

Kilnwood Vale Phase 2.4 – 2.6

Earthworks Specification

For

Crest Strategic Projects

Project Number: 11950

10/04/2019

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Kilnwood Vale Phase 2.4-2.6

EARTHWORKS SPECIFICATION

Project Specification Revision Record

Date	Revision	Clause Revisions	Prepared By	Checked By
25/05/17	A		AED/SMB	AED
08/12/17	B	Appendix 1/5 Table 1/5A, Table 1/5B and notes 24 and 25 modified. Appendix 1/5 Note 26 and Note 27 added. Appendix 6/3 CI14.4 modified.	GMcK	JWC
15/11/18	C	Appendix 1/5: Table 1/5A, Table 1/5B modified and Note 30 added. Appendix 6/1: Table 6/1 modified. Appendix 6/3: CI 13.3.14, Table 6/3-1 and CI 14.5 modified. Appendix 6/3: CI 14.8 added Appendix 6/13: CI 1.1.3 modified.	AED	JWC
28/03/19	D	Appendix 6/3 CI 1.4 modified CI 1.5 added Appendix 6/13 CI1.1.5, CI1.3.1 and CI 1.3.4 modified CI 1.3.3 Added CI 1.5 Numerous modifications and additions CI 1.6 Numerous modifications and additions	AED	-
31/03/19	D2	App 6/3 - CI 1.4, CI 1.5 App 6/13 – CI 1.5, CI 1.6 Text amendments made.	AED	JWC
10/04/19	E	Header text updates Spelling and grammar updates Appendix 0/3. Updated for Landscape Areas Appendix 1/5: Table 1/5A, Table 1/5B modified to include Class 4 Landscape Fill Notes 11 and 29 modified Appendix 1/5: Table 1/5A update to revised testing frequency Appendix 6/1: CI 1.5 modified CI1.9 added, modified Table 6/1 CL 1.10-1.13 added for Japanese Knotweed Appendix 6/3: 12.2 added. 14.7 modified. Appendix 6/13: CI 1.5.38 modified Added Appendix 6/9 and Table 6/9	JB/ AED	AED/SB
31/03/2020	E1	Erratum. Error in Appendix 6/9 in relation to construction drawing reference. Amended to refer to 2.6C CE621	JWC	JWC

APPENDIX 0/3: LIST OF NUMBERED APPENDICES REFERRED TO IN THE SPECIFICATION AND INCLUDED IN THE CONTRACT

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SERIES 600 EARTHWORKS REVISION

The Specification shall be the 'Manual Contract Documents For Highway Works Specification of Highway Works', February 2017 (SHW), produced by the Highways Agency, as amended and added to by the Appendices contained within this document.

Appendix No.	Title.
0/3	List of numbered appendices referred to in this specification and included in the Contract
0/4	List of drawings included in the Contract
	PRELIMINARIES
1/5	Earthworks Testing
	EARTHWORKS
6/1	Requirements for Acceptability & Testing of Earthworks Materials
6/2	Requirements for Dealing with Class U1B and U2 Unacceptable Materials
6/3	Requirements for Excavation, Deposition, Compaction (Other than Dynamic Compaction)
6/8	Topsoil
6/9	Landscaped Areas
6/12	Instrumentation and Monitoring
6/13	Ground Improvement
6/14	Limiting Values for Harm to Human Health and Environment

APPENDIX 0/4: LIST OF DRAWINGS INCLUDED IN THE CONTRACT

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Contractor to refer to current construction issue sheet as drawings likely to be updated iteratively.

PHASE 2.4

Phase 2.4A:Earthworks Finished Levels and Contours	2.4A-CE420
Phase 2.4B Earthworks - Finished Levels and Contours	CE420
Phase 2.4C:Earthworks Finished Levels and Contours	2.4C-CE420
Phase 2.4D:Earthworks Finished Levels and Contours	2.4D-CE420
Phase 2.4E/F/G/H: Earthworks Finished Levels and Contours	2.4E/F/G/H-CE420
Phase 2.4B Earthworks - Excavation Formation Levels	CE421
Phase 2.4E/F/G/H: Earthworks Excavation Formation Levels	2.4E/F/G/H-CE421
Phase 2.4E/F/G/H: Earthworks Top Of Surcharge Levels	2.4E/F/G/H-CE422
Phase 2.4A: Earthworks Instrumentation and Monitoring	2.4A-CE423
Phase 2.4B: Earthworks Instrumentation and Monitoring	2.4B-CE423
Phase 2.4C: Earthworks Instrumentation and Monitoring	2.4C-CE423
Phase 2.4D: Earthworks Instrumentation and Monitoring	2.4D-CE423
Phase 2.4E/F/G/H: Earthworks Instrumentation and Monitoring	2.4E/F/G/H-CE423
Phase 2.4B Earthworks - Section A	SK135
Phase 2.4-2.6 Indicative Surcharge Design	CE424
Phase 2 and 3 Parcel Delivery Programme	11950-SK107
Fill in Areas of Steepened Made Ground Batter	11950-SK53
Engineered Fill Tie in Detail	11950-SK151

PHASE 2.5

Phase 2.5 Earthworks - Finished Levels and Contours	CE520
Phase 2.5 Earthworks - Excavation Formation Levels	CE521
Phase 2.5 Earthworks - Surcharge Levels	CE522
Phase 2.5 Earthworks - Instrumentation and Monitoring Plan	CE523

PHASE 2.6

Phase 2.6A Earthworks - Finished Levels and Contours	CE620
Phase 2.6A Earthworks - Excavation Formation Levels	CE621
Phase 2.6B - Finished Levels and Contours	2.6B-CE620
Phase 2.6B - Excavation Formation Levels	2.6B-CE621
Phase 2.6B - Top of Surcharge Levels	2.6B-CE622
Phase 2.6C - Finished Levels and Contours	2.6C-CE620
Phase 2.6C - Excavation Formation Levels	2.6C-CE621
Phase 2.6C - Top of Surcharge Levels	2.6C-CE622
Phase 2.6D - Finished Levels and Contours	2.6D-CE620
Phase 2.6D - Excavation Formation Levels	2.6D-CE621
Phase 2.6D - Top of Surcharge Levels	2.6D-CE622
Phase 2.6 Instrumentation & Monitoring Plan	2.6-CE623

BEWBUSH BROOK

* Please note a separate specification has been produced for Bewbush Brook (Reinforced Earth Slopes Specification) reference - 'JBaf 11950-18032020 REarth Spec F2'. The Specification herein works in tandem with that Specification and associated drawings (listed below).

Bewbush Brook Diversion – Site Investigation Locations	11950-BBD-SK02
Bewbush Brook Diversion – Setting Out Plan	11950-BBD-CE200-C2
Bewbush Brook Diversion Isopachyte Contours	11950-BBD-CE-CE204-C2
Bewbush Brook Diversion – Retaining Wall Plan	11950-BBD-CE205-C5
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 1)	11950-BBD-CE206A-C5
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 2)	11950-BBD-CE206B-C7
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 3)	11950-BBD-CE206C-C5
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 4)	11950-BBD-CE206D-C5
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 5)	11950-BBD-CE206E-C4
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 6)	11950-BBD-CE206F-C6
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 7)	11950-BBD-CE206G-C6
Bewbush Brook Diversion – Retaining Wall L Sections (Sheet 8)	11950-BBD-CE206H-C4
Bewbush Brook Diversion – Retained Earth Slope Details	11950-BBD-CE208-C6
Bewbush Brook Diversion – Reno Mattress Sections	11950-BBD-CE209-C5
Bewbush Brook Diversion – Headwall Details	11950-BBD-CE210-C7
Bewbush Brook Diversion – Proposed Layout	11950-BBD-CD80-C6
Bewbush Brook Diversion – Proposed V. Profile	11950-BBD-CD81-P4
Bewbush Brook Diversion – Proposed X-sections sheet 1	11950-BBD-CD82-P7
Bewbush Brook Diversion – Proposed X-sections sheet 2	11950-BBD-CD83-P7
Bewbush Brook Diversion – Proposed X-sections sheet 3	11950-BBD-CD84-P7
Bewbush Brook Diversion – Proposed X-sections sheet 4	11950-BBD-CD85-P6
Bewbush Brook Diversion – Proposed X-sections sheet 5	11950-BBD-CD86-P4

Bewbush Brook Diversion – Proposed X-sections sheet 6	11950-BBD-CD87-P2
Bewbush Brook Diversion – Proposed X-sections sheet 7	11950-BBD-CD88-P3
Bewbush Brook Diversion – Culvert Sections 1	11950-BBD-CD100-C2
Bewbush Brook Diversion – Culvert Sections 2	11950-BBD-CD101-C1
Phase 2.4D Earthworks Levels and Finished Contours	11950-2.4D-CE420-C2
Phase 2.4D Minimum Design Formation Level in Brook	11950-2.4D-CE422-C2

APPENDIX 1/5: GEOTECHNICAL TESTING

APPENDIX 1/5: EARTHWORKS TESTING

TABLE 1/5A: FOR USE WHEN SOILS ARE PROCESSED AT THE POINT OF FINAL PLACEMENT

CLAUSe	WORK, GOODS OR MATERIAL		TEST	SOURCE APPROVAL	ROUTINE FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600 Earthworks							
601, 631 to 637, 640	Acceptable Limits						
	Class	General Description					
	1	General Granular Fill	Grading (U) and UC	Included with Routine Testing	1 per 2000m ³⁽ⁱ⁾	Required for all tests	Refer to Table 6/1 of Appendix 6/1 for method of determining the OMC and MDD.
			MC (U)	Included with Routine Testing	1 per 250m ³⁽ⁱ⁾		
			OMC/MDD (U) and Particle Density (U)	Included with Routine Testing	At each in situ density test ⁽ⁱⁱ⁾		
			pH (U), Total SO ₄ (U), W/S SO ₄ (U), and Total S (U)	Included with Routine Testing	1 per 3000m ³		Refer to Appendix 6/12 for method of Drum Tests.
			Forensic TOC tests in accordance with CLAIRE RB17	Included with Routine Testing	1 per 500m ³		
			Drum Test	Included with Routine Testing	1 per 2500m ³		Refer to Notes beneath this Table for additional clarifications including those for F.TOC tests.
			Chemical Analysis (U)	Included with Routine Testing	1 per 2500m ³		
	2	General Cohesive Fill	Grading (U)	Included with Routine Testing	1 per 2000m ³⁽ⁱ⁾		
			Sedimentation Analysis by Pipette (U)	Included with Routine Testing	1 per 5 Gradings		
			PL/LL (U)	Included with Routine Testing	1 per 2000m ³⁽ⁱ⁾		
			MC(U) or MCV(U)	Included with Routine Testing	1 per 250m ³⁽ⁱ⁾		
			Undrained Shear Strength using HSV	Included with Routine Testing	As required in relation to 'Compaction of Fills' below.		

CLAUSE	WORK, GOODS OR MATERIAL		TEST	SOURCE APPROVAL	ROUTINE FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600 Earthworks							
601, 631 to 637, 640	Acceptable Limits						
	Class	General Description					
	2	General Cohesive Fill	OMC/MDD (U) and Particle Density (U)	Included with Routine Testing	At each in situ density test ⁽ⁱⁱ⁾	Required for all tests	Refer to Table 6/1 of Appendix 6/1 for method of determining the OMC and MDD. Refer to Appendix 6/12 for method of Drum Tests. Refer to Notes beneath this Table for additional clarifications including those for F.TOC tests.
			pH (U), Total SO ₄ (U), W/S SO ₄ (U), and Total S (U)	Included with Routine Testing	1 per 3000m ³		
			Drum Test	Included with Routine Testing	1 per 2500m ³		
			Chemical Analysis (U)	Included with Routine Testing	1 per 2500m ³		
			Forensic TOC tests in accordance with CLAIRE RB17	Included with Routine Testing	1 per 500m ³		
			Permeability (U)	As per compaction Trial	N/A		
	4	Landscape Fill	Grading (U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾	Required for all tests	Refer to Appendix 6/12 for method of Drum Tests. Refer to Notes beneath this Table for additional clarifications including those for F.TOC tests.
			Sedimentation Analysis by Pipette (U)	Included with Routine Testing	N/A		
			PL/LL (U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾		
			MC(U) or MCV(U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾		
			Drum Test	Included with Routine Testing	1 per 5000m ³		
			Chemical Analysis (U)	Included with Routine Testing	1 per 2500m ³		
			Forensic TOC tests in accordance with CLAIRE RB17	Included with Routine Testing	1 per 2500m ³		

CLAUSe	WORK, GOODS OR MATERIAL		TEST	SOURCE APPROVAL	ROUTINE FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600 Earthworks							
601, 631 to 637, 640	Acceptable Limits						
	Class	General Description					
612	Compaction of Fills					Required for all tests.	More tests may be required pending monitored performance.
	1, 2	General Granular Fill and General Cohesive Fill	Field Dry Density (including air voids) (U)		1 per 55m x 55m grid per layer on placed and compacted materials.		
			HSV(U)		1 per 70x70m grid per layer on placed and compacted materials.		
			Infiltration Rate via Soakaway Test		Upon completion of filling. 1 per 100x100m, with a minimum of 3 No per individual phase.		
			In situ CBR using plunger (U)		1 per 35m x 35m grid per layer on placed and compacted materials. Top two layers only.		
			In situ CBR using Plate Load Test(U)		1 per 70m x 70m on final layer.		
			Oedometer Tests (U)		Refer to note 30 below		

Test Frequency Notes:

- (i) Or, per layer, or per day of earthworks (whichever gives the highest number of results). This may be modified by the Engineer where only small volumes of fill are placed and treated, for example where <300m³.
- (ii) The need for such testing is to be reviewed based on the Engineer's judgement of the Contractor's processing operation, visual assessment of how homogenous the processed material has become and on laboratory test results. The Engineer shall review how much

consistency is being achieved in the processed material from the laboratory compaction tests, particle density and moisture content results and potentially reduce the need for the laboratory testing based on findings. Such matters are described in item 25, 26 and 27 below.

TABLE 1/5B: FOR USE WITH PROCESSED STOCKPILED SOILS THAT HAVE BEEN SEGREGATED BY SHW MATERIAL CLASS, OR NATURAL SOILS WHICH DO NOT REQUIRE FURTHER PROCESSING AT THE POINT OF FINAL PLACEMENT.

CLAUSe	WORK, GOODS OR MATERIAL		TEST	SOURCE APPROVAL	ROUTINE FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600 Earthworks							
601, 631 to 637, 640	Acceptable Limits						
	Class	General Description					
	1	General Granular Fill	Grading (U) and UC	3 per source	1 per 2000m³	Required for all tests	Refer to Table 6/1 of Appendix 6/1 for method of determining the OMC and MDD. Refer to Appendix 6/12 for method of Drum Tests. Refer to Notes beneath this Table for additional clarifications including those relating to F.TOC.
			MC (U)	3 per source	1 per 250m³		
			OMC/MDD (U) and Particle Density (U)	3 per source	1 per 2000m³		
			pH (U), Total SO₄ (U), W/S SO₄ (U), and Total S (U)	3 per source	1 per 3000m³		
			Forensic TOC tests in accordance with CLAIRE RB17	3 per source (on same materials used in drum tests)	1 per 500m³		
			Drum Test	3 per source	1 per 2500m³		
			Chemical Analysis (U)	3 per source	1 per 2500m³		
	2	General Cohesive Fill	Grading (U)	3 per source	1 per 2000m³	Required for all tests	Refer to Notes beneath this Table for additional clarifications including those relating to F.TOC.
			Sedimentation Analysis by Pipette (U)	3 per source	1 per 5 Gradings		
			PL/LL (U)	3 per source	1 per 2000m³		
			MC(U) or MCV(U)	3 per source	1 per 250m³		
			Undrained Shear Strength using HSV	3 per source	As required in relation to 'Compaction of Fills' below.		

						Required for all tests	
			OMC/MDD (U) and Particle Density (U)	3 per source ⁽ⁱⁱ⁾	1 per 2000m ³		
			pH (U), Total SO ₄ (U), W/S SO ₄ (U), and Total S (U)	3 per source	1 per 3000m ³		
			Drum Test	3 per source	1 per 2500m ³		
			Chemical Analysis (U)	3 per source	1 per 2500m ³		
			Forensic TOC tests in accordance with CLAIRE RB17	3 per source	1 per 500m ³		
			Permeability (U)	As per compaction Trial	N/A		
4	Landscape Fill		Grading (U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾	Required for all tests	Refer to Notes beneath this Table for additional clarifications including those for F.TOC tests. Refer to Appendix 6/12 for method of Drum Tests.
			Sedimentation Analysis by Pipette (U)	Included with Routine Testing	N/A		
			PL/LL (U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾		
			MC(U) or MCV(U)	Included with Routine Testing	1 per 3000m ³⁽ⁱ⁾		
			Drum Test	Included with Routine Testing	1 per 5000m ³		
			Chemical Analysis (U)	Included with Routine Testing	1 per 2500m ³		
			Forensic TOC tests in accordance with CLAIRE RB17	Included with Routine Testing	1 per 2500m ³		

CLAUSE	WORK, GOODS OR MATERIAL		TEST	SOURCE APPROVAL	ROUTINE FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600 Earthworks							
601, 631 to 637, 640	Acceptable Limits						
	Class	General Description					
612	Compaction of Fills					Required for all tests.	More tests may be required pending monitored performance.
	1, 2	General Granular Fill and General Cohesive Fill	Field Dry Density (including air voids) (U)		1 per 55m x 55m grid per layer on placed and compacted materials.		
			HSV(U)		1 per 70x70m grid per layer on placed and compacted materials.		
			Infiltration Rate via Soakaway Test		Upon completion of filling. 1 per 100x100m, with a minimum of 3 No per individual phase		
			In situ CBR using plunger (U)		1 per 35m x 35m grid per layer on placed and compacted materials. Top two layers only.		
			In situ CBR using Plate Load Test(U)		1 per 70m x 70m on final layer		
			Oedometer Tests		Refer to note 30 below		

General Notes:

- These general notes relate to both Tables 1/5A and Table 1/5B unless otherwise indicated.
- With respect to Table 1/5B, the column entitled 'Source Approval' relates to testing of the Contractor's proposed source material, prior to placement and compaction in the works, to provide confidence that it will be acceptable. Where source approval is specified, source testing shall be carried out at each source or stockpile used.

- 3** The columns entitled 'Routine Frequency', relate to testing materials on an on-going basis during placement and compaction in the works.
- 4** The columns entitled 'Clause' in Table 1/5A and Table 1/5B are split into 2 sections: a section dealing with tests required in relation to Cl 601, 631 to 637, 640 of the Specification for Highways Works and a section dealing with testing required in relation to Cl 612 of the Specification Highway Works. The testing in relation to Cl 601, 631 to 637 and 640 is to ensure that materials are physically and chemically acceptable, and they are applicable to all soils to be used in the works. Testing in relation to Cl 612 deals with testing required to ensure that End Product requirements are met. Soils for which the compaction requirement is End Product are detailed in Appendix 6/1.
- 5** Where End Product is required, a compaction trial as detailed in Appendix 6/3 Cl 13.3 is to be undertaken to demonstrate that the End Products are achievable for each source of material and to give confidence that the contractor's compaction method is appropriate. The compaction trial is to be completed in accordance with App 6/3 and be witnessed by the Engineer.
- 6** Should the nature of any given test result be sufficiently unusual as to call the reliability of that test result in to doubt this to be brought the attention of the Engineer within 48hrs of its receipt by the contractor. The sample is to be examined by the testing laboratory and an engineering description provided, a test restriction issued or other formal correspondence issued by the testing laboratory and additional testing undertaken so as to confirm the behaviour of the material.
- 7** All tests are to be undertaken by a reputable independent UKAS accredited testing laboratory. So as to be consistent with the current version of the 600 series of the SHW (February 2017) all geotechnical tests are undertaken in accordance with BS1377 unless otherwise stated. It should be noted however, that parts of BS1377 have been or are in the process of being superseded by BS EN ISO 17892. As when the SHW is up dated to reflect such changes to the testing standards the Engineer is to be contacted to confirm instructions.
- 8** (U) Indicates that a UKAS test report or certificate is required.
- 9** Frequency of testing applies to each separate earthworks source within each of the earthworks material classes. The testing shall be distributed evenly throughout the materials placed.
- 10** In relation to all materials placed to form the permanent works, the co-ordinates of all sample and in-situ test locations are to be surveyed and recorded based on the established grid to an accuracy of 1m in plan. A unique layer number is to be recorded for all such samples/tests such that this can be correlated to survey data for each layer. Each layer of placed material is to be surveyed using topographical surveying techniques to a vertical accuracy not worse than 25mm.
- 11** Definitions of abbreviations:
 - UC: Uniformity Coefficient
 - MC: natural moisture content;
 - OMC: Optimum Moisture Content;
 - MDD: Maximum Dry Density;
 - PL: Plastic Limit;
 - LL: Liquid Limit;
 - MCV: Moisture Condition Value;
 - HSV: Hand Shear Vane;
 - CBR: California Bearing Ratio
 - W/S SO₄: Water Soluble Sulphate;

- Total SO₄: Total Sulphate;
- Total S: Total Sulphur;
- Forensic TOC: Forensic Total Organic Carbon
- POS: Area of Public Open Space

- 12** Control of moisture is to be either via the use of Moisture Content determinations or by the use of Moisture Condition Vale (MCV) apparatus. Such sampling/testing is to be undertaken just prior to compaction. Should results be outside the required range (refer to Appendix 6/1 for details) the material is to be further conditioned and retested until they are within this range just prior to compaction just prior to compaction. Moisture Condition Vale (MCV) apparatus is to be calibrated against MC and undrained shear strength (Cu) at a rate of 1 set of calibrations per day of compaction.
- 13** The method of compaction test is given in Appendix 6/1 for each material type.
- 14** Particle densities shall be determined using a pycnometer or a gas jar, whichever is determined by the independent geotechnical testing laboratory as being most appropriate to the material type.
- 15** Laboratory permeability tests are to be undertaken on remoulded samples, compacted using a compaction apparatus appropriate to the material type as given in Appendix 6/1 and to be compacted to 95% maximum dry density. Testing is to be undertaken using triaxial equipment in accordance with BS1377 Part 6: 6. It is noted that this testing is related to the compaction trials rather than routine works except in the case that this relates to the reinstatement of a drainage corridor by others in which case laboratory permeability is to be applied.
- 16** pH, W/S SO₄, Total SO₄ and Total S tests are to be undertaken in accordance with methods prescribed in TRL Report 447.
- 17** The Contractor may propose the use of additives to treat soil to so as ensure that the engineering characteristics of the soils used will meet with the requirements of Appendix 6/1. Treatment includes moisture conditioning, modification and stabilisation. Where treated soils are used this must be reflected in the laboratory tests undertaken. For example, the samples taken to facilitate the testing must relate to materials in their treated state or mixed in the lab with same additives, to the same proportion and with same degree of mixing. If modification or stabilisation are proposed trials and suchlike are required to understand the treatment process, they shall be fully agreed in advance with the Engineer. Proposals are to be submitted two weeks in advance of any such trial and the trial and associated reporting completed two weeks prior to use in main works.
- 18** Where treatment using lime or cement kiln dust is utilised additional allowance is required for the implementation of heave testing at the instruction of the Engineer. Heave testing to be in accordance with the procedures indicated in HA70/07 'Treatment of Fill and Capping Materials using either Lime or Cement or Both'.
- 19** For chemical analysis requirements refer to Appendix 6/14.
- 20** The chemical analysis suite will be dictated by the proposed depth of the soils tested: for the upper 2.00m of from Finished Earthworks Level the suite will comprise those determinants listed in the Upper 2.00m Engineered Fill column of Table 6/14 (11/04), Appendix 6/14. For fill placed greater than 2.00m below Finished Earthworks Level the suite will be restricted to asbestos quantification, as defined in Table 6/14 (11/04) but with 1 sample in every ten also analysed for the full suite (as listed the Upper 2.00m Engineered Fill column of Table 6/14 (11/04)).
- 21** Forensic TOC analysis is to be undertaken on site won materials after they have been processed and in accordance with CL:aire Research Bulletin 17 (November 2012), Appendix C, whereby all constituents of the Made Ground are assessed and proportioned together with a TOC percentage for the fine soil fraction. It is noted that due to the nature of the test, each sample must weigh a minimum of 10kg and the exact weight shall be confirmed by the laboratory. The selected laboratory must be agreed 2 weeks in advance of any testing with the Engineer.

- 22** Drum Tests are a bespoke form of analysis which are intended to simulate soil conditions to inform the potential for ground gas production. They are also to be undertaken on site won materials after processing and are to be used to further assess and finesse the requirement for gas protection measures. Full details are provided in Appendix 6/12.
- 23** Where HSV testing is to be undertaken to determine undrained shear strength, such tests are to be undertaken in accordance with the manufacturer's user manual. The HSV is to be calibrated against the unconsolidated undrained shear strength laboratory triaxial test to BS 1377: Part 7, clause 8 on 100mm nominal diameter samples. Otherwise, shear strength testing requirements are to be as set out in Clause 633 of the Specification for Highway Works.
- 24** Field Dry Density determinations are to be either via Sand Replacement Density tests or Nuclear Density Gauges or Core Cutter (where appropriate). The test must be taken to sufficient depth to ensure that the layer tested is fully penetrated. For the core cutter this requires a minimum 60mm dolly ring to achieve a sample from 130mm depth. For End Product compaction testing, nuclear surface density gauges shall be permitted so long as the calibrations are deemed by the Engineer to be acceptable. Each instrument in use on the Contract shall be calibrated in accordance with BS 1377: Part 9, as augmented by HA70/94. With respect of both bulk density and moisture density, this is to include the manufacturer's calibrations, initial site calibrations (compliance tests for compacted material), soil calibrations and gauge standardisation procedures. If nuclear density or core cutter testing is used every twentieth determination shall be checked with a sand replacement test (BS1377: PART 9: 1990, Section 2). Nuclear density gauge determinations are not to be undertaken in soils rich in carbonaceous substances or rich in chalk. In such soils Sand Replacement Density tests are to be used.
- 25** With respect to Table 1.5A: Each in situ density test is to be accompanied by a laboratory compaction test to determine MDD and OMC and a particle density determination undertaken. Such data, along with the moisture content associated with the in situ density test will be used to determine the dry density, the %compaction and the Air Voids Ratio. All such data is to be presented on the test sheet and in a manner that enables supporting certificates to be traced. These requirements are to be reviewed based on the Engineer's judgement of the Contractor's processing operation, visual assessment of how homogenous the processed material has become and on initial laboratory test results. The Engineer shall review how much consistency is being achieved in the processed material from the laboratory compaction tests, particle density and moisture content results and potentially reduce the need for the laboratory testing based on findings.

CLAUSES HIGHLIGHTED IN RED BELOW ARE SUBJECT TO AGREEMENT WITH THE CONTRACTOR PRIOR TO IMPLEMENTATION AND SHALL BE SUBJECT TO A SPECIFIC INSTRUCTION PRIOR TO ADOPTION

- 26** With respect to Table 1.5A: Subject to item 25 above, to assess the % compaction, it may be permissible to use representative MDD values based on the following criteria:

- a)** Prior to compaction a sample, of suitable mass for laboratory compaction testing, is to be obtained from each intended in situ density location and retained on site by the contractor. Laboratory compaction testing is to be progressed at a rate to be agreed with Engineer, but no less than (i) one test per day (ii) 1 test per area of placement and (iii) one test per 600m³ (equivalent to a 50m x 50m grid), whichever gives the highest number of results. The number of tests required per volume may potentially decrease to a minimum of 1 per 2000m³ if the Engineer approves in writing. Further details on the requirement for laboratory compaction testing are provided in f and g below.
- b)** A rolling mean average MDD is calculated of the twenty most recent laboratory compaction results. With the most recent defined as the twenty results immediately preceding the time and date of the in situ density test (after exclusion of any unusual values – see d below).

- c) A rolling upper bound MDD is calculated based on the mean average of the highest 10% of results (i.e., where 20 results have been used to inform the mean average MDD, an average of the highest two results constitutes the upper bound MDD).
- d) Prior to establishing both the rolling mean average and the rolling upper bound MDD values the available results are to be reviewed by the contractor for any potentially unusual values (both high and low). Any results considered not to be representative must be agreed with the Engineer prior to being dismissed. The Engineer may request to examine such samples. Such data reduction is to be a documented process (refer to item 6 above) and to be recorded by the contractor and detailed in the validation report.
- e) The contractor is to provide full justification of the rolling upper bound and rolling mean average MDDs values by the representation of the information graphically, including an indication of results dismissed from the data reduction exercise. The rolling upper bound and rolling mean MDDs values are to be agreed with the Engineer.
- f) Where an in situ density result lies between 93% of the rolling upper bound MDD and 95% of the rolling mean average MDD then a test location specific MDD laboratory compaction test is to be undertaken (on the sample retained on site as per item a above).
- g) Where an in situ density result lies outside of the range defined in f above a laboratory compaction is not required (provided the minimum frequency requirements from a above are met).

- 27** With respect to Table 1.5B: 2 weeks. 2 weeks prior to placement of the materials, for each stockpile/source, a suitable MDD and PD values are to be proposed by the Contractor based on source approval testing results and available routine testing results. The agreed values, along with the bulk density and moisture content associated with the in situ density tests, will be used to determine the dry density, the %compaction and the Air Voids Ratio. All such data is to be presented on the test sheet and in a manner that enables supporting data to be traced. The agreed MDD and PD values will be routinely reviewed against on any additional routine testing as the works progress and revised values agreed with the Engineer as required.
- 28** CBR tests by plunger and by plate load tests are to demonstrate a minimum CBR value of 3% at the as constructed soil moisture content. Plate load tests (min 300mm dia. plate) are to be carried out in accordance with Chapter 7 of IAN 73/06.
- 29** Infiltration rates are to be determined using soakaway tests. The tests are not to be performed during periods of rainfall or when there is ponded water on the ground. These are to be undertaken in accordance with BRE Digest 365. They shall be undertaken by an AGS accredited ground investigation specialist contractor with their Method Statement agreed prior to works. The pit dimensions shall be a minimum of 1m wide 1m long and 1m deep (but shall not exceed 1.25m deep). It shall be assumed that the associated pit will need support during the test by backfilling with 10mm clean pea shingle, however, this can be omitted if the contractor can assure that the soakaway pit would otherwise remain stable throughout the test. A data logger is to be used to measure the water during test. Water must be added rapidly. The specialist ground investigation contractor is to provide full time supervision of such tests and is to provide a real time interpretation of the results.
- The duration of the tests shall be such that it can be confirmed in the field the by the specialist subcontractor that the infiltration rate is less than 1×10^{-7} m/s. The Engineer shall be informed of the findings. The test can only be terminated once the Engineer has given his approval to do so. The earthworks contractor and specialist shall work together so as to prevent water (other than that added to perform the test) from entering the excavation. Upon completion of the test any pea shingle and the water is to be fully removed and the excavation re-instated with materials placed and compacted in accordance with this specification so as to form Engineered Fill. The contractor shall provide a report on the soakaway testing, including details of the testing undertaken, the data from the test, the specialist contractor's interpretation and tests associated with the backfilling of the excavation.

The exception to the above is the Engineered Fill placed above landscape fill in the (area of POS as shown on 11950-2.6C-CE621). In this area it will be permissible, in view of the limited thickness of Engineered Fill placed, to undertake tests using Ring Infiltrometers in the accordance with BS EN ISO 22288-5. The duration of the tests shall be such that it can be confirmed in the field the by the specialist subcontractor that the infiltration rate for the Engineered Fill is less than 1×10^{-8} m/s.

30 Oedometer tests shall be undertaken on samples obtained and processed as follows.

- i. Representative samples of fill materials will be taken after processing (including any lime addition and mixing) but before any compaction. The sample volume must be sufficient to enable the tests outlined below to be undertaken.
- ii. A compaction test, in accordance with BS1377, using 2.5kg rammer - with the number of passes and layers appropriate to the mould type, which in turn will be influenced by the testing outlined below. Plots of MC vs dry density and AVR lines to be presented (based on measured particle densities).
- iii. The particle density will be determined as outlined above.
- iv. Tests to determine the particle size distribution and Atterberg limits will be undertaken in accordance with BS1377.
- v. Based on item (ii) the soil will be re-compacted at the moisture content associated with 10% AVR (as determined from ii and iii above). This should be a separate representative sub sample (i.e. not reuse of the material used in ii to iv) - as the associated compaction will could resulting it breaking down.
- vi. Item (v) is to be repeated until a sample of between 9 to 11% AVR is obtained.
- vii. It may be possible to substitute items (i) to (vi) by obtaining an undisturbed sample of the compacted fill, provided that the Engineer is satisfied that the sample is undisturbed, the AVR value of the material is appropriate and that there is sufficient traceability of PI, PSD, OMC/MDD and particle density tests otherwise obtained so as to be confident as the nature of the material compacted.
- viii. The samples thus formed are be prepared for and subjected to oedometer testing in there as compacted state in accordance with BS1377 Part5:1990 Section 4.5. They are only to be inundated with water after settlement under maximum load has been completed. The additional settlement due arising due to this inundation is to be measured until a maximum settlement (if any) is recorded. The load stages for the test are 10, 20, 30, 40, 10kN/m². Prior to this the sample is to be checked for swelling and if the swelling pressure exceed the in the initial pressure, the Engineer is to be contacted. The measured particle density shall be used, unless considered to be unrepresentative by the independent testing sub-contractor, in which case the Engineer is to be contacted. Data relating to voids ratio vs load (and inundation) are to be presented graphically and in tabular form.
- ix. The testing outlined above shall be undertaken at a rate of 1 test per 5, 000m³ until the Engineer is satisfied that a representative range of soils has been tested. The Engineer will undertake an initial review of such matters after 10 sets of results have been obtained. If previously uncharacterised materials are encountered as the work progress then the Engineer may request additional testing, likewise the Engineer may request additional testing if the contractor changes the processing methods needed to render materials acceptable.

31 The Contractor will follow all the Specification Appendices for the form of all deliverables, storage of test records and storage of records of materials imported to and exported from site.

32 Should for any reason materials be imported into the site for use as fill, unless specifically instructed to the contrary, all samples used for testing materials to be incorporated into the works shall be taken from materials after they have been delivered to the site, (where imported) and in such case with 7 days' notice to the Engineer so as to review requirements.

- 33** Unless otherwise shown in this Appendix, tests and test certificates for works, goods or materials as scheduled under any one clause are required for all such work, goods or materials in the works.

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

**APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF
EARTHWORKS MATERIALS**

1.0 Acceptable Limits for Fill Materials

- 1.1 Earthworks materials shall comply with the 600 series of the Highways Agency 'The Manual of Contract Documents for Highway Works, Volume 1: Specification for Highway Works' (SHW) and with the particular requirements of this Appendix. Permitted classes of construction materials are defined in Appendix 6/1, Table 6/1: Acceptable Earthworks Materials: Classification and Compaction Requirements.
- 1.2 All earthworks materials are to meet the acceptability limits as set out in Appendix 6/1, Table 6/1 and SHW Table 6/2.
- 1.3 Unacceptable Material Class U1A shall be:
- material which does not comply with the permitted constituents and material properties of Table 6/1 and Appendix 6/1 for acceptable material;
 - peat, materials from swamps, marshes and bogs;
 - logs, stumps and perishable material;
 - potentially deleterious materials;
 - potentially degradable material that presents a future source of gas;
 - material that exceeds the Forensic TOC content limit of 4%;
 - materials in a frozen condition;
 - clay having a liquid limit determined in accordance with BS1377 : Part 2, exceeding 90% or plasticity index determined in accordance with BS1377 : Part 2, exceeding 65%;
 - material susceptible to spontaneous combustion; and
 - material contaminated with vegetative matter including invasive plant species.
- 1.4 Unacceptable material Class U1B shall be:
- as defined in SHW;
 - contaminated, noxious or deleterious materials;
 - asbestos containing material.
- 1.5 Fill materials will generally comprise:
- Class 2 to provide: Engineered Fill. Placed and compacted to meet the End Product requirements.
 - Class 6 material: used for starter layers, sub-formations and working platform fill below water.
 - Class 4 material: used only in areas for Landscape Fill in **Public Open Space Ground Treatment areas** as specified in Appendix 6/9 and described below.

- 1.6 Material designated as Class U1A due to physical properties that fall outside those permitted in Appendix 6/1, Table 6/1, and Table 6/2 may be physically processed and conditioned to obtain the appropriate classification.
- 1.7 Where possible U1A oversized materials are to be processed to meet the 'recycled aggregate' requirements of Clause 601.12 of SHW and the target acceptability limits as set out in Table 6/1, SHW Table 6/2 and site specific requirements.
- 1.8 When rendering Class U1A material acceptable by lime (quicklime) or another alternative agreed (e.g. ckd) the Contractor shall demonstrate that any swell/heave does not cause damage to overlying materials and that the finished surface remains within the specified tolerances. The method of spreading lime is to provide for a controllable rate of application, even spreading, and for the percentage lime added to be either directly measured or readily calculable. The Contractor is to be responsible for obtaining and keeping full and detailed records of where lime modified material has been incorporated within the works.
- 1.9 Landscape Fills are to exclude substantial quantities of general mixed fill materials, including demolition/construction waste. If present they should be segregated such that only soils and stones are retained for re-use. Segregation will ensure that any such materials must not exceed 300mm in length in their largest dimension.
- 1.10 Class U1A 'material contaminated with vegetative matter including invasive species' where the invasive species comprises Japanese Knotweed can be utilised as Class 4 Landscape Fill material if it is treated in accordance with current best practice. This shall be subject to the prior written agreement of the Engineer and the approval of an agreed Method Statement 4 weeks prior to the commencement of any such works.
- 1.11 Japanese Knotweed contaminated soils can be excavated for stockpiling and treatment for use as Class 4 Landscape Fill material on site if undertaken in accordance with current best practice guidance:
- https://www.property-care.org/wp-content/uploads/2018/05/PCA-COP-Control-of-Knotweed-24pp_04.05.18-WEB.pdf
- 1.12 Excavation of Japanese Knotweed cannot occur within 10m of an active watercourse.
- 1.13 Japanese Knotweed contaminated soils can be excavated and buried on site but only with prior approval from the Environmental Agency waste department and in accordance with current best practice guidance:
- <https://www.gov.uk/guidance/prevent-japanese-knotweed-from-spreading>
 - <https://www.gov.uk/government/publications/treatment-and-disposal-of-invasive-non-native-plants-rps-178/treatment-and-disposal-of-invasive-non-native-plants-rps-178>
- 2.0 Special Requirements for Determining Acceptability, and Whether Sampling and Testing is Required**
- 2.1 The Contractor shall carry out Acceptability and End Product Compaction Testing in accordance with Specification Appendix 6/1, Table 6/1 and at the frequencies given in Appendix 1/5 in an independent UKAS accredited testing laboratory. Each sample and in-situ test shall be identified by a unique identification number directly referenced to both the sample type, location and position.

- 2.2 Testing shall be the responsibility of the Contractor and be carried out in accordance with Specification Appendices 1/5, 6/1 and 6/3. The Contractor shall maintain full records on each sub-unit of materials, including but not limited to, the location of the sources, the suppliers' details, the acceptability testing and the location it has been incorporated within the works. This also applies to Client sourced materials.
- 2.3 Should any material be placed which has not been given prior approval from the Engineer, the Contractor will have done this at its own risk and shall be responsible for any remedial works required to rectify the situation. In this regard, it is noted that the Engineer shall not be assumed to be present on site on Saturdays and works shall accommodate this. All costs associated with any remedial works or actions shall be borne solely by the Contractor.
- 2.4 The Contractor shall undertake testing of fill materials to determine their acceptability with respect to meet the compaction requirements given in this specification. A copy of the results of such testing shall be provided to the Engineer in paper hard copy and digital format (pdf, excel and AGS 4). With respect to provision of AGS data, all laboratory test results shall be submitted in full accordance with The Association of Geotechnical and Geo-environmental Specialists (AGS) version 4 standard (available on the AGS website: <http://www.ags.org.uk> under 'datatransfer'). Each AGS data file must be checked for errors (i.e. must not contain warnings, structural or integrity errors) before it is submitted and it must be accompanied by an error log file to verify
- 2.5 Results of source approval tests are to be provided within 10 days of testing being completed and prior to the materials being placed, with the exception of drum test as detailed elsewhere in this specification. Results of routine tests are to be provided with 10 working days of sampling with the exception of:
- MC tests; to be provided within 24hrs of sampling
 - MCV tests; to be provided within 24hrs of testing
 - Compaction tests: to be provided within 5 working days of sampling
 - Particle Density tests: to be provided within 5 working days of sampling
 - Drum Tests: As detailed elsewhere in this specification
- 2.6 Hand shear vane tests, in situ density and CBR related tests are to be undertaken on the day of compaction and the results provided within 24hrs of testing. Dates for soakaway testing are to be agreed with the engineer.
- 3.0 Permitted Use of Rapid Assessment Procedure for Material Acceptability**
- 3.1 Where moisture content is undertaken as the method of material classification and control, the Contractor may use a 'rapid' method (e.g. microwave oven) as an alternative to the BS1377: Part 2 method provided that such 'rapid' methods are calibrated weekly against conventional BS methods using drying ovens. The 'rapid' procedure will need to be UKAS accredited or a documented in house procedure.
- 4.0 Requirements for the Assessment of the Effects of Water Soluble (WS) Sulphate, Oxidisable Sulphides and Total Potential Sulphate in Accordance with TRL 447, Test Nos. 1 to 5**
- 4.1 Water soluble (WS) sulphate, oxidisable sulphides and total potential sulphate contents are to be determined in accordance with Clause 644 of SHW.

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

TABLE 6/1: ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	A	-	Wet cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) Grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	MDD determined using 2.5kg Rammer. Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. End Product Compaction to achieve: • an undrained shear strength of 50 kN/m² or more • at least 95% Maximum Dry Density • not more than 10% air voids. • A suitably low risk of collapse compression/ inundation settlement • A permeability of not more than 1x10⁻⁷ m/s, reducing to not more than 1x10⁻⁸ m/s in the POS. • CBR 3% at as placed moisture content where used in top 2 layers of Engineered Fill. Where Hydraulic Binders are used maximum TPS is 1%.	2	A	-
							(ii) D10	BS1377-2	-	0.003mm				
							(iii) Plasticity Index (PI)	BS 1377-2	6	40				
							(iv) mc	BS 1377-2	That associated with end product requirements as determined by testing					
							(v) MCV	Clause 632						
							(vi) Permeability of remoulded material	Appendix 1/5 note 15	-	10 ⁻⁷ m/s				
							(vii) Forensic TOC	Cl:aire RB17 (Nov 2012)	-	Total combined Forensic TOC 4%				
							(viii) Chemical analysis	App 6/14	App 6/14					
							(ix) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964	Threshold Concentration is dependent on depth – refer to Table 6/14					
							(x) Undrained shear strength of remoulded material.	Hand shear vane	50 kN/m ²	-				

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	B	-	Dry cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) Grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	MDD determined using 2.5kg Rammer. Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. End Product Compaction to achieve: As per Class 2A above Where Hydraulic Binders are used maximum TPS is 1%.	2	B	-
	(ii) D10	BS1377-2	-				0.003mm							
	(iii) Plasticity Index (PI)	BS 1377-2	6				40							
	(iv) mc	BS 1377-2	That associated with end product requirements as determined by testing											
	(v) MCV	Clause 632												
	(vi) Permeability of remoulded material	Appendix 1/5 note 15	-				10 ⁻⁷ m/s							
	(vii) Forensic TOC	Cl:aire RB17 (Nov 2012)	-				Total combined Forensic TOC 4%							
	(viii) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14											
	(ix) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964												
	(x) Undrained shear strength	Hand shear vane	50 kN/m²				-							

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	C	-	Stony cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) Grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	MDD determined using 2.5kg Rammer. Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. End Product Compaction to achieve: As per Class 2A above Where Hydraulic Binders are used maximum TPS is 1%.	2	C	-
	(ii) D10	BS1377-2	–				0.003mm							
	(iii) Plasticity Index (PI)	BS 1377-2	6				40							
	(iv) mc	BS 1377-2	That associated with end product requirements as determined by testing											
	(v) MCV [where not possible to determine, acceptability shall be by civils]	Clause 632												
	(vi) Permeability of remoulded material	Appendix 1/5 note 15	-				10 ⁻⁷ m/s							
	(vii) Forensic TOC	Cl:aire RB17 (Nov 2012)	-				Total combined Forensic TOC 4%							
	(viii) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14											
	(ix) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964												
	(ix) Undrained shear strength	Hand shear vane	50 kN/m²				-							

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	D	-	Silty cohesive material	General fill	Any material, or combination of materials (excluding those listed in SHW Clause 6.1.2 (i) (b)) other than material designated as Class 3 in the contract	(i) Grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	MDD determined using 2.5kg Rammer. Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. End Product Compaction to achieve: As per Class 2A above Where Hydraulic Binders are used maximum PS is 1%.	2	D	-
	(ii) Plasticity Index (PI)	BS 1377-2	6				40							
	(iii) D10	BS1377-2	–				0.003mm							
	(iv) mc	BS 1377-2	That associated with end product requirements as determined by testing											
	(v) MCV [where not possible to determine, acceptability shall be by (iii)]	Clause 632												
	(vi) Permeability of remoulded material	Appendix 1/5 note 15					10 ⁻⁷ m/s(v)							
	(vii) Forensic TOC	Cl:aire RB17 (Nov 2012)	-				Total combined Forensic TOC 4%							
	(viii) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14											
	(ix) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964												
	(x) Undrained shear strength of remoulded material	Hand shear vane	50 kN/m²				-							

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
LANDSCAPE FILL	4	-	-	Landscape Fill	Fill to Landscape Areas in Public Open Space Ground Treatment Area	Various, site won material excluding substantial quantities of general fill materials, including demolition/construction waste. Any such materials must not exceed 300mm in length in their largest dimension.	(i) Grading	BS 1377-2	-	-	Vibratory tamping roller in the category >5000 kg/m width of roller, using method 5 (800mm layers and 6 passes).	4	-	-
							(ii) Sedimentation Analysis by Pipette	BS 1377-2	-	-				
							(iii) Plasticity Index (PI)	BS 1377-2	-	65%				
							(iv) mc (granular material only)	BS 1377-2	Optimum mc	1.6 x Optimum mc				
							(v) MCV (cohesive material only)	Clause 632	>6	-				
							(vi) Chemical Analysis	App 6/9 Table 6/9	App 6/9 Threshold Concentration is dependent on depth – refer to Table 6/9					
							(vii) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964						
							(viii) Forensic TOC tests in accordance with CLAIRE RB17	Cl:aire RB17 (Nov 2012)	-	Total combined Forensic TOC 4%				

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
TOPSOIL	5	A	-	Topsoil, or turf, existing on site	Top soiling	Topsoil or turf designated as Class 5A in the Contract	(i) Grading	SHW Clause 618	-	SHW Clause 618	-	5	A	-
	(ii) Properties as required by BS 3882	BS 3882	To meet with requirements given in BS 3882											
	(iii) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14											
	(iv) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964												

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED GRANULAR FILL	6	A	-	Selected well graded granular material	Below water	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate	(i) Grading	BS 1377-2 (on-site)	SHW Table 6/2	SHW Table 6/2	No compaction	6	A	-
						(ii) Uniformity coefficient	See note 5	10	-					
						(iii) Plasticity Index (PI)	BS 1377-2	Non-plastic						
						(iv) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14						
						(v) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964							

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
	6	B	-	Selected coarse granular material	Starter layer	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate	(i) Grading	BS 1377-2 (on-site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 5	6	B	-
							(ii) Plasticity Index (PI)	See note 5	10					
							(iii) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14					
							(iv) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964						
							(v) Los Angeles coefficient	SHW Clause 635	-	50				

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
	6	C	-	Selected uniformly graded granular material	Starter layer	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate	(i) Grading	BS 1377-2 (on-site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 OMC to be determined using Vibrating Hammer	6	C	-
							(ii) Uniformity coefficient	See note 5	-	10				
							(iii) Plasticity Index (PI)	BS 1377-2	Non-plastic					
							(iv) Chemical analysis	App 6/14	App 6/14 Threshold Concentration is dependent on depth – refer to Table 6/14					
							(v) Asbestos screen and ID	UKAS Gravimetric Quantification of Bulk Asbestos Products and Fibre Bundles in soils by PLM/PCOM HSG 248/HSG 264/HSE Report NO. 83/19964						
							(vi) Los Angeles coefficient	SHW Clause 635	-	50				
							(vii) mc & OMC/MDD	BS 1377-2 & 4	OMC -2%	OMC +2%				

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING OF EARTHWORKS MATERIALS

Footnotes to Table 6/1:

1. App = Appendix
2. Tab = Table
3. Where BS 1377:Part 2 is specified for MC, this shall mean BS 1377:Part 2 or BS EN 1097-5 as appropriate.
4. Uniformity coefficient is defined as the ratio of the particle diameters D₆₀ to D₁₀ on the particle-size distribution curve, where: D₆₀ = particle diameter at which 60% of the soil by weight is finer and D₁₀ = particle diameter at which 10% of the soil by weight is finer.
5. The Limiting Values for Class U1B material are given in Appendix 6/14. The contents of this table may be revised following periodic Engineering assessments and design by the Engineer.
6. Where supplementary clauses and tables are referenced in Table 6/1, they shall refer to the equivalent clause or table from the Manual of Contract Documents for Highway Works, Specification for Highway Works: Volume 1: (SHW).
7. Definitions of abbreviations: Refer to Appendix 1/5

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNACCEPTABLE MATERIALS

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNACCEPTABLE MATERIALS

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNACCEPTABLE MATERIALS**1 Requirements for Removal Off Site of Excavated Acceptable Material or Unacceptable Material Requiring Processing or Retention of Surplus Material On Site**

- 1.1 Any surplus soils from the site shall be retained on the wider Phase 2&3 site in accordance with a: location plan; CEMP; MMP; and Environmental Permit approved by the Engineer to which the contractor shall fully accord. Where material cannot be maintained in accordance with the above it shall be removed from site by the Contractor in accordance with current regulations.
- 1.2 If any Class U1B or U2 Material is identified at excavation formation level the Engineer shall be notified and the Contractor shall prepare appropriate risk assessments to permit the completion of works. Thereafter the requirements detailed in 1.3 below shall apply and all materials shall be handled by the Contractor in accordance with Environment Agency Pollution Prevention guidance.
- 1.3 If visual or olfactory evidence of soil contamination is identified during the reduced level excavation works, the following actions shall be undertaken:
- work shall cease in the area of visual or olfactory contamination;
 - the area of concern shall be approximately delineated and clearly marked in order that personnel or equipment shall not be permitted to enter into the area of concern;
 - the soils of concern shall be inspected by the Engineer with suitable investigation equipment or operated mechanical excavator provided by the Contractor;
 - suitable samples of the soils of concern shall be recovered and submitted for laboratory testing;
 - suspected contaminated soils shall be excavated and suitably stockpiled in a clearly defined and segregated area whilst the results of laboratory testing are awaited, if required by the Engineer;
 - following receipt of the results of laboratory testing (between three to ten days thereafter, depending upon scope of testing required) the soils may be confirmed to be contaminated or of an unacceptable nature;
 - if soils are deemed contaminated or otherwise unacceptable, they shall be excavated under supervision of the Engineer and placed in a clearly demarked stockpile area pending either onsite treatment or offsite disposal;
 - validation samples of the soils that remain in the vicinity of the soils of concern shall be taken by the contractor under the direction of the Engineer;
 - following receipt of the results of the laboratory testing carried out on the soils that remain (between three to ten days thereafter, depending upon scope of testing required) excavation in this area can then proceed;
 - the results of site inspections, laboratory testing and actions taken shall be recorded by the Contractor as a record of the works carried out;
 - these records shall be compiled within the validation report for the Earthworks to provide a permanent record.

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNACCEPTABLE MATERIALS

- 1.4 For the principle approach to stockpiling and materials movement refer to Section 8.0 and 9.0 of Appendix 6/3, noting that any particular provisions of the SHW shall notwithstanding apply. The requirements for environmental monitoring and protection shall be in accordance with the CEMP.
- 1.5 There is no requirement for the remediation of Unacceptable U1B material. However, such material may potentially be re-classified by the Engineer. Any U1B material that fails the prerequisite Limiting Values (Appendix 6/14) shall be referred to the Engineer for review and associated temporary stockpiles of material maintained. Unless specific approval for these materials is received from the Engineer these shall be considered U1B classification and removed. Any material that fails the Limiting Values shall not be imported to site without prior agreement of the Engineer.
- 1.6 All waste soils shall be removed and disposed of in accordance with the Waste (England and Wales) Regulations 2011 (as amended). All waste soils shall be tested and classified to permit Hazardous Properties Assessment and WAC testing in accordance with Environment Agency Guidance (WM3).

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

**APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION,
COMPACTION (OTHER THAN DYNAMIC COMPACTION)**

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

1.0 Earthworks General

- 1.1 Two weeks prior to work the contractor shall provide method statements for the works required to address this specification to the Engineer.
- 1.2 No ground disturbing activities, including any earthmoving activities, are to commence prior to the Contractor obtaining any necessary permits or licences including those relating to protected species or habitats. If a licence or permit for such works is granted, those works shall only be undertaken during the periods as stated on the licence or permit under the direction of the licence or permit holder. A copy of the licence and/or permit shall be provided to the Engineer prior to commencement of the relevant activities.
- 1.3 Setting out shall be carried out from established grid lines and maintained for the duration of the construction of the ground improvement. A minimum 10 x 10m inspection grid is required.
- 1.4 Two surcharge sequences may be utilised at the site in the areas indicated on the drawings. Both sequences are described below: Sequence A comprises excavation to formation level, placement of RSGs and then construction of the surcharge; Sequence B comprises the placement of Borehole Rod Extensometers from the existing ground level and construction of the surcharge.

SEQUENCE A: Surcharge from Excavation Formation Level

- Agree works Method Statements.
- Set up permanent datum and other survey control stations.
- Undertake compaction and treatment trials.
- Excavate to Excavation Formation Level (refer to associated drawings)
- Identify the engineered fill placed as part of previous works.
- Proof roll and inspect excavation formation.
- Complete surface monitoring and flux chamber tests (S3.0 and 4.0 of Appendix 6/12).
- Complete Validation Trial Pits (S5.0 Appendix 6/12).
- Remove any gaseous, soft or highly degradable materials.
- Construct piezometers (Appendix 6/13).
- Allow piezo readings to settle/become consistent and grout to cure.
- Commence Drum Tests (S2.0 of Appendix 6/12).
- Construct of Rod Settlement Gauges* (Appendix 6/13).
- Commence monitoring in accordance with Appendix 6/13 Table 1.
- Place/compact Engineered Fill, ensuring that the Engineered Fill placed as part of these works tie into those placed as part of the previous phases of works.
- Place surcharge: as shown on drawings. (Appendix 6/13).
- Place gas monitoring installations (S1.0 of Appendix 6/12) and confirm with the Engineer whether any supplemental surface monitoring or flux chamber tests are required.
- Phased removal surcharge after Engineer approval including continued monitoring and reporting in accordance with (Appendix 6/13).
- Grub out and decommission instruments: Place/compact Engineered Fill accordance with the Specification in areas of associated excavation.
- Place/compact Engineered Fill to make up to Finished Earthworks Level.
- Test Finished Earthworks Level (note other tests required as works progress).
- Survey completed works

* Rod Settlement Gauges are to be constructed at the Excavation Formation Level

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

- 1.5 Where indicated on the construction drawings Sequence B shall be implemented, where surcharge is to be placed from current ground level prior to excavation to excavation formation level and the placement of Engineered Fill. This sequence shall only be completed where shown on the drawings.

SEQUENCE B: Surcharge from Existing Ground Level

- Agree works Method Statements.
 - Set up permanent datum and other survey control stations.
 - Undertake compaction and treatment trials.
 - Survey existing ground level in area of treatment.
 - Install Borehole Rod Extensometers (BRE) and piezometers from current ground level (Appendix 6/13).
 - Allow BRE and piezometer readings to settle down/become consistent and grout to cure.
 - Commence Monitoring Appendix 6/13.
 - Place surcharge materials on existing ground level (Appendix 6/13).
 - Phased removal of surcharge and other materials, after Engineer approval including continued monitoring and reporting in accordance with Appendix 6/13, down to Excavation Formation Level (refer to associated drawings).
 - Decommission BREs and Piezometers and make good.
 - Proof roll and inspect excavation formation.
 - Complete surface monitoring and flux chamber tests (S3.0 and 4.0 of Appendix 6/12).
 - Complete Validation Trial Pits (S5.0 Appendix 6/12).
 - Remove any gaseous, soft or highly degradable materials.
 - Commence Drum Tests (S2.0 of Appendix 6/12).
 - Place/compact Engineered Fill, ensuring that the Engineered Fill placed as part of these works tie into those placed as part of the previous phases of works.
 - Place gas monitoring installations (S1.0 of Appendix 6/12) and confirm with the Engineer whether any supplemental surface monitoring or flux chamber tests are required.
 - Grub out and decommission instruments: Place/compact Engineered Fill accordance with the Specification in areas of associated excavation.
 - Survey completed works.
- 1.6 If during excavation undisturbed competent natural ground is encountered, then the excavation is to cease and the Engineer consulted for additional instructions. The Contractor shall provide a full level survey of the associated area.
- 1.7 At the excavation formation level, trial pits will be excavated, to inform the gas assessment and to inspect areas where the ground investigations have identified the presence of the 'poorest' material from a geotechnical point of view. The requirements are detailed in Appendix 6/12, section 5.0.
- 1.8 If unforeseen ground conditions or unforeseen responses to the treatment are encountered, then the Engineer shall be verbally notified immediately (and within 48 hours in writing).
- 1.9 If Unacceptable Materials (class U1B/U2) are observed at the excavation formation then provision shall be made for these to be removed following instruction from the Engineer. Any associated 'hotspot' excavations shall be validated by the Contractor via the application of Forensic TOC tests comprising on composite sample per face and one composite sample from

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

the base. Each spot will be surveyed to include base levels and lateral extents such that volumes can be calculated.

- 1.10 Surcharging operations and associated monitoring are detailed in Appendix 6/13.
- 1.11 Earthworks materials derived from processed Class U1B material are to be used in the works only when agreed with the Engineer. This shall be recorded in the As-Built Drawings.
- 1.12 The Contractor is responsible for the works covered by the Specification. The Contractor shall however require the inspection and approval of works from the Engineer subject to the notice periods presented in the Contract (and a minimum of 7 days) and in particular inspection of:
- a. Excavation formations
 - b. Classified stockpiles
 - c. Material placement and compaction (of permanent fills)
 - d. Unforeseen contamination (Class U1B / U2 Materials)
 - e. Validation trial pits
 - f. Completed works following removal of surcharge
 - g. Instrumentation and monitoring
- 1.13 A tracking system shall be established to the satisfaction of the Engineer to document material movements from excavation to segregation, stockpiling and eventual reuse. A reference grid shall be established to aid the control of material movements and shall be agreed with the Engineer prior to commencement. The proposed system shall be submitted to the Engineer 2 weeks in advance of its required use.
- 1.14 The tracking system shall enable location and extent of materials placed in any one day to be determined in three dimensional space and shall locate in-situ and ex-situ test locations the location of samples taken for laboratory tests and associated levels. This will enable excavation and removal as necessary in the event that pre and/or post placement testing indicates that the soils are unacceptable and/or placement has not achieved the required state of compaction. The tracking system should also incorporate the requirements of the MMP which includes those soils moved off the site due to surplus requirements and/or unacceptability.
- 2.0 **Control of Water**
- 2.1 All works and associated costs relating to the control and management of water on site, from existing, proposed or redundant watercourses or from any other sources including groundwater, rainfall and surface water is the responsibility of and all costs are to be borne by the Contractor. Any uncertainty over the issues associated with water or groundwater control shall be submitted to the Engineer for clarification, as soon as any such issue is noted or identified by any party.
- 2.2 The Contractor shall provide for such measures as may be necessary to ensure that water, whether groundwater, from precipitation or any other source does not accumulate in excavations or on sub-grades, subject to licensing and permitting requirements. In addition, the Contractor shall ensure any adjacent areas, used to source material (subject to agreement) are graded so as to shed water away from the treated area.
- 2.3 The Contractor shall provide, where necessary, temporary watercourses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

include carrying out the work of forming the earthworks in such a manner that their surfaces have at all times a sufficient minimum cross-fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding. This shall include the provision of temporary measures to remove water expelled from the ground due to the application of load from the Engineered Fill and surcharge material.

- 2.4 Will respect to the re-alignment of Bewbush Brook and the ponds the contractor will be responsible for both temporary and permanent works, including temporary diversion of the existing brook and temporary and permanent drainage. In relation to such features the contractor is to note the construction sequence shown on drawings and undertake a full review of the requirements of the GDR issued December 2017.

3.0 Requirements for Groundwater Lowering or Other Treatment (where required)

- 3.1 The Contractor is responsible for all groundwater lowering where this is required for the purposes of the works. This is particularly relevant, but is not limited to, dewatering of deep excavations and trenches.
- 3.2 The Contractor is responsible for obtaining all permits and/or licences required to undertake groundwater lowering and for treatment and/or disposal of said groundwater or other encountered liquids.
- 3.3 Where earthworks operations or ground improvement measures result in the expelling of groundwater into drainage layers or onto earthworks surfaces the discharged water shall be collected, treated if necessary and disposed.

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)**4.0 Blasting for Excavation**

- 4.1 Blasting for excavation is not a permitted alternative to normal excavation methods.

5.0 Stability of Excavation

- 5.1 Where the area to be filled comprises an existing excavation, the excavation shall be inspected and subsequently monitored by the Contractor, to ensure that there is no danger of its collapse during the works with consequences for safety, for existing buildings or for other construction adjoining. Shoring or propping shall be used where appropriate.
- 5.2 The Contractor shall provide appropriate barriers or other preventative measures around open excavations to minimise the health and safety risk to site users of these areas.
- 5.3 The Contractor shall ensure all temporary excavations are formed with suitable, safe batters or other suitable methods of support. The Contractor shall give notice without delay if any newly excavated faces are too unstable to allow work and take immediate action if instability is likely to affect structures, roadways, offsite land or the safety of the site operations.

6.0 Obstructions

- 6.1 An obstruction is deemed to be any material which is comprised principally of concrete, brick or stone, whether loose material or in a homogeneous form >0.2m³. Where obstructions are encountered the Engineer shall be notified immediately. In ground conditions where breaking out is deemed necessary this shall be carried out by a method and to a sequence agreed with the Engineer. All breaking out methods shall be carried out to the relevant professional standards.
- 6.2 Where encountered during the works, obstructions shall be removed to a minimum depth of 1m below the underside of the proposed excavation formation level. Where obstructions encountered in the works extend below this depth, they shall either be removed in their entirety, or cut down, surveyed and recorded if confirmed to be deep obstructions (e.g. piles). The preferred option shall be confirmed by the Engineer.
- 6.3 Where the obstruction extends beyond the boundary of any zone or area to be excavated, remediated and/or treated, the obstruction shall be removed 1m beyond the boundary except where this extends beyond the demise of the client's ownership or interferes with a permanent structure (such as adjacent building or footpath).
- 6.4 Where any obstruction to be removed extends beyond the demise of the client's ownership or interferes with a permanent structure, the obstruction shall be carefully removed up to the site demise in a way that causes no damage.
- 6.5 All obstructions discovered shall be marked on a set of the construction drawings indicating the position, extent and a description of the materials evident together with details of any residual obstructions left in. These details shall be made available to the Engineer. Prior to any filling, the Engineer shall be given the opportunity to decide if further works should be carried out beyond that specified. In the event of a residual obstruction being left in situ its location, extent and level are to be recorded by topographical surveying.
- 6.6 Where obstructions are broken out, filling or infilling of voids shall be deemed to be included with approved materials arising from the general works. Voids, pits, vents and the like shall be reported to the Engineer and shall be filled or capped with approved materials arising from the Works.
- 6.7 The Contractor shall contact the Engineer before the disconnection and removal of any services

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

comprising pipes, cables and general service installations discovered where they are above the Excavation Formation Level. These shall each be marked on a drawing and handed to the Engineer. The extent of any removal shall be within the plane of the works plus 1m where such service installations are discovered and are to be removed. The ends of any remnant pipework at the edge of any such excavation shall be cut and sealed.

7.0 Cutting Faces

- 7.1 No specific limitations or restrictions on undercutting are included, but the Contractor shall comply with his appointed Temporary Works Designer's requirements when excavating trenches at or within the vicinity of the toe of any slopes.
- 7.2 Clearing loose material from cutting slopes by airline hose is not permitted.
- 7.3 The Contractor shall provide additional drainage measures to intercept and discharge seepages from cutting or embankment slopes. The Contractor is responsible for all drainage required to carry out the works and to protect them upon completion, which will include, where necessary, temporary drainage measures.

8.0 Segregation of Excavated Materials

- 8.1 During excavation, materials arising are to be inspected and segregated to Classes U1A, U1B, U2, 5A, General Fill Classes (and further segregation as may be required to ensure adequate control of compaction behaviour). Classes U1A, U1B, U2, 5A materials must be separated.

9.0 Stockpile Management

- 9.1 When materials are to be stockpiled, clearly defined segregated stockpiles are to be formed for different sub-classes of processed material. The maximum permitted height of stockpiles, excluding topsoil Class 5, shall be 5.00m unless otherwise agreed with the Engineer. Stockpiles of different materials shall be clearly separated by a gap of not less than 5.00m.
- 9.2 Stockpiles of topsoil shall be formed in accordance with guidance provided by DEFRA 'Construction code of Practice for the Sustainable Use of Soils on Construction Sites (2009)' and research carried out by non-statutory bodies, which suggests that optimum stockpiles of topsoil shall not exceed 1.3 m in height and that topsoil shall not be stockpiled for more than 1 year.
- 9.3 On completion of a stockpile the slopes shall be trimmed to falls to shed rain water and the surface sealed via compaction to limit infiltration. Temporary drainage shall be provided at the base of the stockpile to collect runoff from the stockpile and to carry any surface water away from the base of the stockpile.
- 9.4 The Contractor shall provide and maintain such measures as necessary to eliminate the production of dust from the stockpile during its life.

Existing Stockpiles

- 9.5 The earthworks carried out for previous phases of the Kilnwood Vale development has resulted in the formation of various stockpiles of potentially acceptable fill materials. The existing stockpiled materials may also be reused provided they are or can be demonstrated as having been subject to the testing as defined in Appendix 1/5 and meet the criteria given in Appendix 6/1.

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- 9.6 The Contractor shall include details of the movement of these soils in the Materials Tracking documentation as detailed in Section 1.0 of Appendix 6/3.

10.0 Geotechnical Methods for Soil Treatment

- 10.1 The Contractor shall provide moisture conditioning, modification and solidification/ stabilisation and physical treatment to render soils suitable under in accordance with Appendix 6/1, Table 6/1 and Table 6/2.
- 10.2 Moisture conditioning is defined as works that may be required to ensure that stockpiled or as dug materials comply with the requirements of this specification and the Specification for Highways Works. These are processes where, either through the addition of chemicals such as lime, or through physical processes such as spreading out and air drying, the moisture content of the soils may be rendered acceptable for earthworks.
- 10.3 The physical treatment of unacceptable materials is defined as physical screening/crushing of stockpiled or as-dug soils to remove timber, wood, general construction waste (e.g. plasterboard, glass, wood), potentially deleterious materials and oversized fragments of bricks, concrete and the like.
- 10.4 Rendering SHW Class U1A material acceptable by lime (quicklime) modification (or other additives) is permitted provided the modified material is able to meet the performance requirements given and that it or its method of placement do not result in a risk to the environment. The design of any such treatment shall be based on HA74/07 'Treatment of Fill and Capping Materials using either Lime or Cement or Both'. The Contractor shall demonstrate, to the satisfaction of the Engineer, that the treated materials do not have any significant potential to swell/heave. The method of spreading the additives is to provide a controllable rate of application and even spreading. It shall also enable the percentage of additives added to be either directly measured or readily calculable.
- 10.5 The Contractor shall be responsible for obtaining and keeping full and detailed records of where treated/modified material has been incorporated within the works.
- 10.6 Prior to undertaking any such soil treatment the Contractor shall submit full details to all relevant statutory authorities and the Engineer and obtain their approval to his proposals. The Contractor's attention is brought to the environmental sensitivity of the site and any such works must be undertaken in full compliance with the relevant statutory authority requirements and the requirements of the agreed Construction and Environmental Management Plan.

11.0 Water Courses

- 11.1 Details regarding existing water courses, construction of new water courses and earthworks drainage ditches are shown on the Drawings provided by the Engineer.
- 11.2 Redundant watercourses shall be drained and cleaned. Excavated arisings are to be treated as described in Appendix 6/2.

12.0 Construction of Fill

- 12.1 Engineered Fill: This is to comprise Class 1 and 2 material and must be compacted to achieve End Product requirements given in Appendix 6/1, Table 6/1 and as detailed below. Class 1 materials are not to be used within 2m of final earthworks level.

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- 12.2 Landscape Fill: To Comprise Class 4 material. To be placed in the Public Open Space **Ground Treatment Area only**, as detailed in Appendix 6/9.
- 12.3 Surcharge Fill: This is a temporary fill and can be Class 1 or Class 2 material. This is discussed in more detailed in Appendix 6/13.
- 12.4 Treated Fill: Site won fill that is treated using additives. The approved method of treatment, placement, mixing and compaction shall be informed by a trial. On-going testing types and frequency beyond those already required in Appendix 1/5 shall be agreed with the Engineer after review of trials to establish an appropriate methodology.
- 12.5 Any material placed by the Contractor prior to the provision of full testing shall be at their risk. If fill material is to be screened, processed or treated after excavation, laboratory testing shall be required after the material has been processed in order to determine its acceptability. Material will only be considered suitable, based on the results of the testing, if it is placed and compacted during a period of time in which the moisture content could not have varied outside of the appropriate range to meet the compaction requirements.
- 12.6 After materials have been brought up to Finished Earthworks Levels where required, ground improvement via the use of a surcharge to preload the ground will then be undertaken as shown on the drawings. Full details of the surcharge operation are given in Appendix 6/13. Subsequent to the removal of the surcharge, site levels are then to be brought back up by Engineered Fill materials which will be placed and compacted to meet End Product requirements. It is noted that the surcharge material does not generally have an End Product requirement, apart from the basal 250mm. The basal 250mm shall be placed and compacted as Engineered Fill to allow for settlement and the residual of this removed following surcharge completion.
- 12.7 Embankment slopes shall not be constructed steeper than that considered safe by the contractor's temporary works engineer. Temporary over-widening or steepening to achieve adequate compaction of the shoulders of the embankment are permitted.
- 12.8 Any sub-formation areas requiring protection against weather should be protected in accordance with SHW.
- 12.9 Formations for earthworks construction and cutting formations shall be proof-rolled using as a minimum, the compactive effort detailed in SHW. This compactive effort shall be increased for cutting formations where different compactive efforts, dependent on the type of follow-on earthworks operations, are required by the Specification. Observations shall be made by the contractor to identify soft spots. The identification of a 'soft spot' is qualitative and depends on the response of the ground to the compactive effort during proof-rolling. As a minimum excessive matting, bow-waving or ground heave shall be indicative of a 'soft spot'. The Contractor shall agree with the Engineer the extent and nature of 'soft spot' treatment. The extent of the soft spot and associated treatment are to be recorded.
- 12.10 As part of the requisite compaction trials, consideration for dealing with soft spots shall be addressed by the contractor and agreed with the Engineer.
- 12.11 The earthworks construction formations and cutting formations shall be inspected by the Engineer for the possible presence of any soils that have visual or olfactory evidence of contamination and/or the presence of any significant concentrations of organic or decayable material. The contractor shall agree with the Engineer on the course of action to be taken where such 'hot spots' are encountered.

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- 12.12 Fill shall be placed and compacted in near-horizontal layers of the thickness required to achieve the required end product and shall, as far as practicable, be brought up at a uniform rate so that all parts of the site reach Finished Earthworks Levels at the same time.
- 12.13 Where different thicknesses of fill material are to be employed, the thickness shall be benched to ensure that differential settlements are minimised.
- 12.14 No fill shall be placed and left uncompacted at the end of a working day. Compacted fill shall be sealed and graded to falls to ensure free runoff of rainwater without ponding.
- 12.15 Compaction plant and compaction method shall be selected having regard to the proximity of existing trenches, excavations, retaining walls, monitoring installations or other structures and all work shall be performed in such a way as to ensure that their existing stability is not impaired.
- 12.16 After removal of surcharge (Appendix 6/13) material exposed is to be proof rolled as per the compaction method used for the Engineered Fill.

13.0 Compaction**13.1 General**

- 13.1.1 All materials shall be placed and compacted to achieve the associated End Product requirements as given in Appendix 6/1 of this specification. The compaction techniques to be adopted for materials are to be informed by compaction trials as outlined below.

13.2 Use of Nuclear Density Gauges

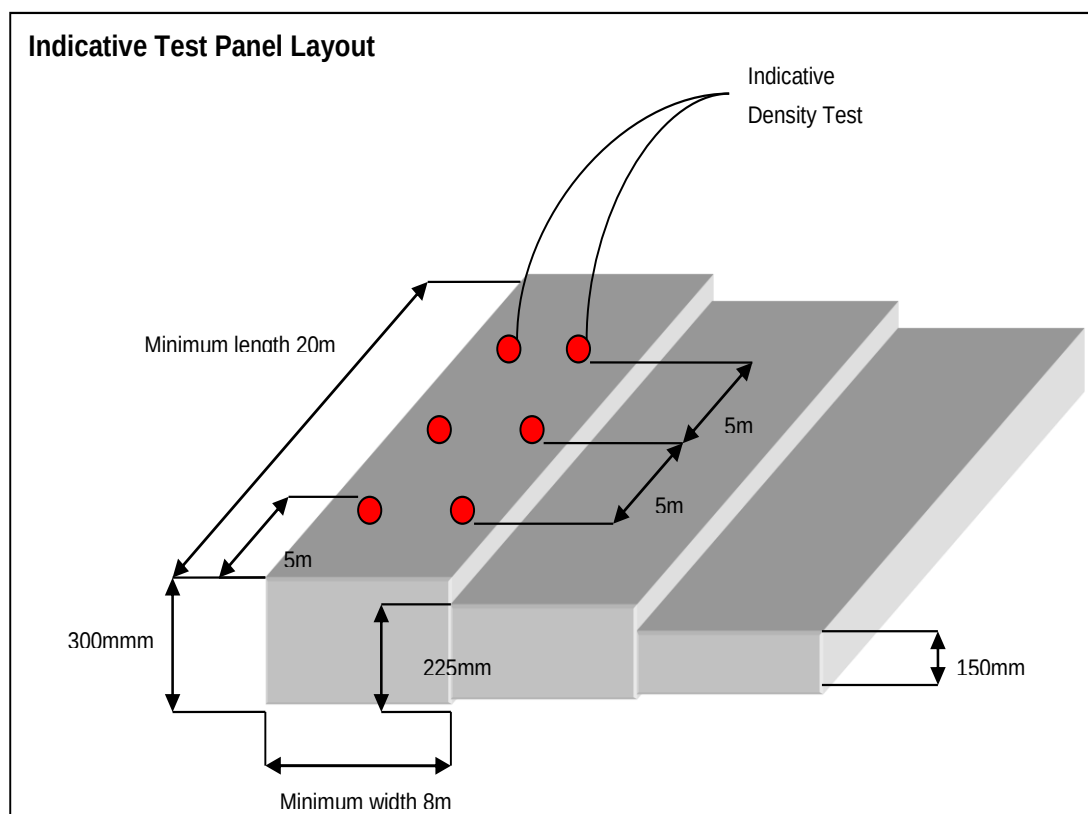
- 13.2.1 Refer to Appendix 1/5 Note 24.

13.3 Compaction Trial For Engineered FillInitial Considerations

- 13.3.1 Compaction trials are required for each material source to be used in the main works and, in relation to such materials, for each compaction method to be used. Compaction trials shall be undertaken with the Engineer in attendance. Two week notice is to be provided and two weeks prior to the trial the Contractor shall provide the Engineer with the geotechnical and chemical results relating to the source material suitability testing. The contractor shall plan his works so as to ensure that compaction trial and associated testing and appraisal is complete in good time in advance of the main works. Failure to do so will result in materials being placed at the contractor's risk. The site of the trials shall be clearly marked and levels taken to determine the thickness of each layer before and after compaction.
- 13.3.2 The exception to the above is where the same materials have been placed and compacted in previous phases of work and where it has been possible to demonstrate that the End Product requirements considered herein have been met for the method of compaction that the contractor proposes to use. Approval of the omission of a compaction trial would be required in writing from the Engineer, however, subject to confirmation of proposed plant and method as described in CI 13.3.5. This must be sought at least 2 weeks prior the scheduled commencement of the compaction trial. The scheduled commencement of the compaction trial must be in good time in advance of the placement of permanent fill as outlined above.

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- 13.3.3 For each material type, a number of test panels will be required in order that a full assessment of the material and compaction method can be completed, which would then constitute the Compaction Trial. Although the size of each panel will reflect the size of the compaction plant and methodology of work proposed, a minimum width of 10m by 20m in length is recommended, with a number of different layer thicknesses trialled as indicated in the Figure below. Any existing topsoil shall be removed from the area of the compaction trial and the formation proof rolled and inspected for soft spots as described in Cls 12.8 and Cl12.9.
- 13.3.4 The depth of each layer forming the test panel shall reflect the likely range of depths of compacted material to be adopted in the main works, but is not to exceed a compacted layer thickness of 250mm (i.e. an uncompacted layer thickness of not more than 300mm, assuming a 20% reduction in thickness upon compaction, which is to be confirmed by the compaction trial). Each panel shall be made up using the layer thickness being trialled until the total thickness for each trial panel is not less than 1m



- 13.3.5 Each test panel shall be laid out and clearly identified and defined separately from any other test panel to avoid accidental influence from adjacent works. At least 2 weeks prior to undertaking the trial, the Contractor shall confirm to the Engineer the following:
- What compaction plant is to be used, including but not limited to the type of equipment, manufacturer, mass per meter width and any other relevant information which can be used to assess its suitability for the material to be compacted.
 - What method of compaction is to be used in the trial and whether or not it has been based upon the guidance from SHW Table 6/4.
 - Confirmation of the source of material to be used.

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- Confirmation that they understand the minimum specification requirements for end-performance of the fill which are to be assessed and demonstrated during the trial.
- The methodology for assessing fill, including test type and frequency and who will be undertaking the testing both on site and for the subsequent laboratory analysis.
- Confirmation that all parties who are to attend the trial have been informed of when and where the trial will be undertaken.

13.3.6 For each proposed compaction method, a number of test panels shall be constructed in order to allow a full assessment to be completed. Key criteria to identify during the compaction trial will be:

- Change in density and air voids against number of passes.
- Change in density and air voids against thickness of layer.
- Change in engineering performance against compactive effort.
- Identification of point of over-compaction/softening of fill.
- Comparative analysis between different plant.
- Suitability of material for use on site for the proposed end-use.
- Confirmation of classification and engineering performance of material, including sampling, laboratory testing and classification of the material.
- Comparison of actual performance of material against End Product requirements.
- Initial calibration of testing equipment, in particular where the use of a Nuclear Density Gauge [NDG] is proposed for the monitoring of earthworks operation.

Compaction of Test Panels

13.3.7 Earthmoving plant shall not be accepted as compaction equipment, nor the use of lighter compaction plant to provide any preliminary compaction prior to the use of heavier equipment.

13.3.8 Although the guidance from Table 6/4 of the SHW may indicate the optimum number of passes of the appropriate plant, it is important that the progression of improvement of the material is monitored throughout the compaction process. As such, after every two passes of the appropriate roller, in-situ assessment of the density of the material shall be undertaken. One pass of the roller is defined as a single movement of the compaction plant, in one direction, over a given strip of the test panel.

13.3.9 Where the width of the test panel or roller requires a number of passes in order to ensure the full width of the surface is compacted, it is acceptable for the roller to overlap the previous strip by a small margin [no more than 25% of the maximum roller width]. However, the Contractor shall ensure that no in-situ testing is undertaken in this zone to prevent the effect of over-compaction influencing the assessment of the performance of the plant and material.

13.3.10 Compaction of the test panel shall continue incrementally until a clear indication has been obtained to show that the soil has either achieved a maximum density, i.e. where after a

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number of repeat passes is completed no change is identified or has been over compacted and the performance of the material begins to deteriorate.

13.3.11 The exception to this will be where the final performance of the test panel is required to be confirmed using plate load testing, and in this instance it is recommended that a separate panel is constructed, to the same specification as has been identified during the compaction trial, in order that the assessment of the performance can be completed without the detrimental influence of over-compacted material. Guidance on the point of over compaction may be readily identifiable on site from a number of key parameters:

- Reduction in bulk density/dry density with increasing compaction.
- Increase in moisture content, where the over-compaction of the material drives moisture up through the material to the surface [mobilisation of excess pore pressure]. This may also be observed during the passage of the roller, with material adhering to the roller, and/or the surface of the compacted layer beginning to tear.
- Reduction in engineering performance of the material with increasing compaction.
- Visible movement of the surface of the material during the passage of the compaction plant, typically exhibited as a 'bow wave' in front of the roller.

13.3.12 Identifying the point at which the materials become over-compacted is very important for a number of reasons. Should the material not be competent to undergo additional compaction and/or trafficking, then an engineering decision will be required by the Contractor prior to the commencement of the main earthworks program.

Assessment of Test Panels

13.3.13 The compaction trials shall be undertaken in such a way as to demonstrate what works are able to achieve the End Product criteria given in Appendix 6/1.

13.3.14 Initial characterisation of the material shall comprise: sets of testing (one from each layer) each comprising grading, Atterberg Limits laboratory compaction curves [OMC/MDD using the test appropriate to the material type as given in Appendix 6/1], particle density, field moisture content laboratory permeability testing and laboratory oedometer testing (refer to Appendix 5/1 for full details of laboratory permeability and oedometer testing).

13.3.15 In-situ density (bulk and dry) measurement of the compacted material and moisture content shall comprise: on each layer and at each increment of two passes: six nuclear density gauge readings, evenly spaced in two rows at distances of 5m, 10m and 15m along the test layer. Refer to Appendix 1/5 with respect to the use of NDG equipment. Undrained Shear Strength using hand shear vane shall comprise: on each completed panel: one test per density test location. Refer to Appendix 1/5 regarding the use of Hand Shear Vane equipment.

13.3.16 A CBR value using conventional CBR testing apparatus shall be determined on each completed test panel to determine the materials suitability for use in the upper 2 layers of Engineered Fill. Tests shall be evenly spaced in a central row at distances of 5m, 10m and 15m along the test panel.

13.3.17 CBR using Plate Load Tests shall be completed after CBR testing outlined in 13.3.16 has indicated that a value of 3% has been achieved for a given number of passes. 1 Plate Load Test shall be undertaken per trial panel. The test is to be undertaken in the centre of the panel

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and in multiple cycles as defined in IAN 73/06.12.3.18. Table 6/3-1 summarises the minimum testing requirements to be undertaken for each trial panel.

- 13.3.18 Upon completion of the above a soakaway test shall be performed in the test panel materials so as to determine the infiltration rate. The base of the associated excavation shall such that not less than 500mm of trialled material is present below the test. Refer to Appendix 1/5 for further details for the test method.
- 13.3.19 The Contractor shall provide a report describing the findings of the test panel. The proposed report format shall be presented to the Engineer 2 weeks in advance of any test panel tests for approval. The report shall include:
- Date and weather conditions, personnel recording the test panel findings.
 - Description of the plant and method used (make, weight, model, roller size etc.).
 - Description of material used in the test panel (source, tests result certificates, Class type).
 - Photographic records of material used, plant used and examples of the as compacted condition.
 - Certificates for in situ and laboratory tests undertaken on the compacted layers.
 - Appraisal of test results, conclusions and description of the method proposed for the main works.

Table 6/3-1 Compaction Trial Testing Requirements

Test Property	Recommended Frequency of Testing
Bulk Samples before compaction	Per layer for MC, PI, PSD, OMC/MDD, particle density laboratory permeability testing and laboratory oedometer testing.
Bulk, Dry Density and Air Voids	6 tests per compaction increment per layer using NDG ¹ All such tests to include particle density and moisture content determinations hence derivation of air voids. % relative compaction to be determined relative to the MDD established for the layer.
Undrained shear strength ²	1 per NDG test using HSV
NDG Calibration ¹	As part of each compaction trial initial calibration of NDG equipment shall be undertaken for each instrument used. The calibration shall be undertaken in accordance with methods prescribed in BS1377 Part 9: 2.5 and to the satisfaction of the Engineer.
CBR (BS1377 Part 9 Section 4.3)	3 test per panel at the specified locations.

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Plate Load Test to IAN 73/06	1 per completed trial panel, multiple cycles as defined in IAN 73/06
Soakaway Test (BRE 365)	1 set of tests per completed trial panel

1. Subject to revision depending on soil type – refer to note 24 in Appendix 1/5.
2. Where fill is cohesive

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)**13.4 Placing and Compacting Fill**

- 13.4.1 Cobbles, boulders, rocks or fragments whose largest dimension is greater than two-thirds of the compacted layer thickness shall not be incorporated into the Earthworks Material. Any softened cohesive materials encountered in stockpiles shall be removed and not incorporated into the fill. Potentially deleterious materials shall not be incorporated into the fill.
- 13.4.2 The contractor shall take all necessary steps to ensure that fills are placed at the moisture content/condition necessary to achieve the compaction specification and shall, where necessary, add water to or dry the fill, in order to obtain this value. Where it is necessary to add water, this shall be done as a fine spray and in such a way that there is time for the water to be absorbed into the fill before being rolled by the plant.
- 13.4.3 Compaction plant and compaction method shall be selected having regard to the proximity of existing trenches, excavations, retaining walls or other structures and all work shall be performed in such a way as to ensure that their stability is not impaired.
- 13.4.4 If the results of control tests indicate that the fill is being placed and compacted in such a way that the desired End Product is not being achieved, the Contractor shall further compact or, if necessary, shall excavate the affected work and replace with new fill, compacted to meet the specification requirements.

14.0 End Product Testing

- 14.1 The compliance of the compacted materials meeting the compaction specification shall be demonstrated by undertaking End Product testing as detailed in Appendix 1/5 and with reference to End Product requirements given in Table 6/1 of Appendix 6/1. Test locations shall be evenly distributed throughout the fill area at the frequency defined in Appendix 1/5. The Contractor shall agree test locations with the Engineer.
- 14.2 The Engineer shall be at liberty to request additional tests considered necessary to confirm that the End Product requirements are being met.
- 14.3 In the event of a test failure the Contractor shall provide a full comprehensive interpretation of the nature of the failure based on the test results and propose suitable remedial action. In the event of a test failure the Engineer shall be informed verbally immediately and (no later than 48 hours in writing), all work should cease in the associated area until a full comprehensive interpretation and solution has been found to rectify any such failure.
- 14.4 The relative dry density requirement shall be deemed to have been obtained provided that the following criteria are met:
- a) Where testing is progressed based on Appendix 1/5 note 25: at least 90% of in situ density tests attain the specified relative compaction, provided that no value falls below 93% relative compaction.
 - b) Where testing is progressed based on Appendix 1/5 note 26: The sample exceeds 95% of the rolling mean MDD and 93% of the rolling upper bound MDD this is considered to be a pass. Where the sample lies between these two values an individual laboratory compaction test is to be undertaken on the sample and the result considered a pass if the relative compaction is at least 95% of the individual MDD.

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- 14.5 The air voids criterion shall be deemed to have been achieved if no air voids determination exceeds 10%.
- 14.6 Placed and compacted cohesive soils are to have an undrained shear strength of 50kN/m² using the testing methods described in Appendix 1/5.
- 14.7 With respect to permeability the end product requirements can be considered to be met provided all of the following requirements are satisfied (i) laboratory permeability tests undertaken in the compaction trial record permeability values of not more than 1x10⁻⁷ m/s and (ii) the requirements for relative density and air voids given above are met and (iii) the soakaway tests determine an infiltration rate of not more than 1x10⁻⁷ m/s. The exception to this is the Engineered Fill in the POS (to be placed above the landscape fill) for which item (iii) is modified as follows: the ring infiltrometer tests determine an infiltration rate of not more than 1x10⁻⁸ m/s.
- 14.8 A suitably low risk of collapse compression/ inundation settlement is considered to have been achieved if the dry density, air voids and permeability requirements given above are met and that the oedometer tests indicate either no settlement resulting from inundation with water or record a collective total settlement of 0.05mm or less at the of monitoring after inundation (assuming a sample 20mm thick oedometer sample).
- 14.9 CBR tests are to be undertaken on placed and compacted materials in the upper 2 layers of Engineered Fill. CBR tests shall be undertaken at the as placed moisture content at a rate of 1 per 35m x 35m grid per layer and are to demonstrate a CBR of 3%.
- 14.10 Plate load tests (min 300mm dia. plate) shall be carried out in accordance with IAN 73/06 on the completed Earthworks Formation Level to demonstrate a minimum CBR value of 3% at the as placed moisture content. Such testing is to be undertaken on a 70x70m grid, subject to modification to ensure that any marginal pass CBR determinations (arising from testing based Appendix 1/5 and Appendix 6/1) are tested.
- 14.11 The requirement for flux chamber tests and a surface emission mapping survey for ground gas assessment purposes is detailed in Appendix 6/12.
- 15.0 Additional Limitations of Deposition of Materials Referred to in 601.13, 601.14 and 601.17**
- 15.1 Cobbles having an equivalent diameter of more than 150mm shall not be deposited within 2m of the finished surface at any location.
- 16.0 Permissible Deviation**
- 16.1 Permissible deviation from formation levels +/- 50mm.
Permissible deviation from linear dimensions +/- 75mm.
- 16.2 In addition the requirements of Appendix 6/13 should be noted. In the event of conflict Appendix 6/13 takes precedence.
- 17.0 Restrictions on Battering of Excavations for Foundations and Trenches and Requirements for Benching**
- 17.1 No specific limitations or restrictions are included for the battering of excavations for foundations and, but the contractor shall be responsible for ensuring safe working practices.

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

Battered excavations are to be benched prior to backfilling. Contractor to also note the specific requirements for batter where existing Made Ground is to receive fill as indicated on SK53

Benching or shaping of earthworks slope faces to receive fill

- 17.2 Where existing embankments are to be extended and where fill is to be constructed on ground with a slope steeper than one in eight, benching of the existing slope shall be formed as per the SHW. Bench heights are to be a multiple of the relevant compaction layer thickness, with the maximum vertical height of each bench not exceeding 500mm.
- 17.3 Where, during the progress of the work, the difference in level between adjacent areas of filling exceeds 600mm, the Contractor shall cut into the edge of higher filling to form benches having a minimum width of 600mm and a height equivalent to the depth of a layer of compacted filling. The Contractor shall spread and compact new filling to ensure maximum continuity with the previous filling.
- 17.4 Where the Engineered Fill is to be placed against a batter comprising existing Made Ground (which is to be treated by preload/surcharge loading) the tie in will be based on a suitable benching arrangement which is described thus: the material is to be placed and compacted in a prepared benched excavation formed in the natural undisturbed clay. The height of the benches shall be as per the layer thickness required by the compaction method used but the height shall not exceed 250mm. The width of each bench shall be the greater (i) 3 x bench height, (ii) 1.0m or (iii) the width required to ensure adequate compaction by the plant used. Refer to 11950-SK53 for detail.
- 17.5 Fill material in areas of benching shall be carefully placed and compacted to ensure that no voids occur at the upright steps of the benching.
- 17.6 Placement and compaction of the fill material shall continue to the level of an adjacent bench before material is placed upon that bench.
- 17.7 Four additional passes of the roller shall be made on the area within two metres each side of the upright face immediately following the compaction of the first layer of fill material on each bench.

18.0 Excavation Supports to be Left in Place

- 18.1 No excavation supports are to be left in place.

19.0 Mixing of Excavated Materials

- 19.1 Mixing of acceptable and unacceptable excavated material is not permitted.

20.0 Fill to Excavated Voids.

- 20.1 Areas of inadequate strength shall be removed and backfilled and replaced with materials placed and compacted in accordance with this Specification.

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)**21.0 Deterioration of Fill Materials**

- 21.1 If an authorised formation or material deposited as fill subsequently deteriorates due to inclement weather or water ingress (or for any other reason) such that, in the opinion of the Engineer, it would be reclassified as unacceptable and cannot be compacted in accordance with the Contract, the Contractor shall:
- i. Cease work on the material until its condition is such that it can again be classified as acceptable.
 - ii. Make good by removing and disposing of the unacceptable material and replacing it with acceptable material.
- 21.2 Where, in the opinion of the Engineer, earthworks have been adversely affected by the ingress of water during the earthworks contract so as to render the material unacceptable, these works shall be removed and made good at the Contractor's expense subject to test results proving the material to be unacceptable

22.0 Reporting

- 22.1 For each phase of works, the contractor shall prepare and present to the Engineer on weekly basis a report which provides the following:
- Volume of Fill Placed
 - Per Test: quantity of test required by the specification based on this volume
 - Per Test: quantity scheduled to date
 - Per Test: quantity of results received to date
 - Confirmation that all MCV or MC results are within the required range
 - Per Test: quantity of results that do not comply with the specification
 - An outline of corrective action in relation to any non-compliant results
 - An indication if the corrective action has been completed or is pending (with dates).
 - Confirmation that the corrective action has resolved the issue
 - A spreadsheet based detailing the above and the test results, which is to be traceable between the test/sample location, layer, grid coordinate, a unique sample/ testing ID and the related test certificates.
- 22.2 On completion of earthworks in each development sub-phase (refer to 11950-SK107 for sub-phase areas), the Contractor will prepare a collated factual Validation Report and submit this to the Engineer. In addition to the items list below it shall also include information needed for completion of the geotechnical feedback report as defined in Design Manual for Roads and Bridges (BMRB) HD22/08 Managing Geotechnical Risk.
- The validation report is to include, but is noted limited to, the following:
- a) general description of the earthworks, excavations, placement and compaction methodology and plant used;
 - b) quantities of excavated, imported, re-used, treated and disposed materials;
 - c) details of remediation and treatment, including quantities, licence arrangements;
 - d) the extent of the excavation formation;
 - e) details and quantities of any grouting, sealing or similar of historical structures;
 - f) surveyed location of all remnant obstructions and week by week progress drawings;
 - g) detailed weather conditions;
 - h) formation treatment including ground improvement, drainage measures and treatment of soft areas or contamination;

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- i) data relating to the relevant compaction trial reports.
- j) application of acceptability criteria and summary of the end product test results for each specific earthworks material placed during the earthworks operations;
- k) a copy of all test results including grid location and level;
- l) actions taken in relation to any test failures and the results of any testing associated with this;
- m) drawings showing the location of each specific earthworks material placed during the earthworks operations on a layer by layer basis, any feature or operation relevant to the earthworks including instrumentation and the location of the trial areas and control tests;
- n) drawings showing the location, extent and contours of all stockpiles formed from surplus site won soils;
- o) an electronic copy of all the test results and monitoring associated with the earthworks operations, including chemical validation results and including those associated with surplus soil stockpiles;
- p) environmental and groundwater monitoring results;
- q) additional requirements of the Local Authority and Environment Agency;
- r) Contamination relevant records including:
 - Description of U1B / U2 material actions
 - Description of residual contamination
 - Volumes of Materials Treated, Disposed of, Imported and Stockpiled (Soil and Water)
 - Description of Waste Management: Quantities, Classification, Licensing and Documentation
 - Formation Inspection
 - Remnant Obstructions
 - QP Declaration for MMP
 - All records required for the MMP validation report
 - Details of Regulatory Liaison and Discussions
 - Waste Records (including classification and Duty of Care)
 - Laboratory analytical results.
 - Photographs

23.0 Other survey Requirements

- 23.1 Before starting work the Contractor shall complete a visual survey and update the topographical survey of the site and submit the survey report to the Engineer.
- 23.2 During works the Contractor shall survey the extents of excavation, retained features (such as obstructions) and ~~underground services (if encountered) prior to backfilling.~~
- 23.3a For each development sub-phase the Contractor shall provide a survey of: the full extent of the Excavation Formation Level including any side batters; location of former subterranean structures removed; drainage routes; extent and level of each layer of compacted earthworks layer placed (see below); the Finished Earthworks Level and extent of Engineered Fill; and the extent of surcharge load. All retained exploratory locations and supplementary investigation points shall also be surveyed and included.
- 23.3b Subject to the prior written agreement of the Engineer and the presentation of an agreed Method Statement, the contractor shall be permitted to omit the survey of each Engineered Fill layer placed on the provision that all the associated earthworks plant is demonstrated to have a working GPS layer control in addition to other earthworks controls on level thickness. The contractor shall still maintain a layer control system such that each layer can be individually identified and sample locations still surveyed (along with other survey requirements noted

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

above/elsewhere). If in the opinion of the Engineer layer control is not being achieved the Contractor shall be required to implement the survey of each layer.

- 23.4 For each development sub-phase on completion of the bulk earthworks and the surcharge loading treatment (as discussed in Appendix 6/13 and including any making good of levels and re-making up to final site level), an as built survey, including level data of the completed works shall be undertaken by the Contractor. All level survey information and an assessment of volumes of excavated, remediated and surplus soil shall be provided to the Engineer. The final 'as built' topographic survey shall include details of the earthworks placement areas, reduced level areas and remaining stockpiles.
- 23.5 Upon request by the Engineer the contractor shall provide cross sections through the works so as to demonstrate (i) the excavation formation level (ii) layer thicknesses and (iii) extent of engineered fill (so as to facilitate construction of any tie in arrangements) and (iv) any side batters. The cross sections are to be geo-referenced, provide level information to Ordnance Datum Newlyn, provided with chainage and produced to scale. The vertical scale may be exaggerated to as to illustrate key features. Any such sections are to be accompanied with plan showing the extent and orientation of the cross-section along with the chainage. The plans are to be to scale and to be related to the National Grid coordinate system.
- 23.6 Survey works shall ensure that the reporting requirements given above can be met along with any other survey requirements given in this specification.
- 23.7 All levels shall be related to Ordnance Datum Newlyn and surveys shall be based on the national grid coordinate system and shall be considered with the updated topographical survey.
- 23.8 The maximum error between permanent survey control stations shall not exceed 1:20,000.
- 23.9 A drawing shall indicate each permanent survey control station showing its general location with dimensions to at least three easily recognisable and durable points.
- 23.10 The maximum distance between adjacent spot levels shall not exceed 15 metres. Ground survey spot levels on hard surfaces shall be correct to +/- 10mm r.m.s.e. and elsewhere to +/- 25mm r.m.s.e. Accuracy for linear dimensions is to be +/- 25mm. The drawing shall be supplied in 3D AUTOCAD.DWG format, at a scale of 1:200 on CD ROM. It shall be kept up to date on at least a weekly basis with respect to ground excavations and be made available to the Engineer on request.

24.0 Tie in Of Engineered Fill with Surrounding Ground

- 24.1 As part of the excavation works for each development phase as built plans for the surrounding phases area (as provided by the relevant contractor) will be referred to by contractor who will locate any Engineered Fill placed as part of the previous work. The placement and compaction of Engineered Fill as of the current Phase works shall be undertaken by the contractor so as to tie into the any previously placed Engineered Fill. The nature of this tie in detail will be in accordance with Drawing SK 151. Likewise, Engineered Fill is to tie in to the Weald Clay
- 24.2 Fill material in areas of benching shall be carefully placed and compacted to ensure that no voids occur at the upright steps of the benching.
- 24.3 Placement and compaction of the fill material shall continue to the level of the adjacent bench before material is placed upon that bench.
- 24.4 Four additional passes of the roller shall be made on the area within two metres each side of the upright face immediately following the compaction of the first layer of fill material on each bench.

APPENDIX 6/8: TOPSOIL

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Strip topsoil and stockpile. Stockpiles of topsoil and pseudo-topsoil shall be formed in accordance with guidance provided by DEFRA '*Construction code of Practice for the Sustainable Use of Soils on Construction Sites (2009)*'.

APPENDIX 6/9: LANDSCAPE AREAS

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- 1.1 Landscape Fill shall only be placed in the Public Open Space Ground Treatment Area in the drawing 11950-2.6C-CE621 C6. Such materials are not to be placed within 500mm of the Bulk Earthwork Level. 500mm below Bulk Earthworks level to Bulk Earthworks Level, Engineered Fill shall be placed.
- 1.2 Class 4 material will be site won as described by the SHW and shall comply with the requirements specified in Appendix 6/1.
- 1.3 The extent of Landscape Fill placed adjacent to the proposed route of the brook indicated in Phase 2.4D shall not ingress more than 10m from the crest of the brook slope and shall not affect the adjacent engineered fill constructed in 2.4D such as the construction of the adjacent brook slopes.
- 1.4 Method compaction is specified for Class 4 Landscape Material tested and compacted in accordance with Table 6/1 of Appendix 6/1.
- 1.5 Compaction shall be sufficient to remove large voids and to produce a coherent mass whilst preventing over-compaction, any build-up of excess pore pressures or damage to plant and machinery.

TABLE 6/9: LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

	Units	Upper 2.00m Engineered Fill*	General Fill Beneath 2.00m final earthworks level **
GENERAL REQUIREMENTS			
Asbestos ^c	% weight	<0.001	<0.1
Arsenic ^a	mg/kg	79	n/a
Cadmium ^a	mg/kg	120	n/a
Chromium (total)	mg/kg	1,500	n/a
Lead ^a	mg/kg	630	n/a
Mercury (total)	mg/kg	120	n/a
Selenium	mg/kg	1,100	n/a
Nickel	mg/kg	230	n/a
Copper	mg/kg	12,000	n/a
Zinc	mg/kg	81,000	n/a
Benzo(a)pyrene ^a (use as surrogate for PAH)	mg/kg	10	n/a
TPH Total ^b	mg/kg	3,800	n/a
Aliphatic >C5 – C6	mg/kg	570,000	n/a
Aliphatic >C6 – C8	mg/kg	600,000	n/a

APPENDIX 6/9: LANDSCAPE AREAS

	Units	Upper 2.00m Engineered Fill*	General Fill Beneath 2.00m final earthworks level **
GENERAL REQUIREMENTS			
Aliphatic >C8 – C10	mg/kg	13,000	n/a
Aliphatic >C10 – C12	mg/kg	13,000	n/a
Aliphatic >C12 – C16	mg/kg	13,000	n/a
Aliphatic >C16 – C21	mg/kg	250,000	n/a
Aliphatic >C21 – C35	mg/kg	250,000	n/a
Aromatic C5 – C7	mg/kg	56,000	n/a
Aromatic >C7 – C8	mg/kg	56,000	n/a
Aromatic >C8 – C10	mg/kg	5,000	n/a
Aromatic >C10 – C12	mg/kg	5,000	n/a
Aromatic >C12 – C16	mg/kg	5100	n/a
Aromatic >C16 – C21	mg/kg	3800	n/a
Aromatic >C21 – C35	mg/kg	3800	n/a
Phenols	mg/kg	440	n/a
Cyanide (total) ^c	mg/kg	22	n/a
pH	Units	5 – 10	n/a
* based on a Public Open Space (residential) end use and 1%SOM ** 1 sample every ten will also be analysed for the full suite (i.e. as per the samples for the upper 2m engineered fill) S4ULs used unless otherwise stated (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL 3036. All rights reserved) ^a – C4SL used ^b – Based on the S4UL for Aromatic C16 – C21 but assumes no petroleum hydrocarbon contamination is present ^c – S4UL and C4SL not generated, use in-house GAC/value			

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Refer to Appendix 6/13 for instrumentation and monitoring associated with the ground treatment works.

Refer to the CEMP for environmental monitoring requirements

1.0 Post Earthworks Gas Monitoring

1.1 In order to inform the requirement for gas protection measures in the proposed development gas monitoring will be required. Locations are shown on the Instrumentation and Monitoring drawings.

1.2 Installations will be carried out via Dynamic Continuous Sampler (DCS) at the locations indicated on drawings. Two holes will be required at those locations where different depths and/or strata require monitoring (as detailed below). The response zones shall be isolated into one material only and single locations with dual installations shall not be carried out. The following criteria shall be followed:

a) Locations in the Surcharge Area - two installations required. The shallow well shall be progressed through the surcharge, where present, and extend 1m into the underlying Engineered Fill with a 0.5m response zone at the base. The holes shall be sealed with bentonite above the response zone to the surface. The deeper well shall be sealed with bentonite all the way through the clay cap and the response zone shall be 3m long in the underlying fill material (not to extend into the Weald Clay, if encountered).

b) Locations outside the Surcharge Area and over Engineered Fill which is deeper than 2.5m - two installations required at those locations where Engineered Fill exceeds 2.5m depth. The shallow well shall be 1m deep overall with a 0.5m response zone at the base. The deeper wells, where installed, shall be sealed with bentonite to 2m below ground level. The response zone will extend to the base of the Engineered Fill or be 3m in length, whichever is the shallower.

c) Locations outside the Surcharge Area and over Engineered Fill which is less than 2.5m depth, or over natural clay (i.e. no fill materials present) - the well shall be 1m deep overall with a 0.5m response zone at the base.

1.3 The works shall be progressively carried out as phases are completed across the site.

1.4 The works shall be carried out in accordance with BS 8576: 2013 and the UK Specification for Ground Investigation, 2nd Edition, published by Thomas Telford Ltd 2012 with the following amendment to Clause 12.4.1:

1. The following parameters shall be monitored and recorded on each visit to the site. Items iv to viii shall proceed in the order stated and the gas tap shall be closed between the flow and gas concentration stages.

i) Weather conditions on the day of and 24 hours prior to the visit.

ii) Air temperature.

iii) Barometric Pressure on day of visit and preceding 3 days.

iv) Downhole temperature.

v) Downhole pressure and the flow rate should be recorded every minute over a 10-minute period.

vi) Concentrations (% vol) of CH₄, CO₂ and O₂ (ppm) over a 10 minute period with concentrations recorded every minute.

vii) Water level

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If water is encountered the Engineer may instruct removal.

Engineer approval shall be obtained prior to commencement of any laboratory analysis.

The Engineer may instruct that prolonged pumping gas monitoring is undertaken over a period of up to 2 hours on selected wells.

2. Monitoring on-site shall generally be undertaken using portable handheld equipment. The performance specification and accuracy of the equipment employed shall meet the requirements of Table 2 in BS8576: 2013 and be stated in the final report.

3. Any damage to the monitoring installation or incidents of open gas taps upon arrival shall be recorded.

4. The name of the person monitoring shall be stated and wherever possible the same person shall be used on each monitoring visit to maximise consistency. Monitoring visits shall be coordinated so as to include 'worst case' events comprising periods of rapidly falling barometric pressure.

- 1.5 Before construction of each ground gas standpipe the Engineer shall be contacted to agree installation details.
- 1.6 Bulk bag soil samples shall be taken in order to accommodate Forensic TOC analysis that may be scheduled. For the shallow installations one representative samples shall be taken of the Engineered Fill (all sampled soils will be placed into a large bulk bag throughout the full depth of the fill); and for the deeper installations one representative samples shall be taken of the unclassified fill (all sampled soils will be placed into a large bulk bag throughout the full depth of the fill).
- 1.7 The temperature of the soil shall be recorded every 1m on removal of the borehole tool.
- 1.8 Soil descriptions and logs are required in accordance with BS 5930:2015.
- 1.9 Raised covers will be provided and these will be protected via concrete drainage rings or similar (e.g. 0.5m depth, 2m diameter)
- 1.10 Monitoring for flammable gases via Flame Ionisation Detector (FID) is required at 1m intervals during formation of each borehole. Results to be provided on the respective logs.
- 1.11 Provision shall be made for 3 months monitoring at *weekly intervals* on the surcharged areas of the site. Monitoring may be curtailed in areas where initial monitoring results are within acceptable parameters but this will require agreement with the Regulator. Three monitoring visits should be required in total in the single installation DCS 1102 in the non surcharge area which has been subject to a cut and fill treatment.
- 1.12 Groundwater samples shall be obtained for each installation on the first 2 sequential visits and the samples tested for pH, conductivity, ammonia, dissolved oxygen, dissolved carbon dioxide and SO₄. Samples shall be obtained using low flow sampling methods.
- 1.13 Data shall be provided in excel, pdf and AGS 3.1 in full incorporating both the main phase of fieldwork and all subsequent gas and water monitoring visits and iterative phases of chemical analysis. The data shall be checked by the Contractor prior to issue and be accompanied by the error log.

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- 1.14 In order to prevent the creation of gas migration pathways and to prevent water ingress all installations will be decommissioned upon completion of the monitoring (as agreed with the regulatory authorities) in accordance with EA guidance (Decommissioning Redundant Boreholes and Wells).

2.0 Large Scale Gas Generation Field Tests (Drum Tests)

- 2.1 Drum Tests shall be undertaken as per the frequency provided in Appendix 1/5 on the following classes of soils: 1A – 1C and 2A – 2D.

2.2 Scope

- 2.2.1 This document specifies test methods for assessing the gas generation potential of fill materials used below developments.

- 2.2.2 This is intended as a test from which the risk associated with ground gas generation from fill materials below developments can be assessed following guidance in documents such as the Local Authority Guide to Ground Gas (CIEH, 2007).

- 2.2.3 This test provides a measure of the potential amount of biogas (methane and carbon dioxide) that might be released if it is placed in the ground. It is a large scale test that is intended to replicate the actual ground conditions in a site. As such it is not artificially seeded with an inoculum of methanogenic bacteria and any gas generated is the result of bacteria present in the fill already.

2.3 Terms and definitions

- 2.3.1 For the purposes of this document the following terms and definitions apply.

Biogas – methane and carbon dioxide.

Aerobic – Soil atmosphere that is rich in oxygen.

Anaerobic – Soil atmosphere that does not contain oxygen.

Biodegradation - chemical dissolution of materials by bacteria, fungi or other biological means.

2.4 Principle

- 2.4.1 When fill material is placed in the ground it will initially be in an aerobic environment as oxygen is trapped in the material. Aerobic degradation of any degradable organic matter occurs and uses up the oxygen. Once anaerobic conditions are established methanogenic bacteria continue to degrade the organic material that is available for degradation until it is used up and gas production ceases.

- 2.4.2 A representative sample of fill material and groundwater from a site is placed in a sealed steel drum. A sealable gas tap is fitted to the top of the drum to allow gas monitoring from the headspace above the sample. The concentration of methane and carbon dioxide in the headspace of the drum is recorded at set intervals over a period from 20 days to 100+ days.

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The temperature during the test is recorded (but is not maintained at a set value). The ambient temperature during the tests must not drop below 10°C (in winter the tests will need to be housed indoors and appropriate safety precautions taken).

2.4.3 The results are reported as litres of biogas per kg of fill material.

2.5 Equipment

Biodegradation test vessels – a series of steel drums of height 0.85m and diameter 0.57m. This gives 0.22m³ internal volume with an air tight lid and a sealable gas tap. (other dimensions to be agreed with the Engineer)

Balance – capable of weighing mass of sample to +/- 1%

Thermometer – capable of measuring air temperature to +/- 0.5°C

Gas monitor – Meeting the requirements of BS8576: 2013, Guidance on investigations for ground gas – permanent gases and volatile organic compounds (VOCs). Clause 9.3 and Table 2. The sample pump rate should be stated.

2.6 Sample Size

2.6.1 The sample should be sufficient to fill a 0.22m³ drum and leave a 100mm deep headspace at the top of the drum when loosely compacted down in the drum. The weight of the sample should be recorded.

2.7 Procedure**Filling**

2.7.1 A steel drum is filled with the material to be tested.

2.7.2 The materials shall be loosely compacted into the steel drum to remove all large voids and leaving a 0.1m depth of headspace (this equates to 0.025 m³ headspace volume). The mass of each material used to fill the barrels should be measured using a balance to determine the approximate wet bulk density of the material within each barrel. The moisture content of the materials placed into the barrels will be measured using either a theta probe or by sending samples to a laboratory.

2.7.3 Groundwater from the site should be used to fill the barrels with at least 20 litres of water (to the top of the soil).

2.7.4 Following emplacement of the materials into the barrels and filling with water, the barrel lids should be secured and sealed using a volatile organic compound (VOC) free sealant. A small hole (0.5mm diameter) should be drilled into the top of the barrel lid for insertion of a gas tap. The gas tap should be sealed into the barrel lid using a VOC free sealant. Filling of the drum and sealing and securing of the gas tap should be carried out on the same day.

2.7.5 Filled barrels should be located in a safe location agreed with site staff where there is no need for disturbance of the barrels during the test period. The ambient temperature during the tests should not fall below 10°C for any significant period of time and therefore a heated container shall be provided, if required, to ensure temperature does not fall below 10°C.

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Biogas measurement

- 2.7.6 Following filling of the barrels on day zero, measurements of ground gas concentrations should be made twice per week at three day intervals (e.g. Monday and Thursday) over a period of 100 days. Each measurement event shall last for exactly 5 minutes (if this is amended then the time shall be recorded but amendments must be avoided where at all possible). Concentrations of ground gases will be recorded each minute over the 5 minute period. The tests may be extended up to a total period beyond 100 days if required. The date of the first test should be recorded as T1 and dated, the second as T2 and dated, and so on.
- 2.7.7 Concentrations of ground gases will be measured using the gas monitor. Gases measured should be methane (CH₄), carbon dioxide (CO₂), oxygen (O₂), carbon monoxide (CO) and hydrogen sulphide (H₂S). Flow measurements are not required but the differential (may be referred to as borehole pressure on some gas monitors) is required. The temperature of the barrels should be recorded during each measurement event.
- 2.7.8 To measure the temperature of the soils within the drum one thermometer/thermocouple should be attached to the side of each of the drums and protected as necessary. The bulb/thermocouple wire leg junction should be thermally protected from the elements using insulation spray foam or similar.

Reporting for Drum Tests and Gas Monitoring

- 2.7.9 The test report should provide the following:
1. Date of test
 2. Description of material tested and source
 3. Cumulative record of biogas concentration and number of sampling events.
 4. Temperature record over period of test
- 2.7.10 The test results shall be provided in an excel spreadsheet that is updated each time measurements are taken. The results should be provided in tabular form in the spreadsheet in a layout that is agreed with the Engineer.
- 2.7.11 The results of each weekly monitoring round will be forwarded to the Engineer on completion.
- 2.7.12 The Drum Test is for information and assessment purposes and the results will be used to inform remedial and re-use decisions.

3.0 Flux Chamber Tests

- 3.1 Flux chamber test shall be undertaken prior to the validation trial pits detailed in App 6/12, Section 5.0. The results of the tests shall be forwarded to the Engineer, for approval and comment, at least one week before commencement of the validation trial pits.
- 3.2 Flux chamber tests shall be undertaken to measure methane emissions, as shown on Instrumentation and Monitoring drawings. For the Surcharged Area the tests will be carried out over the surface of the excavated formation layer, including over dig, and prior to installation of Engineered Fill. If the results indicate a potential gas risk, then the monitoring shall be repeated on completion of the installation of the engineered fill and prior to the installation of the

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surcharge. For non-surcharged areas they shall be carried out across the finished formation layer.

- 3.3 The flux chamber tests shall be undertaken in accordance with the guidance in the Environment Agency LFGTN 07, Guidance on monitoring landfill gas surface emissions. The results should include an excel spreadsheet which includes the flux calculations. The location of the tests shall be agreed with the Engineer in advance. A method statement for the works shall be agreed with the Engineer for prior approval. If the Contractor is not able to carry out the works then the work shall be sub contracted, at no additional cost to the client, to a suitable specialist who must be approved by the Engineer prior to appointment.

4.0 Surface Emission Tests

- 4.1 A surface emission mapping survey shall be carried out to measure methane emissions. Surface emission tests shall be undertaken prior to the validation trial pits detailed in App 6/12, Section 5.0. The results shall be forwarded to the engineer for approval and comment at least one week before commencement of the validation trial pits.
- 4.2 For Surcharged Areas the survey shall be carried out over a 5m grid (i.e. on a series of traverse lines spaced at 5.0m centres). The survey will be carried out over the surface of the excavated formation layer, including over dig, and prior to installation of Engineered Fill. If the results indicate a potential gas risk then the monitoring shall be repeated on completion of the installation of the engineered fill and prior to the installation of the surcharge.
- 4.3 For non surcharged areas the survey shall be conducted on a 25m grid across the finished formation layer
- 4.4 All measurements shall be taken at 10mm above ground level with a laser diode methane detector calibrated to detect methane and with a detection threshold of 1 ppm. The instrument shall have a response time less than 5 seconds. Readings shall be taken every 3 seconds and shall be time stamped with the time and GPS location.
- 4.5 The survey work shall be carried out by an experienced and competent technician who has undertaken similar work for compliance testing on licensed landfill sites. A method statement for the works will be submitted to the Engineer for prior approval. If the Contractor is not able to carry out the works, then the work shall be sub contracted to a suitable specialist who must be approved by The Engineer prior to appointment. The results shall be reported as a table of results alongside a contour plot of the emissions recorded. The wind speed/direction, temperature, atmospheric pressure and rainfall on the site at the time of the survey shall be recorded.

5.0 Validation Trial Pits in Surcharged Area

- 5.1 At the excavation formation level and prior to construction of the Engineered Fill, trial pits shall be excavated to 4m below excavation formation level across landfilled areas on an approximate 50m grid and/or where elevated TOC concentrations and/or elevated methane concentrations were detected.
- 5.2 The locations are shown on the Instrumentation and Monitoring drawings and these are subject to review and possible relocation following the Engineers review of the flux chamber and surface emission test results. The purpose of these is to inspect for both gaseous material and soft / organic material that could present a ground settlement issue. The trial pits will require inspection by the Engineer and therefore the Contractor will provide 5 days' notice of the works. All trial pits shall be surveyed in accordance with this specification (one survey point per trial pit location is sufficient).

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Gas Related Pits

- 5.3 Composite samples of representative soils from the excavated soils shall be taken for one Forensic TOC and one Drum Test per trial pit.
- 5.4 If Forensic TOC analysis and/or assessments associated with the Drum Tests indicate Unacceptable Material then these may require excavation as part of a hot spot exercise and the soil will be stockpiled for further assessment. The Contractor shall therefore allow time in the programme for results to be returned and assessed to accommodate this potential outcome.

Geotechnical Trial Pits

- 5.5 Where shown on drawings, trial pits shall be excavated to 4m below excavation formation level in areas where the ground investigation identified potentially compressible material beneath the excavation formation level the pits are required to determine whether the zones represent significant soft spots that require excavation and replacement with Engineered Fill.
- 5.6 Subject to the Engineers instruction the Contractor shall excavate any soft or highly degradable materials and replace with Engineered Fill.

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1.0 Geotechnical Improvement by Placement of Engineered Fill and Preloading by Surcharge**1.1 General**

- 1.1.1 Geotechnical improvement will not be required where the excavation formation reveals the presence of undisturbed natural strata comprising firm clay or medium dense sand or better. Geotechnical improvement will be required in areas where Made Ground is encountered at Excavation Formation Level. The purpose of the ground treatment is to ensure that the resultant works meet with the 'Performance Criteria' agreed with the Client (the performance criteria agreed with the client comprise total post construction settlements of not more than 75mm a differential movement of not more than 1/100, a permeability of not more than 10^{-7} m/s and a CBR value of 3% as the final and penultimate layers.
- 1.1.2 To ensure that the post treatment load-settlement characteristics of the treated materials are within the performance criteria mentioned above, geotechnical improvement is to be undertaken by forming: (i) pre-loading and surcharge loading of the pre-existing Made Ground; (2) the placement and compaction of fill materials to End Product criteria, as outlined below, totalling a 2m minimum thickness.
- 1.1.3 This fill is to be placed and compacted so as to form an Engineered Fill. The Engineered Fill is to have the following properties: (i) a permeability of less than 10^{-7} m/sec (ii) an air voids content of not more than 10%, (iii) relative density of not less than 95% Maximum Dry Density based on the appropriate compaction test for the material type (see Appendix 6/1), (iv) low risk of significant collapse compression/inundation settlement; and (v) a CBR value of not less than 3% at as placed moisture content in the upper 2 layers. The exception to foregoing is the Engineered Fill in the POS (to be placed above the landscape fill) for which item (i) is modified to a permeability of not more than 1×10^{-8} m/s. Refer to Cl 14 of Appendix 6/3 for full details of end product requirements.
- 1.1.4 The earthworks operations undertaken to form the Engineered Fill outlined above shall be informed by compaction trials as detailed in Appendix 6/3. The compaction trials shall be witnessed by the Engineer. The Engineer will also witness the construction of installations and monitoring devices associated with the geotechnical improvement works.
- 1.1.5 Depending on location, as shown on plans provided by the Engineer, the works shall be undertaken in either Sequence A or Sequence B as stated in Appendix 6/3.
- 1.1.6 All earthworks and associated compliance testing shall be carried out in accordance with Appendix 6/3. The placement and compaction of the Engineered Fill will be monitored full time by the Engineer.
- 1.1.7 If unforeseen ground conditions or unforeseen responses to the treatment are encountered then the Engineer shall be notified immediately.
- 1.1.8 In the event of a test failure the Contractor shall provide a full comprehensive interpretation of the nature of the failure based on the test results and propose suitable remedial action. In the event of a test failure the Engineer shall be verbally informed immediately (and no later than 48 hours in writing), all work should cease in the associated area until a full comprehensive interpretation and solution has been found to rectify any such failure.
- 1.1.9 Prior to the commencement of the construction of the surcharge embankment the Contractor shall confirm their proposed sequence and phasing of embankment construction: this shall indicate the location and phasing of each discrete embankment location. Where not otherwise

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detailed the Contractor shall construct each sequential surcharge embankment with a full height 5m overlap with the previous embankment when these are sequentially constructed.

APPENDIX 6/13: GROUND IMPROVEMENT**1.2 Formation of Engineered Fill**

1.2.1 The formation of the fills is detailed in Appendix 6/3.

1.3 Surcharge Construction

1.3.1 The surcharge fills are to be placed to levels and over areas indicated on the Drawings and Sections provided by the Engineer.

1.3.2 No surcharge materials shall be placed closer than 10m to any existing structures, services or road pavements that are to be retained or that are off site.

1.3.3 The surcharge is to be constructed to its full design height except in areas where plans provided by the Engineer indicated that a revised sequence to the works is to be adopted (Sequence B). In such areas in such areas the surcharge is to be constructed to higher of either (i) the required design surcharge height or (ii) a minimum of at least 1.5m above the ground level recorded on the 2015 survey or (iii) 1.5m above current ground level. If, in the opinion of the Engineer, during monitoring nature of the data recorded at these locations indicates that an insufficient amount of movement has been induced to facilitate a meaningful and rational interpretation of the data (i.e. the point of inflection cannot be readily identified) he may instruct the placement of additional surcharge materials.

1.3.4 The surcharge material is to comprise either Class 1 or Class 2 materials, as defined in the Specification for Highway Works (SHW) or, subject to the approval of the Engineer, (iii) Class 5 material as defined in the SHW. A minimum of 2 weeks shall be allowed for the Engineer to approve Class 5 material after the Contractor has presented supporting information. The surcharge materials shall be placed and compacted in layers not more than 500mm thick and, to confirm the bulk density of such surcharge materials, in situ density tests are to be undertaken at a frequency of 2 per 2000m³ for each 1m of lift, the test depth for these shall be 300mm below the then current surface of the works. Compaction shall be undertaken using the same plant and number of passes as used for compaction of each material type used in forming the Engineered Fill (i.e. same compactive effort as used for each layer of the Engineered Fill but layer thickness will be greater for the surcharge fill). Alternatively, the surcharge can be constructed from Engineered Fill as detailed in Appendix 6/3. In either case, the bulk density information is to be provided to the Engineer who may instruct alterations to the surcharge height so as to ensure an adequate surcharge pressure.

1.3.5 The contractor is responsible for controlling the rate of construction so as to prevent temporary slope failure due to the temporary increase in pore pressure arising from the earthworks. The contractor is to use the piezometers proposed on drawings and is to install any additional piezometers as he may require so as to ensure adequate control of the works. Considering his governing criteria for the control the works vs. piezometric level along with associated calculations. The contractor shall employ a suitably qualified temporary works designer to provide this based on established soil mechanics theory and to be referenced accordingly.

1.3.6 The surcharge shall be trimmed to falls to shed rain water and the surface sealed to limit infiltration. The Contractor shall provide temporary drainage at the base of the surcharge to collect run off and to carry any surface water away from the base of the surcharge.

1.3.7 The full extent of the surcharge and its side slopes shall be surveyed upon completion.

1.3.8 Each surcharge treatment zone is to be left in situ for the minimum duration of 24 weeks after completion of construction to enable the amount and rate of settlement to be monitored and hence establish that 90% of primary consolidation has been achieved and any residual

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settlement is approximately linear when plotted against log time. The duration can be altered by the Engineer depending on the findings of the monitoring data.

- 1.3.9 If 90% consolidation and/or linear settlement vs. log time has not been established at the end of the surcharge period, the Engineer will instruct: (i) additional time for surcharging; (ii) increased surcharge loading; or (iii) acceptance of the anticipated further settlement. Conversely if these criteria are achieved sooner this period may be shortened by the Engineer and it should be recognised therefore the early provision of specified data could provide the Engineer the option to reduce the surcharge programme.
- 1.3.10 If the surcharge is constructed as a number discrete panels then there is to be a 5m overlap of each individual panel constructed i.e. surcharge panels shall be constructed such that the embankment (at its full height) extends 5m beyond the shoulder of any previous placed surcharge embankment.
- 1.3.11 Following completion of treatment work, panel load tests may be required by the Engineer. Test panels will comprise earth mounds 13m x 13m x 2m high with additional side slopes constructed at 1:3. A settlement plate will be installed centrally beneath the base of the panel to the Engineer's requirements.
- 1.4 **Permanent Datum**
- 1.4.1 Two permanent datum's are required to provide a reference for the measurement of ground levels and instrumentation and to provide crosschecks with one another. The datum's are to be fixed into deeper, competent ground and isolated from any soft or compressible strata or strata subject to shrink-swell movements. These datum's are to be as per Fig 6 of BRE Digest 386 'Monitoring Building and Ground Movement by Precise Levelling', are to be at least 25m from existing or recently removed trees and to be secured at a minimum depth of 6m. The datum's shall be fenced off with a fence comprising at least three wooden stakes, 75mm square, preserved in accordance with BS8417, firmly bedded in the ground and stoutly cross-braced and projecting at least 1m above ground level. The woodwork is to be brightly painted.
- 1.4.2 The Contractor shall agree the locations of the permanent datum's with the Engineer 2 weeks ahead of their installation. It may be permissible to utilise datum's from previous phases of work, subject to discussion with the Engineer, in which case agreement must be sought two weeks prior to commencement of earthworks or the installation of instruments, whichever is the earliest. The datum's are to be located so as to minimise risk of damage from the proposed works, with due regard to any constraints as advised by the client and in areas where the contractor can be sure of security throughout the duration of the monitoring period. The installation of permanent datum's shall be completed prior to the installation of instruments and the commencement of earthworks
- 1.4.3 The level of the permanent datum's shall be established by the levelling techniques with reference to agreed benchmarks or survey stations in the vicinity. Levelling shall be closed back to the benchmarks to check accuracy.
- 1.4.4 The level value and co-ordinate position shall be measured three times soon after installation of the datum's and shall be checked at intervals to be established by the Engineer.
- 1.4.5 The following data shall be recorded for the permanent datum's:
- Reduced level of datum (m OD)
 - Plan position (National Grid Co-ordinates)

APPENDIX 6/13: GROUND IMPROVEMENT**1.5 Treatment Monitoring**

- 1.5.1 Installation of instruments will be required prior to surcharge construction in order to monitor key parameters during the placement of the surcharge and the subsequent monitoring period. Rod settlement Gauges (RSGs) shall be constructed at an approximate grid spacing of 40m. The RSGs, piezometers and Borehole Rod Extensometers (BREs) are to be installed at positions and levels indicated on drawings. The location and level of each location shall be surveyed and the National Grid Co-ordinates and level (m OD) shall be provided.
- 1.5.2 The Contractor shall be responsible for following the manufacturers' instructions and the requirements of this specification in the installation, calibration and testing of all measuring instruments and equipment, which shall be carried out in the presence of the Engineer.
- 1.5.3 The Contractor shall inform the Engineer at least 10 working days prior to undertaking the installation of the equipment. The Contractor shall make due allowances in his construction programme for delays which may arise on account of the installation of the instruments and of their maintenance.
- 1.5.4 The Contractor shall provide a geotechnical engineer or engineering geologist, as approved by the Engineer, experienced in the installation of geotechnical instrumentation for full time supervision of the drilling of boreholes and installation of the instrumentation equipment. The Contractor shall instruct a member of his engineering staff in the use of the equipment.
- 1.5.5 Boreholes for instruments are to be formed by a reputable AGS accredited ground investigation sub-contractor in accordance with the UK Specification for Ground Investigation (Second Edition). They may be drilled by any method provided that it results in a clean and stable hole of the required diameter to the correct depth. The holes are to be formed and instruments are to be installed by a BDA accredited driller with a NVQ Level 2 qualification in Land Drilling for the equipment used. Additional requirements regarding the drilling and supervision of the installation of Borehole Rod Extensometers are given below. Boreholes shall be cased to their full depth unless strata are sufficiently competent for the hole to stay open. Drilling mud or polymer additives shall only be used with the prior approval of the Engineer. The Engineer is to be given 2 weeks' notice if mud or polymers are proposed. In the case of piezometer installation, drilling mud or polymer additives shall not be permitted.
- 1.5.6 During drilling, care shall be taken to ensure that the minimum material is lost from outside the casing. Surging casing shall not be allowed and flushing of drilling water up the outside of the casing shall be minimised.
- 1.5.7 The method of borehole formation, including the procedure for advancing casing, shall be submitted to the Engineer for approval 2 weeks before the commencement of the works. The works shall not commence until such time as the Engineer has approved the proposals.
- 1.5.8 A small disturbed sample and a bulk disturbed sample shall be taken during drilling of the boreholes at 1.0m centres and at every change in stratum. SPTs are to be performed at 1m intervals. If an SPT test is undertaken at the base of a borehole, it shall be ensured that the borehole extends at least 200mm beyond the base of the SPT test and cleaned out. A geotechnical log shall be produced in accordance with BS5930:2015 from the samples and borehole records submitted to the Engineer one working day after drilling has been completed at that location. The logs are to include full details of any instruments constructed along with specific details of any grout used and associated volumes. The logs are to include the National Grid coordinates of the device and the ground level at time of installation in m OD.
- 1.5.9 For all piezometers placed in boreholes, grouting is required for part or all of the borehole during installation. The grout shall be a bentonite: cement mixture with sufficient water to

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achieve a pumpable mix. For piezometers it shall be ensured that grout placement does not affect the response zone. Grout shall be poured or pumped into boreholes using a tremie pipe. Specific requirements for Borehole Rod Extensometers are given below.

- 1.5.10 All instruments shall be labelled with their reference number at the location where readings or measurements are to be taken. The labelling shall be permanent using a method or material to be agreed with the Engineer.
- 1.5.11 The Contractor shall provide suitably qualified and competent staff to take readings of instruments during construction and provide measurements/data at the time the instruments are read. The Contractor shall submit names and evidence of competence of personnel to carry out the instrumentation installation and commissioning for the approval of the Engineer before the commencement of the Works.
- 1.5.12 All records produced for the instrumentation must include the following data:
- Project name
 - Contract name and number
 - Instrument reference number and type
 - Dates of installation, reading or summary
 - Times of installation or reading
 - National Grid co-ordinates
 - Personnel responsible for undertaking the monitoring
 - Any relevant comments or remarks
- 1.5.13 The Contractor shall prepare an installation record sheet for each instrument installed. The format of the sheet shall be prepared by the Contractor and submitted to the Engineer for approval at least one week before installation commences. The record sheet shall include the following information in addition to the general information required:
- Existing ground level at the time of installation
 - Location in plan and elevation – Planned and 'As Built'
 - Orientation – Planned and 'As Built'
 - Lengths, widths, diameters, depth and volumes of backfill – Planned and 'As Built'
 - Equipment used, including diameter and depth of any drill casing used
 - Spaces for necessary measurements or readings required during installation to ensure that all previous steps have been followed correctly, including acceptance tests
 - A simplified log of ground conditions (obtained during each boring)
 - Type of backfill used
 - Weather conditions
 - Space for notes, including problems encountered, delays, unusual features of the installation and any events that may have a bearing on instrument behaviour
 - record of commissioning information and readings
 - Any colour coding used
 - Additional requirements for Borehole Rod Extensometers are as given below
- 1.5.14 The Contractor shall submit to the Engineer a copy of each installation report sheet within one working day of completion of the installation, including taking of base readings.
- 1.5.15 The Contractor shall maintain the instrumentation in working order throughout the Contract or until the Engineer informs him that monitoring is no longer required. The Contractor shall ensure that the frequency of monitoring is adequate and in compliance with all requirements for control of construction and associated monitoring of constructions, as detailed on the Drawings.

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Rod Settlement Gauges

- 1.5.16 Steel plate settlement gauges (300mm square) shall be placed at excavation formation level. Monitoring of these and analysis of the data obtained should enable determination as to when the rate of settlement has suitably reduced and therefore when the surcharge can be removed.
- 1.5.17 The plates shall have a welded $\frac{3}{4}$ " BSPF socket and are to be connected to reference rods which will extend through the surcharge materials. The steel rods are to be in 1m lengths and to have a 25mm OD with a $\frac{3}{4}$ " BSPF thread and external socket. The settlement gauge base plate and first length of rod shall be placed as early as possible during the earthworks, i.e. before any filling has taken place in the vicinity of the settlement gauge location. Extension lengths shall be installed when the level of the surrounding materials has been brought up to 250mm below the top of the preceding length. Levels shall be taken of the top of the rod and the surcharge fill adjacent to the gauge (i.e. outside the manhole ring) on each occasion. When rods are extended, levels (including the level of the base plate upon addition of the 1st rod) shall be measured immediately before and immediately after adding the extension. Good levelling practice should be observed.
- 1.5.18 Protective tubes will be placed around the reference rods as the surcharge are placed. These are to have an internal diameter of 52mm. In addition, manhole rings shall be placed around the settlement gauges and associated rods, which are to be brought up progressively with the formation of the surcharge. Between the manhole ring and the protective tube, Class 6L (sand) shall be evenly placed. This is also to be brought up at the same rate as the construction of the surcharge. Care will be taken so as to prevent the sand from entering the protective tube.
- 1.5.19 Any fill placed around a settlement gauge should be placed in a 5m x 5m area using small manoeuvrable suitably sized compaction plant to avoid the risk of disturbance to the monitoring rod. The fill should be placed in layers of a thickness appropriate to the materials and compaction plant used. A method statement shall be provided by the contractor for approval by the Engineer 2 weeks prior to the works.
- 1.5.20 The following data shall be recorded for the settlement gauges and similar settlement monitoring equipment:
- Original ground level at the gauge location (m OD)
 - Reduced level of the top of the rod (m OD) and length of rod(s) from this level to base plate (m)
 - The reduced level of the base plate (mOD)
 - Reduced level of the ground adjacent to the gauge (m OD)
 - A record of the height of fill placed and the start/finish dates of filling
 - The total thickness of the fill (m)
 - A record of extensions to the gauge, including before/after reduced levels of the gauge
 - The settlement of the plate relative to base readings and previous readings (m)

Borehole Rod Extensometers (Sequence B)

- 1.5.21 As shown on design drawings and as discussed above, in parts of the site materials shall be placed to form surcharge prior to any other construction activity (Sequence B). Prior to the placement of these surcharge materials Borehole Rod Extensometers (BREs) shall be constructed from current ground level.
- 1.5.22 A co-ordinated method statement shall be provided by the Contractor 2 weeks prior to the works encompassing input from the specialist manufacturer, the specialist ground investigation sub-contractor (the installer) and the Contractor. This shall be based on the equipment trial

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previously undertaken by the Contractor with any improvements considered necessary or beneficial to performance highlighted.

- 1.5.23 Based on a trial previously undertaken by the contractor the BRE equipment shall comprise:
- Geosense 3 point hydraulic borros anchors
 - Geosense 5mm GRP Rods with Geosense GRP Rod Flexible Sleeves
 - GXB2-300-VW-F Reference Head
 - VWDT-5000 300mm displacement gauges with cable - 900/M/04/022/PUR/OG/5.0 per m attached.
 - Rod and sleeve system attached to head to survey level of head (consisting of lengths of 3/4" X 1M PIEZOMETER PIPE TT with an inner rod of M10 stainless steel studding with survey cap)
 - Geosense Wi-SOS 480 wireless data acquisition system
 - Wi-SOS gateway (if one not already present on site)
- 1.5.24 The Reference Head shall have a borros anchor attached to it so as to ensure that the head is in a fixed position and to protect against buoyancy uplift.
- 1.5.25 A basal borros anchor shall be installed in undisturbed Weald Clay. This basal anchor shall be installed at least 2m below the level from which this comprises either stiff or very stiff clay or mudstone. A second borros anchor shall be installed mid depth between the headworks and the base of compressible strata (Made Ground and/or Alluvial soils and/or very soft or soft clays as established by drilling operations). At the discretion of the Engineer, this second anchor can be omitted where the thickness of compressible strata below the headworks is less than 4m. The reference head is to be installed at the proposed Excavation Formation level or within 0.5m of this level.
- 1.5.26 If the installation of an anchor indicates the potential for an issue, the expert installer (see below) is to propose remedial action to the Engineer.
- 1.5.27 The drilling technique utilised in the trial is to be adopted so as to facilitate installation of the reference head and associated equipment at the depth indicated above. This is to include a step down in drilling diameter so as to form a suitable ledge to support the reference head and associated equipment. The equipment to have a suitable flange that will sit on the ledge thus formed. A sketch and details of this operation are to be provided in the Method Statement. If the Contractor is unable to form a stable platform for the equipment the Engineer is to be contacted and additional attempts at drilling/installation are to be made. The equipment shall be capable of recording both settlement and heave and to have a total travel of at total travel of 300mm.
- 1.5.28 The headworks must ensure that the survey rod and sleeve are protected and nodes are not at risk of submersion. Any cables shall be suitably protected from damage, shall be waterproof, robust and to be able to withstand ground movements associated with surcharge loading and unloaded. The contractor is to detail damage protection measures in his Method Statement but shall comprise, as a minimum, manhole rings filled with sand and suitably obvious warning signs.
- 1.5.29 Should the equipment trial result in modifications to the above being considered necessary or beneficial for the performance of the monitoring to be undertaken, then proposals (including the technical benefit that would arise from the change clearly stated) shall be submit not less than 2 weeks in advance of the works.
- 1.5.30 The installation of the shall be supervised on site by a suitably qualified technical expert provided by the specialist manufacturer. This shall be a named individual and they must have

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at least 5 years of direct experience of satisfactory installation the equipment required for this contract. This expert shall provide clear instruction to the Contractor so as to ensure the safe and satisfactory installation of the equipment, including but not limited to the selection of appropriate grout so to facilitate installation without compromising its ability to accurately measure ground movements

- 1.5.31 If, as the works progress, issues are experienced shall that the expert has concerns regarding the adequate performance of the equipment, the expert is to present alternative or remedial solutions to the Engineer for agreement.
- 1.5.32 The expert outlined above shall be on site full time so as to supervise and witness drilling and installation of the BREs at least five locations. During this period the expert is to provide suitable training to the specialist ground investigation contractor's named personnel undertake further installations without his/her presence on site. For each item below the expert shall sign off as being installed to his satisfaction:
1. Each anchor
 2. The grout used at each hole
 3. Each reference head and sensor set up
 4. Each set of wireless telemetry equipment
 5. Each head works (300mm rod travel)
 5. Each back up system
 6. The protection measures deployed at each location
- 1.5.33 The expert shall also confirm in writing that each BRE installation as whole has been constructed to his instructions and confirm that the installations shall prove reliable ground movement data for at least 1 year.
- 1.5.34 The specialist installer shall provide a brief report providing full details of all the drilling, the equipment deployed and the depths at which each element was installed (m OD and m bgl) and the ground conditions at that location. This is to include full details of grouts and grout volumes used. This is to provide comment on the functioning of the equipment during the establishment of baseline conditions. The report is to detail any revisions to the equipment installed and the technical reasoning behind any such revisions. If considered technically beneficial the report is to provide recommendations for further revisions. The report shall have a full set of relevant finalised and engineer verified borehole logs appended.
- 1.5.35 Based on the above expert will also sign off named personnel as competent installers. If this cannot be done, the expert is to remain on site until such time that he/she able to provide such sign off. At this stage the expert is no longer required to be on site full time, but is to be retained so as to provide sub-consultancy services as required. At this stage the specialist sub-contractors professional staff are to be responsible for signing off each installation based on the above criteria and for the provision of full records regarding the constructed installations as outlined above.
- 1.5.36 The following data shall be recorded for the BRE Equipment:
- Original ground level at the BRE location (m OD)
 - Reduced level of the reference head (m OD)
 - Reduced level of the anchors (m OD)
 - The ground Level at the time of each monitoring observation (m OD)
 - The total thickness of the fill (m)
 - The settlement of the reference Head relative to the basal anchor relative to the baseline data and previous readings (mm)

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- The settlement of any other anchors relative to the basal anchor relative to the baseline data and previous readings (mm)

1.5.37 After installation and after any associated curing period for the gout used monitoring is to be undertake for a minimum of at least 2 weeks so as to provide baseline data. No fill is to be placed until the Engineer is satisfied that sufficient base line data has been recorded. During each lift of surcharge materials, the ground level at each BRE is to be recorded so as to facilitate the above.

Piezometers

- 1.5.38 Generally, prior to placing Engineered Fill vibrating wire piezometers (VWP) shall be installed from the base of the excavation. The exception to this are areas where surcharge is to be formed prior to other earthworks activities, as shown on drawings and out lined above (Sequence B). At these locations the piezometers are to be installed from existing ground level. Piezometers response zones will be installed in the underlying pre-existing Made Ground materials. The piezometer locations and response zones are shown on drawings. The VWPs would need to be installed prior to any nearby BREs so as to reduce the risk of potential disturbance.
- 1.5.39 The piezometers shall be of the VWP-3000 type and are to be installed by a specialist ground investigation subcontractor who is a member firm of the AGS. Piezometers are to be installed in accordance with the UK Specification for Ground Investigation (2nd Edition). The equipment shall be installed strictly in accordance with the manufacturer's instructions.
- 1.5.40 Prior to installation of piezometers, the piezometer tips shall be thoroughly saturated by boiling them in previously de-aired water. The piezometer shall be assembled and connected to the tubing while still underwater and the entire arrangement kept saturated and filled with de-aired water for at least 24 hours and until it is installed.
- 1.5.41 The following data shall be provided from the VWP readings:
- Water pressure reading (m water)
 - File name of data stored on the data logger
 - Reduced level of piezometer tip as installed (m OD)
 - Reduced level of ground adjacent to piezometer (m OD)
 - Estimated or measured settlement of piezometer tip (m)
 - Water head (m OD)
 - Water level (m OD)
 - Change in water head relative to base reading (m)
- 1.5.42 Initial readings shall be taken to demonstrate when conditions have stabilised following installation. Further readings shall be taken as given in Table 1. Monitoring and analysis by the contractor of this data should enable the rate of land raising to be controlled by preventing a build-up of destabilising excess porewater pressures (which could otherwise result in an increased risk of shear failure) and will aid the Engineer in identifying when the rate of settlement has been suitably reduced. The piezometers shall be remotely monitored using data loggers and associated equipment (Contractor to submit proposals 2 weeks ahead of installation).
- 1.5.43 Available ground investigation data suggests that the groundwater level at the site can vary considerably with location and with time. This may limit the usefulness of the piezometer data. This matter is to be kept under review by the Engineer.

General Monitoring Requirements

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- 1.5.44 All level monitoring and surveying should be accurate to within ± 1 mm in the vertical plane and ± 2.5 mm in the horizontal plane.
- 1.5.45 Monitoring of settlement gauges and piezometers is to commence at least 5 days before earthworks materials are placed. The frequency of monitoring observations is given in Table 1 below. In all cases the frequency of readings may be altered at any time by the Engineer if circumstances so dictate.

Table 1: Instrument Reading Frequency Summary

Instrument	Initial Reading(s)	Commence Sequential Readings	Initial Sequential Frequency ¹	Subsequent Frequency ¹	Surcharge Removal ^{1,2}
Rod Settlement Gauges	Survey position and level immediately following installation	5 days prior to placement of earthworks in the surrounding area	Daily (Monday to Friday) until 15 days have elapsed past completion of surcharge earthworks. Then twice weekly until one month has elapsed.	Weekly for the three subsequent months and then monthly	Daily until 2 weeks after the surcharge is fully removed, then as advised by the Engineer subject to results from the 2 week period.
Borehole Rod Extensometer	Daily for a minimum of 2 weeks	Daily post installation	Daily	Daily	Daily
Piezometers	Daily following installation until stable reading obtained. Readings can then be suspended until commencement of sequential readings	5 days prior to placement of earthworks in the surrounding area	Daily (Monday to Friday) until 15 days have elapsed past completion of surcharge construction. Then twice weekly until one month has elapsed	Weekly for the three subsequent months and then monthly	Daily until 2 weeks after the surcharge is fully removed, then as advised by the Engineer subject to results from the 2 week period.

Note: 1. This period may be extended by the Engineer if monitoring suggests insufficient diminution of settlement rate or pore pressures.

2. The surcharge removal and heave monitoring is a two phase operation as outlined below.

- 1.5.46 For each 40x40m area of treatment the twice weekly, weekly and monthly observations are to be made on the same day. To achieve this when different installations are completed at different times in one location, an initial interval shall be reduced to achieve synchronisation, rather than extended.
- 1.5.47 During the monitoring programme, the Contractor shall report on results twice a week from initial reading through to 15 days after completion of the surcharge placement, and then at weekly intervals.
- 1.5.48 The Contractor shall be responsible for preparing a final factual report (paper and pdf copy) of the instrumentation, installation and monitoring, and including graphical plots of the monitoring results. The draft reports shall be forwarded to the Engineer for comment within 2 weeks following physical completion of the works. The Contractor shall forward 2 bound copies of the final report to the Engineer the within 2 weeks of receipt of any comments from the Engineer.

APPENDIX 6/13: GROUND IMPROVEMENT***Calibration Requirements***

- 1.5.49 The Contractor shall test the whole instrumentation installation by taking three sets of base readings at suitable intervals and shall provide two copies of the results to the Engineer and shall satisfy him that all instruments are functioning correctly and readings are repeatable before the associated earthworks are commenced.
- 1.5.50 After installation, the functioning and monitoring of each instrument shall be demonstrated to the Engineer, including the recording of measured values using the appropriate readout device. As part of the commissioning, three sets of readings shall be taken and compared. If there are significant differences or anomalies, then further readings shall be taken. For instruments installed prior to the earthworks commencing this process is to be repeated at the start of the earthworks. Once two sets of comparable data have been obtained, these shall be averaged to form the base reading, representing the conditions before the start of earthworks.
- 1.5.51 In cases where instruments are installed during earthworks, three sets of readings shall be taken in quick succession and the results compared. These results shall be used to provide base readings in a manner to be agreed with the Engineer.

Protection of Instruments

- 1.5.53 The Contractor shall take all necessary precautions to protect the instruments and maintain the instruments in good working order after commissioning. For all instruments which project through and above the fill, special precautions shall be taken to provide protection from vehicles and plant, including substantial and readily visible barriers at a distance of no less than 750mm around each instrument.
- 1.5.54 Heavy compaction equipment shall not approach within 5m of projecting instruments. Compaction around any cabling to be by hand held tools and to be in accordance with the manufacturer's requirements.
- 1.5.55 Cables and connections are to be of a form that can withstand the subsequent placement of materials settlement and weathering they are to have appropriately welded joints and protection as needed to ensure they do not malfunction under loading of soils and traffic. Adequate cable slack shall be provided during installation to prevent failure as a result of stretching. If the specialist installer wishes to propose an alternative design to ensure the protection of cables this shall be submitted to the Engineer with an associated method and design 14 days prior to works and subject to the Engineer's approval. The cabling shall not be placed within the Engineered Fill as this could present a potential hydraulic pathway.
- 1.5.56 Adequate protection measures shall be provided for all new and existing instrumentation to protect it from vandalism or damage during construction.
- 1.5.57 Any damage to instruments or cabling shall be reported immediately to the Engineer. Damaged instruments and cabling shall be replaced or repaired by the Contractor at his own expense within seven days of its reported damage.
- 1.5.58 Should any settlement monitoring location be damaged or moved, a new level should be taken on the damaged rod immediately and the incident reported to the Engineer. Earthworks must be suspended in that area until the problem has been resolved. Replacement of the damaged rods and plates may be required.

1.6 Surcharge Removal

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- 1.6.1 The surcharge is only to be removed when instructed by the Engineer based on 1.3.8 and 1.3.19. During and after each stage of soil removal the settlement gauges are to be monitored. For each stage this monitoring is to continue until, to the satisfaction of the Engineer, any heave has effectively ceased.
- 1.6.2 (Sequence A)
- The surcharge removal is to be done in two stages comprising (i) lowering the surcharge mound by 2m and (ii) then removal of the remaining surcharge materials down to bulk earthworks level with due allowance for the amount of settlement recorded during monitoring.
- 1.6.3 Removal of the surcharge shall be a controlled operation so as to minimise damage of the any underlying Engineered Fill. Once the surcharge has been removed and once instructed by the Engineer based on 1.6.1 above, the Rod Settlement Gauges are to be grubbed out and reinstated with Engineered Fill so as to ensure that the Engineered Fill is as specified and its integrity as a low permeability layer maintained.
- 1.6.4 Once the materials have been removed as outlined above the formation is to be inspected for any soft spots or relict surcharge materials, which are to be removed and placed with Engineered Fill placed and compacted in accordance with this specification. The whole surface is to be recompacted using the same compaction technique used in its initial construction, the surface surveyed and, if required, brought up with the same materials placed and compacted in accordance with the specification.
- 1.6.5 (Sequence B). The exception to the above is areas where, as shown on plans provided by the Engineer, surcharge is to initially be placed from current ground level with excavation and filling operations to be undertaken subsequently (i.e. Sequence B). At these locations, the materials are to be removed in three phases (i) excavation to 2m above Bulk Earthworks level, (ii) Bulk Earthworks Level and (iii) Excavation Formation Level.
- 1.6.6 During and after surcharge removal operations care shall be taken by the contractor to prevent damage or disturbance to the RSGs or BRE equipment in a way that could detrimentally influence the monitoring results (e.g. vibrations from plant, including haulage plant). Temporary haul roads are to be constructed no closer than 10m from the RSGs/BREs. Such requirements apply to the RSGs and BREs until the Engineer instructs their removal. The process for maintaining the equipment during the excavation of the materials shall be proposed by the Contractor and agreed with the Engineer not less than 2 weeks prior to the removal of surcharge.
- 1.6.7 At the start of the surcharge removal operation all the RSGs are to be resurveyed. As the surcharge is removed the RSGs are to be sequentially dismantled in such a manner that they can still be used to determine movements of their respective base plates. This it to be a closely controlled operation undertaken by the contractor. Levels shall be taken of the top of the rod and the fill adjacent to the gauge on each occasion. When rods are removed, levels (including the level of the base plate upon removal of the final rod) shall be measured immediately before (on the rod to be removed and that left in situ) and immediately after removal (on the rod length left in situ). Good levelling practice shall be observed.
- 1.6.8 During surcharge removal, the Contractor shall report on monitoring results (see Table 1 above for monitoring frequency) daily from commencement of surcharge removal in the vicinity of the RSG through to 2 weeks after complete removal. The need for and frequency of any continued monitoring and reporting shall be reviewed by the Engineer after the initial 2-week period.
- 1.6.9 Where excavation and filling operations are to follow surcharging (Sequence B), upon instruction from the Engineer upon completion of the heave monitoring, the BRE piezometer

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headworks are to be removed and the associated boreholes are to be decommissioned in accordance with the Environment Agency publication 'Good Practice for Decommissioning Redundant Boreholes and Wells' October 2012.

1.7 Survey of Completed Works

- 1.7.1 On completion a full 3D topographic survey referenced to ordinance datum is to be undertaken to enable a cross check against design formations to be undertaken.

1.8 Reporting of the Surcharged Area

- 1.8.1 See CI 1.5.31, CI 1.5.32 and 1.6.6 for frequency of reporting associated with monitoring.
- 1.8.2 On completion of the works a detailed Ground Treatment Completion Report will be provided by the Contractor for each sub-phase (refer to 11950-SK107 for sub-phases) subject to surcharge treatment. The reports will describe the procedures undertaken at the site and include all relevant factual data for the ground treatment works. They shall also include information needed for completion of the geotechnical feedback report as defined in Design Manual for Roads and Bridges (BMRB) HD22/08 Managing Geotechnical Risk.
- 1.8.3 This reports shall include all relevant site records and illustrate that the remedial and ground preparation works have been carried out in accordance with the design. The report is to be provided at the conclusion of the works (including the surcharge/monitoring period).
- 1.8.4 The reports shall include but not be restricted to:
- As required by Appendix 6/3 S22
 - any supplementary ground investigation undertaken;
 - the design information and design revisions or additional design work that arise during the works;
 - all records referred to elsewhere in this specification;
 - full details of all instrumentation and associated ground conditions;
 - all monitoring data associated with the works.
- 1.8.5 The reports shall also include:
- daily record sheets to include a summary of the day's activities in relation to the ground improvement operations;
 - progress photographs;
 - general description of the works completed, including any earthworks, excavations (including excavations of hard obstructions or foundations), placement and compaction methodology and plant used;
 - information on weather conditions;
 - application of acceptability criteria and a summary of control test results sufficient to allow interpretation by the Engineer for each specific earthworks material placed during the ground improvement operations;
 - geotechnical test certificates and monitoring data including location and level, with associated drawings;
 - as built surveys (to include drawings);
 - drawings showing the location and level of each specific earthworks material placed during the ground treatment operations, any feature or operation relevant to the works including instrumentation and the location of trial areas and control tests;
 - Full as-built details of all monitoring instruments installed and associated exploratory hole records;
 - All monitoring data relating to surcharge monitoring or as otherwise required by this Specification.

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APPENDIX A

EARTHWORKS – SUPPLEMENTARY INFORMATION FOR SITE SURVEYOR

- Set out and establish the level and coordinates of a stable datum monitoring point remote from the influence of the works to which subsequent monitoring will be related.
- Set out monitoring station plate positions, using suitable co-ordinates and record the existing ground level.
- When the monitoring station plate is positioned record precisely the level of the base plate, plus the top of the first rod fitted.
- During the earthwork and surcharge operations, monitor on a daily basis the precise level of the top of rod on each monitoring station plate together with the surface level of the adjacent Engineered Fill.
- When monitoring station rods are raised during earthworks, level the top of the existing rod, top of the new rod placed and the then existing adjacent ground level.
- Survey the positions extent and levels of completed surcharge mounds for checking against design.
- Survey the finished level of the engineered material using a 25m grid and check that the design tolerances have been achieved.
- Survey the finished level of the base of the treated material using the 25m grid and check that the design tolerances have been achieved.
- Survey compliance test locations and levels within the Engineered Fill.
- Provide the foregoing services for any trial loading panels specified.
- All monitoring station levels should be recorded to an accuracy within + or – 1mm using an automatic barcode reading level.

APPENDIX 6/14: LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

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TABLE 6/14: (11/04) LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

	Units	Upper 2.00m Engineered Fill*	General Fill Beneath 2.00m final earthworks level **
GENERAL REQUIREMENTS			
Asbestos ^c	% weight	<0.001	<0.1
Arsenic ^a	mg/kg	37	n/a
Cadmium ^a	mg/kg	26	n/a
Chromium (total)	mg/kg	910	n/a
Lead ^a	mg/kg	200	n/a
Mercury (total)	mg/kg	40	n/a
Selenium	mg/kg	250	n/a
Nickel	mg/kg	180	n/a
Copper	mg/kg	2400	n/a
Zinc	mg/kg	3700	n/a
Benzo(a)pyrene ^a (use as surrogate for PAH)	mg/kg	5.0	n/a
TPH Total ^b	mg/kg	260	n/a
Aliphatic >C5 – C6	mg/kg	42	n/a
Aliphatic >C6 – C8	mg/kg	100	n/a
Aliphatic >C8 – C10	mg/kg	27	n/a
Aliphatic >C10 – C12	mg/kg	130	n/a
Aliphatic >C12 – C16	mg/kg	1100	n/a
Aliphatic >C16 – C21	mg/kg	1100	n/a
Aliphatic >C21 – C35	mg/kg	1100	n/a
Aromatic C5 – C7	mg/kg	70	n/a
Aromatic >C7 – C8	mg/kg	130	n/a
Aromatic >C8 – C10	mg/kg	34	n/a
Aromatic >C10 – C12	mg/kg	74	n/a

APPENDIX 6/14: LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

	Units	Upper 2m of Engineered Fill *	General Fill Beneath 2m below final earthworks level
GENERAL REQUIREMENTS			
Aromatic >C12 – C16	mg/kg	140	n/a
Aromatic >C16 – C21	mg/kg	260	n/a
Aromatic >C21 – C35	mg/kg	1100	n/a
Phenols	mg/kg	120	n/a
Cyanide (total) ^c	mg/kg	18	n/a
pH	Units	5 – 10	n/a
* based on a residential with plant uptake end use ** 1 sample every ten will also be analysed for the full suite (i.e. as per the samples for the upper 2m engineered fill) S4ULs used unless otherwise stated (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL 3036. All rights reserved) ^a – C4SL used ^b – Based on the S4UL for Aromatic C16 – C21 but assumes no petroleum hydrocarbon contamination is present ^c – S4UL and C4SL not generated, use in-house GAC/value			

1.0 LABORATORY AND SAMPLING REQUIREMENTS ARE PROVIDED BELOW**1.1 Purpose**

- 1.1.1 The works specified herein are required to ensure a minimum standard for the preparation and receipt of analytical data from the works for comparison to the Limiting Values set for the works. The Contractor shall also satisfy the requirements of BS 5930 and 10175, as subsidiary standards in the completion of all fieldworks and sampling and any supplementary investigations required. In addition, works shall be undertaken in accordance with the ICE Specification for Ground Investigation (2nd Ed). This document shall be read in conjunction with other related Specifications and where any ambiguity arises this shall be clarified with the Engineer.

1.2 Protocol

- 1.2.1 The Contractor shall supply suitably qualified specialist environmental staff to carry out the monitoring works. All sub-contractors should have in place appropriate written quality control and quality assurance procedures. Evidence of UKAS and MCERTS accreditation for the specified chemical analytical testing and testing laboratory shall be provided to the Engineer. All testing shall be UKAS and MCERTS accredited where this is currently available. All sampling, monitoring and subsequent analysis shall be documented and managed using a Chain of Custody system to track the fate of all samples. All field and laboratory analytical results shall be reported to the Engineer for review and subsequent inclusion within the Contractor's Validation Reports.

APPENDIX 6/14: LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT**1.3 Laboratory Testing**

- 1.3.1 All preparation, testing and reporting shall be where applicable in accordance with the relevant British Standards. Where tests are not covered by British Standards they shall be performed in accordance with the procedures in the references or as described in the Schedules. Analysis of samples will also be required for waste classification purposes. The scope of such testing shall be determined by the Contractor in accordance with the technical requirements of Environment Agency guidance for Waste Classification (EA Document WM2 as revised (assumed to be WM3 circa 2015)).

1.4 Personnel

- 1.4.1 The Contractor shall nominate an individual Technical Advisor to control all processes associated with site investigation, analysis and data management. The person should be suitably qualified. Details of the required qualifications for each of these proposed designations are given in SITE INVESTIGATION STEERING GROUP, *Site investigation on construction. Part 2: Planning procurement and quality management of site investigation*. London: Thomas Telford, 1993. This person shall be Qualified as Section 2.2e (or greater) e.g. a Chartered Engineer/Geologist/Environmental Scientist with at least 5 years of relevant experience.

1.5 Further Investigation

- 1.5.1 Where any additional site investigation, including groundwater monitoring or associated boreholes, are required, the Contractor shall submit proposals for the scope and detail of works proposed for the approval of the Engineer. This shall accord with the requirements of the technical standards noted above.

2.0 SAMPLING PROTOCOL

- 2.1 Samples of suspected contaminated ground, groundwater and leachate for chemical analysis shall be taken in accordance with BS10175 and the companion publication (UK Specification for Ground Investigation, 2nd edition (Site Investigation Steering Group, 2011) under the supervision of an appropriately qualified environmental scientist (SISG 2.2d or more).
- 2.2 The size and type of sample and container, method of sampling and time limitations for carrying out specific analyses shall be commensurate with current guidance.
- 2.3 As a minimum: soil samples shall comprise as a minimum a 1kg plastic tub and 500ml glass bottle; and, water samples shall comprise a 1l plastic and 1l glass bottle.
- 2.4 Sampling shall be undertaken such that cross contamination between samples and sampling locations does not occur. Sampling utensils shall be stainless steel and shall be cleaned prior to the commencement of the excavation works as a minimum and between holes. Where visual or olfactory evidence of contamination is noted equipment shall be cleaned between each sample retrieval.
- 2.5 All samples shall be examined and described by a suitably qualified geotechnical engineer meeting the requirements of BS EN ISO 14688-1:2002. Samples of suspected contaminated ground and leachate shall be described by a qualified environmental or geotechnical person meeting the requirements of SISG Clause 2.2 item d). Descriptions shall include colour and smell with reference to specific inclusions.
- 2.6 All samples shall be labelled with sample location, depth, sample ID (job number, client reference, AGS sample type), time and date of collection. All samples for contamination analysis shall be stored and transported in cool boxes with pre-frozen ice packs and submitted

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directly to the laboratory from the site within 24hrs of sampling. Samples shall be protected to ensure that their temperature does not fall below 2°C or rise above 45°C. They shall also be protected from direct heat and sunlight.

- 2.7 A 'Chain of Custody' form shall accompany each batch of samples with a copy retained on-site during works and submitted to the Engineer with the exploratory hole logs. The Chain of Custody shall include the sample details in full combined with any special instructions indicated by the Engineer.

3.0 LABORATORY & ANALYTICAL METHODOLOGY ACCREDITATION**3.1 Accreditation**

- 3.1 The Contractor shall select laboratories which are compliant to ISO 17025 and MCERTs. Where necessary, the Contractor may need to use a range of laboratories to ensure that all reported results meet these accreditations. In particular, it is noted that all asbestos testing must be undertaken by a laboratory who are ISO 17025 accredited for the test. With respect to asbestos in soils analysis the laboratory proposed must have undergone an inspection in accord with UKAS ABS001 note during 2011.

4.0 DATA MANAGEMENT

- 4.1 All chemical data shall be provided in Adobe PDF, 'CrossTab' collated Microsoft Excel, and validated AGS 4.0 format. AGS data shall be complete with wider site data such as stratigraphy and sample coordinates. AGS data shall be compiled into a single file by the Contractor and forwarded to the Engineer on a weekly basis.
- 4.2 All laboratory test results must be submitted in **full** accordance with The Association of Geotechnical and Geoenvironmental Specialists (AGS) version 4 standard (available on the AGS website: <http://www.ags.org.uk/site/datatransfer/intro.cfm>). Each AGS data file must be checked for errors (i.e. must not contain warnings, structural or integrity errors) before it is submitted and it must be accompanied by an error log file to verify.
- 4.3 On receipt of the AGS file, the Engineer will check for errors before loading it into its central database. If any errors are found, the data shall be returned to the Contractor (accompanied with an error log file detailing all errors) for corrections and editing.
- 4.4 The Engineer will not accept and will return to the Contractor any data that does not meet the AGS standards or has not been checked (i.e. is not accompanied by an error-free log file).
- 4.5 In addition to the above requirements, chemical analysis spread sheets shall be provided in:
- Excel spread sheet format that shall follow a consistent order and format for rows and columns to allow direct referencing across a given row/column for either a single determinant across all exploratory samples or vice versa all results for a single exploratory sample;
 - Separate sheets shall be provided for the analysis results for soil, water, leachate and gas;
 - Each of the spread sheet fields shall be populated free of hidden data, spaces, or other insertions (other than explained symbols) that inhibit interpretation of data;
 - The detection limit applicable to each chemical analysis, agreed at appointment, shall remain consistent throughout the works; and,
 - The units of expression shall be consistent (e.g. micrograms or milligrams) and shall remain consistent throughout the works for a given medium and parameter.

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5.0 DATA QUALITY

- 5.1 Provision shall be made for a suitable quantity of blanks and duplicate sampling to be collected and analysed in order to express the sampling and analytical error.

6.0 DATA MANAGEMENT SYSTEM

- 6.1 The Contractor shall maintain a data management system in order to coordinate all validation testing, appraisals and reporting. This shall be kept current with works with a delay of no more than 2 weeks from the point of a given sample.
- 6.2 The Contractor shall provide the Engineer with results upon request and present a summary of results at the Progress Meetings of works.

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