



Queens Park, Millom, Cumbria
Phase II Geo-Environmental Assessment
For
Home Group

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Executive Summary

Site Investigation	The investigation involved: • Inspection of the desk study information. • 15 no. mini-percussion boreholes to a maximum depth of 5.45m (WS01 to WS15). • 1 no. hand excavated trial pit (HDP01) • Installation of 6 no. ground gas and water monitoring wells. • 4 no. variable head (falling) permeability tests. • Geotechnical and contamination related testing. • Ground gas and groundwater monitoring.
Ground Conditions	Made ground beneath the site was recorded within WS04, WS05, WS09 and WS10 to depths of between 0.30m and 1.20m below existing ground levels (begl). These materials generally comprised brown sandy clay with occasional brick fragments. The remaining investigation positions identified reworked topsoil comprising brown slightly sandy clay to depths of between 0.40m and 0.60m begl. Typically, the majority of the reworked topsoil or made ground was underlain by firm and stiff slightly sandy gravelly clay, with occasional sand and gravel bands, to depths of between 3.00m to 5.45m. Underlying these deposits within WS09 to WS12, sand and soft silty clays were recorded from depths of between 3.40m to 4.10m, extending to depths of between 4.50m to 5.00m (terminal depth of boreholes). At the locations of WS02 and WS06 a highly saturated slightly gravelly fine to coarse sand was identified to depths of between 2.10m and 3.00m. Probable bedrock was encountered within WS01 at a depth of 3.60m begl. Bedrock deposits were identified as an extremely weak grey laminated mudstone.
Groundwater	Groundwater was encountered during the investigation works within a number of the borehole positions at variable depths between 0.60m and 4.10m beneath the site. However, groundwater recorded appears to have a direct correlation to bands, lens and layers of granular deposits or deposits with high silt content. It should be noted that groundwater levels may vary seasonally and that a higher water table than recorded could occur. Based on the information to date, groundwater beneath the site likely represents perched groundwater rather than a continuous groundwater surface.
Gas Monitoring	Combustible ground gas (Methane) has not been detected, with Carbon Dioxide present to a maximum concentration of 3.8 %v/v, suggesting a BS8485:2015 and CIRIA C665 Characteristic Situation 1 (CS1) or NHBC Green. The final classification will be confirmed on completion of the remaining ground gas monitoring and is subject to change.

Contamination	Based on the results of the chemical analysis, no significantly elevated levels of contamination were identified within the majority of topsoil made ground screened from across the site, based on a residential end use. In addition, no asbestos was identified within any of the topsoil or made ground screened from across the site as a whole. However, an isolated level of non-volatile PAH contamination has been identified at the location of WS01 associated with the topsoil at this location. At present, due to generally limited testing within the immediate vicinity of WS01 there is considered to be insufficient data available to accurately assess whether the levels of PAH contamination are representative of an isolated 'hotspot' or are more pervasive within the reworked topsoil made ground below this area of the site. Therefore, in order to more accurately assess the level of risk to human health in this regard, it is recommended that further sampling and screening of the topsoil be undertaken around WS01 to evaluate the extent of the affected materials. In addition, to confirm that PAH contamination is not more pervasive within the made ground it is also recommended that additional sampling and screening be completed across the site as a whole. Based upon the findings of the above recommended works, should this area (WS01) be confirmed as being representative of an isolated 'hotspot' in order to negate any risk to future end users (i.e. human health) the most appropriate remedial solution for this site would be excavation and removal of the affected materials off-site to a suitable landfill facility. Following excavation this would effectively remove the source of contamination off-site and negate the requirement for further remedial measures (i.e. a dedicated clean cover system). Alternatively, if no further assessment works are undertaken based upon the soil screening completed to date, the most appropriate remedial solution for this site would likely be the implementation of a dedicated clean cover system within all areas of soft landscaping, to ensure an absence of risk to future end users (i.e. human health). When considering the generally low levels of contamination identified during the investigation works, no significant risk is anticipated to controlled waters.
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Remediation	At this stage, based upon the results of the soil screening two potential remedial options could represent viable solutions for this site, comprising the following: • Excavation and removal of PAH affected soils ('hotspot') from around WS01 off-site to a suitable landfill facility. The removal of contaminative materials with suitable validation testing, would remove the source off-site and therefore negate the risk to future end-users, resulting in no further remedial works being required. • The introduction of an engineered clean cover system (i.e. 600mm) within all areas of proposed soft landscaping, to provide a safe and permanent barrier against potentially contaminative substances within the made ground. To determine the most appropriate remedial solution for this site, further soil sampling and chemical analysis are recommended. Prior to commencing with any future remedial works, a detailed Remediation Strategy should be prepared and agreed with the Local Authority, and once implemented the remediation work should be validated by a suitably qualified engineer.
Off-Site Disposal	The results of the chemical analyses suggest that generally the made ground (topsoil) materials could potentially be classed as Inert for disposal. In addition, any natural soil is also considered to be likely suitable for disposal as Inert waste. However, it is recommended that the results of these investigation works be made available to the waste carrier/receiver in order to confirm the waste classification, costs for disposal and the potential requirement for further testing.
Concrete Design	Within the made ground water soluble sulphate concentrations ranged between <10mg/l and 72mg/l with pH values between 6.2 and 7.9. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-2_z. Within the natural drift deposits, water soluble sulphate concentrations ranged between <10mg/l and 17mg/l with pH values between 6.7 and 8.2. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-1.

Foundations Appraisal	The use of conventional foundations (i.e. strip or pad) is considered to represent the most viable option for this site, based wholly within the natural firm to stiff clay deposits at a minimum depth of 0.90m below finished ground levels. However, due to the occasional variability of the upper superficial deposits below the site, we would recommend an allowable bearing pressure not exceeding 100kN/m², with foundations suitably reinforced in order to minimise excessive differential settlements. When considering the localised more variable superficial deposits identified within WS02 and WS06, due to the potential for foundations to span between these deposits and surrounding more competent clay, it is recommended that footings around this location be suitably reinforced and designed to a reduced maximum allowable bearing pressure not exceeding 90kN/m², to avoid the potential for differential settlements to occur. Additional investigations following the demolition of current properties within the north eastern parts of the site (plots 59 to 66) are recommended in order to establish ground conditions. Upon completion of the additional intrusive investigations, appropriate foundation recommendations can be produced.
Surface Water Disposal	In view of the results of the falling head tests carried out, presence of generally impermeable clay superficial deposits below the site and evidence of shallow perched water within in the granular soils, where encountered, the use of soakaways for surface water disposal is not considered viable and alternative method will need to be explored.
Additional Investigations	Due to restrictive site access within parts the north eastern areas of the site, intrusive investigation surrounding plots 59 to 66 was unable to progress. As such, it is recommended that this portion of the site be targeted following the completion of demolition activities to ensure a site wide coverage is achieved prior to redevelopment. In addition to the above, it may be considered prudent to undertake additional mini percussive boreholes and mechanically excavated trial pits post demolition in order to access areas unavailable during the preliminary works and confirm general site wide ground conditions.

1 INTRODUCTION

1.1 3e Consulting Engineers Ltd (3e) were commissioned Home Group, to carry out a Phase II Geo-Environmental Assessment for a proposed development at Queens Park, Millom, Cumbria. Proposed development plans include the construction of residential dwellings, with associated access road/s, parking and soft landscaping, details of which are provided in **Appendix A**.

1.2 The following Phase II Geo-environmental Assessment Report was also produced for this site by 3e and should be read in conjunction with this report, referenced as follows:

- 3e Consulting Engineers Limited (3e), Phase I Geo-environmental Assessment, Queens Park, Millom, Cumbria (Ref: P18-498/P1, January 2019).

1.3 The investigation works were undertaken between 19th and 22nd November 2018, and comprised 15 no. mini percussive boreholes (referenced as WS01 to WS15) and 1 no. hand excavated trial pit (HDP01) with associated sampling and testing. In addition, a series of variable (falling) head tests were undertaken in WS01, WS06, WS10 and WS14.

1.4 The objectives of this assessment were:

- To investigate near surface soil and groundwater conditions.
- To determine the potential risks posed by any ground or groundwater contamination and provide recommendations on remedial measures to manage such risks.
- To assess the potential risk posed by hazardous ground gas.
- To provide advice relating to geotechnical issues associated with the site.
- To provide foundation recommendations.

1.5 This report presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the scope of works outlined above. It has been assumed in the production of this report that the site is to be redeveloped for a residential end use.

1.6 Responsibility cannot be accepted for any conditions not revealed by this investigation and which have not been taken into account by this report. Any diagram or opinion relating to

site geology, contamination or other spatially variable features between or beyond investigation positions is conjectural and provided for guidance only. Confirmation of ground conditions between exploratory holes should be undertaken if deemed necessary.

1.7 Evaluation of ground gas and groundwater is based on observations made at the time of the investigation and any monitoring visits, but it should be noted that levels may vary due to seasonal effects.

1.8 References to possible asbestos containing material made within this report do not constitute an asbestos survey. 3e are not asbestos specialists and cannot provide specific asbestos risk assessment advice, it is recommended that the Client appoints an asbestos consultant to advise on any matters relating to asbestos.

1.9 This report has been prepared for the sole use of Home Group. No other third party may rely upon or reproduce the contents of this report without the written approval of 3e. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and 3e do not owe them any Duty of Care or Skill.

2 THE SITE

Location and Description

2.1 The site centred on National Grid Reference 316610, 480160 and is located west of Millom town centre within the southern Lake District, Cumbria. A site location plan is included as **Drawing G001**.

2.2 The site is a residential estate located on the western parts of Millom, comprising terrace, semi-detached and detached houses with associated gardens, parking and road infrastructure.

2.3 The adjacent land use is as follows:

- North: A5093 and residential dwellings.
- South: Public Park and Black Combe Junior School.
- East: Residential dwellings with Millom town centre beyond.
- West: Residential dwellings with agricultural land recorded beyond.

2.4 During the walkover survey completed as part of the Phase I report, no visual evidence of contamination (i.e. asbestos, tanks, etc.,) was identified at the surface across the site.

3 METHOD OF INVESTIGATION

Fieldwork

3.1 The investigation works were undertaken between 19th and 22nd November 2018, and comprised 15 no. mini percussive boreholes (referenced as WS01 to WS15) and 1 Hand Excavated Trial Pit (referenced as HDP01), with associated sampling and testing. In addition, a series of variable (falling) head tests were undertaken in WS01, WS06, WS10 and WS14, to aid in assessing the permeability of the upper natural deposits below the site.

3.2 Copies of the exploratory hole records are included in **Appendix B** with their locations indicated on the Exploratory Hole Location Plans; **Drawings G002A** and **G002B**. All depths recorded are taken from below existing ground level and the exploratory holes were located within accessible areas of the site to provide a general coverage whilst also making allowance for existing access restrictions and buried utilities.

3.3 Due to restrictive site access within the north eastern parts of the site, intrusive investigation surrounding plots 59 to 66 was unable to progress. As such, it is recommended that this portion of the site be targeted following the completion of demolition activities to ensure a site wide coverage is achieved prior to redevelopment. In addition to the above, a hand excavated trial pit was undertaken within the rear to plot 11 in order to obtain samples for chemical screening and determine levels to natural strata.

3.4 The mini-percussive boreholes were sunk in order to determine the soil profile, with a series of combined ground gas and groundwater monitoring well also installed in WS01, WS04, WS06, WS07, WS10 and WS14. Disturbed samples were recovered as appropriate for soil descriptions and laboratory testing. In situ hand shear vanes (HSV) were carried out to provide an assessment of the in situ strength of the natural deposits below the site where arisings were suitable for testing.

3.5 The gas/groundwater monitoring wells, comprising slotted 50mm diameter HDPE pipe set within a granular filter, were installed in WS01, WS04, WS06, WS07, WS10 and WS14 to depths of between 3.70m and 5.00m. The wells were sealed at the base and surface using bentonite and a lockable cover was fitted. To date, the wells have been monitored on three occasions; 22nd November 2018, 14th January 2019 and 20th January 2019 for methane, carbon dioxide and oxygen using a portable infra-red gas monitor. The rate of gas flow from

the boreholes was also recorded using a portable flow meter and the groundwater levels were recorded using a portable dip meter. The results of the gas monitoring undertaken to date are included in **Appendix C**.

3.6 Fieldwork and soil descriptions were carried out in general accordance with BS5930:2015 Code of Practice for Ground Investigations and BS10175:2011+A2:2017: Investigation of Potentially Contaminated Sites – Code of Practice. In addition, where applicable reference has also been to CIRIA Publication C733 'asbestos in soil and made ground: a guide to understanding and managing risks'.

Laboratory Chemical Testing

3.7 In order to provide an assessment of potential contamination, 10 no. representative samples of made ground and reworked topsoil recovered from the mini percussive boreholes and hand excavated trial pit were screened for the range of determinands.

- 10 no. samples screened for Metals: Arsenic, Boron, Copper, Cadmium, Chromium (total), Chromium (VI), Lead, Mercury, Nickel, Selenium, Zinc and TOC.
- 10 no. samples screened for PAH's (USEPA 16).
- 7 no. samples screened for TPH's (TPH CWG).
- 10 no. samples screened for Asbestos (presence).

Laboratory Geotechnical Testing

3.8 Geotechnical related testing was carried out to determine the physical characteristics of the soils and comprised the following:

- 10 no. Atterberg limits determinations to classify cohesive soils.
- 2 no. Particle Size Distribution tests to confirm field descriptions.

3.9 In addition to the above, 7 no. samples of topsoil, 3 no. samples of made ground, and 4 no. samples of natural soil were scheduled for water soluble sulphate and pH determinations to assess the potential for sulphate attack on buried concrete. The results of the geotechnical test results are included as **Appendix E** whilst the results of the water soluble sulphate and pH analysis can be seen within the chemical analytical test report included in **Appendix D**.

4 RESULTS OF THE INVESTIGATION

Soil Profile

4.1 Detailed descriptions of the materials encountered together with observations of groundwater behaviour, the results of insitu testing and sampling information are given on the exploratory hole records included as **Appendix B**. A summary of the ground conditions encountered is presented below:

Made Ground

4.2 Made ground beneath the site was recorded within WS04, WS05, WS09 and WS10 to depths of between 0.30m and 1.20m below existing ground levels (begl). Made ground beneath the site was identified as brown sandy clay with occasional brick fragments.

Reworked Topsoil

4.3 The remaining investigation positions identified reworked topsoil comprising brown slightly sandy clay to depths of between 0.40m and 0.60m begl.

Natural Superficial (Drift) Deposits

4.4 Typically, the majority of the site was underlain by firm and stiff slightly sandy gravelly clay with occasional sand and gravel bands to depths of between 3.00m to 5.45m. Underlying these deposits within WS09 to WS12 sand and soft silty clays were recorded from depths of between 3.40m to 4.10m, extending to depths of between 4.50m to 5.00m (terminal depth of boreholes).

4.5 At the locations of WS02 and WS06 a highly saturated slightly gravelly fine to coarse sand was identified to depths of between 2.10m and 3.00m.

Bedrock

4.6 Probable bedrock was encountered within WS01 only at a depth of 3.60m begl. The deposits recovered were recorded as an extremely weak grey laminated mudstone.

Visual and/or Olfactory Evidence of Potential Contamination

4.7 During the investigation works, no visual and/or olfactory evidence of potentially significant contamination (i.e. hydrocarbons, etc.) was identified within the exploratory positions sunk during the investigation works.

In Situ Test Results

Hand Shear Vanes

4.8 Hand Shear Vane (HSV) readings carried out on undisturbed samples of the natural clay deposits beneath the site. In general, the site was dominated by a firm and stiff sandy clay which varied between 55kPa and 140kPa, though the majority of the tests undertaken averaged above 90kPa, which is indicative of high strength deposits. Silty clay underlies the initial sandy clays, encountered at depths of between 3.40m and 3.70m begl. These deposits recorded between 20kPa and 70Kpa, indicative of low to medium strength deposits.

Standard Penetration Tests (SPT)

4.9 SPT 'N' values were undertaken within both the cohesive and granular natural deposits beneath the site. Typically, the sand deposits encountered beneath the site recorded 'N' values of between 9 and 35, which are indicative of loose and dense deposits.

Variable (Falling) Head Tests

4.10 To aid in assessing the permeability of the upper soils below the site a series of variable head (falling) permeability tests were undertaken within WS01, WS06, WS10 and WS14.

4.11 Within boreholes WS01 and WS10, the results of the falling head tests recorded a coefficient of permeability values of $2.2 \times 10^{-8} \text{m/s}$ and $2.8 \times 10^{-8} \text{m/s}$, indicating a very low permeability classification and poor drainage characteristics.

4.12 Within boreholes WS06 and WS14, the results of the falling head tests recorded a coefficient of permeability values of $2.1 \times 10^{-7} \text{m/s}$ and $2.3 \times 10^{-7} \text{m/s}$, indicating a low permeability classification and poor drainage characteristics. However, it is considered within areas where significant thicknesses of granular deposits are present (i.e. WS06) groundwater at shallow depth would render the use of soakaways unsuitable.

4.13 It is considered the limited permeability identified within these locations is associated with the limited granular deposits recorded within the boreholes. The results of the infiltration tests are presented in **Appendix F**.

Groundwater

4.14 Groundwater was encountered during the investigation works within a number of the borehole positions at variable depths between 0.60m and 4.10m beneath the site. However, groundwater recorded appears to have a direct correlation to bands, lens and layers of granular deposits.

4.15 The results of the groundwater monitoring are presented in **Appendix C**. It should be noted that groundwater levels vary seasonally and that a higher water table than recorded could occur. Based on the information to date, groundwater beneath the site likely represents perched groundwater rather than a continuous groundwater surface.

Geotechnical Related Testing

4.16 The results of the geotechnical testing are presented in **Appendix E**.

Classification Tests

4.17 Ten Atterberg limit determinations made on the natural clay deposits at depths of between 1.00m and 2.00m gave plasticity indices of between 17% and 25%, with a modified plasticity indices of between 14.5% and 22.5%, indicative of clays of low to medium volume change potential.

Particle Size Distribution (PSD) Testing

4.18 Particle size distribution analysis was carried on two samples of the granular superficial deposits, to confirm field descriptions and classify these materials. From these results, the sample tested from WS02 indicates a generally well graded deposit comprising slightly clayey silty sand and gravel, whilst the sample from WS06 indicates poorly graded clayey very silty slightly gravelly sand.

Sulphate and pH Determinations

4.19 Within the made ground water soluble sulphate concentrations ranged between <10mg/l and 72mg/l with pH values between 6.2 and 7.9. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-2_z.

4.20 Within the natural drift deposits, water soluble sulphate concentrations ranged between <10mg/l and 17mg/l with pH values between 6.7 and 8.2. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-1.

Gas Monitoring

4.21 The results of the ground gas monitoring carried out to date between the 22nd November 2018 and 20th January 2019 are presented in **Appendix C** and are summarised in the following table.

Date	Location	CH ₄ (% v/v)	CO ₂ (% v/v)	O ₂ (% v/v)	Flow (l/hr)	Barometric Pressure (mb)	Maximum GSV*	
							CO ₂	CH ₄
22/11/18	WS01	0.00	0.10	20.10	<0.10	1027	0.0019	0.00
22/11/18	WS04	0.00	1.90	20.00	<0.10			
22/11/18	WS06	0.00	0.90	20.40	<0.10			
22/11/18	WS07	0.00	1.20	19.90	<0.10			
22/11/18	WS10	0.00	0.10	20.50	<0.10			
22/11/18	WS14	0.00	1.10	20.70	<0.10			

Date	Location	CH ₄ (% v/v)	CO ₂ (% v/v)	O ₂ (% v/v)	Flow (l/hr)	Barometric Pressure (mb)	Maximum GSV*	
							CO ₂	CH ₄
14/01/19	WS01	0.00	0.00	20.20	<0.10	1006	0.0002	0.00
14/01/19	WS04	0.00	2.00	19.70	<0.10			
14/01/19	WS06	0.00	1.10	20.00	<0.10			
14/01/19	WS07	0.00	1.10	20.10	<0.10			
14/01/19	WS10	0.00	0.10	20.30	<0.10			
14/01/19	WS14	0.00	1.30	19.80	<0.10			
20/01/19	WS01	0.00	0.20	19.50	0.50	1018	0.019	0.00
20/01/19	WS04	0.00	3.80	14.80	<0.10			
20/01/19	WS06	0.00	0.40	17.20	<0.10			
20/01/19	WS07	0.00	3.30	11.20	0.30			
20/01/19	WS10	0.00	2.80	4.20	0.30			
20/01/19	WS14	0.00	1.80	18.0	0.30			

* CIRIA 665 Gas Screening Value, based on maximum flow and concentration

4.22 In summary, Methane was not recorded whilst Carbon Dioxide was detected at a maximum concentration of 3.80%v/v. Negligible flow rates of <0.1l/hr were recorded during the monitoring. Based on the results of the monitoring completed to date, maximum initial CIRIA Gas Screening Values (GSV's) of between 0.0019l/hr and 0.019l/hr have been calculated for Carbon Dioxide.

4.23 At present, the preliminary GSV's for Carbon Dioxide fall below the GSV minimum assessment value of 0.07l/hr suggesting a BS8485:2015 and CIRIA C665 Characteristic Situation 1 (CS1) or NHBC Green Classification. However, a further 3 no. gas monitoring visits are planned and any conclusions may be subject to change until completion of the monitoring programme.

Contamination Related Testing

4.24 The results of the contamination related testing undertaken on samples of made ground and topsoil are included as **Appendix D**. Generally, the results have been assessed using the LQM/CIEH Suitable for Use Levels (S4ULs) for Human Health Risk Assessment

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4.25 Where no S4UL is available, reference is made to published DEFRA, SP1010L Category 4 Screening Levels (C4SL) with the use of these values considered to represent the more conservative approach for assessing the level of potential risk to Human Health. For the purpose of this report, all S4UL's or C4SL's will be referred to as Generic Assessment Criteria (GAC).

4.26 With respect to the assessment, as residential properties are proposed, the most appropriate values are considered to be the GAC's for a residential end use. Based on the laboratory results, a SOM of 1% has been used in the assessment. A summary of the contamination related testing is presented in the table on the following page.

Determinand	Minimum conc. mg / kg	Maximum conc. mg / kg	No of Samples Tested	Generic Assessment Criteria (GAC) ⁽¹⁾ mg / kg	No of Samples Exceeding GAC
Arsenic	<0.1	15	10	37	0
Boron	0.5	1.4	10	290	0
Cadmium	<0.2	1.2	10	11	0
Chromium (III)	<1	145	10	910	0
Chromium (VI)	<1	<1	10	6	0
Lead	2	181	10	200 ⁽²⁾	0
Mercury	<0.5	<0.5	10	40	0
Selenium	<0.3	1.10	10	250	0
Copper	<1	84	10	2400	0
Nickel	<1	29	10	130	0
Zinc	<5	333	10	3700	0
Speciated PAH's					
Naphthalene	<0.01	0.02	10	2.3	0
Acenaphthylene	<0.01	<0.01	10	170	0
Acenaphthene	<0.01	0.49	10	210	0
Fluorene	<0.01	0.74	10	170	0
Phenanthrene	<0.02	8.40	10	95	0
Anthracene	<0.02	3.10	10	2400	0
Fluoranthene	0.04	13.42	10	280	0
Pyrene	0.02	9.79	10	620	0
Benzo(a)anthracene	<0.02	5.37	10	7.2	0
Chrysene	<0.01	5.39	10	15	0
Benzo(b)fluoranthene	<0.02	5.26	10	2.6	1
Benzo(k)fluoranthene	<0.02	2.39	10	77	0
Benzo(a)pyrene	<0.02	4.22	10	2.2	1
Indeno(1,2,3-cd)pyrene	<0.02	2.46	10	27	0
Dibenz(a,h)anthracene	<0.02	0.73	10	0.24	1
Benzo(g,h,i)perylene	0.03	2.21	10	320	0
TPH Carbon Bandings					
VPH Aliphatic EC 5-6	<0.1	<0.1	7	42	0
VPH Aliphatic EC 6-8	<0.1	<0.1	7	100	0
VPH Aliphatic EC 8-10	<0.1	<0.1	7	27	0
EPH Aliphatic EC 10-12	<4	<4	7	130	0
EPH Aliphatic EC 12-16	<4	<4	7	1100	0
EPH Aliphatic EC 16-35	<10	68	7	65000	0
EPH Aliphatic EC 35-44	<10	<10	7	65000	0
VPH Aromatic EC 5-7	<0.01	<0.01	7	70	0
VPH Aromatic EC 7-8	<0.01	<0.01	7	130	0
VPH Aromatic EC 8-10	<0.01	<0.01	7	34	0
EPH Aromatic EC 10-12	<1	<1	7	74	0
EPH Aromatic EC 12-16	<1	<1	7	140	0
EPH Aromatic EC 16-21	<1	35	7	260	0
EPH Aromatic EC 21-35	<1	26	7	1100	0
EPH Aromatic EC 35-44	<1	2	7	1100	0

Notes

(1) LQM/CIEH S4UL for Residential – with home grown produce end use unless otherwise stated

(2) Category 4 Screening Level (C4SL)

4.27 The results of the chemical screening indicate elevated concentrations of non-volatile PAH's (Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene) in the reworked topsoil made ground at the location of WS01, which are in exceedance of the adopted assessment criteria.

4.28 When considering the potential risk associated with the levels of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene at the location of WS01, as the recorded levels are noticeably increased at this location, with all other values falling below assessment criteria for this site, it is considered that these levels are potentially representative of an isolated 'hotspot'. In order to more accurately assess the level of potential risk in this regard further statistical analysis has been undertaken utilising the contaminated land statistical analysis sheets developed by CL:AIRE, with copies of the calculation sheets included in **Appendix G**.

4.29 In view of the results of this analysis, when including the levels of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene for WS01 within the sample population, the statistical upper confidence limit value ($UCL_{0.95}$) is noted to exceed assessment criteria for this site, with a resultant $UCL_{0.95}$ values of 4.07mg/kg, 3.25mg/kg and 0.57mg/kg recorded for these analytes respectively. The levels of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene within WS01 are also shown to be representative of a statistical outlier indicating the presence of a potential isolated 'hotspot' at this location.

4.30 This is further confirmed following removal of the soil screening results for WS01 from the statistical analysis sheet, which results in the $UCL_{0.95}$ value for of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene falling below assessment for this site, with the resultant $UCL_{0.95}$ values of 0.23mg/kg, 0.14mg/kg and 0.073mg/kg respectively being recorded for the remainder of the reworked topsoil from across the site. Therefore, the elevated levels of non-volatile PAH contamination recorded at the location of WS01, are considered to be potentially representative of an isolated 'hotspot' associated with topsoil at this location only.

4.31 At this stage, in order to more accurately assess the potential for the levels of PAH contamination within the made ground at the locations of WS01 are representative of an isolated 'hotspot' further sampling and screening of the made ground from around this location is recommended to evaluate the extent of the affected materials.

4.32 In addition, to confirm that the identified PAH contamination is not more pervasive within the reworked topsoil below the site as a whole, it is also recommended that additional sampling and screening of the shallow topsoil be completed across the site as a whole.

4.33 Based upon the findings of the above works, should topsoil around WS01 be confirmed as representative of an isolated 'hotspot' in order to negate any future risk it is recommended that the full extent of the affected materials be excavated and removed off-site to a suitable landfill facility, which will form part of any future remedial works with appropriate validation testing. Following removal of the affected materials from around this location this would effectively remove the source of contamination off-site and negate the requirement for further remedial measures, such as a dedicated clean cover system.

4.34 Alternatively, if the presence of PAH contamination is confirmed as being pervasive within the topsoil below the site, further remedial measures (i.e. the implementation of a clean cover system) will be required for this site to negate any risk to future end users.

Asbestos

4.35 10 no. samples of made ground were tested for the presence of asbestos fibres, none were identified.

Modified Site Conceptual Model

Sources of Contamination

4.36 Based on the information gathered during the desk study, it was concluded that the main sources of contamination on the site is reworked topsoil made ground and ground gas, primarily associated with former development activities and biodegradation or organic matter within the natural drift deposits.

4.37 Based on the findings of the investigation works, no visual and olfactory evidence of potentially significant contamination was encountered within any of the exploratory hole locations. In addition, the results of the laboratory chemical analysis identified no significantly elevated levels of contamination within the majority of the reworked topsoil and made ground samples screened from across the site, whilst no asbestos was identified across the site.

4.38 However, an increased level of PAH contamination has been identified at the location of WS01 associated with the reworked topsoil at this location, which is considered to represent a potential risk to human health. When considering the generally low levels of contamination identified during the investigation works, no significant risk is anticipated to controlled waters with the presence of low permeability clay beneath the site restricting lateral movement of contamination.

4.39 Based on the results of the initial gas monitoring no increased concentrations of methane and carbon dioxide have been recorded indicating this site as falling within a Characteristic Situation 1 (CS1) or NHBC Green Classification, in accordance with CIRIA C665 and BS8485:2015. However, at present gas monitoring is ongoing and is therefore subject to confirmation following completion of the gas monitoring regime and addendum reporting.

4.40 In summary, the following are still considered applicable for this site.

Source

- From the information gathered during the desk study, it was concluded that the main sources of contamination were made ground, associated with historical development activities and former site uses. Based on the results of the chemical screening elevations of PAH analytes were recorded at the location of WS01.
- In addition to the above, potential sources of ground gas production and/or migration were also identified, associated with the potential presence of organic matter beneath the site. However, at this stage the development is considered to be located within a low risk setting.

Pathways

- Human Health (end users and construction workers) – direct contact, ingestion and dust inhalation.
- Human Health (end users and property) - Vertical and lateral migration of ground gas into buildings and service entries (manholes).

Receptors

- Human Health - Site end users.
- Human Health – Construction workers.

Pollutant Linkage Assessment

4.41 On the basis of the above, an assessment of potential pollutant linkages at the site has been made as follows:

Contamination source	Pathway	Hazard	Potential Receptors	Linkage Complete
Made Ground: The majority of the site falls within the designated assessment criteria for residential end use. However, elevated levels of PAH contamination have been identified at the location of WS01 which are considered to be potentially representative of an isolated 'hotspot'.	Direct contact, ingestion, dust inhalation	Human health risk	Site construction workers	Yes, can be removed by the use of appropriate PPE and limited exposure.
	Direct contact, ingestion, dust inhalation	Human health risk	Site end users	Yes, although only considered to represent a risk in areas of future soft landscaping, but can be mitigated by a clean capping or removal from site.
Ground Gas	Vertical migration into buildings or confined spaces (inhalation)	Human health risk. Fire risk	Human health and property	Yes. The results of the gas monitoring completed to date indicate that the site does not require ground protective measures and falls within a Characteristic Situation 1 (CS1) however a full assessment will be provided following the completion of the remaining gas monitoring visits.

5 DISCUSSION

5.1 Development proposals include the construction of residential dwellings, with associated access road, parking and communal landscaping. This investigation was carried out to provide geotechnical information with respect to foundations for the proposed development and contamination related testing to outline potential constraints.

Contamination Assessment

5.2 Based on the results of the chemical analysis, no significantly elevated levels of contamination were identified within the majority of topsoil made ground screened from across the site, based on a residential end use. In addition, no asbestos was identified within any of the topsoil or made ground screened from across the site as a whole. However, an increased level of non-volatile PAH contamination has been identified at the location of WS01 associated with the reworked topsoil at this location.

5.3 At present, due to generally limited testing within the immediate vicinity of WS01 there is considered to be insufficient data available to accurately assess whether the levels of PAH contamination are representative of an isolated 'hotspot' or are more pervasive within the topsoil below the site as a whole.

5.4 Therefore, in order to more accurately assess the level of risk to human health in this regard, it is recommended that further sampling and screening of the reworked topsoil be undertaken around WS01 to evaluate the extent of the affected materials. In addition, to confirm that PAH contamination is not more pervasive within the made ground it is also recommended that additional sampling and screening be completed across the site as a whole.

5.5 Based upon the findings of the above recommended works, should this area (WS01) be confirmed as being representative of an isolated 'hotspot' in order to negate any risk to future end users (i.e. human health) the most appropriate remedial solution for this site would be excavation and removal of the affected materials off-site to a suitable landfill facility. Following excavation and suitable validation, this would effectively remove the source of contamination off-site and negate the requirement for further remedial measures (i.e. a dedicated clean cover system).

5.6 Alternatively, if no further assessment works are undertaken based upon the soil screening completed to date, the most appropriate remedial solution for this site would likely be the implementation of a dedicated clean cover system within all areas of soft landscaping, to ensure an absence of risk to future end users (i.e. human health).

5.7 When considering the generally low levels of contamination identified during the investigation works, no significant risk is anticipated to controlled waters.

Remediation

5.8 At this stage, based upon the results of the soil screening two potential remedial options could represent viable solutions for this site, comprising the following:

- Excavation and removal of PAH affected soils ('hotspot') from around WS01 off-site to a suitable landfill facility with suitable validation testing. The removal of contaminative materials would remove the source off-site and therefore negate the risk to future end-users, resulting in no further remedial works being required.
- The introduction of an engineered clean cover system (i.e. 600mm) within all areas of proposed soft landscaping, to provide a safe and permanent barrier against potentially contaminative substances within the topsoil.

5.9 To determine the most appropriate remedial solution for this site, further soil sampling and chemical analysis are recommended.

5.10 Prior to commencing with any future remedial works, a detailed Remediation Strategy should be prepared and agreed with the Local Authority, and once implemented the remediation work should be validated by a suitably qualified engineer.

Disposal of Materials

5.11 The results of the chemical analyses suggest that generally the made ground (topsoil) materials could potentially be classed as Inert for disposal. In addition, any natural soil is also considered to be likely suitable for disposal as Inert waste. Where off-site disposal of waste soils is required, it is recommended that the results of the investigation works be made available to the waste carrier/receiver in order to confirm the waste classification, costs for disposal and the potential requirement for further testing.

5.12 In addition, sufficient time should also be allowed in the site programme to effectively segregate soils based on material type, including the time allowed for any further laboratory classification analysis as required (i.e. WAC screening).

Foundations

5.13 The use of conventional foundations (i.e. strip or pad) is considered to represent the most viable option for this site, based wholly within the natural firm to stiff clay deposits at a minimum depth of 0.90m below finished ground levels. However, due to the occasional variability of the upper superficial deposits below the site, we would recommend an allowable bearing pressure not exceeding 100kN/m^2 , with foundations suitably reinforced in order to minimise excessive differential settlements.

5.14 When considering the localised more variable superficial deposits identified within WS02 and WS06, due to the potential for foundations to span between these deposits and surrounding more competent clay, it is recommended that footings around this location be suitably reinforced and designed to a reduced maximum allowable bearing pressure not exceeding 90kN/m^2 , to avoid the potential for differential settlements to occur.

5.15 Given the majority of foundations will be based within cohesive deposits the depth of foundations will need to take into account past, existing and proposed trees within influencing distance.

5.16 Additional investigation, following the demolition of current properties within the north eastern parts of the site (plots 59 to 66), is also recommended in order to establish ground conditions. Upon completion of the additional intrusive investigations, more detailed foundation recommendations can be produced.

Excavations and Dewatering

5.17 If man entry is proposed into excavations the use of support to excavation sides is recommended, in line with health and safety guidelines. Significant groundwater ingress into excavations are anticipated surrounding saturated granular materials, particularly within deeper excavations water ingress should be controlled adequately by localised pumping from sumps within excavations.

Gas Protection Measures

5.18 Radon protection measures are not required for the proposed development.

5.19 Based on the results of the gas monitoring completed to date no increased concentrations of methane and carbon dioxide have been recorded indicating this site as falling within a Characteristic Situation 1 (CS1) or NHBC Green Classification, in accordance with CIRIA C665 and BS8485:2015. However, at present gas monitoring is on-going and is therefore subject to confirmation following completion of the gas monitoring regime and addendum reporting.

Surface Water Disposal

5.20 In view of the results of the falling head tests carried out, presence of generally impermeable clay superficial deposits below the site and evidence of shallow perched water within in the granular soils, where encountered, the use of soakaways for surface water disposal is not considered viable and alternative method will need to be explored.

Sulphate Attack on Buried Concrete

5.21 Within the made ground water soluble sulphate concentrations ranged between <10mg/l and 72mg/l with pH values between 6.2 and 7.9. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-2_z.

5.22 Within the natural drift deposits, water soluble sulphate concentrations ranged between <10mg/l and 17mg/l with pH values between 6.7 and 8.2. These indicate a BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-1.

Drawings



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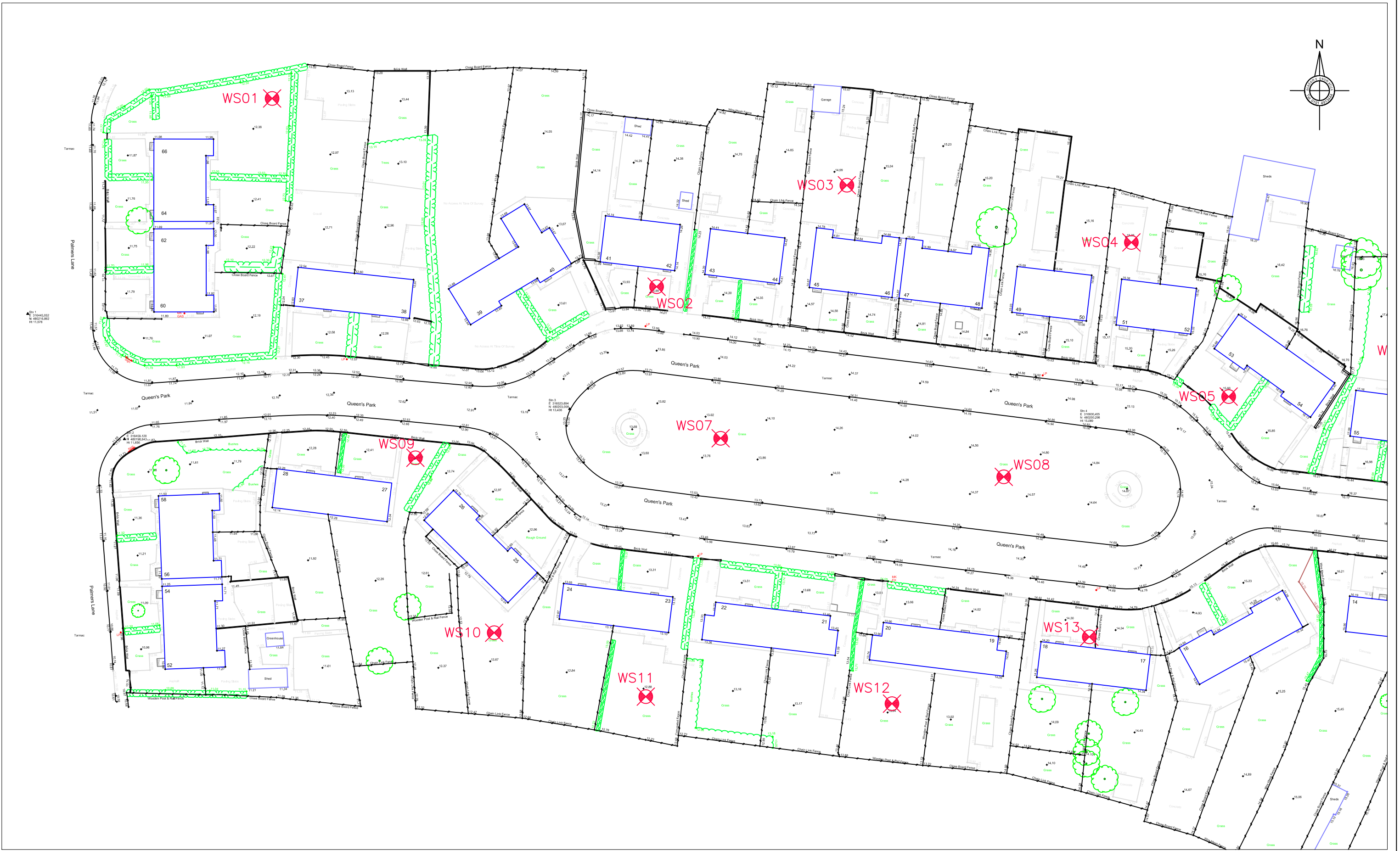


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Date	Revision	Checked	Rev.
Project Queens Park, Millom for Home Group			
Title Site Location Plan			
Scale 1:25,000 at A4	Drawn CB	Checked NW	Date Jan '19
Job No P17-498	Drawing No. G001	Rev 0	



KEY:



Mini Percussive Borehole Location



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Project		Queens Park, Millom for Home Group		
Title		Exploratory Hole Location Plan (West)		
Scale	NTS	Drawn	NW	Checked ~
Job No.	P17-498	Drawing No.	G002A	Date 14.02.19
				Rev 0



KEY:



Mini Percussive Borehole Location



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Project		Queens Park, Millom for Home Group		
Title		Exploratory Hole Location Plan (East)		
Scale	NTS	Drawn	NW	Checked ~ Date 14.02.19
Job No.	P17-498	Drawing No.	G002B	Rev 0

Appendix A

Proposed Development Plan

LAYOUT MASTERPLAN



Schedule

2 Bed Bungalow	- 21
3 Bed Bungalow	- 12
2 Bed Semi-Detached	- 24
3 Bed Semi-Detached	- 25
4 Bed Detached	- 7
Total	- 89

(75% private)
(25% social rent)

LAYOUT PHASE I PLAN



LAYOUT
PHASE 2 PLAN



LAYOUT PHASE 3 PLAN

Phase 1 Schedule

2 Bed Bungalow - 5
3 Bed Bungalow - 1
2 Bed Semi-Detached - 0
3 Bed Semi-Detached - 13
4 Bed Detached - 0
Total - 19

Phase 2 Schedule

2 Bed Bungalow - 6
3 Bed Bungalow - 8
2 Bed Semi-Detached - 8
3 Bed Semi-Detached - 8
4 Bed Detached - 4
Total - 34

Phase 3 Schedule

2 Bed Bungalow - 10
3 Bed Bungalow - 3
2 Bed Semi-Detached - 16
3 Bed Semi-Detached - 4
4 Bed Detached - 3
Total - 36



Appendix B

Exploratory Hole Records



Trial Pit Log

Trialpit No
HDP01
Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -
Level:

Date
21-11-2018

Location: Millom, Cumbria

Dimensions
(m):

Depth
1.20

Scale
1:25

Logged
AM

Client: Home Group

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
	0.20	ES					MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
				0.60			Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
				1.20			End of pit at 1.20 m	2
								3
								4
								5

Remarks: 1. No groundwater encountered.

Stability:





Borehole Log

Borehole No.

WS01

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

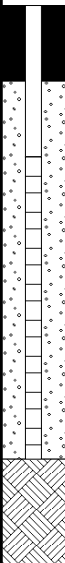
Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES		0.40			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D	HVP=84				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
		2.00	D	HVP=100					2
		3.00	D	HVP=140					3
		3.50 - 3.60	D		3.50			Red coarse SAND.	
		3.60 - 3.70	D		3.60 3.70			Extremely weak grey laminated MUDSTONE. End of borehole at 3.70 m	4
									5
									6
									7
									8
									9
									10

Remarks

1. Groundwater encountered at a depth of 3.60m.





Borehole Log

Borehole No.

WS02

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 19-11-2018 - 19-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES		0.40			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00 1.00	D	N=9 (1,1/2,2,2,3)				loose to medium dense brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse, subrounded to rounded to sandstone and siltstone.	1
		2.00 2.00	D	N=15 (2,2/3,3,4,5)	2.10			End of borehole at 2.10 m	2
									3
									4
									5
									6
									7
									8
									9
									10

Remarks

1. Groundwater encountered at a depth of 0.60m.





Borehole Log

Borehole No.

WS03

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 19-11-2018 - 19-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES	HVP=140	0.50			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		0.50	D						
		1.00	D						
		2.00	D	HVP=140					
		3.00	D	HVP=140	3.00		End of borehole at 3.00 m		
									</

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS04

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 19-11-2018 - 19-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES	HVP=55	0.60			MADE GROUND: Gravel surfacing over brown sandy clay with occasional brick fragments.	1
		1.00	D					Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	2
		2.00	D	HVP=105	3				
		3.00	D	HVP=120	4				
		4.00	D	HVP=100	5				
		5.00	D	HVP=87		End of borehole at 5.45 m	6		
		5.45		7					
				8					
				9					
				10					

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS05

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 19-11-2018 - 19-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.50	ES		0.70			MADE GROUND: Gravel surfacing over brown sandy clay with occasional brick fragments.	
		0.90	D		1.10			Brown slightly clayey fine to medium SAND.	1
				HVP=100				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	
		2.00	D						2
		3.00	D						3
		4.00	D						4
		5.00	D						5
				HVP=110					
				HVP=140					
				HVP=130					
				HVP=130					
					5.45			End of borehole at 5.45 m	

Remarks

1. Groundwater encountered at a depth of 0.70m.





Borehole Log

Borehole No.

WS06

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

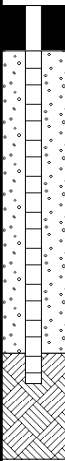
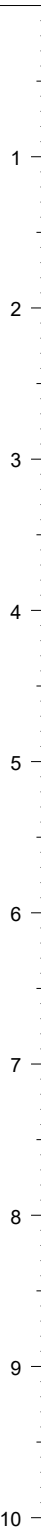
Level:

Scale
1:50

Client: Home Group

Dates: 21-11-2018 - 21-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES	N=36 (2,4/8,10,10,8)	0.40			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00 1.00	D					Dense brown slightly gravelly fine to coarse SAND. Gravel is fine to coarse, subrounded to rounded to sandstone and siltstone.	
		2.00	D						
					3.00			End of borehole at 3.00 m	

Remarks

1. Groundwater encountered at a depth of 1.00m





Borehole Log

Borehole No.

WS07

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES		0.40			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D	HVP=110				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
		2.00	D	HVP=110					2
		3.00	D	HVP=140					3
		4.00	D	HVP=110					4
		5.00	D	HVP=110	5.00			End of borehole at 5.00 m	5
									6
									7
									8
									9
									10

Remarks

1. No groundwater encountered.







Borehole Log

Borehole No.

WS09

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES					MADE GROUND: Grass over brown sandy clay with occasional brick fragments.	
					0.70				
		1.00	D					MADE GROUND: Firm brown slightly sandy clay with occasional brick fragments.	1
					1.20				
		1.50	D	HVP=120				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	2
				HVP=140					
		2.50	D						
		3.00	D	HVP=90					3
					3.50				
		4.00	D	HVP=58				Soft and firm brown silty CLAY.	4
					4.50			End of borehole at 4.50 m	
									5
									6
									7
									8
									9
									10

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS10

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES		0.30			MADE GROUND: Grass over brown sandy clay with occasional brick fragments.	
		1.00	D	HVP=140				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
		2.00	D	HVP=140					2
		3.00	D	HVP=130					3
		4.00	D	HVP=60 HVP=80	3.60 4.20			Soft and firm brown silty CLAY.	4
		5.00	D		4.80			Firm brown and grey laminated SILT.	
								End of borehole at 4.80 m	5
									6
									7
									8
									9
									10

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS11

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	ES	HVP=100	0.50			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D					Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	
		2.00	D	HVP=120	3.40		Soft and firm brown silty CLAY.		
		3.00	D	HVP=140					
		4.00	D	HVP=70					
		5.00	D						
						End of borehole at 5.00 m			

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS12

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 20-11-2018 - 20-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES		0.60			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D	HVP=90 HVP=140				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
		2.00	D	HVP=140					2
		3.00	D	HVP=140					3
		4.00	D	HVP=60	3.70			Firm brown silty CLAY.	4
		4.30	D		4.10			Brown slightly silty fine to medium SAND.	
					4.50			Soft brown silty CLAY.	
		5.00	D	HVP=20	5.00			End of borehole at 5.00 m	5
									6
									7
									8
									9
									10

Remarks

1. Groundwater encountered at a depth of 4.10m.





Borehole Log

Borehole No.

WS13

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 21-11-2018 - 21-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES		0.60			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D	HVP=90				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	1
		2.00	D	HVP=75 HVP=140					2
		3.00	D	HVP=140					3
		4.00	D	HVP=140	4.00			End of borehole at 4.00 m	4
									5
									6
									7
									8
									9
									10

Remarks

1. No groundwater encountered.





Borehole Log

Borehole No.

WS14

Sheet 1 of 1

Project Name: Queens Park, Millom

Project No.
P17-498

Co-ords: -

Hole Type
WS

Location: Millom, Cumbria

Level:

Scale
1:50

Client: Home Group

Dates: 21-11-2018 - 21-11-2018

Logged By
AM

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES		0.50			MADE GROUND: Grass over dark brown slightly sandy clay. (REWORKED TOPSOIL).	
		1.00	D		1.30			Brown silty fine to coarse SAND.	1
		2.00	D	HVP=110				Firm to stiff brown slightly sandy CLAY with occasional gravel bands. Sand is fine to medium.	2
		3.00	D	HVP=140					3
		4.00	D	HVP=140	4.00				4
								End of borehole at 4.00 m	5
									6
									7
									8
									9
									10

Remarks

1. Groundwater encountered at a depth of 0.60m.





Appendix C

Gas and Groundwater Monitoring Results

Gas monitoring record

Job no: P17-498
Site: Queens Park, Millom
Date: 22-Nov-18
Weather: Sunny
Pressure Trend: Falling
Monitored by: AM

3e Consulting Engineers Ltd
 2 Esh Plaza
 Sir Bobby Robson Way
 Newcastle Upon Tyne
 NE13 9BA

BH No	Conc. Methane (%v/v)		Conc. Carbon Dioxide (%v/v)		Conc. Oxygen (%v/v)		Barometric Pressure (mb)	Flow (l/hr)		Flooded Response Zone (Yes/No)	Water Level (m bgl)	Remarks
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady			
WS01	0.0	0.0	0.1	0.1	20.1	20.1	1027	<0.1	<0.1	NO	Dry	-
WS04	0.0	0.0	1.9	1.9	20	20	1027	<0.1	<0.1	NO	2.64	-
WS06	0.0	0.0	0.9	0.9	20.4	20.4	1027	<0.1	<0.1	NO	1	-
WS07	0.0	0.0	1.2	1.2	19.9	19.9	1027	<0.1	<0.1	NO	Dry	-
WS10	0.0	0.0	0.1	0.1	20.5	20.5	1027	<0.1	<0.1	NO	Dry	-
WS14	0.0	0.0	1.1	1.1	20.7	20.7	1027	<0.1	<0.1	Yes	0.9	-

Date: 14-Jan-19
Weather: Sunny
Pressure Trend: Rising
Monitored by: AM

BH No	Conc. Methane (%v/v)		Conc. Carbon Dioxide (%v/v)		Conc. Oxygen (%v/v)		Barometric Pressure (mb)	Flow (l/hr)		Flooded Response Zone (Yes/No)	Water Level (m bgl)	Remarks
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady			
WS01	0.0	0.0	0.0	0.0	20.2	20.2	1006	<0.1	<0.1	NO	Dry	-
WS04	0.0	0.0	2.0	2.0	19.7	19.7	1006	<0.1	<0.1	NO	2.6	-
WS06	0.0	0.0	1.1	1.1	20.0	20.0	1006	<0.1	<0.1	Yes	0.9	-
WS07	0.0	0.0	1.1	1.1	20.1	20.1	1006	<0.1	<0.1	Yes	0.3	-
WS10	0.0	0.0	0.1	0.1	20.3	20.3	1006	<0.1	<0.1	NO	4.5	-
WS14	0.0	0.0	1.3	1.3	19.8	19.8	1006	<0.1	<0.1	Yes	0.9	-

Date: 20-Jan-19
Weather: sunny
Pressure Trend: Rising
Monitored by: SG

BH No	Conc. Methane (%v/v)		Conc. Carbon Dioxide (%v/v)		Conc. Oxygen (%v/v)		Barometric Pressure (mb)	Flow (l/hr)		Flooded Response Zone (Yes/No)	Water Level (m bgl)	Remarks
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady			
WS01	0.0	0.0	0.2	0.2	19.5	19.5	1018	0.5	0.5	NO	Dry	-
WS04	0.0	0.0	3.8	3.8	14.8	14.8	1018	<0.1	<0.1	Yes	0.65	-
WS06	0.0	0.0	0.4	0.4	17.2	17.2	1018	<0.1	<0.1	NO	1.3	-
WS07	0.0	0.0	3.3	3.3	11.2	11.2	1018	0.3	0.3	Yes	0.3	-
WS10	0.0	0.0	2.8	2.8	4.2	4.2	1018	0.3	0.3	NO	Dry	-
WS14	0.0	0.0	1.8	1.8	18.0	18.0	1018	0.5	0.5	NO	Dry	-

Appendix D

Laboratory Chemical Test Results



2531



ANALYTICAL TEST REPORT

Contract no: 75428

Contract name: Queens Park, Millom

Client reference: P17-498

Clients name: 3E Consulting Engineers

Clients address: Second Floor, 2 Esh Plaza
Sir Bobby Robson Way, Great Park
Newcastle Upon Tyne
NE13 9BA

Samples received: 28 November 2018

Analysis started: 28 November 2018

Analysis completed: 06 December 2018

Report issued: 06 December 2018

Notes: Opinions and interpretations expressed herein are outside the UKAS accreditation scope. Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling. Methods, procedures and performance data are available on request. Results reported herein relate only to the material supplied to the laboratory. This report shall not be reproduced except in full, without prior written approval. Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed. BTEX compounds are identified by retention time only and may include interference from co-eluting compounds.

Key: U UKAS accredited test
M MCERTS & UKAS accredited test
\$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by:

Karan Campbell
Director

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
75428-1	HDP1	0.20	Clay	-	-	23.9
75428-2	WS01	0.20	Clay	-	-	24.8
75428-3	WS01	2.00	Clay	-	-	13.9
75428-4	WS03	0.20	Clay with Gravel	-	-	26.2
75428-5	WS05	0.50	Clay with Gravel	-	-	16.9
75428-6	WS06	2.00	Sand	-	-	17.5
75428-7	WS07	0.20	Clay with Gravel	-	-	18.6
75428-8	WS08	0.30	Clay	-	-	20.2
75428-9	WS08	2.00	Clay	-	-	13.9
75428-10	WS09	0.30	Clay with Gravel	-	-	17.1
75428-11	WS10	0.20	Clay	-	-	20.0
75428-12	WS12	0.30	Clay with Gravel	-	-	21.5
75428-13	WS14	1.00	Sandy Clay	-	-	25.8
75428-14	WS15	0.20	Clay	-	-	20.7

Chemtech Environmental Limited

SOILS

Lab number			75428-1	75428-2	75428-3	75428-4	75428-5	75428-6
Sample id			HDP1	WS01	WS01	WS03	WS05	WS06
Depth (m)			0.20	0.20	2.00	0.20	0.50	2.00
Date sampled			27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018
Test	Method	Units						
Arsenic (total)	CE127 ^M	mg/kg As	13	13	-	15	<1	-
Boron (water soluble)	CE063 ^M	mg/kg B	1.4	0.9	-	<0.5	<0.5	-
Cadmium (total)	CE127 ^M	mg/kg Cd	0.3	0.4	-	1.2	<0.2	-
Chromium (total)	CE127 ^M	mg/kg Cr	112	109	-	142	<1	-
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	-	<1	<1	-
Copper (total)	CE127 ^M	mg/kg Cu	31	35	-	84	<1	-
Lead (total)	CE127 ^M	mg/kg Pb	102	181	-	168	2.2	-
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	<0.5	-	<0.5	<0.5	-
Nickel (total)	CE127 ^M	mg/kg Ni	22	21	-	29	<1	-
Selenium (total)	CE127 ^M	mg/kg Se	0.8	0.7	-	0.9	<0.3	-
Zinc (total)	CE127 ^M	mg/kg Zn	92	114	-	333	<5	-
pH	CE004 ^M	units	7.3	7.1	7.6	7.5	7.9	7.6
Sulphate (2:1 water soluble)	CE061 ^M	mg/l SO ₄	16	17	<10	15	15	<10
Total Organic Carbon (TOC)	CE072 ^M	% w/w C	2.64	0.19	-	2.88	0.84	-
Estimate of OMC (calculated from TOC)	CE072 ^M	% w/w	4.55	0.33	-	4.97	1.45	-
PAH								
Naphthalene	CE087 ^M	mg/kg	<0.01	0.02	-	<0.01	<0.01	-
Acenaphthylene	CE087 ^M	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
Acenaphthene	CE087 ^M	mg/kg	<0.01	0.49	-	<0.01	<0.01	-
Fluorene	CE087 ^U	mg/kg	<0.01	0.74	-	0.01	<0.01	-
Phenanthrene	CE087 ^M	mg/kg	0.13	8.40	-	0.19	0.13	-
Anthracene	CE087 ^U	mg/kg	0.02	3.10	-	0.03	<0.02	-
Fluoranthene	CE087 ^M	mg/kg	0.31	13.42	-	0.58	0.54	-
Pyrene	CE087 ^M	mg/kg	0.25	9.79	-	0.44	0.45	-
Benzo(a)anthracene	CE087 ^U	mg/kg	0.12	5.37	-	0.23	0.18	-
Chrysene	CE087 ^M	mg/kg	0.13	5.39	-	0.29	0.27	-
Benzo(b)fluoranthene	CE087 ^M	mg/kg	0.20	5.26	-	0.30	0.32	-
Benzo(k)fluoranthene	CE087 ^M	mg/kg	0.06	2.39	-	0.12	0.11	-
Benzo(a)pyrene	CE087 ^U	mg/kg	0.12	4.22	-	0.20	0.19	-
Indeno(123cd)pyrene	CE087 ^M	mg/kg	0.17	2.46	-	0.22	0.16	-
Dibenz(ah)anthracene	CE087 ^M	mg/kg	0.06	0.73	-	0.06	0.04	-
Benzo(ghi)perylene	CE087 ^M	mg/kg	0.18	2.21	-	0.22	0.16	-
PAH (total of USEPA 16)	CE087	mg/kg	1.76	64.0	-	2.88	2.55	-
BTEX & TPH								
MTBE	CE057 ^U	mg/kg	<0.02	<0.02	-	<0.02	<0.02	-
Benzene	CE057 ^U	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
Toluene	CE057 ^U	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
Ethylbenzene	CE057 ^U	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
m & p-Xylene	CE057 ^U	mg/kg	<0.02	<0.02	-	<0.02	<0.02	-
o-Xylene	CE057 ^U	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-

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SOILS

Lab number			75428-1	75428-2	75428-3	75428-4	75428-5	75428-6
Sample id			HDP1	WS01	WS01	WS03	WS05	WS06
Depth (m)			0.20	0.20	2.00	0.20	0.50	2.00
Date sampled			27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018
Test	Method	Units						
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	-	<0.01	<0.01	-
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	0.01	<0.01	-	<0.01	<0.01	-
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	<1	-	<1	<1	-
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	<1	<1	-	<1	<1	-
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	1	35	-	1	1	-
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	1	26	-	1	1	-
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	<1	2	-	<1	<1	-
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-
EPH Aliphatic (>C10-C12)	CE068	mg/kg	<4	<4	-	<4	<4	-
EPH Aliphatic (>C12-C16)	CE068	mg/kg	<4	<4	-	<4	<4	-
EPH Aliphatic (>C16-C35)	CE068	mg/kg	30	68	-	21	<10	-
EPH Aliphatic (>C35-C44)	CE068	mg/kg	<10	<10	-	<10	<10	-
Subcontracted analysis								
Asbestos (qualitative)	\$	-	NAD	NAD	-	NAD	NAD	-

Chemtech Environmental Limited

SOILS

Lab number			75428-7	75428-8	75428-9	75428-10	75428-11	75428-12
Sample id			WS07	WS08	WS08	WS09	WS10	WS12
Depth (m)			0.20	0.30	2.00	0.30	0.20	0.30
Date sampled			27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018
Test	Method	Units						
Arsenic (total)	CE127 ^M	mg/kg As	4.4	6.9	-	8.9	8.0	7.9
Boron (water soluble)	CE063 ^M	mg/kg B	<0.5	0.6	-	0.7	0.5	0.6
Cadmium (total)	CE127 ^M	mg/kg Cd	<0.2	<0.2	-	<0.2	<0.2	<0.2
Chromium (total)	CE127 ^M	mg/kg Cr	77	52	-	145	83	84
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	-	<1	<1	<1
Copper (total)	CE127 ^M	mg/kg Cu	8.5	10	-	18	14	14
Lead (total)	CE127 ^M	mg/kg Pb	19	17	-	35	52	53
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	<0.5	-	<0.5	<0.5	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	9.0	16	-	18	16	16
Selenium (total)	CE127 ^M	mg/kg Se	0.4	0.5	-	0.8	0.5	0.5
Zinc (total)	CE127 ^M	mg/kg Zn	22	27	-	39	68	69
pH	CE004 ^M	units	7.1	6.9	8.0	7.4	6.2	6.7
Sulphate (2:1 water soluble)	CE061 ^M	mg/l SO ₄	10	<10	<10	<10	72	11
Total Organic Carbon (TOC)	CE072 ^M	% w/w C	0.17	0.80	-	1.35	0.29	1.74
Estimate of OMC (calculated from TOC)	CE072 ^M	% w/w	0.29	1.38	-	2.33	0.50	3.00
PAH								
Naphthalene	CE087 ^M	mg/kg	<0.01	<0.01	-	<0.01	<0.01	<0.01
Acenaphthylene	CE087 ^M	mg/kg	<0.01	<0.01	-	<0.01	<0.01	<0.01
Acenaphthene	CE087 ^M	mg/kg	0.01	<0.01	-	<0.01	<0.01	<0.01
Fluorene	CE087 ^U	mg/kg	<0.01	<0.01	-	<0.01	<0.01	<0.01
Phenanthrene	CE087 ^M	mg/kg	0.10	<0.02	-	0.05	0.05	0.06
Anthracene	CE087 ^U	mg/kg	<0.02	<0.02	-	<0.02	<0.02	<0.02
Fluoranthene	CE087 ^M	mg/kg	0.28	0.04	-	0.24	0.23	0.15
Pyrene	CE087 ^M	mg/kg	0.22	0.02	-	0.20	0.19	0.11
Benzo(a)anthracene	CE087 ^U	mg/kg	0.09	<0.02	-	0.06	0.07	0.02
Chrysene	CE087 ^M	mg/kg	0.11	<0.01	-	0.06	0.11	0.05
Benzo(b)fluoranthene	CE087 ^M	mg/kg	0.15	<0.02	-	0.09	0.13	0.10
Benzo(k)fluoranthene	CE087 ^M	mg/kg	0.03	<0.02	-	<0.02	0.03	<0.02
Benzo(a)pyrene	CE087 ^U	mg/kg	0.07	<0.02	-	0.05	0.07	0.05
Indeno(123cd)pyrene	CE087 ^M	mg/kg	0.10	<0.02	-	0.07	0.09	0.11
Dibenz(ah)anthracene	CE087 ^M	mg/kg	<0.02	<0.02	-	<0.02	<0.02	<0.02
Benzo(ghi)perylene	CE087 ^M	mg/kg	0.09	0.03	-	0.07	0.10	0.12
PAH (total of USEPA 16)	CE087	mg/kg	1.26	<0.27	-	0.88	1.05	0.77
BTEX & TPH								
MTBE	CE057 ^U	mg/kg	-	<0.02	-	-	<0.02	-
Benzene	CE057 ^U	mg/kg	-	<0.01	-	-	<0.01	-
Toluene	CE057 ^U	mg/kg	-	<0.01	-	-	<0.01	-
Ethylbenzene	CE057 ^U	mg/kg	-	<0.01	-	-	<0.01	-
m & p-Xylene	CE057 ^U	mg/kg	-	<0.02	-	-	<0.02	-
o-Xylene	CE057 ^U	mg/kg	-	<0.01	-	-	<0.01	-
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	-	<0.01	-	-	<0.01	-

Chemtech Environmental Limited

SOILS

Lab number			75428-7	75428-8	75428-9	75428-10	75428-11	75428-12
Sample id			WS07	WS08	WS08	WS09	WS10	WS12
Depth (m)			0.20	0.30	2.00	0.30	0.20	0.30
Date sampled			27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018	27/11/2018
Test	Method	Units						
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	-	<0.01	-	-	<0.01	-
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	-	<0.01	-	-	<0.01	-
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	-	<1	-	-	<1	-
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	-	<1	-	-	<1	-
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	-	<1	-	-	<1	-
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	-	<1	-	-	<1	-
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	-	<1	-	-	<1	-
VPH Aliphatic (>C5-C6)	CE067	mg/kg	-	<0.1	-	-	<0.1	-
VPH Aliphatic (>C6-C8)	CE067	mg/kg	-	<0.1	-	-	<0.1	-
VPH Aliphatic (>C8-C10)	CE067	mg/kg	-	<0.1	-	-	<0.1	-
EPH Aliphatic (>C10-C12)	CE068	mg/kg	-	<4	-	-	<4	-
EPH Aliphatic (>C12-C16)	CE068	mg/kg	-	<4	-	-	<4	-
EPH Aliphatic (>C16-C35)	CE068	mg/kg	-	14	-	-	<10	-
EPH Aliphatic (>C35-C44)	CE068	mg/kg	-	<10	-	-	<10	-
Subcontracted analysis								
Asbestos (qualitative)	\$	-	NAD	NAD	-	NAD	NAD	NAD

Chemtech Environmental Limited

SOILS

Lab number			75428-13	75428-14
Sample id			WS14	WS15
Depth (m)			1.00	0.20
Date sampled			27/11/2018	27/11/2018
Test	Method	Units		
Arsenic (total)	CE127 ^M	mg/kg As	-	9.2
Boron (water soluble)	CE063 ^M	mg/kg B	-	0.7
Cadmium (total)	CE127 ^M	mg/kg Cd	-	<0.2
Chromium (total)	CE127 ^M	mg/kg Cr	-	93
Chromium (VI)	CE146	mg/kg CrVI	-	<1
Copper (total)	CE127 ^M	mg/kg Cu	-	7.3
Lead (total)	CE127 ^M	mg/kg Pb	-	17
Mercury (total)	CE127 ^M	mg/kg Hg	-	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	-	12
Selenium (total)	CE127 ^M	mg/kg Se	-	1.1
Zinc (total)	CE127 ^M	mg/kg Zn	-	27
pH	CE004 ^M	units	7.0	8.2
Sulphate (2:1 water soluble)	CE061 ^M	mg/l SO ₄	12	13
Total Organic Carbon (TOC)	CE072 ^M	% w/w C	-	1.15
Estimate of OMC (calculated from TOC)	CE072 ^M	% w/w	-	1.98
PAH				
Naphthalene	CE087 ^M	mg/kg	-	<0.01
Acenaphthylene	CE087 ^M	mg/kg	-	<0.01
Acenaphthene	CE087 ^M	mg/kg	-	<0.01
Fluorene	CE087 ^U	mg/kg	-	<0.01
Phenanthrene	CE087 ^M	mg/kg	-	0.03
Anthracene	CE087 ^U	mg/kg	-	<0.02
Fluoranthene	CE087 ^M	mg/kg	-	0.15
Pyrene	CE087 ^M	mg/kg	-	0.12
Benzo(a)anthracene	CE087 ^U	mg/kg	-	0.08
Chrysene	CE087 ^M	mg/kg	-	0.11
Benzo(b)fluoranthene	CE087 ^M	mg/kg	-	0.14
Benzo(k)fluoranthene	CE087 ^M	mg/kg	-	0.04
Benzo(a)pyrene	CE087 ^U	mg/kg	-	0.06
Indeno(123cd)pyrene	CE087 ^M	mg/kg	-	0.09
Dibenz(ah)anthracene	CE087 ^M	mg/kg	-	<0.02
Benzo(ghi)perylene	CE087 ^M	mg/kg	-	0.08
PAH (total of USEPA 16)	CE087	mg/kg	-	0.89
BTEX & TPH				
MTBE	CE057 ^U	mg/kg	-	<0.02
Benzene	CE057 ^U	mg/kg	-	<0.01
Toluene	CE057 ^U	mg/kg	-	<0.01
Ethylbenzene	CE057 ^U	mg/kg	-	<0.01
m & p-Xylene	CE057 ^U	mg/kg	-	<0.02
o-Xylene	CE057 ^U	mg/kg	-	<0.01
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	-	<0.01

Chemtech Environmental Limited

SOILS

Lab number			75428-13	75428-14
Sample id			WS14	WS15
Depth (m)			1.00	0.20
Date sampled			27/11/2018	27/11/2018
Test	Method	Units		
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	-	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	-	<0.01
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	-	<1
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	-	<1
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	-	<1
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	-	1
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	-	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	-	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	-	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	-	<0.1
EPH Aliphatic (>C10-C12)	CE068	mg/kg	-	<4
EPH Aliphatic (>C12-C16)	CE068	mg/kg	-	<4
EPH Aliphatic (>C16-C35)	CE068	mg/kg	-	<10
EPH Aliphatic (>C35-C44)	CE068	mg/kg	-	<10
Subcontracted analysis				
Asbestos (qualitative)	\$	-	-	NAD

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE063	Boron (water soluble)	Hot water extract, ICP-OES	Dry	M	0.5	mg/kg B
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE127	Chromium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cr
CE146	Chromium (VI)	Acid extraction, Colorimetry	Dry		1	mg/kg CrVI
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Zinc (total)	Aqua regia digest, ICP-MS	Dry	M	5	mg/kg Zn
CE004	pH	Based on BS 1377, pH Meter	Wet	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	M	10	mg/l SO ₄
CE072	Total Organic Carbon (TOC)	Removal of IC by acidification, Carbon Analyser	Dry	M	0.1	% w/w C
CE072	Estimate of OMC (calculated from TOC)	Calculation from Total Organic Carbon	Dry	M	0.1	% w/w
CE087	Naphthalene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Acenaphthene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	Wet	U	0.01	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	Wet	M	0.01	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	Wet	U	0.02	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	Wet	M	0.02	mg/kg
CE087	PAH (total of USEPA 16)	Solvent extraction, GC-MS	Wet		0.27	mg/kg
CE057	MTBE	Headspace GC-FID	Wet	U	0.02	mg/kg
CE057	Benzene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	Toluene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	Ethylbenzene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE057	m & p-Xylene	Headspace GC-FID	Wet	U	0.02	mg/kg
CE057	o-Xylene	Headspace GC-FID	Wet	U	0.01	mg/kg
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	Wet		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	Wet		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	Wet		0.01	mg/kg
CE068	EPH Aromatic (>EC10-EC12)	Solvent extraction, GC-FID	Wet		1	mg/kg
CE068	EPH Aromatic (>EC12-EC16)	Solvent extraction, GC-FID	Wet		1	mg/kg
CE068	EPH Aromatic (>EC16-EC21)	Solvent extraction, GC-FID	Wet		1	mg/kg

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE068	EPH Aromatic (>EC21-EC35)	Solvent extraction, GC-FID	Wet		1	mg/kg
CE068	EPH Aromatic (>EC35-EC44)	Solvent extraction, GC-FID	Wet		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	Wet		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	Wet		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	Wet		0.1	mg/kg
CE068	EPH Aliphatic (>C10-C12)	Solvent extraction, GC-FID	Wet		4	mg/kg
CE068	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID	Wet		4	mg/kg
CE068	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID	Wet		4	mg/kg
CE068	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID	Wet		10	mg/kg
\$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
75428-1	HDP1	0.20	N	
75428-2	WS01	0.20	N	
75428-3	WS01	2.00	N	
75428-4	WS03	0.20	N	
75428-5	WS05	0.50	N	
75428-6	WS06	2.00	N	
75428-7	WS07	0.20	N	
75428-8	WS08	0.30	N	
75428-9	WS08	2.00	N	
75428-10	WS09	0.30	N	
75428-11	WS10	0.20	N	
75428-12	WS12	0.30	N	
75428-13	WS14	1.00	N	
75428-14	WS15	0.20	N	

Appendix E

Laboratory Geotechnical Test Results

NORTHUMBERLAND

COUNTY COUNCIL

Highways Laboratory
Bassington Drive • Cramlington • Northumberland • NE23 8AJ
Tel (01670) 737575 • Fax (01670) 732044 • Email highwayslaboratory@northumberland.gov.uk

CLASSIFICATION OF SOILS

Tests according to B.S. 1377 : 1990

Client: **3E Consulting Engineers Ltd , Holland Drive, Newcastle, NE2 4LD**

Engineer: **Alex Middleton**

Project: **P17-498, Queens Park, Millom**

Location: **WS01 at 1.00m**

Material Type: **Red, Brown sandy CLAY with occasional gravel**

Source: **Site**

Date Sampled:

Date Received: **03/12/2018**

Sampled By: **Clients Staff**

Test Results

Specification

Water Content (%): **24.6** BS EN ISO 17892-1;2014

The liquid and Plastic Limits are prepared in accordance with BS1377: Part 2: Clause 4.2.4 due to the nature of most materials in the surrounding area (Sandy CLAY with gravel cobbles and boulders)

Liquid Limit (%): **45** Part 2 Clause 4.4 (One point method)

Plastic Limit (%): **20** Part 2 Clause 5.3

Plasticity Index (%): **25** Part 2 Clause 5.4

Passing 425mic (%): **90**

Soil Classification: **CI**

Mean Particle Density **N/A** Part 2 Clause 8.2 (Gas Jar Method)

The following tests are NOT accredited.

Moisture Condition Value* **N/A** Part 4 Clause 5.4

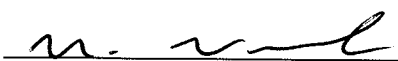
MCV Test Moisture Content (%): **N/A**

Permeability (m/s) * **N/A**

(Method as given in Head's "Manual Of Soil Laboratory Testing" Volume 3 Section 20.4.2)

Remarks: **None**

Certificate of sampling received: ☐

Signed: 

☒ M. Newton, Laboratory Manager

☐ P. Fletcher, Senior Technician

Start of Test Date: **05/12/2018**

End of Test Date: **13/12/2018**

Report Date: **13/12/2018**



LABORATORY REPORT REPORT



4043

Contract Number: PSL18/6353

Report Date: 06 December 2018

Client's Reference:

Client Name: 3E Consulting Engineers Ltd
1st Floor, Block C
Holland Park
Holland Drive
Newcastle Upon Tyne
NE2 4LD

For the attention of: Alex Middleton

Contract Title: Queens Park, Millom

Date Received: 30/11/2018

Date Commenced: 30/11/2018

Date Completed: 6/12/2018

Notes: Opinions and Interpretations are outside the UKAS Accreditation

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

R Gunson
(Director)

A Watkins
(Director)

R Berriman
(Quality Manager)

L Knight
(Senior Technician)

S Eyre
(Senior Technician)

A Fry
(Senior Technician)

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth	Description of Sample
WS02		D	1.00		Reddish brown slightly clayey silty SAND and GRAVEL.
WS03		D	1.00		Reddish brown slightly gravelly sandy CLAY.
WS04		D	2.00		Brown slightly gravelly sandy CLAY.
WS06		D	1.00		Reddish brown slightly gravelly clayey very silty SAND.
WS07		D	2.00		Reddish brown slightly gravelly sandy CLAY.
WS08		D	1.00		Brown slightly gravelly sandy CLAY.
WS09		D	1.50		Reddish brown slightly gravelly sandy CLAY.
WS10		D	1.00		Reddish brown slightly gravelly sandy CLAY.
WS12		D	2.00		Reddish brown slightly gravelly sandy CLAY.
WS14		D	2.00		Reddish brown sandy CLAY.
WS15		D	1.00		Reddish brown slightly gravelly very sandy CLAY.



Queens Park, Millom

Contract No:
PSL18/6353
Client Ref:
P17-498

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % Clause 3.2	Linear Shrinkage % Clause 6.5	Particle Density Mg/m ³ Clause 8.2	Liquid Limit % Clause 4.3/4	Plastic Limit % Clause 5.3	Plasticity Index % Clause 5.4	Passing .425mm %	Remarks
WS03		D	1.00		19			45	20	25	88	Intermediate plasticity CI.
WS04		D	2.00		20			36	18	18	84	Intermediate plasticity CI.
WS07		D	2.00		20			39	19	20	87	Intermediate plasticity CI.
WS08		D	1.00		17			38	19	19	88	Intermediate plasticity CI.
WS09		D	1.50		19			40	20	20	86	Intermediate plasticity CI.
WS10		D	1.00		17			40	21	19	87	Intermediate plasticity CI.
WS12		D	2.00		17			39	18	21	85	Intermediate plasticity CI.
WS14		D	2.00		19			41	20	21	100	Intermediate plasticity CI.
WS15		D	1.00		14			33	16	17	85	Low plasticity CL.

SYMBOLS : NP : Non Plastic

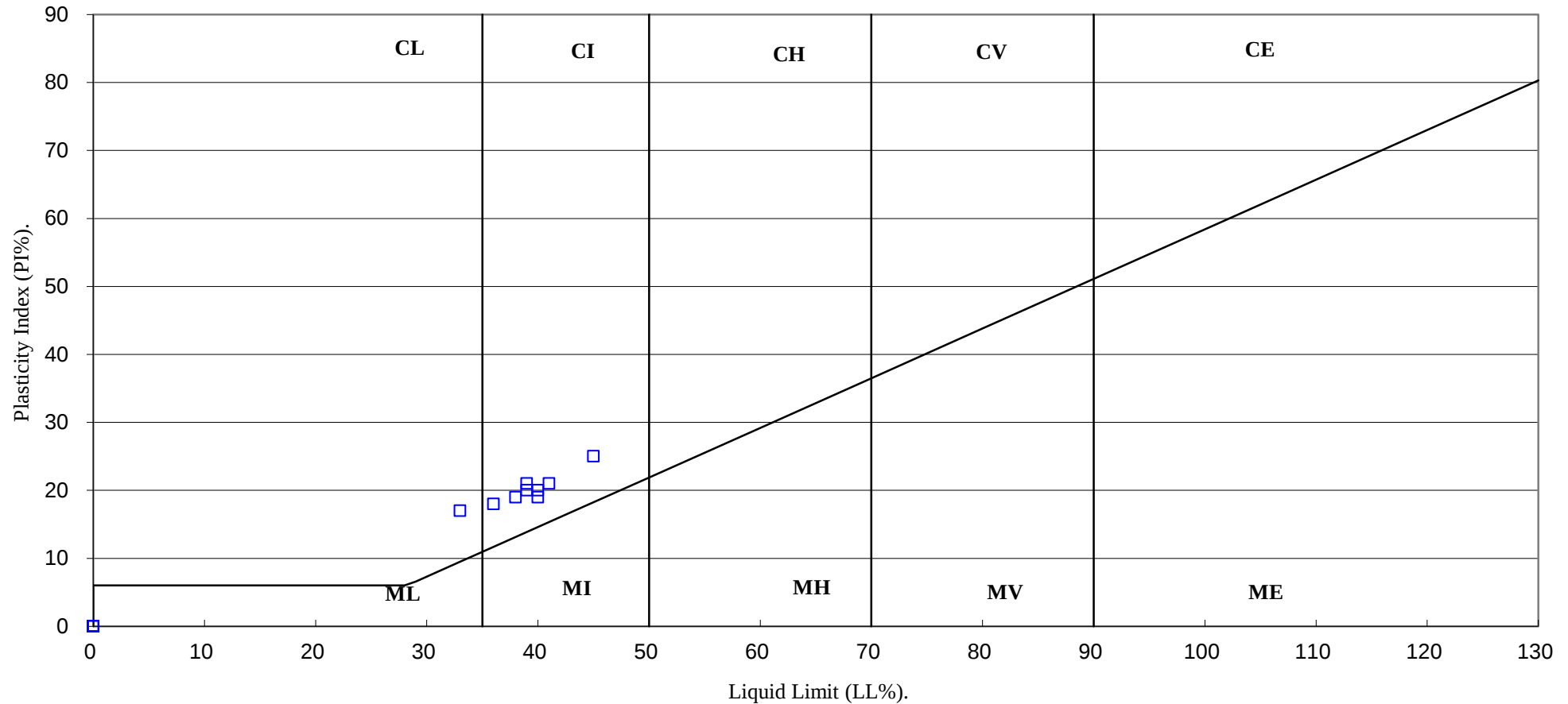
* : Liquid Limit and Plastic Limit Wet Sieved.



Queens Park, Millom

Contract No:
PSL18/6353
Client Ref:
P17-498

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



4043

PSL

Professional Soils Laboratory

Queens Park, Millom

Contract No:

PSL18/6353

Client Ref:

P17-498

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number:

WS02

Top Depth (m):

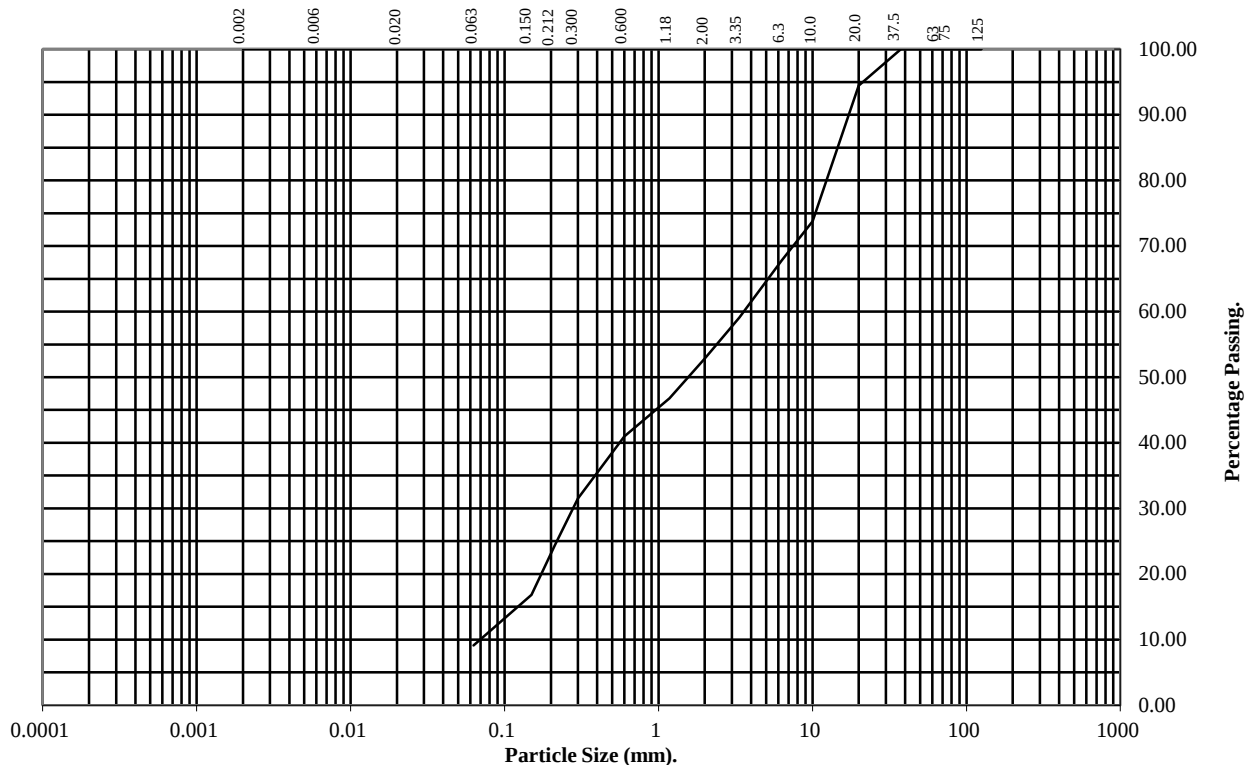
1.00

Sample Number:

Base Depth(m):

Sample Type:

D



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	94
10	74
6.3	68
3.35	59
2	53
1.18	47
0.6	41
0.3	32
0.212	24
0.15	17
0.063	9

Soil Fraction	Total Percentage
Cobbles	0
Gravel	47
Sand	44
Silt/Clay	9

Remarks:

See Summary of Soil Descriptions



PSL
Professional Soils Laboratory

Queens Park, Millom

Contract No:

PSL18/6353

Client Ref:

P17-498

PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

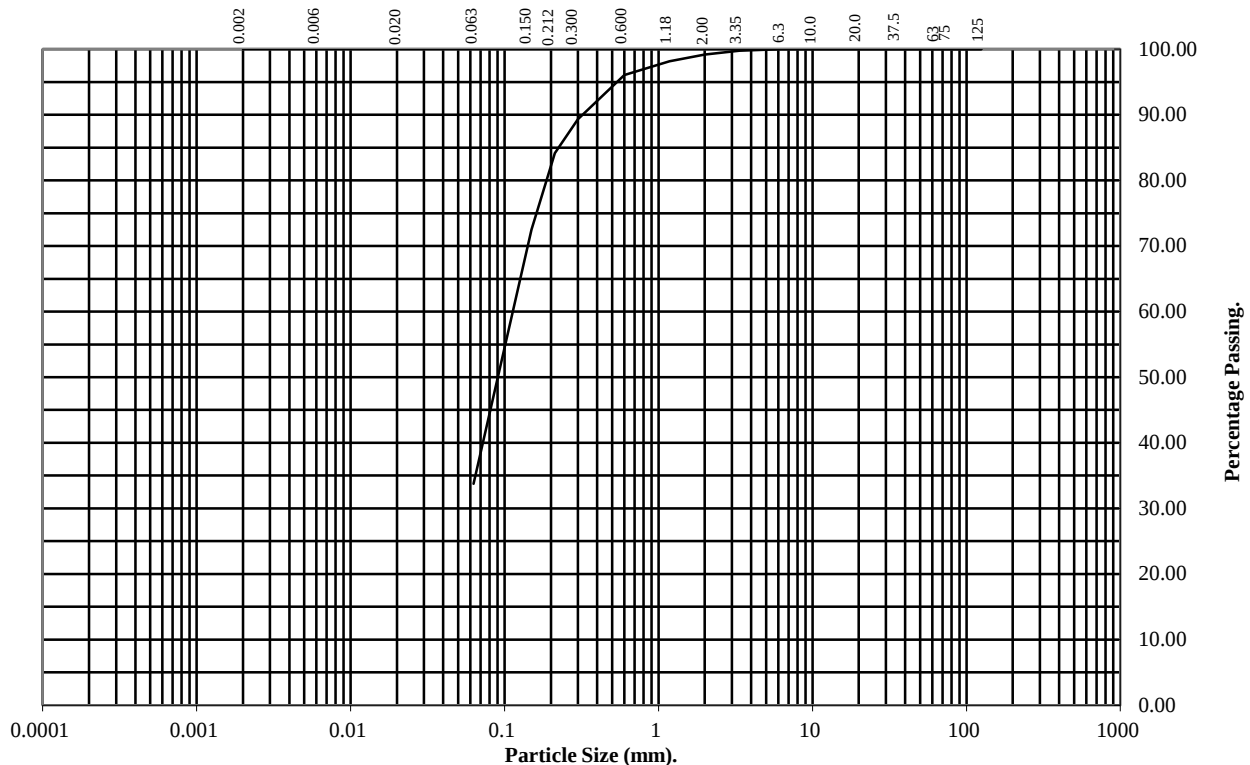
Hole Number: WS06

Top Depth (m): 1.00

Sample Number:

Base Depth(m):

Sample Type: D



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2	99
1.18	98
0.6	96
0.3	89
0.212	84
0.15	73
0.063	34

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	65
Silt/Clay	34

Remarks:

See Summary of Soil Descriptions



PSL
Professional Soils Laboratory

Queens Park, Millom

Contract No:
PSL18/6353
Client Ref:
P17-498

Appendix F

Variable Head (Falling) Permeability Calculation Sheets

3E CONSULTING ENGINEERS LIMITED

VARIABLE HEAD PERMEABILITY TEST

P17-498

Variable Head (Falling) Permeability Test in Borehole WS01

3.70 mBGL

SITE Queens Park, Millom

CONTRACT P17-498 BOREHOLE WS01 DEPTH 3.70 mBGL

INITIAL CONDITIONS

Bottom of Borehole	3.70	mBGL
Base of casing	1.00	mBGL
Diameter of casing	115.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	3.70	mBGL

Operator	AM
Date	14-01-19
Time	
Weather	Dry
Calculated	AM
Test Zone	2.70 m

TEST CALCULATION

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	1.000	2.700	1.000
1	0	60	1.000	2.700	1.000
2	0	120	1.000	2.700	1.000
3	0	180	1.000	2.700	1.000
4	0	240	1.000	2.700	1.000
5	0	300	1.000	2.700	1.000
10	0	600	1.000	2.700	1.000
20	0	1200	1.000	2.700	1.000
30	0	1800	1.100	2.600	0.963
45	0	2700	1.100	2.600	0.963
60	0	3600	1.150	2.550	0.944
120	0	7200	1.300	2.400	0.889

Intake Factor, F

$$F = \frac{2 \cdot \pi \cdot L}{\ln\{(L/D) + \sqrt{1 + (L/D)^2}\}} \quad (i)$$

(From BS 5930:1999 for standpipes)

L=length of test zone

D=diameter of standpipe

Permeability, K

$$K = \frac{A}{F \cdot (t_2 - t_1)} \cdot \ln(H_1/H_2) \quad (ii)$$

or

$$K = \frac{A}{F \cdot T} \quad (iii)$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

L= 2.70 m
D= 0.115 m
L/D= 23.4782609

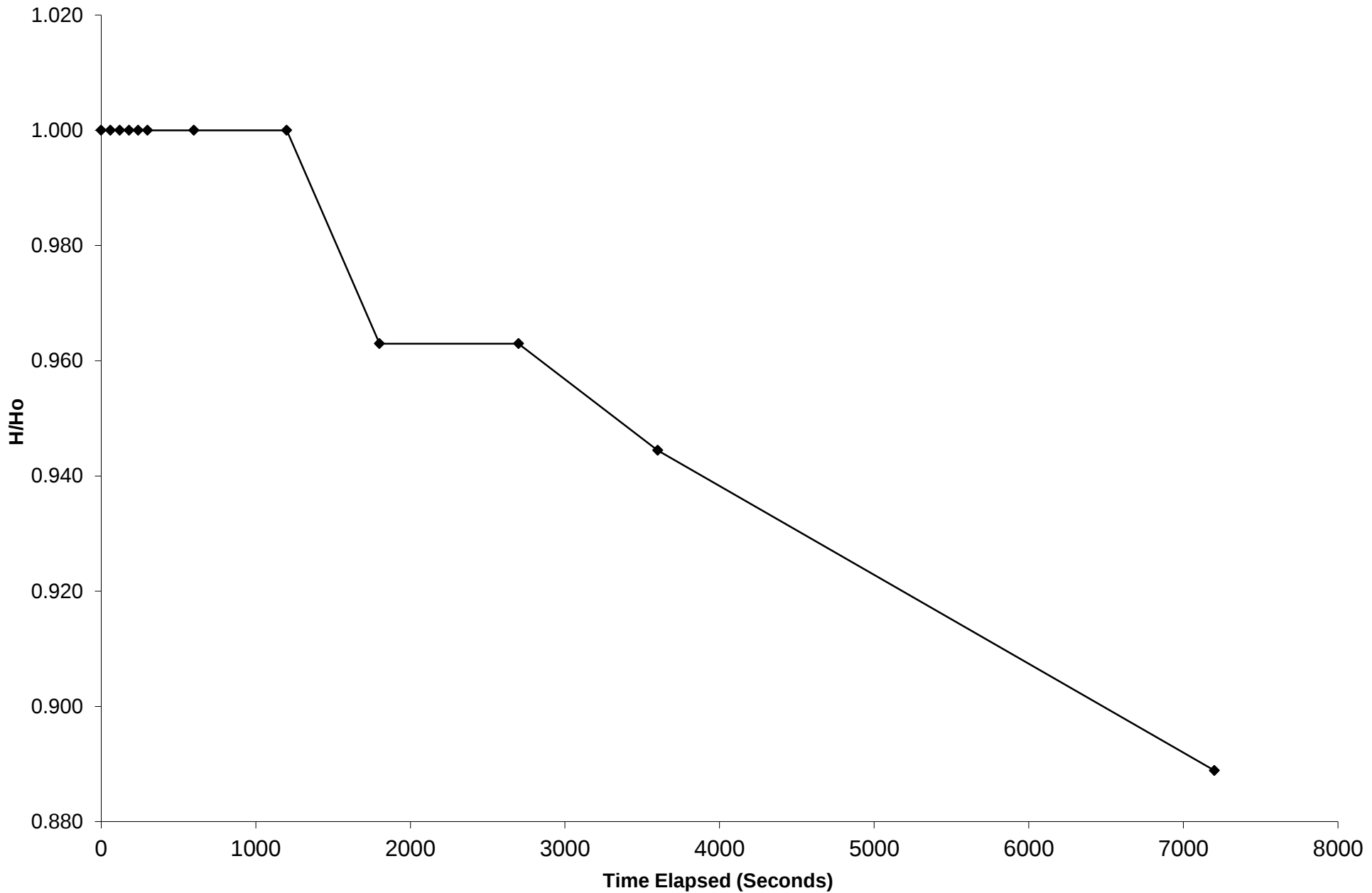
t1= 0 s
t2= 7200 s
H1= 2.70 m
H2= 2.40 m

A= 0.01039 m²
F= 4.4068 From (i)
T= s
K= 3.8558E-08 m/s From (ii)
K= m/s From (iii)

Remarks

Drainage Characteristics - POOR Permeability
Classification - VERY LOW

P17-498 - Queens Park, Millom
Variable Head (Falling) Permeability Test in WS01 at 3.70m BGL



3E CONSULTING ENGINEERS LIMITED

VARIABLE HEAD PERMEABILITY TEST

P17-498

Variable Head (Falling) Permeability Test in Borehole WS10

4.80 mBGL

SITE Queens Park, Millom

CONTRACT P17-498 BOREHOLE WS10 DEPTH 4.80 mBGL

INITIAL CONDITIONS

Bottom of Borehole	4.80	mBGL
Base of casing	1.00	mBGL
Diameter of casing	115.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	4.80	mBGL

Operator	AM
Date	14-01-19
Time	
Weather	Dry
Calculated	AM
Test Zone	3.80 m

TEST CALCULATION

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	1.000	3.800	1.000
1	0	60	1.000	3.800	1.000
2	0	120	1.000	3.800	1.000
3	0	180	1.000	3.800	1.000
4	0	240	1.000	3.800	1.000
5	0	300	1.000	3.800	1.000
10	0	600	1.100	3.700	0.974
20	0	1200	1.130	3.670	0.966
30	0	1800	1.150	3.650	0.961
60	0	3600	1.210	3.590	0.945
120	0	7200	1.320	3.480	0.916

Intake Factor, F

$$F = \frac{2 \cdot \pi \cdot L}{\ln\{(L/D) + \sqrt{1 + (L/D)^2}\}} \quad (i)$$

(From BS 5930:2015 for standpipes)

L=length of test zone

D=diameter of standpipe

Permeability, K

$$K = \frac{A}{F \cdot (t_2 - t_1)} \cdot \ln(H_1/H_2) \quad (ii)$$

or

$$K = \frac{A}{F \cdot T} \quad (iii)$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

L= 3.80 m

D= 0.115 m

L/D= 33.0434783

t1= 0 s

t2= 7200 s

H1= 3.80 m

H2= 3.48 m

A= 0.01039 m²

F= 5.6967 From (i)

T= s

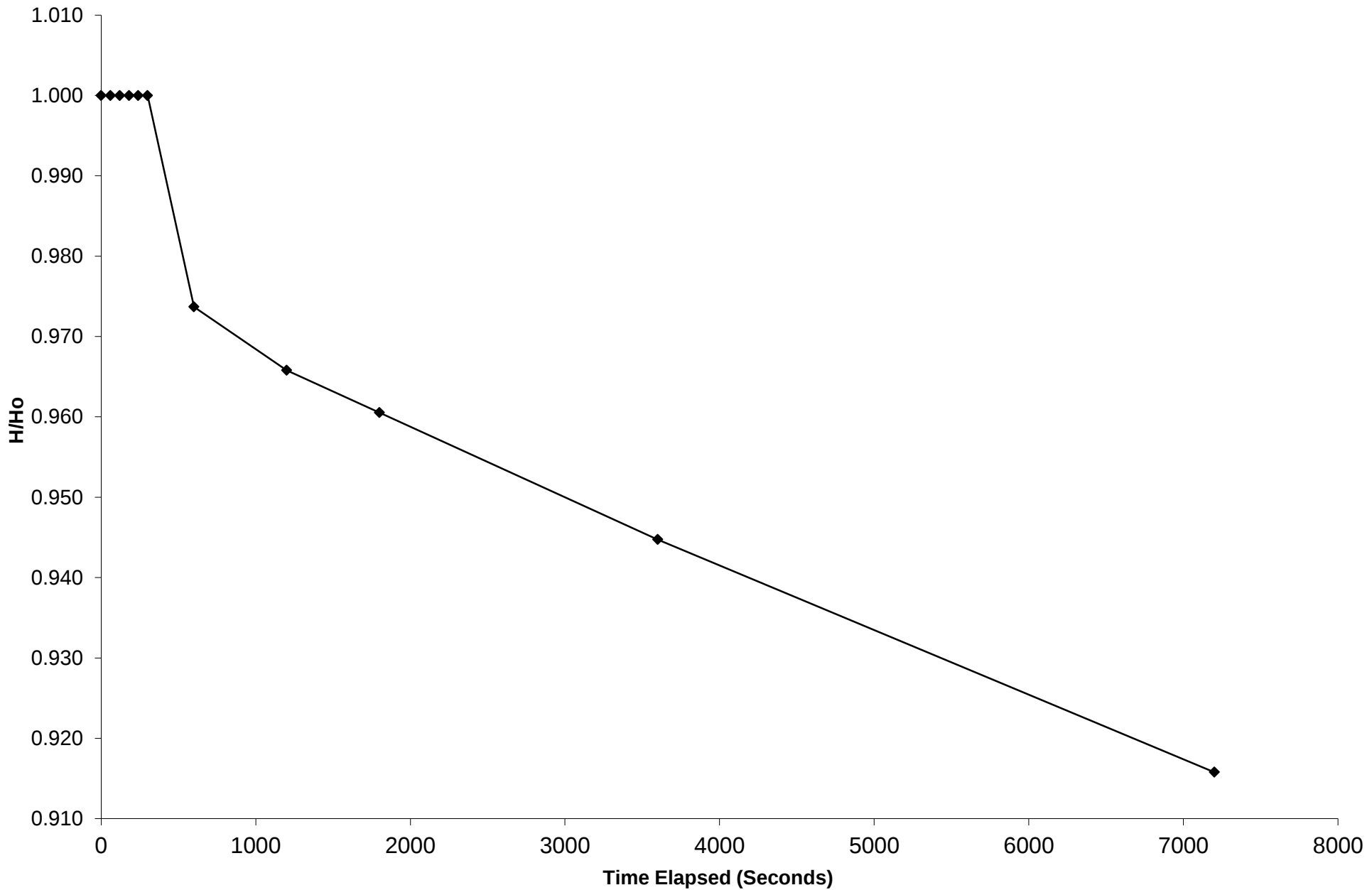
K= 2.2277E-08 m/s From (ii)

K= m/s From (iii)

Remarks

Drainage Characteristics - POOR Permeability
Classification - VERY LOW

P17-498 - Queens Park, Millom
Variable Head (Falling) Permeability Test in WS10 at 4.80m BGL



3E CONSULTING ENGINEERS LIMITED

VARIABLE HEAD PERMEABILITY TEST

P17-498

Variable Head (Falling) Permeability Test in Borehole WS06

3.00 mBGL

SITE Queens Park, Millom

CONTRACT P17-498 BOREHOLE WS10 DEPTH 3.00 mBGL

INITIAL CONDITIONS

Bottom of Borehole	3.00	mBGL
Base of casing	1.00	mBGL
Diameter of casing	115.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	0.90	mBGL

Operator	AM
Date	14-01-19
Time	
Weather	Dry
Calculated	AM
Test Zone	2.00 m

TEST CALCULATION

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	0.500	0.400	1.000
1	0	60	0.500	0.400	1.000
2	0	120	0.500	0.400	1.000
3	0	180	0.500	0.400	1.000
4	0	240	0.500	0.400	1.000
5	0	300	0.500	0.400	1.000
10	0	600	0.500	0.400	1.000
20	0	1200	0.500	0.400	1.000
30	0	1800	0.550	0.350	0.875
60	0	3600	0.600	0.300	0.750
120	0	7200	0.670	0.230	0.575

Intake Factor, F

$$F = \frac{2 \cdot \pi \cdot L}{\ln\{(L/D) + \sqrt{1 + (L/D)^2}\}} \quad (i)$$

(From BS 5930:2015 for standpipes)

L=length of test zone

D=diameter of standpipe

Permeability, K

$$K = \frac{A}{F \cdot (t_2 - t_1)} \cdot \ln(H_1/H_2) \quad (ii)$$

or

$$K = \frac{A}{F \cdot T} \quad (iii)$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

L= 2.00 m

D= 0.115 m

L/D= 17.3913043

t1= 0 s

t2= 7200 s

H1= 0.40 m

H2= 0.23 m

A= 0.01039 m²

F= 3.5399 From (i)

T= s

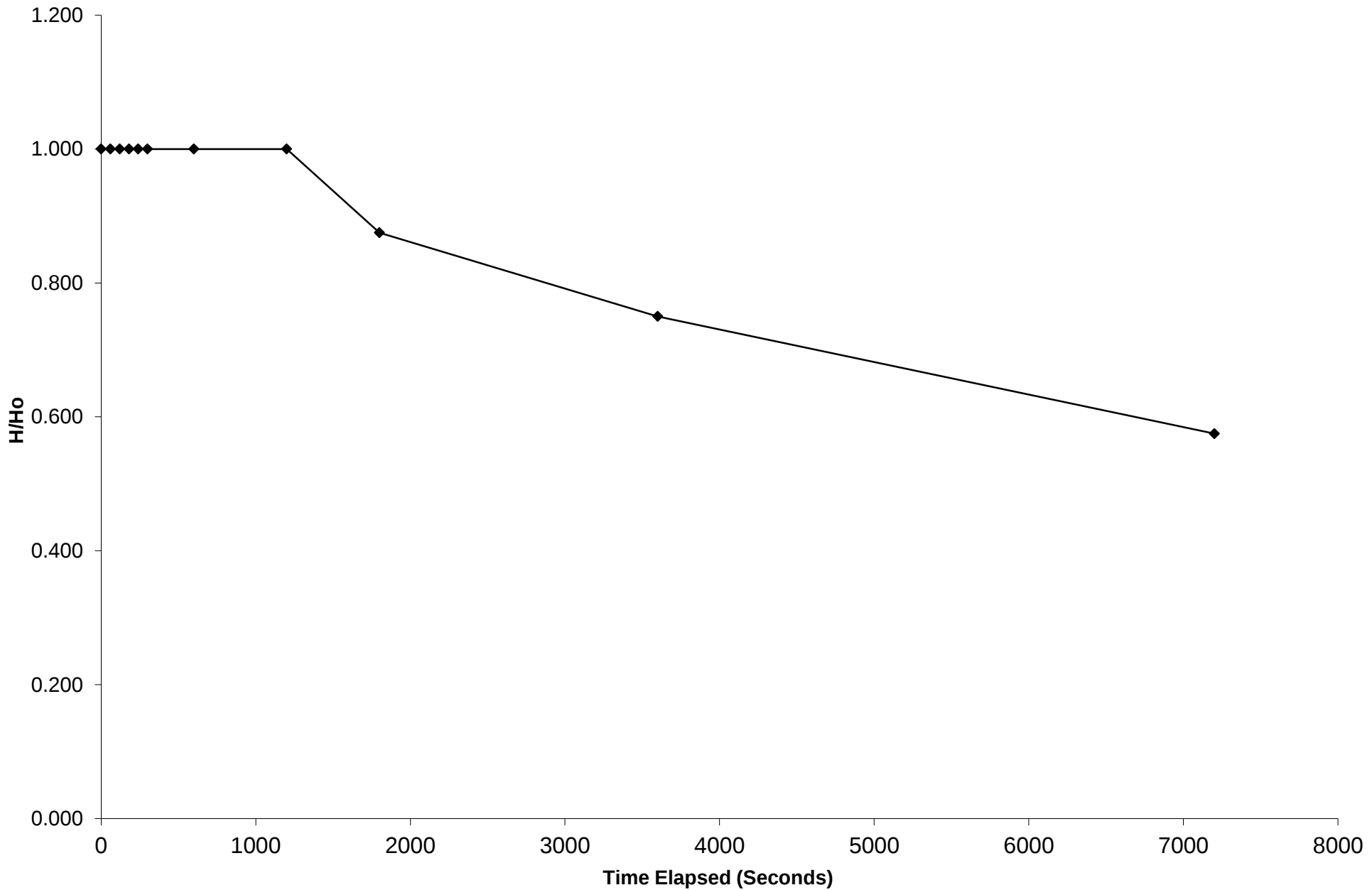
K= 2.2552E-07 m/s From (ii)

K= m/s From (iii)

Remarks

Drainage Characteristics - POOR Permeability
Classification - LOW

P17-498 - Queens Park, Millom
Variable Head (Falling) Permeability Test in WS06 at 3.00m BGL



3E CONSULTING ENGINEERS LIMITED

VARIABLE HEAD PERMEABILITY TEST

P17-498

Variable Head (Falling) Permeability Test in Borehole WS14

4.00 mBGL

SITE Queens Park, Millom

CONTRACT P17-498 BOREHOLE WS14 DEPTH 4.00 mBGL

INITIAL CONDITIONS

Bottom of Borehole	4.00	mBGL
Base of casing	1.00	mBGL
Diameter of casing	115.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	0.90	mBGL

Operator	AM
Date	14-01-19
Time	
Weather	Dry
Calculated	AM
Test Zone	3.00 m

TEST CALCULATION

Elapsed (minutes)	Elapsed (seconds)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0	0	0	0.500	0.400	1.000
1	0	60	0.500	0.400	1.000
2	0	120	0.500	0.400	1.000
3	0	180	0.500	0.400	1.000
4	0	240	0.500	0.400	1.000
5	0	300	0.500	0.400	1.000
10	0	600	0.550	0.350	0.875
20	0	1200	0.550	0.350	0.875
30	0	1800	0.550	0.350	0.875
60	0	3600	0.600	0.300	0.750
120	0	7200	0.700	0.200	0.500

Intake Factor, F

$$F = \frac{2 \cdot \pi \cdot L}{\ln\{(L/D) + \sqrt{1 + (L/D)^2}\}} \quad (i)$$

(From BS 5930:2015 for standpipes)

L=length of test zone

D=diameter of standpipe

Permeability, K

$$K = \frac{A}{F \cdot (t_2 - t_1)} \cdot \ln(H_1/H_2) \quad (ii)$$

or

$$K = \frac{A}{F \cdot T} \quad (iii)$$

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

L= 3.00 m

D= 0.115 m

L/D= 26.0869565

t1= 0 s

t2= 7200 s

H1= 0.40 m

H2= 0.20 m

A= 0.01039 m²

F= 4.7661 From (i)

T= s

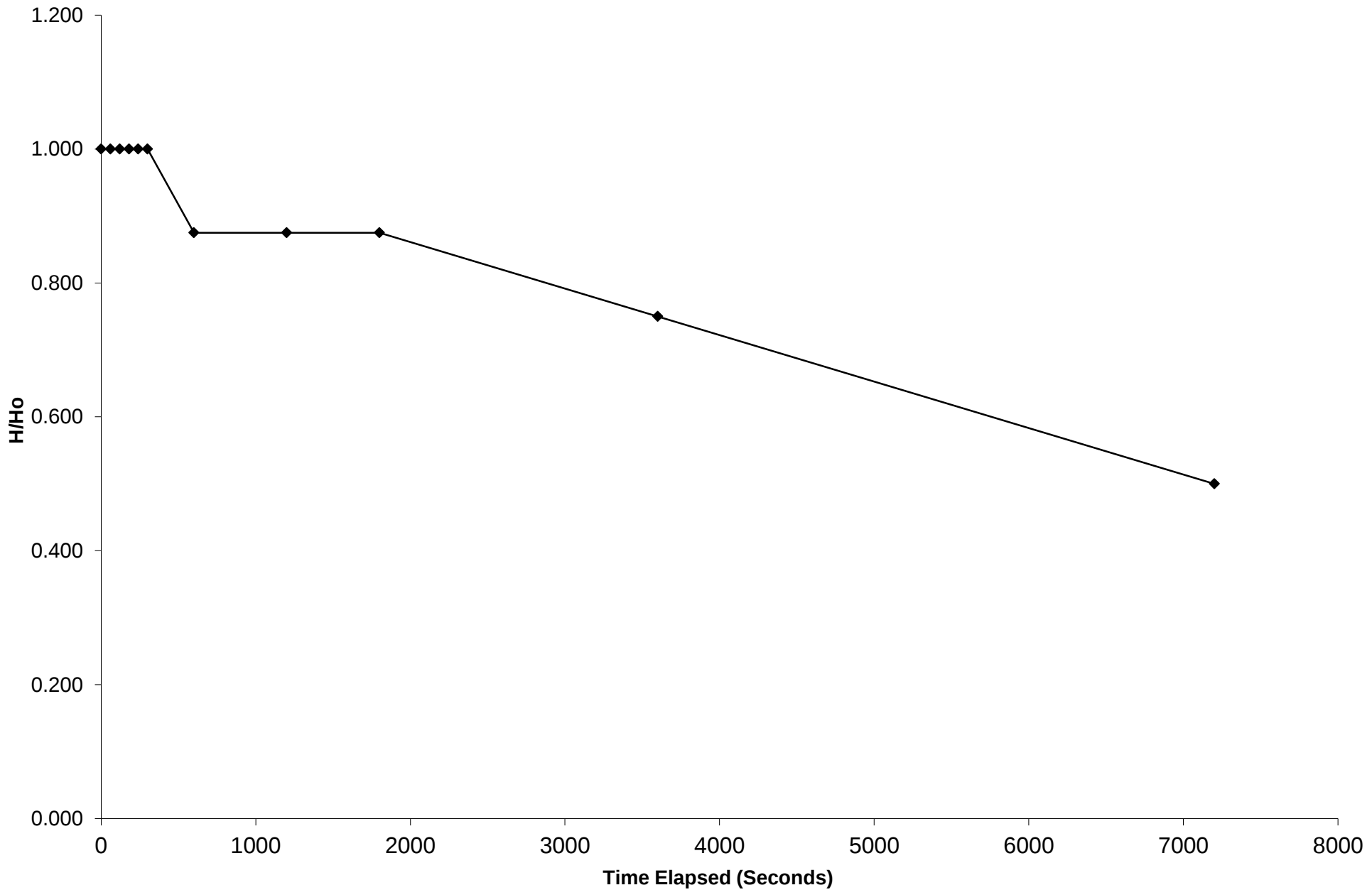
K= 2.0981E-07 m/s From (ii)

K= m/s From (iii)

Remarks

Drainage Characteristics - POOR Permeability
Classification - LOW

P17-498 - Queens Park, Millom
Variable Head (Falling) Permeability Test in WS14 at 4.00m BGL



Appendix G

Statistical Analysis

3e Consulting Engineers Ltd. - CL:AIRE Statistical Analysis Sheet (Made Ground - excluding WS01)

Client/client ref: Home Group
Project ref: P17-498
Site ref: Queens Park, Millom
Data description: Screening Results -
Topsoil (excluding WS01)
Contaminant(s): Generic Soils Suite
Test scenario: Planning
Date: 18th January 2019

	Benzo(b)Fluoranthene (mg/kg)	Benzo(a)pyrene (mg/kg)	Diabenz(ah)anthracene (mg/kg)								
Critical concentration, C _c	2.6	2.2	0.24								
Notes	S4UL	S4UL	S4UL								
Sample size, n	6	6	6	0	0	0	0	0	0	0	0
Sample mean, $\bar{x}$	0.15	0.085	0.02666667	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Standard deviation, s	0.09715966	0.06655825	0.02581989								
Number of non-detects	1	1	4								
Set non-detect values to:	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit
Outliers?	No	No	No								
Distribution	Normal	Normal	Non-normal								
Statistical approach	Auto: One-sample t	Auto: One-sample t	Auto: Chebychev	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto

Test scenario:	Planning: is true mean lower than critical concentration ($\mu < C_c$)			Evidence level required:	95%	Use Normal distribution to test for outliers					
t statistic, t ₀ (or k ₀)	-61.7668868	-77.83664958	-20.23857703								
Upper confidence limit (on true mean concentration, μ)	0.22992743	0.13975348	0.0726135								
Evidence level	100%	100%	100%								
Base decision on:	evidence level	evidence level	evidence level								
Result	$\mu < C_c$	$\mu < C_c$	$\mu < C_c$								
Select dataset	☒ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y

Back to data

Go to outlier test

Go to normality test

Show individual summary

3e Consulting Engineers Ltd. - CL:AIRE Statistical Analysis Sheet (Made Ground - Including WS01)

Client/client ref: Home Group
Project ref: P17-498
Site ref: Queens Park, Millom
Data description: Screening Results -
Topsoil (including WS01)
Contaminant(s): Generic Soils Suite
Test scenario: Planning
Date: 18th January 2019

	Benzo(b)Fluo ranthene (mg/kg)	Benzo(a)pyre ne (mg/kg)	Diabenz(ah)a nthracene (mg/kg)								
Critical concentration, C _c	2.6	2.2	0.24								
Notes	S4UL	S4UL	S4UL								
Sample size, n	7	7	7	0	0	0	0	0	0	0	0
Sample mean, $\bar{x}$	0.88	0.67571429	0.12714286	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Standard deviation, s	1.93343391	1.56406369	0.26687789								
Number of non-detects	1	1	4								
Set non-detect values to:	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit	Half detection limit
Outliers?	Yes	Yes	Yes								
Distribution	Non-normal	Non-normal	Non-normal								
Statistical approach	Auto: Chebychev	Auto: Chebychev	Auto: Chebychev	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto

Test scenario:	Planning: is true mean lower than critical concentration ($\mu < C_c$)			Evidence level required:	95%	Use Normal distribution to test for outliers					
t statistic, t ₀ (or k ₀)	-2.3536839	-2.57846336	-1.118833527								
Upper confidence limit (on true mean concentration, μ)	4.06534965	3.25252321	0.56682657								
Evidence level	85%	87%	56%								
Base decision on:	evidence level	evidence level	evidence level								
Result	$\mu \approx \geq C_c$	$\mu \approx \geq C_c$	$\mu \approx \geq C_c$								
Select dataset	☒ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y	☐ Y

Back to data

Go to outlier test

Go to normality test

Show individual summary