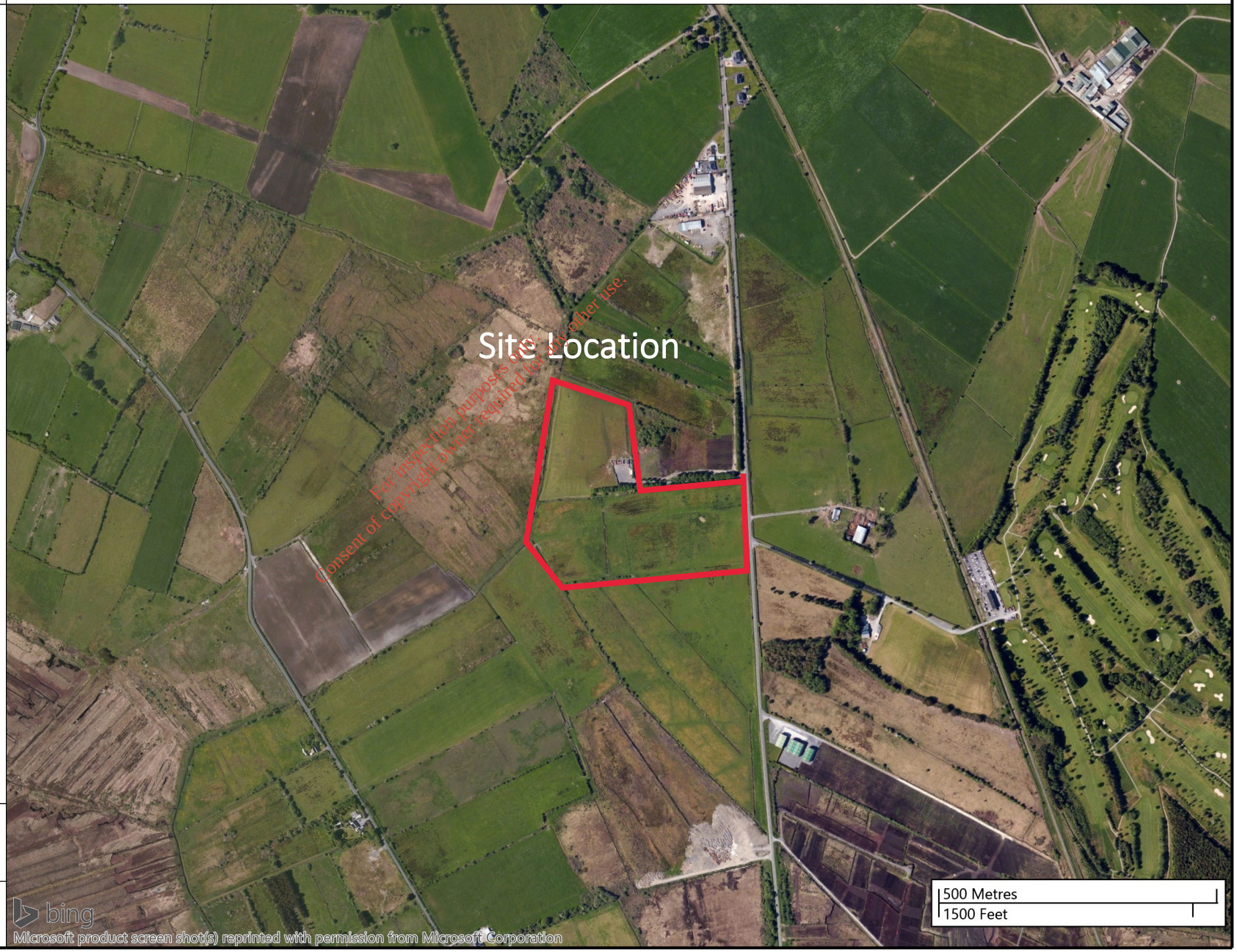
BS EN ISO 14689-1:2018: Geotechnical investigation and testing. Identification and classification of rock. Identification and description.

APPENDIX A

SITE AND EXPLORATORY HOLE LOCATION PLAN

Project No.:	19-1465A	**Client:**	Galway County Council
Project Name:	Galway Historic Landfills - Tuam	**Client's Representative:**	Feehily Timoney

Legend Key



Title:
Site Location Plan

Last Revised:	**Scale:**
21/09/2020	1:10000

CAUSEWAY GEOTECH

Project No.:	19-1465A	**Client:**	Galway County Council
Project Name:	Galway Historic Landfills - Tuam	**Client's Representative:**	Feehily Timoney

Legend Key

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

Title:
Exploratory Hole Location Plan

Last Revised:	**Scale:**
21/09/2020	1:2000

CAUSEWAY GEOTECH

APPENDIX B
BOREHOLE LOGS

CAUSEWAY GEOTECH

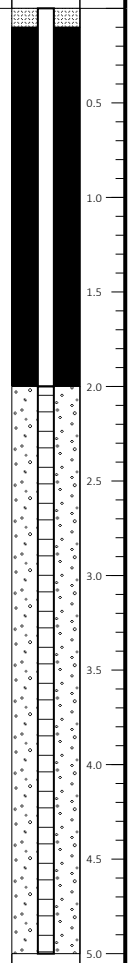
Project No.	Project Name: Galway Historic Landfills - Tuam	Borehole ID
19-1465A	Client: Galway County Council	GW01
	Client's Rep: Feehily Timoney	

Method	Plant Used	Top (m)	Base (m)	Coordinates
Rotary Drilling	Hanjin 8D	0.00	5.00	543727.49 E 749783.09 N

Final Depth:	5.00 m	Start Date:	18/09/2020	Driller:	KW	Sheet 1 of 1 Scale: 1:40
Elevation:	34.24 mOD	End Date:	18/09/2020	Logger:	SR	FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description
					34.14	0.10		TOPSOIL Brown PEAT. (Driller's description)
					33.24	1.00		Brown sandy gravelly SILT. (Driller's description)
					31.24	3.00		Grey sandy gravelly CLAY with low cobble content. (Driller's description)
					29.24	5.00		End of Borehole at 5.00m

Water / Backfill



Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Casing Details

To (m)	Diam (mm)
5.00	200

Water Added

From (m)	To (m)

Remarks

No noticeable groundwater strikes, but water present at the bottom of hole upon completion.

Core Barrel	Flush Type	Termination Reason	Last Updated
	Air	Terminated at scheduled depth.	21/09/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name: Galway Historic Landfills - Tuam			Borehole ID
19-1465A	Client: Galway County Council			GW02
	Client's Rep: Feehily Timoney			

Method	Plant Used	Top (m)	Base (m)	Coordinates	Final Depth: 12.00 m	Start Date: 18/09/2020	Driller: KW	Sheet 1 of 2
Rotary Drilling	Hanjin 8D	0.00	12.00	543727.03 E 749785.25 N	Elevation: 34.35 mOD	End Date: 18/09/2020	Logger: SR	Scale: 1:40 FINAL

Depth (m)	Sample / Tests	Field Records	Casing Depth (m)	Water Depth (m)	Level mOD	Depth (m)	Legend	Description
					34.25	0.10		TOPSOIL Brown PEAT. (Driller's description)
					33.35	1.00		Brown sandy gravelly SILT. (Driller's description)
					31.35	3.00		Grey sandy gravelly CLAY with low cobble content. (Driller's description)
		Strong water strike at 5.00m			29.85	4.50		Grey sandy fine to coarse GRAVEL. (Driller's description)
					27.95	6.40		Grey LIMESTONE. (Driller's description)

Water

Backfill

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0

Water Strikes			
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
5.00	5.00	20	0.50

Casing Details		Water Added	
To (m)	Diam (mm)	From (m)	To (m)
12.00	200		

Remarks

Core Barrel	Flush Type	Termination Reason	Last Updated
	Air	Terminated at scheduled depth.	21/09/2020

AGS

CAUSEWAY GEOTECH

Project No.	Project Name: Galway Historic Landfills - Tuam	Borehole ID
19-1465A	Client: Galway County Council	GW02
	Client's Rep: Feehily Timoney	

Method	Plant Used	Top (m)	Base (m)	Coordinates	Final Depth: 12.00 m	Start Date: 18/09/2020	Driller: KW	Sheet 2 of 2
Rotary Drilling	Hanjin 8D	0.00	12.00	543727.03 E 749785.25 N	Elevation: 34.35 mOD	End Date: 18/09/2020	Logger: SR	Scale: 1:40 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)		
					22.35	12.00		End of Borehole at 12.00m		

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)
5.00	5.00	20	0.50

Casing Details

To (m)	Diam (mm)
12.00	200

Water Added

From (m)	To (m)

Remarks

Core Barrel	Flush Type	Termination Reason	Last Updated
	Air	Terminated at scheduled depth.	21/09/2020

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CAUSEWAY GEOTECH

APPENDIX C

TRIAL PIT LOGS

CAUSEWAY GEOTECH

Project No. 19-1465A	**Project Name:** Galway Historic Landfills - Tuam		**Trial Pit ID** TP01
Coordinates 543837.44 E 749999.13 N	**Client:** Galway County Council		
Method: Trial Pitting	**Client's Representative:** Feehily Timoney		Sheet 1 of 1 Scale: 1:25
Plant: 13t Tracked Excavator	**Elevation** 45.05 mOD	**Date:** 07/07/2020	**Logger:** JG	FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
0.10 - 0.40	B1		44.65	0.40		TOPSOIL	
						End of trial pit at 0.40m	

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

Water Strikes	
Struck at (m)	Remarks

Depth: 0.40
Width: 0.40
Length: 1.10

Remarks:
Geocomposite clay liner below topsoil at 0.40m.
No groundwater encountered.

Stability:	Termination Reason:	Last Updated
Stable	Geocomposite clay liner proven.	21/09/2020

AGS

CAUSEWAY GEOTECH

Project No. 19-1465A	**Project Name:** Galway Historic Landfills - Tuam		**Trial Pit ID** TP02
Coordinates 543812.74 E 749973.63 N	**Client:** Galway County Council		
Method: Trial Pitting	**Client's Representative:** Feehily Timoney		Sheet 1 of 1 Scale: 1:25
Plant: 13t Tracked Excavator	**Elevation** 46.74 mOD	**Date:** 07/07/2020	**Logger:** JG	FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
0.00 - 0.20	B1		46.54	0.20		TOPSOIL End of trial pit at 0.20m	

Water Strikes	
Struck at (m)	Remarks

Depth: 0.20
Width: 0.30
Length: 1.20

Remarks:
Geocomposite clay liner below topsoil at 0.20m.
No groundwater encountered.

Stability:	Termination Reason:	Last Updated
Stable	Geocomposite clay liner proven.	21/09/2020

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CAUSEWAY GEOTECH

Project No. 19-1465A	**Project Name:** Galway Historic Landfills - Tuam		**Trial Pit ID** TP03
Coordinates 543774.50 E 749918.67 N	**Client:** Galway County Council		
Method: Trial Pitting	**Client's Representative:** Feehily Timoney		Sheet 1 of 1 Scale: 1:25
Plant: 13t Tracked Excavator	**Elevation** 44.26 mOD	**Date:** 07/07/2020	**Logger:** JG	FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
0.00 - 0.20	B1		44.06	0.20		TOPSOIL	
						End of trial pit at 0.20m	

Water Strikes	
Struck at (m)	Remarks

Depth: 0.20
Width: 0.60
Length: 1.80

Remarks:
Geocomposite clay liner below topsoil at 0.20m.
No groundwater encountered.

Stability: Stable

Termination Reason: Geocomposite clay liner proven.

Last Updated 21/09/2020

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CAUSEWAY GEOTECH

Project No. 19-1465A	**Project Name:** Galway Historic Landfills - Tuam		**Trial Pit ID** TP04
Coordinates 543848.05 E 749935.17 N	**Client:** Galway County Council		
Method: Trial Pitting	**Client's Representative:** Feehily Timoney		Sheet 1 of 1 Scale: 1:25
Plant: 13t Tracked Excavator	**Elevation** 42.38 mOD	**Date:** 07/07/2020	**Logger:** JG	FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
			42.33	0.05		TOPSOIL MADE GROUND: Light greyish brown sandy subangular to subrounded fine to coarse GRAVEL of mixed lithologies. Sand is fine to coarse.	
			42.13	0.25		BITMAC	
			42.08	0.30		MADE GROUND: Very soft to soft light greyish brown sandy gravelly silty CLAY with medium cobble content and fragments of timber, plastic, glass, steel, wire, brick and concrete. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subangular of mixed lithologies.	
			41.18	1.20		MADE GROUND: Soft dark grey and black sandy gravelly silty CLAY with medium cobble content and fragments of plastic, glass, clothing, timber, brick and concrete. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mixed lithologies. Cobbles are subangular of mixed lithologies.	
			40.38	2.00		End of trial pit at 2.00m	

Water Strikes	
Struck at (m)	Remarks

Depth: 2.00
Width: 0.60
Length: 4.20

Remarks:
Geocomposite clay liner below topsoil at 0.25m.
No groundwater encountered.
Strong pungent odour present from 0.30-2.00m.
Moved into filed at the request of GCC engineer (Colin Ryder).

Stability:	Termination Reason:	Last Updated
Slightly unstable	Terminated at scheduled depth.	21/09/2020

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CAUSEWAY GEOTECH

Project No.	Project Name:	Trial Pit ID
19-1465A	Galway Historic Landfills - Tuam	TP05
Coordinates	**Client:**	
543859.01 E	Galway County Council	
749890.35 N	**Client's Representative:** Feehily Timoney	Sheet 1 of 1
		Scale: 1:25
Method: Trial Pitting		
Plant: 13t Tracked Excavator	**Elevation** 41.73 mOD	**Date:** 07/07/2020
		Logger: JG
		FINAL

Depth (m)	Sample / Tests	Field Records	Level (mOD)	Depth (m)	Legend	Description	Water
			41.68	0.05		TOPSOIL	
						MADE GROUND: Light grey slightly gravelly silty fine to coarse SAND. Gravel is subangular fine to coarse of mixed lithologies.	
			41.53	0.20		End of trial pit at 0.20m	

Water Strikes	
Struck at (m)	Remarks

Depth: 0.20
Width: 0.30
Length: 3.20

Remarks:
Geocomposite clay liner below topsoil at 0.20m.
Moved to field side of Civic Area as per GCC engineer request.
No groundwater encountered.

Stability:	Termination Reason:	Last Updated
Stable	Geocomposite clay liner proven.	21/09/2020

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