

CEMEX UK Materials Ltd

Whitehall Landfill

CQA Validation Report Northern
Sidewall Barrier – fourth lift

CQA VAL007

Issue | 21 August 2019

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 237156

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Document Verification

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1 Introduction

Whitehall Landfill is owned and operated by CEMEX UK materials Ltd (CEMEX), under Environmental permit (LP 3630 MR) issued by the Environment Agency (EA) on 17 March 2006. The landfill site is located at National Grid Reference ST 1170 7345 to the north-west of Wenvoe, South Wales. The site is approximately 6 miles west of Cardiff city centre.

This document has been produced for CEMEX by Ove Arup and Partners Ltd (Arup), in accordance with the requirements of the Environmental Permit that authorises the use of the site for disposal of inert waste.

This report presents a summary and discussion of the Construction Quality Assurance (CQA) checks, inspections and tests that were implemented throughout the construction of the fourth lift on northern sidewall enhanced geological barrier in Phases 2A and 2b at Whitehall Landfill site as shown in Drawing CG-001 and Drawing CG-002.

The enhanced geological barrier is required to provide a low permeability geological barrier beneath the site and around the perimeter, thus hydraulically separating the inert waste landfill from the surrounding area. The full CQA methodology and requirements are documented in the CQA plan for Whitehall Landfill, reference CQA01 Rev A (Arup, January 2013) which has been approved by the Environment Agency (EA).

Previously approved CQA reports are listed below:

- Phase 2b Area 1 Basal Geological Barrier CQA Report CQA VAL001. June 2013.
- Phase 2b Area 2 Basal Geological Barrier CQA Report CQA VAL002. September 2013.
- Phase 2A and 2B Basal and Sidewall Geological Barrier – Old Haul Road CQA VAL003. February 2015 (Northern sidewall geological barrier - first lift).
- Phase 2A and 2B Northern Sidewall Geological Barrier – second lift CQA VAL004, March 2016.
- Phase 2A and 2B Southern Sidewall Geological Barrier – first lift CQA VAL005, September 2016
- Phase 2A and 2B Northern Sidewall Geological Barrier – third lift CQA VAL006, September 2016.

This report pertains to the fourth lift of the Northern Sidewall Geological Barrier following a hiatus of approximately two years due to low input rates. This report includes records of all inspections, checks and testing undertaken, details of any non-conformances identified during the execution of the works and details of the remedial measures implemented to rectify the non-conformances.

2 Description of the works

2.1 Overview

Whitehall Landfill is regulated by Environmental Permit LP 3630 MR, issued by the Environment Agency. The permit authorises the disposal of inert waste and requires an artificially enhanced basal and sidewall geological barrier comprising a minimum of 1.0m of material with a permeability of 1×10^{-7} m/s or lower.

Artificially enhanced basal and sidewall geological barriers are required to separate the waste in new areas of the site from the surrounding limestone, which is classified as a Principal Aquifer. Independent validation is required to confirm that the artificially enhanced basal and sidewall geological barriers satisfy the regulatory requirements. This includes a suitability assessment of the material to be placed, monitoring of the formation preparation, monitoring of the methods of construction and compliance testing following the completion of the barrier construction.

As described in the CQA Plan, for safety reasons it is not possible for dozers to work close to the quarry walls to spread and compact clay due to the risk of rockfall. Consequently, a stand-off of approximately 3m is left between the rockface and the waste.

A site trial to confirm the method of constructing the sidewall barrier is described in CQA VAL003 (Basal and Sidewall Geological Barrier – Old Haul Road).

Construction of the enhanced sidewall geological barrier for the fourth lift on the northern boundary comprised the following:

- Inspection, sampling and analysis of proposed source material to confirm suitability;
- Preparation of formation;
- Haulage of acceptable imported material deposited in a stockpile set back from the quarry face;
- Deposition and spreading of material using an excavator;
- Compaction of acceptable material in 250mm layers using a boom mounted vibrating plate compactor to form an enhanced geological barrier at least 1.0m thick.

2.2 Suitability assessment

The material used to construct the enhanced sidewall geological barrier for the northern sidewall was sourced from St Fagan's Museum, Cardiff (WHL0104) as used for lift 3, which has been stockpiled on site adjacent to the construction works for use in barrier construction. Site staff have been briefed on the requirements of the CQA Plan, including assessment of the suitability of the material for use within the basal and sidewall geological barriers.

The suitability assessment was undertaken by the Site Manager in accordance with the CQA plan to assess whether the material was appropriate for use.

The corresponding Waste Information Form WHL0104 is included in Appendix A.

2.3 Construction

Construction of the enhanced geological barrier was carried out from October to November 2018 and proceeded as described below:

- Vegetation was scraped from the sidewall and the top of the previously placed clay barrier using the excavator;
- The formation was graded smooth using an excavator to remove any cracks, humps or hollows;
- The excavator placed barrier material adjacent to the rock face in an uncompacted layer of approximately 300mm thick;
- The vibrating plate compactor was fitted onto the end of the excavator and compacted the geological barrier material in 250mm layers;
- Successive layers were constructed as described above;
- The sidewall geological barrier was approximately 100m long, between 2 and 6m wide (to tie into the existing surface of the quarry wall), and typically 3-4m high for the fourth lift.

Selected photographs are included within the site visit records in Appendix B.

Construction was carried out under the supervision of the Site Manager.

3 CQA Inspections, Checks and Tests

3.1 Formation

The formation for the fourth lift of the barrier was on the completed third lift level.

The following checks were undertaken:

- A visual inspection of the suitability of the material was undertaken on October 26th 2018 in advance of constructing the fourth lift. The material was subsequently re-inspected during construction;
- A visual inspection of the formation level for the fourth lift was undertaken by the CQA Inspector on October 26th 2018 prior to commencing the construction of the enhanced geological barrier;
- A topographic survey of the formation was undertaken in July 2016 to allow comparison of levels with subsequent survey and hence determine layer thickness. The topographic survey for pre-construction is included as Drawing CG-001.

3.2 Material

3.3 Inspections during construction

A visual inspection of the construction of the geological barrier was undertaken by the CQA Inspector on November 8th 2018, to observe the material placed and ensure that the working method employed was acceptable. The CQA Inspection records are included in Appendix B.

3.4 Completed Sidewall Geological Barrier

The following tests and inspections shown in Table 1 were undertaken on the enhanced sidewall geological barrier, a volume of approximately 1,500m³.

Table 1 Schedule of validation tests and inspections

Test	Number	Equivalent Frequency *	Target frequency
Field strength assessment	4	1 per 26m per 5m lift	1 per 50m per 5m lift
Particle size distribution (PSD) analysis	4	1 per 26m per 5m lift	1 per 50m per 5m lift
Plasticity characteristics analysis	4	1 per 26m per 5m lift	1 per 50m per 5m lift

*height of geological barrier = 4m

Bulk samples were recovered from the as-built barrier at locations selected at random by the CQA Inspector (NSW101-104) as shown on Drawing CG-001.

On completion, bulk samples were taken for geotechnical testing. The results obtained from the tests undertaken are presented in Table 2. The laboratory test results have been included in Appendix C.

Table 2 Results from Validation Tests and Inspections

Test	NW101	NW102	NW103	NW104	Acceptance Criteria
Particle size distribution PSD - % passing 0.002mm	17	25	12	15	> 10
Field strength assessment	Firm	Firm-stiff	Firm-stiff	Firm	Firm or stiff (40-150 kPa)
Particle size distribution PSD - % passing 125mm	100	100	100	100	100
Plasticity Index (%)	23	22	19	20	> 10
Liquid limit (%)	43	49	39	39	< 90
Permeability testing in the lab BS1377 (m/s)	3.2×10^{-10}	3.2×10^{-10}	3.2×10^{-10}	3.2×10^{-10}	$\leq 1.0 \times 10^{-7}$

4 Non-conformance and Remedial Action

No non-conformances were raised and therefore no corrective action was required.

5 Discussion of Inspections and Testing Results

5.1 Particle Size Distribution

The requirements were for 100% of the material to pass the 125mm sieve, and for greater than 10% to pass the 0.002mm sieve (i.e. to be clay sized particles).

The percentage passing shown in Table 2 indicates the percentage passing a sieve size smaller than the 0.002mm required by the CQA plan. The results from the particle size distribution analyses indicate that the materials included in the geological barrier meet the grading requirements of the CQA Plan.

5.2 Shear Strength Properties

Requirements for the material were for an undrained shear strength of the remoulded material greater than 40 kPa. This requirement was assessed by handling the material.

The results from the field strength assessments indicated that the strength of the placed barrier material was firm, locally stiff, which meets the strength requirements of the CQA Plan.

5.3 Plasticity Characteristics

Requirements were for the material to be rolled into 3mm thick samples without crumbling. Material handled in the field passed the plasticity requirements of the CQA Plan.

Laboratory results undertaken on samples showed high plasticity, confirming the suitability of the material.

5.4 Permeability

Requirements for the geological barrier were for a permeability of less than or equal to 1×10^{-7} m/s.

The results from four laboratory permeability tests yielded permeabilities below the maximum permitted by the CQA Plan.

5.5 Layer thickness

Due to the undulating nature of the quarry face, the thickness of the barrier wall is in places locally up to 6m in thickness. Pre- and post-construction surveys are presented in this report in Drawing CG-001 which confirm the presence of at least 1m width of material complying with the requirements of the sidewall geological barrier.

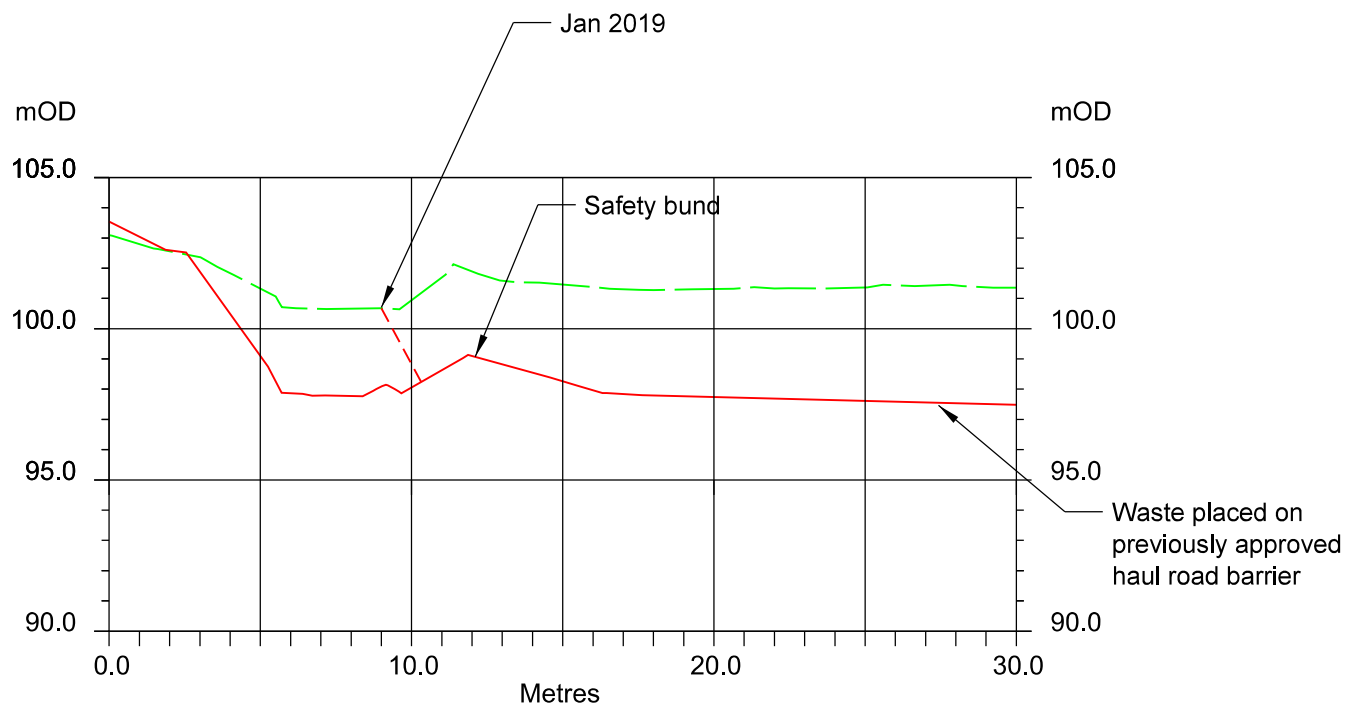
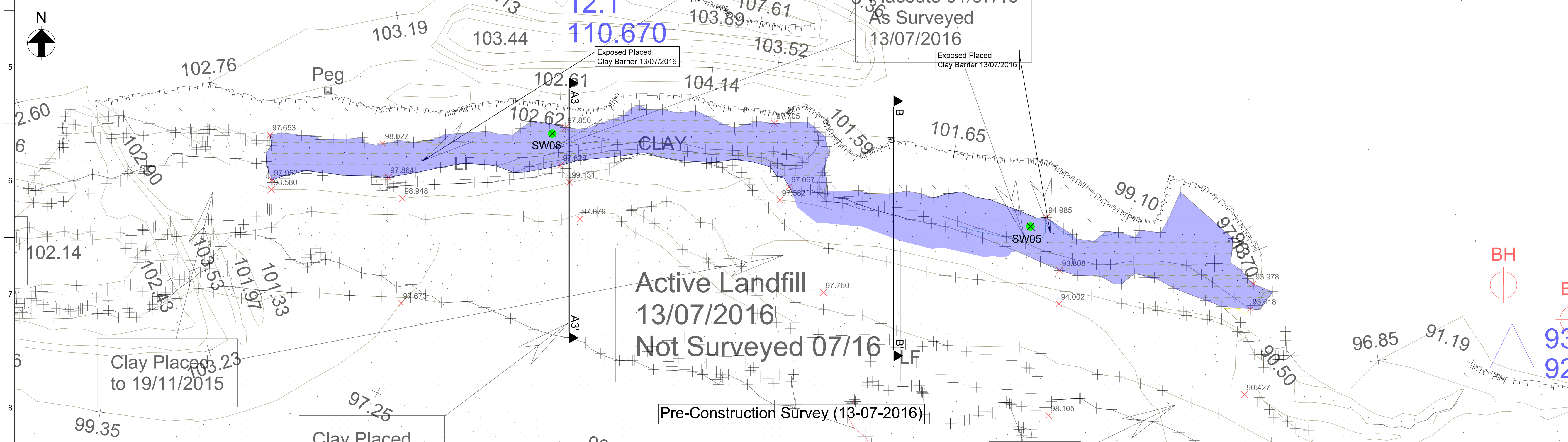
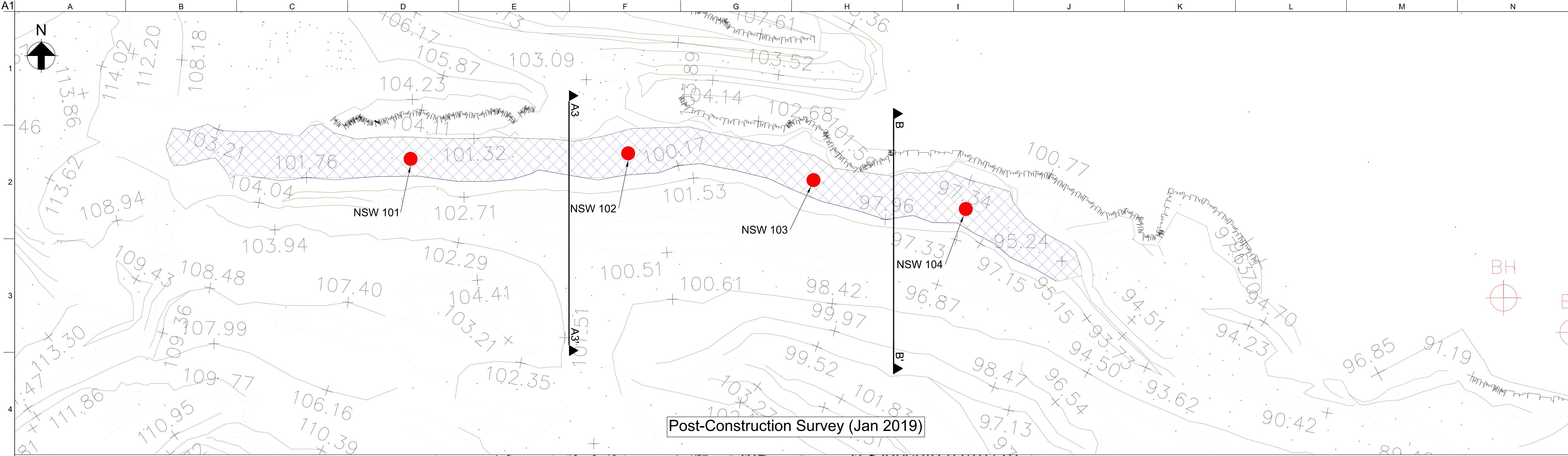
6 Summary

On the basis of the tests and inspections described in this report, we are satisfied that the enhanced sidewall geological barrier meets the requirements of the CQA Plan and the Environmental Permit.

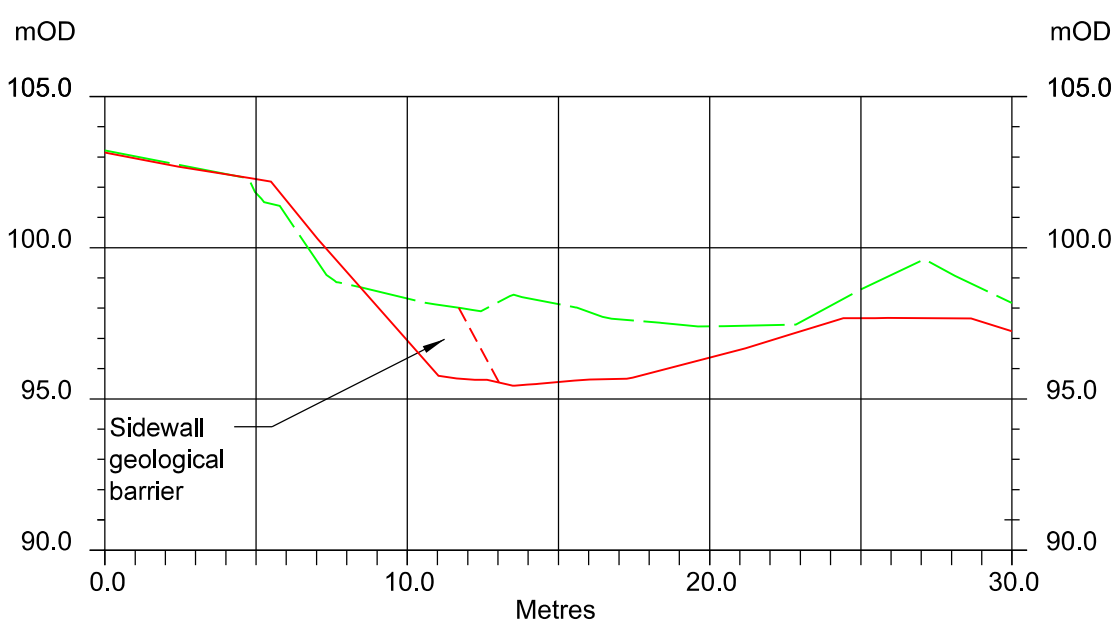
Drawings

Drawing 1 CG-001 Pre-Construction and Post Construction Plan and Sections

Drawing 2 CG-002 Geological Barrier Summary January 2019



Section A3 - A3'



Section B - B

- Key
- Post-construction Jan 2019
 - Pre-construction survey, 13-07-2016
 - Northern sidewall third lift
 - Northern sidewall fourth lift
 - Sample location
 - Post-construction survey spot level
 - NWS Trail Pit Locations

P6	20/08/19	AD	GS	AGH
NSW Trial Pits Added				
P5	31/05/19	AD	GS	AGH

P4	28/11/16	ST	GS	AGH
Pre-construction levels added, sidewall barrier barrier profile added to sections				
P3	14-09-16	ST	GS	AGH
Northern sidewall third lift updated				
P2	13-04-16	ST	GS	AGH
Northern sidewall second lift updated				
P1	10/02/16	ST	GS	AGH
Preliminary				
Rev	Date	By	Chkd	Appd

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Client
CEMEX UK Materials Ltd

Project Title
**Whitehall Landfill
Northern Sidewall Fourth Lift**

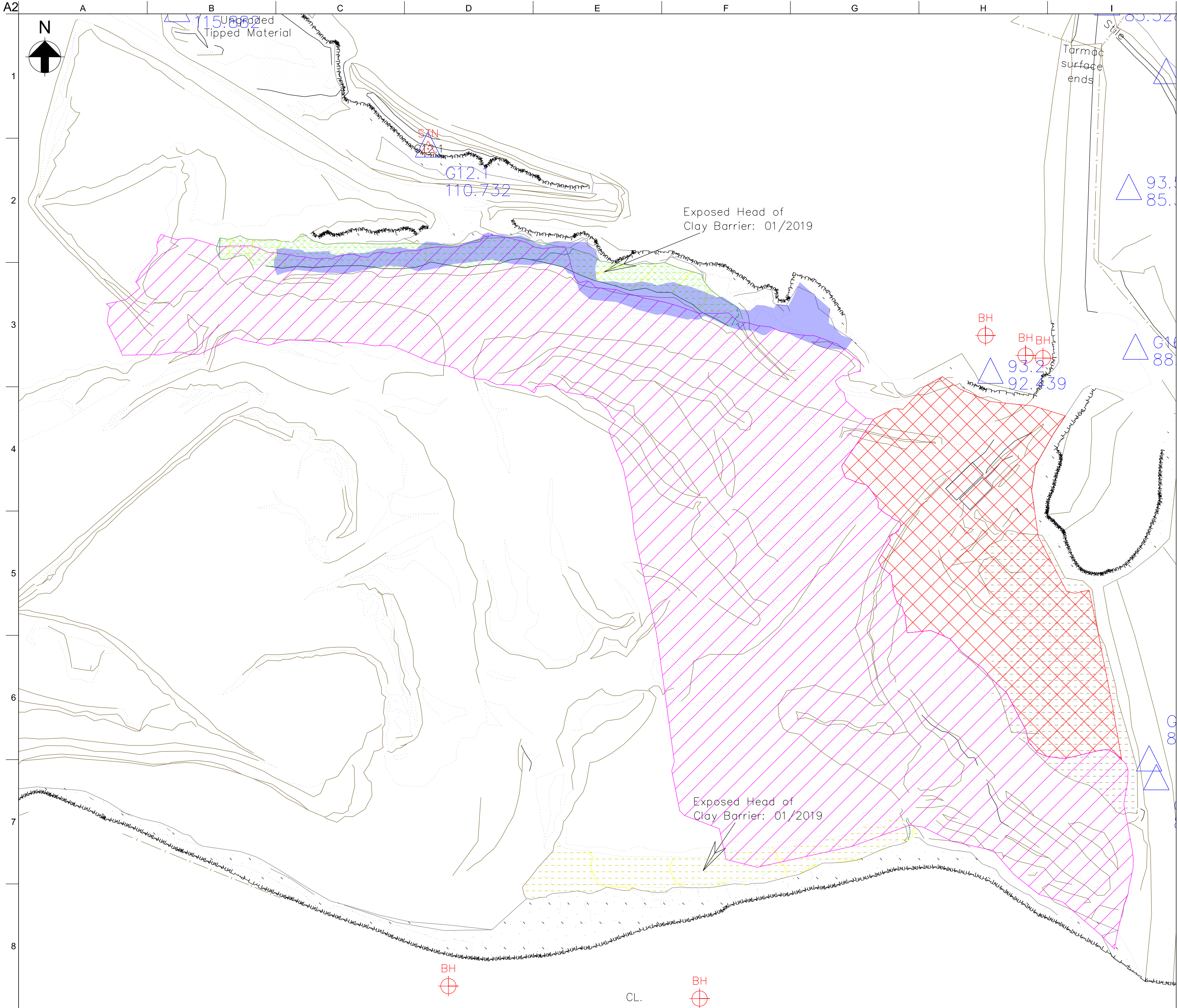
Drawing Title
**Pre-Construction and
Post-Construction Plans
and Sections**

Scale at A1
1:250

Role
Civil - Geotechnics

Suitability
Preliminary

Arup Job No 237156-00	Rev P6
Name CG_001	



Key:

- Northern sidewall third lift
- Completed and approved clay geological barrier
- Proposed remaining basal clay geological barrier
- Northern sidewall fourth lift

Notes:

- Topographic survey, Jan 2019.
- See Drawing CG_001 for cross sections.

P4	20-08-19	AD	GS	AGH
Northern sidewall fourth lift				
P3	14-09-16	ST	GS	AGH
Northern sidewall third lift				
P2	13-04-16	ST	GS	AGH
Northern sidewall second lift updated				
P1	10-02-16	ST	GS	AGH
Preliminary				
Rev	Date	By	Chkd	Appd

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Client
CEMEX UK Materials Ltd

Project Title
**Whitehall Landfill
Northern Sidewall Fourth Lift**

Drawing Title
**Geological Barrier Summary
Jan 2019**

Scale at A2 1:500	
Role Civil - Geotechnics	
Suitability Preliminary	
Arup Job No 237156-00	Rev P4
Name CG_002	

Appendix A

Waste Information Form

CONCENTRATED BY WASTE PRODUCER AND/OR WASTE CARRIER

TO BE COMPLETED BY CEMEX

CEMEX Audit Trail

Date WIF sent to Assessor: 6/11/14 Sent by: Gerri Norris

TO BE COMPLETED BY WASTE ASSESSOR (e.g. CEMEX or advisor)

Do any determinands exceed Waste Management Licence / PPC Permit criteria?

No topsoil & vegetation

Comments:

The waste is suitable for disposal at Whitehall

The waste is not suitable for disposal at _____

Signature of Waste Assessor: [Signature] Date Returned: 7/11/14

YES ☒ NO

Accepted
2500m³ only

NOTE: Please complete all parts of upper section of form – refer to Waste Producer for any missing information

NOTE: Please complete all parts of upper section of form – refer to Waste Producer for any missing information

Appendix B

CQA Inspection Records

FORM 4		
ARUP	CQA INSPECTOR SITE DIARY	PROJECT: Whitehall Landfill JOB NO: 237156 SHEET: 1 OF 2

Day: Friday	Date: 26.10.18	Week No.
Weather Sunny and dry		
CQA Inspector Claire Bennett	CEMEX Staff - Martyn Hearn	
Instructions None		
Plant in use None – excavator present on site but not in use during visit.		
Materials Barrier material from existing stock pile on site from WIF WHL0104 (this material was previously inspected in June 2017). Material noted to be a firm clay, predominantly orangey brown, locally brown to grey clay (see Photo 1)		
Unusual Occurrences None		

FORM 4**ARUP****CQA
INSPECTOR
SITE DIARY****PROJECT: Whitehall Landfill
JOB NO: 237156
SHEET: 2 OF 2****REPORT**

ELEMENT	DETAILS OF INSPECTION	LOCATION	PASS/FAIL	COMMENTS
Formation for lift 4 of geological barrier	Inspection of formation level for next lift of sidewall barrier layer alongside northern rock face	Northern sidewall	Pass subject to vegetation removal	Martyn Hearn stated that sidewall barrier construction on Northern Sidewall was to recommence, and inspection of formation level was undertaken. Some vegetation present on surface of previous barrier lift – discussed with Martyn Hearn that this was to be removed prior to construction starting (see photos 2 and 3).
Barrier material suitability	Walkover inspection	Centre of site, on mid-level plateau.		Localised stockpile formed of St Fagan's material (WIF 0104). Material is predominantly clay, with occasional gravels and cobbles. Clay is firm, locally stiff in nature. Material is considered suitable for placement and geological sidewall barrier for Lift 4.
Geological barrier	Walkover inspection	Southern sidewall		No apparent changes since previous inspection (see photo 4)

ADDITIONAL COMMENTS

Photograph 1- Stockpiled firm, locally stiff, clayey materials from St Fagan's



Photograph 2 – Northern sidewall showing formation for Lift 4 (surface of Lift 3) – looking east. Vegetation to be removed prior to barrier construction



Photograph 3 – Northern sidewall showing formation for Lift 4 (surface of Lift 3) – looking west



Photograph 4 – Southern sidewall showing no changes to sidewall construction – looking east



FORM 4		
ARUP	CQA INSPECTOR SITE DIARY	PROJECT: Whitehall Landfill JOB NO: 237156 SHEET: 1 OF 2

Day: Thursday	Date: 08.11.2018	Week No.
Weather Overcast, drizzly		
CQA Inspector Claire Bennett	CEMEX Staff - Martyn Hearn	
Instructions None		
Plant in use Excavator CAT 320E with a boom mounted compactor for compaction of the geological barrier Bulldozer		
Materials Barrier material from existing stock pile on site		
Unusual Occurrences None		

FORM 4**ARUP****CQA
INSPECTOR
SITE DIARY****PROJECT: Whitehall Landfill
JOB NO: 237156
SHEET: 2 OF 2****REPORT**

ELEMENT	DETAILS OF INSPECTION	LOCATION	PASS/ FAIL	COMMENTS
Geological barrier	Formation and construction of northern geological sidewall barrier	Northern sidewall	Pass	Works on site paused due to machine issues. Formation level of eastern section of geological sidewall barrier re-inspected to confirm vegetation removal prior to placement of barrier material (photo 1). Placement of compacted barrier material in western section of sidewall inspected to confirm suitable compaction (photo 2). Material inspected for suitability and samples taken for laboratory testing.
ADDITIONAL COMMENTS				

Photograph 1- Formation level of Lift 4 prior to placement of material (eastern section)



Photograph 2 – Construction of geological sidewall barrier (western section)



FORM 4		
ARUP	CQA INSPECTOR SITE DIARY	PROJECT: Whitehall Landfill JOB NO: 237156 SHEET: 1 OF 2

Day: Monday	Date: 12.11.2018	Week No.
Weather Overcast (~10°)		
CQA Inspector Claire Bennett	CEMEX Staff - Martyn Hearn	
Instructions None		
Plant in use None		
Materials Stockpile of materials adjacent to Southern Geological Barrier understood to be that previously used (Trident Park). Material is grey, locally brownish, firm to stiff clay, with some gravels.		
Unusual Occurrences None		

FORM 4**ARUP****CQA
INSPECTOR
SITE DIARY****PROJECT: Whitehall Landfill
JOB NO: 237156
SHEET: 2 OF 2****REPORT**

ELEMENT	DETAILS OF INSPECTION	LOCATION	PASS/ FAIL	COMMENTS
Geological barrier	Formation inspect of Southern Sidewall	Southern Sidewall	Pass	Vegetation has been cleared from the top surface of the sidewall (following the previous works in 2016). Some vegetation noted on the side of the rockface, which will be removed prior to placement of materials. Formation surface shown in Photographs 1 and 2.
Sidewall material	Visual inspection	Stockpiled next to Southern Sidewall		Material to be used in sidewall construction stockpiled adjacent to works. Material is generally firm to stiff grey clay, with some gravels and larger items. Discussed with Martyn Hearn that the larger inclusions would require removal prior to placement. See Photograph 3 for details of material.
Geological barrier	Post-construction inspection	Northern Sidewall		Inspection of the completed works at the Northern Sidewall. Material has been compacted into place with no visible large inclusions. Barrier material has been placed to the top of the quarry lower quarry face. Discussions with Martyn Hearn indicated that this was completion of the Northern Sidewall Barrier.

ADDITIONAL COMMENTS

Completion of Northern Sidewall Barrier noted.

Photograph 1- Formation surface of Southern Sidewall (west)



Photograph 2 – Formation surface of Southern Sidewall (east)



Photograph 3 – Stockpiled materials for placement



Appendix C

Laboratory Test Results

[illegible]

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Determination of Permeability in a Triaxial Cell (BS1377 : Part 6 : 1990, clause 6 - Constant Head test)

Project No	N8275-18	Sample Details:	Hole No.	NSW101		
Project Name	Whitehall Landfill Geological Barrier		Depth (m BGL)			
			Sample No	1	Type	B
			ID			
			Spec Ref			

Specimen Details

Soil Description Brown slightly sandy slightly gravelly CLAY.

Specimen Type /Preparation RECOMPACTED Using 2.5Kg effort at as received moisture content

Length 100.0 mm

Diameter 103.7 mm

Particle density 2.65 Mg/m³ Assumed

Bulk Density

Water Content

Dry density

Voids ratio

Degree of saturation

Initial

Final

2.01 2.04 Mg/m³

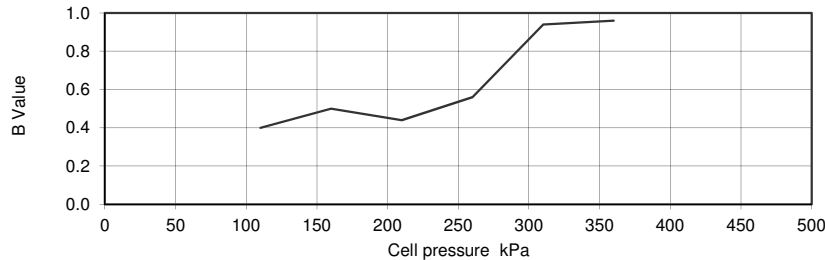
22.7 20.8 %

1.64 1.69 Mg/m³

0.62 0.57

98 97 %

Saturation Stage



Method:

Increments of cell and back pressure

Cell pressure increments 50 kPa

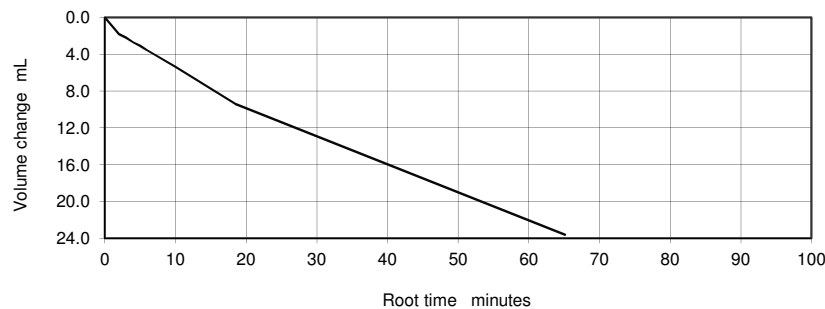
Differential Pressure 10 kPa

Final Cell Pressure 360 kPa

Final pore water pressure 337 kPa

Final B Value 0.96

Consolidation Stage



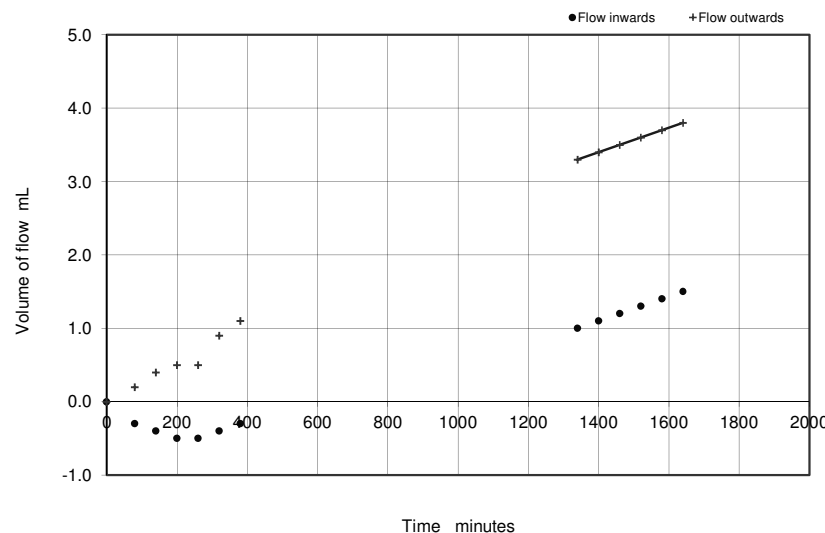
Drainage Condition to one end only

Cell pressure applied 390 kPa

Back pressure applied 300 kPa

Effective stress 90 kPa

Permeability Stage



Cell Pressure 395 kPa

Top Pressure 300 kPa

Base Pressure 310 kPa

Mean Effective Stress 90 kPa

Differential Pressure 10 kPa

Hydraulic gradient 10

Mean rate of flow 0.00167 ml/min

Temperature during test 20.1 °C

PERMEABILITY, k_v

(at 20°C) 3.2×10^{-10} m/s

Notes H.G=10kPa increasing to 30kPa

Ref SLR6.6 Rev 2.0 Feb18	 	Printed:08/01/2019 10:38	Figure TXLP sheet 1 of 1
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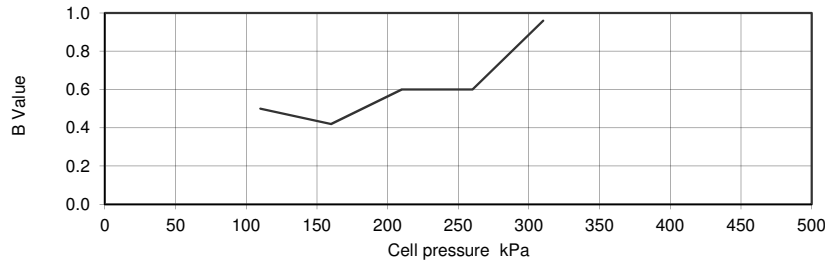
Determination of Permeability in a Triaxial Cell (BS1377 : Part 6 : 1990, clause 6 - Constant Head test)

Project No	N8275-18	Sample Details:	Hole No.	NSW102		
Project Name	Whitehall Landfill Geological Barrier		Depth (m BGL)			
			Sample No	1	Type	B
			ID			
			Spec Ref			

Specimen Details

Soil Description	Brown slightly sandy slightly gravelly CLAY			
Specimen Type /Preparation	RECOMPACTED Using 2.5Kg effort at as received moisture content		Bulk Density	Initial 1.99 Final 2.05 Mg/m³
Length	100.0 mm		Water Content	25.3 23.1 %
Diameter	103.7 mm		Dry density	1.59 1.66 Mg/m³
Particle density	2.65 Mg/m³	Assumed	Voids ratio	0.66 0.59
			Degree of saturation	101 103 %

Saturation Stage

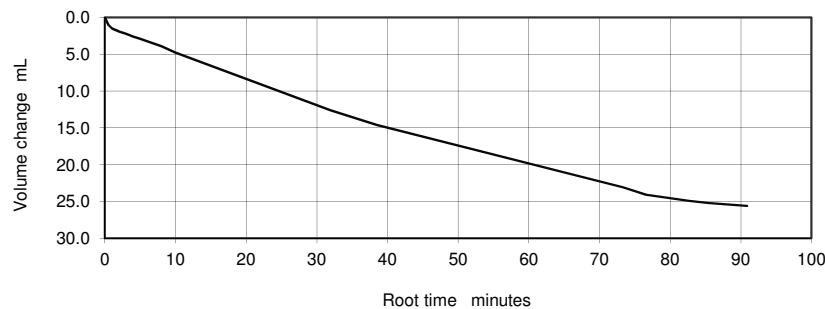


Method:

Increments of cell and back pressure

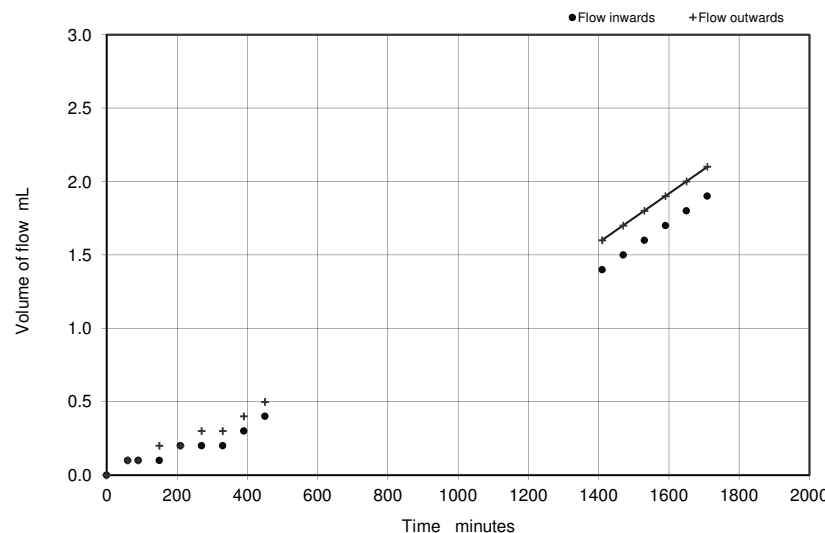
Cell pressure increments	50	kPa
Differential Pressure	10	kPa
Final Cell Pressure	310	kPa
Final pore water pressure	288	kPa
Final B Value	0.96	

Consolidation Stage



Drainage Condition	to one end only
Cell pressure applied	390 kPa
Back pressure applied	300 kPa
Effective stress	90 kPa

Permeability Stage



Cell Pressure	395	kPa
Top Pressure	300	kPa
Base Pressure	310	kPa
Mean Effective Stress	90	kPa
Differential Pressure	10	kPa
Hydraulic gradient	10	

Mean rate of flow	0.00167	ml/min
Temperature during test	20.1	°C

PERMEABILITY, k_v

(at 20°C) 3.2×10^{-10} m/s

Notes

Ref SLR6.6 Rev 2.0 Feb18	 	Printed:08/01/2019 10:39	Figure TXLP sheet 1 of 1
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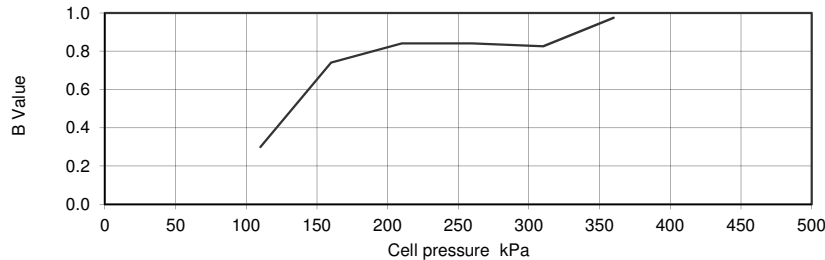
Determination of Permeability in a Triaxial Cell (BS1377 : Part 6 : 1990, clause 6 - Constant Head test)

Project No	N8275-18	Sample Details:	Hole No.	NSW103		
Project Name	Whitehall Landfill Geological Barrier		Depth (m BGL)			
			Sample No	1	Type	B
			ID			
			Spec Ref			

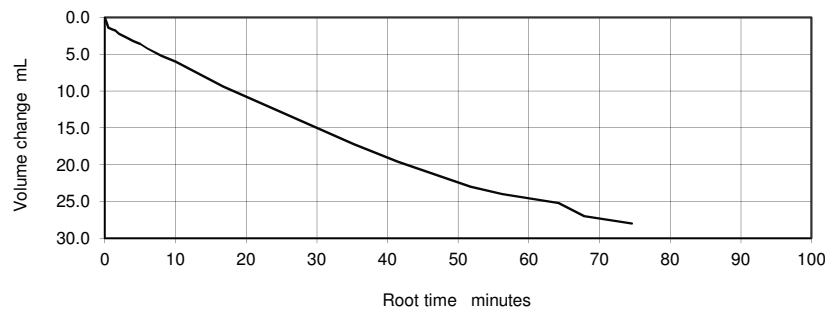
Specimen Details

Soil Description	Brown slightly sandy slightly gravelly CLAY				
Specimen Type /Preparation	RECOMPACTED Using 2.5Kg effort at as received moisture content		Bulk Density	Initial 2.07	Final 2.09 Mg/m³
Length	100.0 mm		Water Content	22.1	19.9 %
Diameter	103.7 mm		Dry density	1.70	1.74 Mg/m³
Particle density	2.65 Mg/m³	Assumed	Voids ratio	0.56	0.52
			Degree of saturation	104	101 %

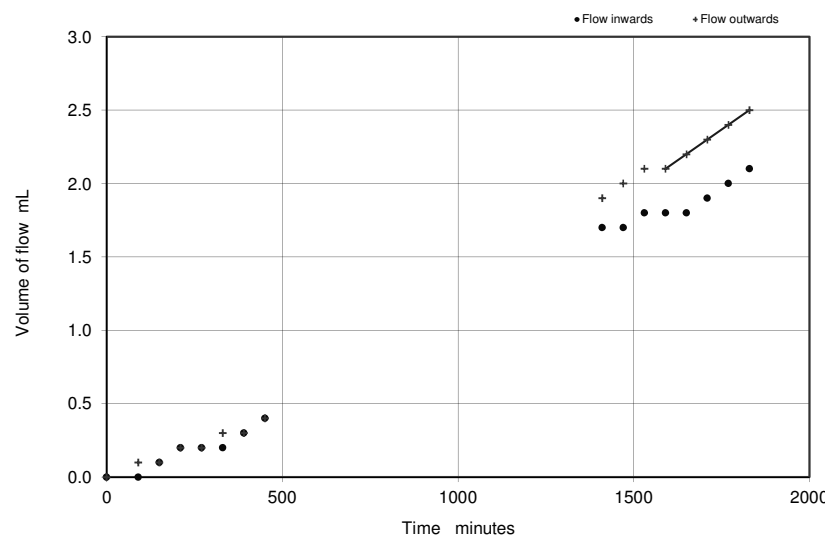
Saturation Stage



Consolidation Stage



Permeability Stage



PERMEABILITY, k_v

(at 20°C) **3.2×10^{-10} m/s**

Notes

Ref	 		Figure
SLR6.6 Rev 2.0 Feb18	Printed:08/01/2019 10:40 © Copyright 2017 SOCOTEC UK Limited. All rights reserved		TXLP sheet 1 of 1

Determination of Permeability in a Triaxial Cell (BS1377 : Part 6 : 1990, clause 6 - Constant Head test)

Project No	N8275-18	Sample Details:	Hole No.	NSW104		
Project Name	Whitehall Landfill Geological Barrier		Depth (m BGL)			
			Sample No	1	Type	B
			ID			
			Spec Ref			

Specimen Details

Soil Description Brown slightly sandy slightly gravelly CLAY.

Specimen Type /Preparation RECOMPACTED Using 2.5Kg effort at as received moisture content

Length 100.0 mm

Diameter 103.7 mm

Particle density 2.65 Mg/m³ Assumed

Bulk Density

Water Content

Dry density

Voids ratio

Degree of saturation

Initial

Final

2.05 2.11 Mg/m³

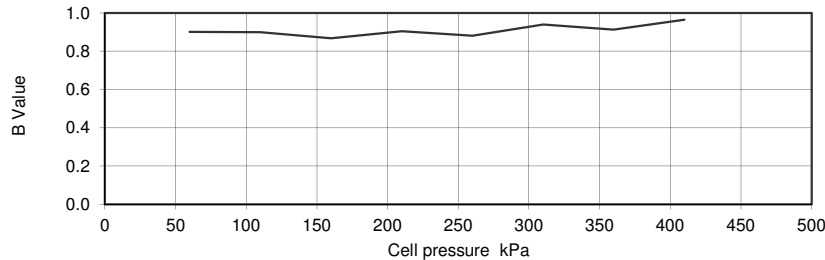
22.0 19.6 %

1.68 1.76 Mg/m³

0.58 0.50

101 103 %

Saturation Stage



Method:

Increments of cell and back pressure

Cell pressure increments 50 kPa

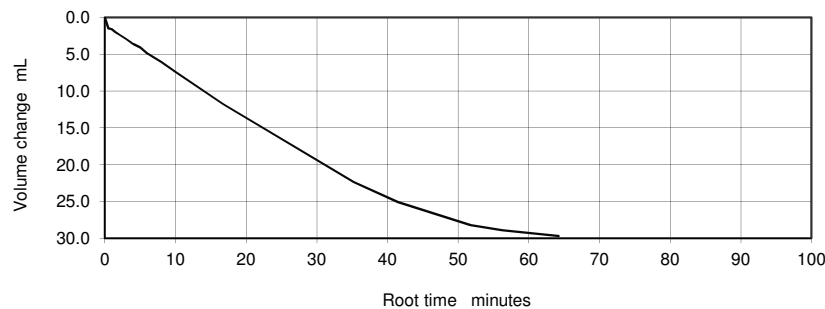
Differential Pressure 10 kPa

Final Cell Pressure 410 kPa

Final pore water pressure 392 kPa

Final B Value 0.96

Consolidation Stage



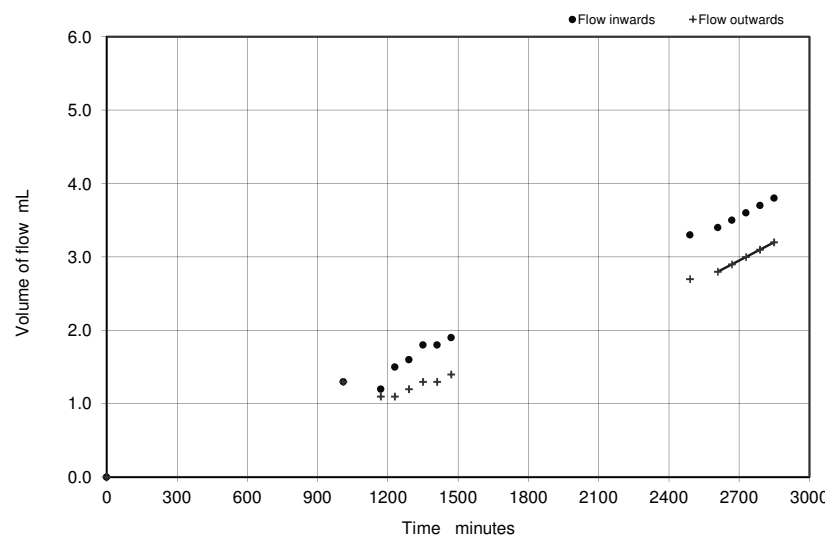
Drainage Condition to one end only

Cell pressure applied 440 kPa

Back pressure applied 350 kPa

Effective stress 90 kPa

Permeability Stage



Cell Pressure 445 kPa

Top Pressure 350 kPa

Base Pressure 360 kPa

Mean Effective Stress 90 kPa

Differential Pressure 10 kPa

Hydraulic gradient 10

Mean rate of flow 0.00167 ml/min

Temperature during test 20 °C

PERMEABILITY, k_v

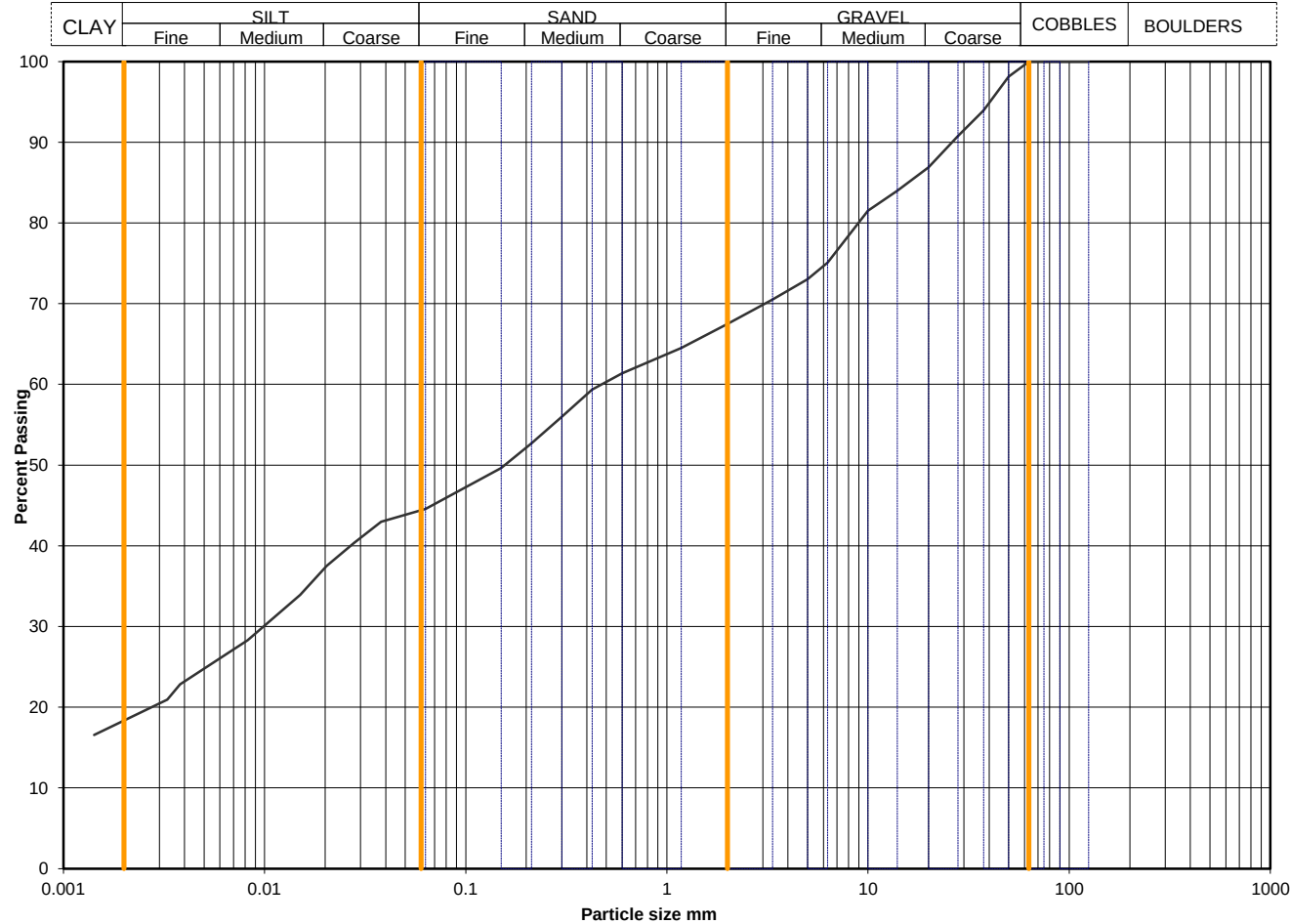
(at 20°C) 3.2×10^{-10} m/s

Notes H.G=10kPa increasing to 20kPa

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Particle Size Distribution Analysis

Sample Details:	SAMPLE ID:	Hole No	NSW101
	N8275-18201812061101512	Sample Depth (m BGL)	0.00 - 0.00
		Sample Type and No	B1
		Specimen Ref	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	45
90	100	0.0379	43
75	100	0.0278	40
63	100	0.0204	38
50	98	0.0150	34
37.5	94	0.0082	28
28	91	0.0038	23
20	87	0.0033	21
14	84	0.0014	17
10	82		
6.3	75		
5.0	73		
3.35	71		
2.00	68		
1.18	65		
0.600	61	Particle density, Mg/m3 2.65 assumed	
0.425	59		
0.300	56	Dry mass of sample, kg 14.5	
0.212	53		
0.150	50		
0.063	45		

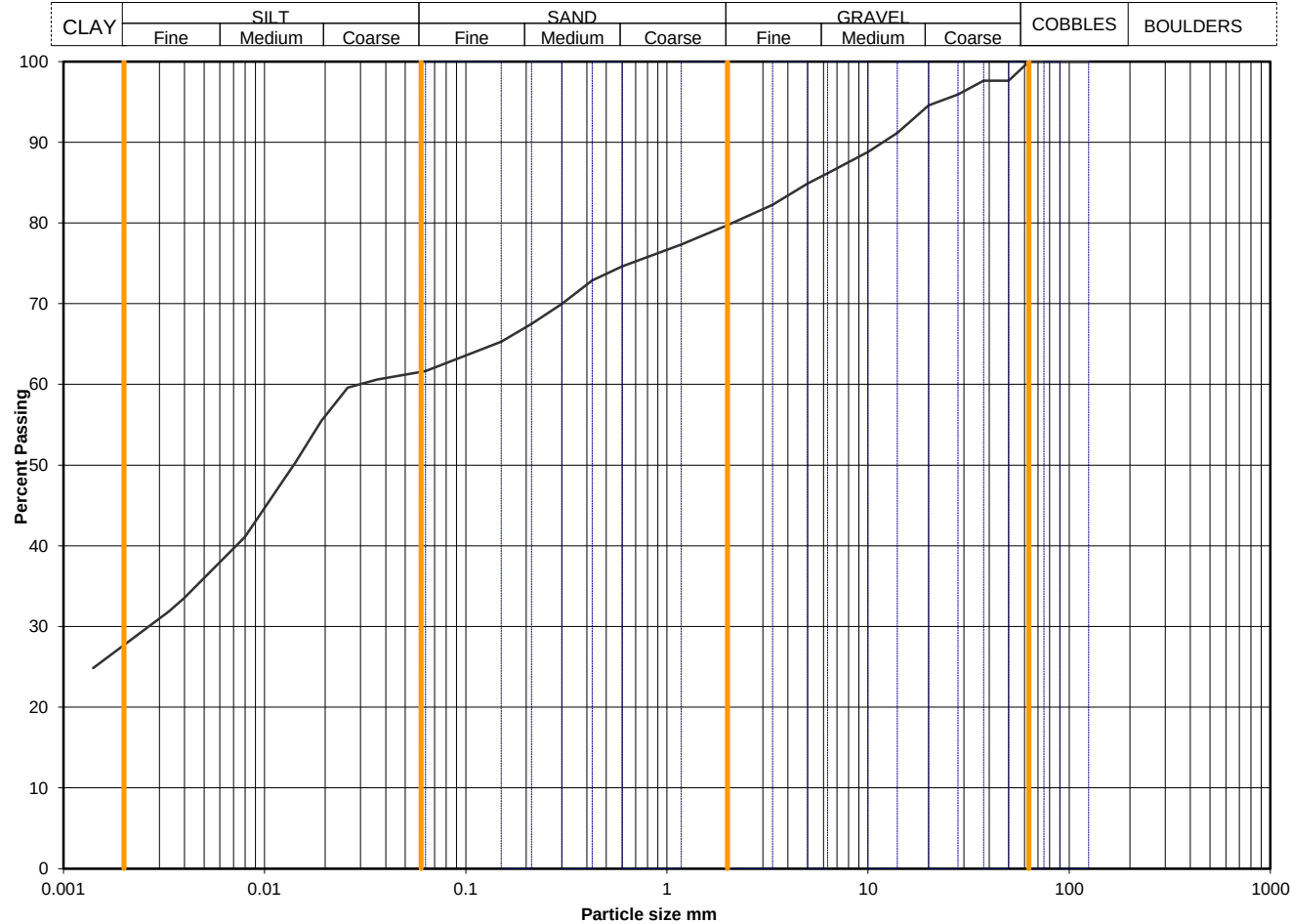
Soil description	Dark brown slightly sandy slightly gravelly CLAY with occasional rootlets.		
Preparation / Pretreatment	Sieve: natural material Hydro: as BS1377		
Remarks			
Sample Proportions * <60mm values to aid description only	Cobbles / boulders Gravel Sand Silt Clay	Whole	* <60mm
		0	0
		32	32
		23	23
		26	26
		18	18

Uniformity Coefficient	D60 / D10	Not applicable
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Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.5 hydrometer

Particle Size Distribution Analysis

Sample Details:	SAMPLE ID:	Hole No	NSW102
	N8275-18201812061101513	Sample Depth (m BGL)	0.00 - 0.00
		Sample Type and No	B1
		Specimen Ref	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	62
90	100	0.0362	61
75	100	0.0259	60
63	100	0.0192	55
50	98	0.0143	50
37.5	98	0.0080	41
28	96	0.0040	33
20	95	0.0033	32
14	91	0.0014	25
10	89		
6.3	86		
5.0	85		
3.35	82		
2.00	80		
1.18	77		
0.600	75	Particle density, Mg/m3 2.65 assumed	
0.425	73		
0.300	70	Dry mass of sample, kg 11.9	
0.212	67		
0.150	65		
0.063	62		

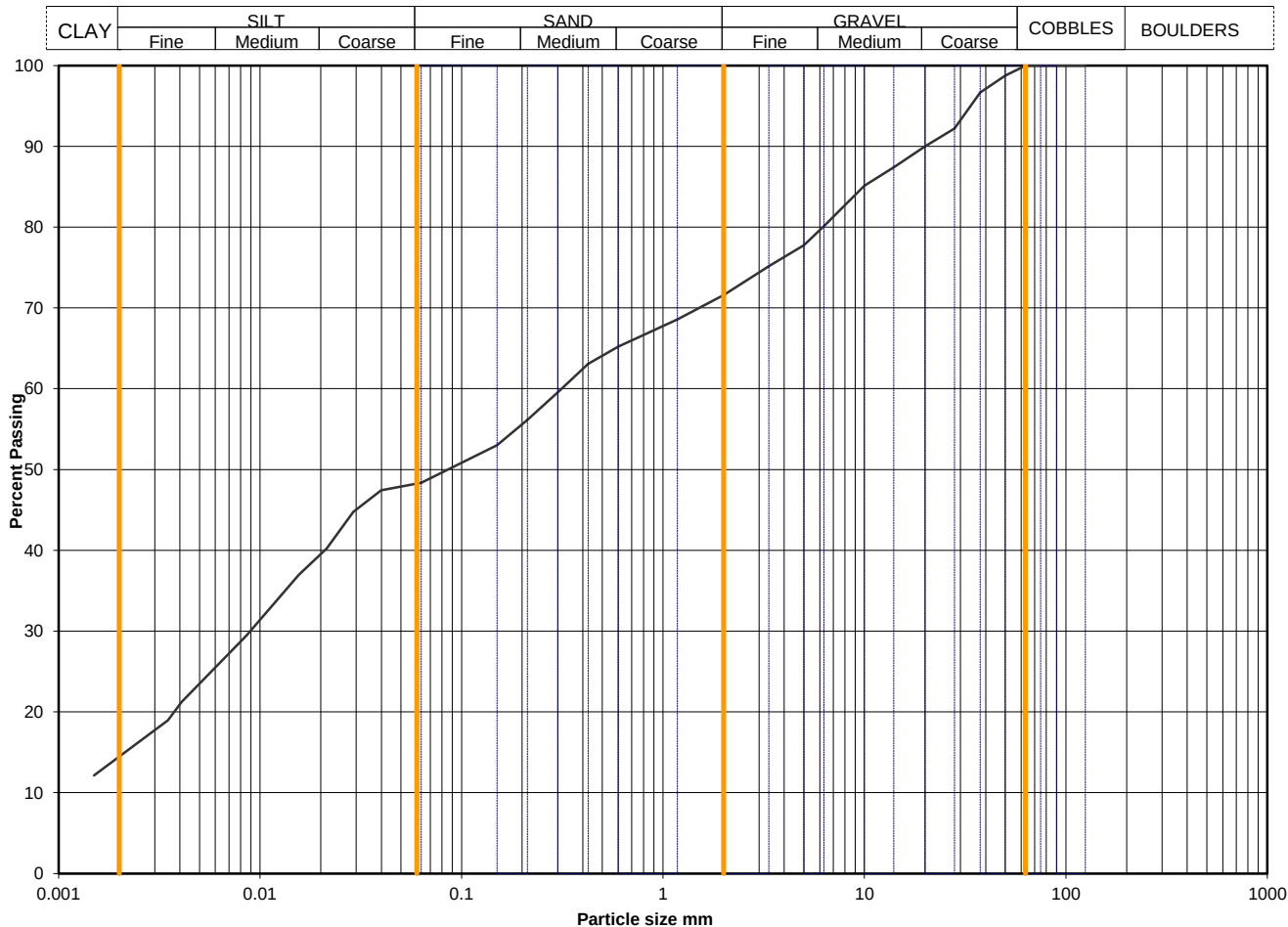
Soil description	Greenish brown slightly sandy slightly gravelly CLAY with occasional rootlets.		
Preparation / Pretreatment	Sieve: natural material Hydro: as BS1377		
Remarks			
Sample Proportions * <60mm values to aid description only	Cobbles / boulders Gravel Sand Silt Clay	Whole	* <60mm
		0	0
		20	20
		18	18
		34	34
		28	28

Uniformity Coefficient	D60 / D10	Not applicable
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Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.5 hydrometer

Particle Size Distribution Analysis

Sample Details:	SAMPLE ID:	Hole No	NSW103
	N8275-18201812061101514	Sample Depth (m BGL)	0.00 - 0.00
		Sample Type and No	B1
		Specimen Ref	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	48
90	100	0.0400	47
75	100	0.0290	45
63	100	0.0214	40
50	99	0.0156	37
37.5	97	0.0085	29
28	92	0.0041	21
20	90	0.0035	19
14	87	0.0015	12
10	85		
6.3	80		
5.0	78		
3.35	75		
2.00	72		
1.18	69		
0.600	65	Particle density, Mg/m3 2.65 assumed	
0.425	63		
0.300	60	Dry mass of sample, kg 9.8	
0.212	56		
0.150	53		
0.063	48		

Soil description	Brown slightly sandy slightly gravelly silty CLAY.		
Preparation / Pretreatment	Sieve: natural material Hydro: as BS1377		
Remarks			
Sample Proportions * <60mm values to aid description only	Cobbles / boulders Gravel Sand Silt Clay	Whole	* <60mm
		0	0
		28	28
		23	23
		34	34
		14	14

Uniformity Coefficient	D60 / D10	Not applicable
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Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.5 hydrometer

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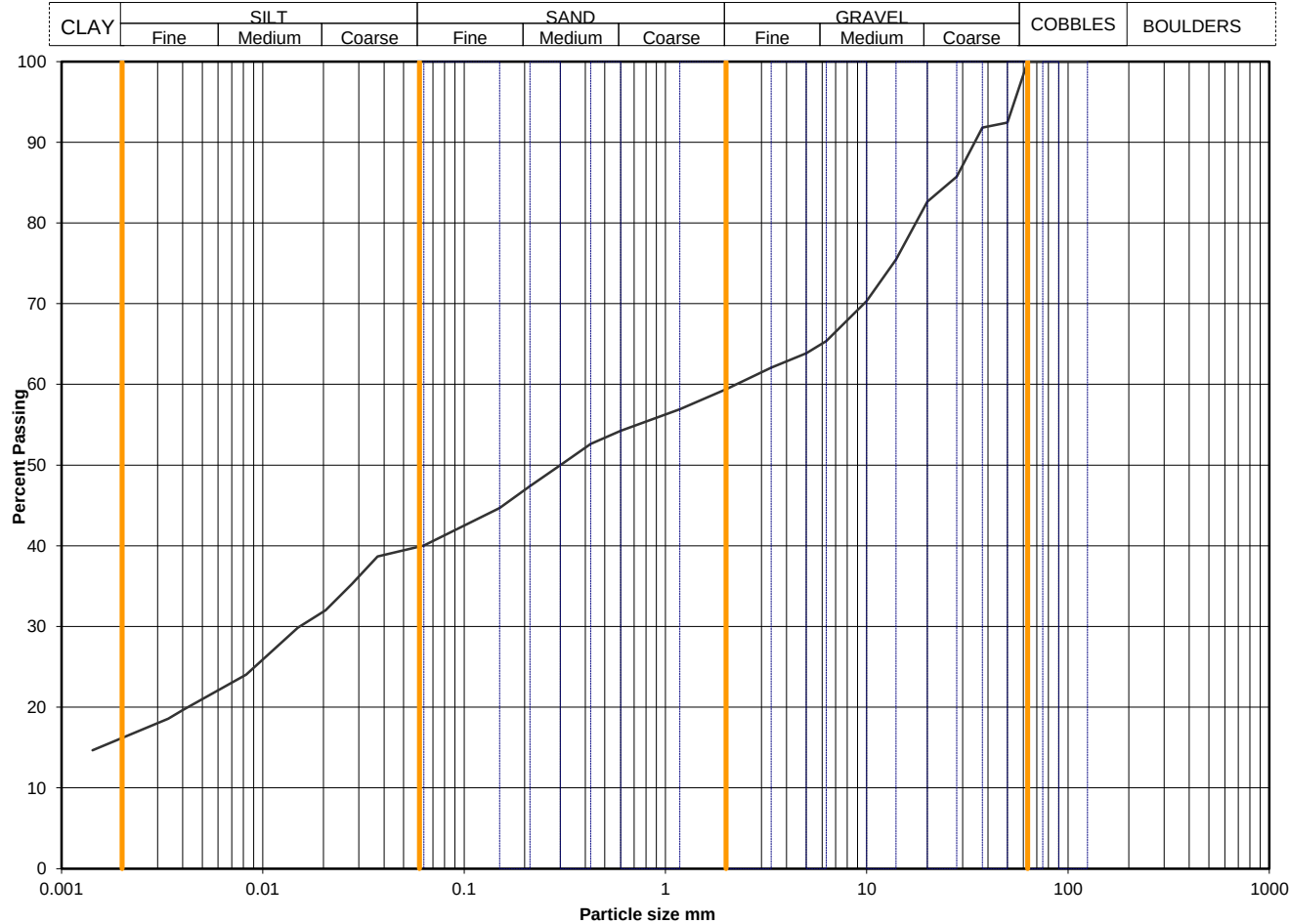
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Particle Size Distribution Analysis

Sample Details:	SAMPLE ID:	Hole No	NSW104
	N8275-18201812061101515	Sample Depth (m BGL)	0.00 - 0.00
		Sample Type and No	B1
		Specimen Ref	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	40
90	100	0.0371	39
75	100	0.0277	35
63	100	0.0205	32
50	92	0.0149	30
37.5	92	0.0083	24
28	86	0.0040	20
20	83	0.0034	19
14	75	0.0014	15
10	70		
6.3	65		
5.0	64		
3.35	62		
2.00	59		
1.18	57		
0.600	54	Particle density, Mg/m3 2.65 assumed	
0.425	53		
0.300	50	Dry mass of sample, kg 10.7	
0.212	47		
0.150	45		
0.063	40		

Soil description	Brown slightly sandy gravelly CLAY.		
Preparation / Pretreatment	Sieve: natural material Hydro: as BS1377		
Remarks			
Sample Proportions * <60mm values to aid description only	Cobbles / boulders Gravel Sand Silt Clay	Whole	* <60mm
		0	0
		41	41
		19	19
		24	24
		16	16

Uniformity Coefficient	D60 / D10	Not applicable
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Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.5 hydrometer

QA Ref
SLR 2.9
Rev 2.21
Jul 17



Project No N8275-18
Project Name Whitehall Landfill Geological Barrier

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