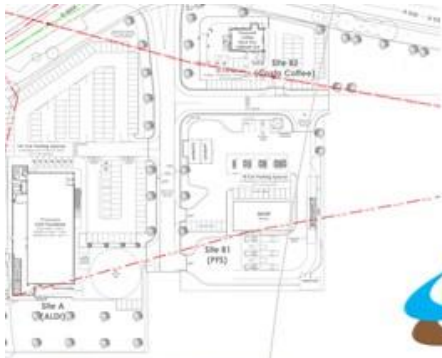




Earth Environmental
& Geotechnical

GeoEnvironmental Investigation

Ruabon Park
Wrexham

February 2018

On behalf of

Liberty Property Developments Ltd
&
ALDI Stores UK Ltd



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**GEOENVIRONMENTAL
INVESTIGATION**

RUABON PARK

WREXHAM

Report Ref: A2352/18

FEBRUARY 2018

Prepared on Behalf of:

LIBERTY PROPERTY DEVELOPMENTS LTD & ALDI STORES UK

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GEOENVIRONMENTAL INVESTIGATION

RUABON PARK, WREXHAM

A Report Reference: A2352/17

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Date: 16th February 2018

Prepared for: Liberty Property Developments Ltd & ALDI Stores UK

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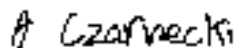
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1.0 INTRODUCTION

1.1 Background

A Geo-Environmental Site Investigation has been commissioned by SWF Consulting Ltd on behalf of Liberty Property Developments Ltd and ALDI Stores UK (the Client) to examine ground conditions and retrieve soil samples for chemical and geotechnical testing for a proposed retail store in Ruabon Park, Wrexham.

1.2 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) was commissioned by the Client to undertake a Geo-Environmental Investigation of the site in accordance with a proposal A2352 dated 13th December 2017.

The objectives of this investigation are as follows:

- Factual information on the work undertaken including sampling location plan, borehole logs, trial pit logs and chemical testing.
- Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of potential soil contaminants identified against current and appropriate published guidelines, in relation to identified receptors, e.g. existing/ future end users and site neighbours.
- Assessment of ground conditions for foundation design purposes.
- Assessment of soil quality for offsite disposal purposes.
- Assessment of infiltration rates from soakaway testing.

1.3 Limitations of the Study

The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information, improved practices or changes in legislation may require a reinterpretation of the report in whole or in part. EEG reserve the right to amend either conclusions or recommendations in light of any further information that may become available. The report is provided for the sole use by the client and is confidential to them.

Recommendations within this report are also based on exploratory records and examination of samples and, where applicable, laboratory tests. No liability can be accepted for conditions not revealed by the boreholes and trial pits, particularly at intervening locations. Whilst every effort is made to ensure accuracy of data supplied, all opinions expressed as to the spatial distribution of strata between sampling locations is for guidance only and no responsibility is accepted as to its accuracy.

2.0 SITE LOCATION & DESCRIPTION

2.1 Site Location & Description

The site is located central of the central of Ruabon, within Ruabon Park, approximately 2.3km east of Acrefair and 3.35km west of Pen-y-Lan. The site is an irregular shape approximately 160m x 170m, 2.45ha, National Grid Reference SJ 29872 43466 (329872E, 343466N). At the time of the investigation the site was being used as agricultural land for the production of rapeseed. The site is generally sloping gently to the south with a lake directly south west of the site. The site is bound by agricultural land to the east, south and west with a dual carriageway with a roundabout to the north followed by residential homes. There is a sewer that runs across the north of the site orientation east west easily identifiable by risen manhole covers. In addition to the sewer there are overhead cables from electricity pylons that run east west across the southern extent of the site.

The site location is shown in Figure 1.

Figure 1 Site Location Plan



Site photographs are presented in Figures 2 to 10 below.

Figure 2 Photograph at entrance to site



Figure 3 Photograph at entrance, facing west towards the site



Figure 4 Photograph facing west towards the site



Figure 5 Photograph facing west towards the site, towards roundabout



Figure 6 Photograph facing west towards the lake



Figure 7 Photograph of samples recovered from WS1



Figure 8 Photograph of samples recovered from WS2



Figure 9 Photograph of samples recovered from WS3



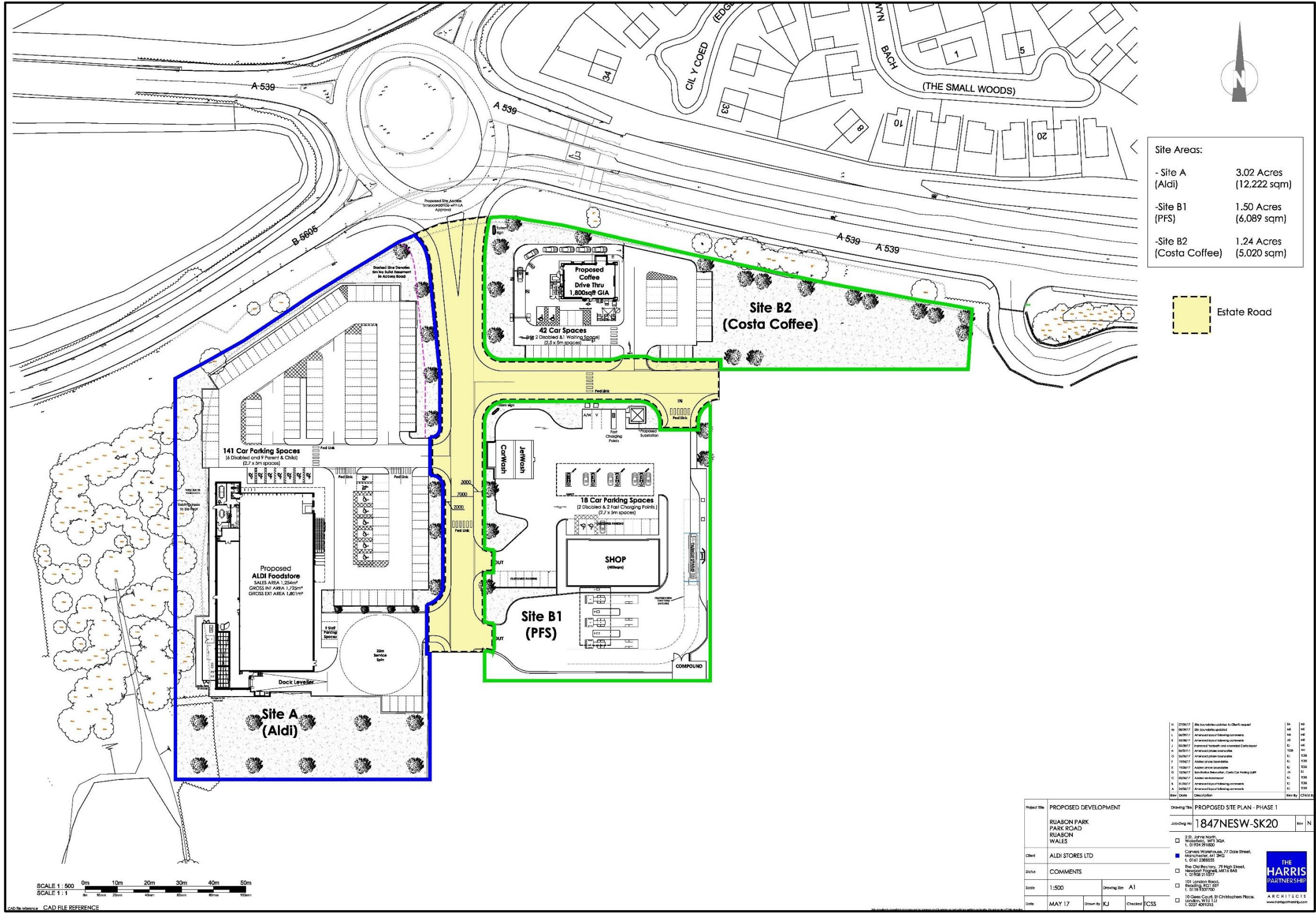
Figure 10 Photograph of samples recovered from WS4



2.2 Proposed Development

The current proposed development of the land includes an ALDI retail store with 141 car parking spaces including six disabled and nine parent and child spaces to the west. A Costa drive thru with 42 car spaces including two disabled and one waiting space to the north east and a fuelling station with a shop and carwash with associated 18 car parking spaces including two disabled and two fast charging points as seen in Figure 10 (overleaf).

Figure 11 Proposed Development Plan



3.0 SITE INVESTIGATION

3.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on the 15th and the 19th January 2018 and comprised:

- Five window sample boreholes (designated WS1 to WS5 inclusive) were each sunk to depths of between 4.0m and 6.0m below existing ground level. Window sampler boring is carried out with a small, track-mounted rig, which uses a chain-driven trip hammer to drive sampling tubes or penetrometers into the ground. These tools are coupled to the anvil of the hammer by solid drill rods. Sampling tubes comprise “windowless samplers”, which are plain sampler tubes in which a continuous disturbed sample is recovered within a semi-rigid plastic liner. In order to reduce friction within the borehole, sampling tubes of progressively smaller diameter are used as the borehole depth increases. Sampler diameters generally range from between approximately 90mm to 50mm. Standard Penetration Tests (SPTs) were undertaken in the boreholes in accordance with BS EN ISO 22476-3. Exploratory Hole logs are included in Appendix 1.

13 Trial pits (designated TPA, B, D, E, G, H, J, N, O, R, S, U and V) were excavated to a depth between 2.0m and 3.m below existing ground level, using a wheeled excavator. Representative disturbed samples were recovered from the excavated material as pitting proceeded. In situ soakaway testing was carried out in the base of the Trial Pit B, D, G, O and R, in accordance with the methods described in BRE Digest 365⁽²⁰⁰⁷⁾, the results of which are included in Appendix 2. The trial pits were backfilled immediately on completion of sampling and testing.

Figure 12 Exploratory Hole Location Plan



Each exploratory location was scanned using a Cable Avoidance Tool (CAT) in order to locate unrecorded underground services, and the exploratory locations were repositioned if necessary.

All locations were surveyed by use of a hand held Trimble GPS with a positional accuracy of less than 1m, depending upon satellite coverage.

On completion, all samples recovered from the site were taken to a specialist laboratory for testing.

All site investigation work was supervised full time by a representative of EEG. The logging of soils and rocks has been carried out in accordance with BS5930⁽²⁰¹⁵⁾ except where superseded by the soil and rock description methodology in BS EN14688-1⁽²⁰⁰²⁾, BS EN 14688-2⁽²⁰⁰⁴⁾ and BS EN 14689-1⁽²⁰⁰³⁾.

A summary of exploratory holes undertaken during the investigation is presented in Table 1.

Table 1 : Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Backfill Details**
WS1	WS	5.00	19/01/2018	19/01/2018	A
WS2	WS	5.00	19/01/2018	19/01/2018	A
WS3	WS	6.00	19/01/2018	19/01/2018	A
WS4	WS	4.00	19/01/2018	19/01/2018	A
WS5	WS	5.00	19/01/2018	19/01/2018	A
TPA	TP	3.10	15/01/2018	15/08/2017	A
TPB	SA	2.10	15/01/2018	15/01/2018	A
TPD	SA	2.00	15/01/2018	15/01/2018	A
TPE	TP	3.00	15/01/2018	15/01/2018	A
TPG	SA	2.30	15/01/2018	15/01/2018	A
TPH	TP	2.50	15/01/2018	15/01/2018	A
TPJ	TP	3.40	15/01/2018	15/01/2018	A
TPN	TP	2.80	15/01/2018	15/01/2018	A
TPO	SA	2.00	15/01/2018	15/01/2018	A
TPR	SA	2.20	15/01/2018	15/01/2018	A
TPS	TP	2.80	15/01/2018	15/01/2018	A
TPU	TP	3.00	15/01/2018	15/01/2018	A
TPV	TP	3.10	15/01/2018	15/01/2018	A
*WS= Window Sample Borehole, TP = Trial Pit, SA = Soakaway					

3.2 Laboratory Testing Programme

3.2.1 Geotechnical Testing

A programme of laboratory testing was carried out on samples taken from the various strata to assist in classification and determine the engineering properties of the materials underlying the site. The test procedures used were generally in accordance with the methods described in BS1377:1990. Details of the specific tests used in each case are given below:

TEST	STANDARD (BS1377:1990)	No.
Liquid Limit, Plastic Limit, Plasticity Index	Part 2, Clause 4 / 5	4
Particle size distribution (wet)	Part 2, Clause 9.5	4
Sulphate content of 2:1 soil: water extract	Part 3,	4
pH value	Part 3,	4

The results of the laboratory geotechnical tests are discussed in Section 5 and included in Appendix 4.

3.2.2 Environmental Testing

The environmental chemistry of the ground was investigated by specialist chemical analysis of selected samples, scheduled by EEG and carried out by QTSE.

Chemical analyses were carried out on sixteen soil samples and were submitted for the following suite of determinants:

Asbestos Screen, Arsenic, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc, Cyanide, Thiocyanate, Phenol, Sulphate (SO₄), Sulphide, pH, Sulphur, Soil Organic Matter and speciated Polyaromatic Hydrocarbons (PAH) and Total Petroleum Hydrocarbons (TPH).

The results of the laboratory contamination tests are discussed in Section 7 and included in Appendix 3.

4.0 GROUND CONDITIONS ENCOUNTERED

4.1 Soil Profile Encountered

The sequence of strata encountered beneath the site was:

- Topsoil.
- Devensian Glaciofluvial Deposits

The depths of the various materials encountered in each of the exploratory holes are summarised in the following table.

Table 2 : Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m)							GROUNDWATER
	TOPSOIL	MADE GROUND	DEVENSIAN GLACIALFLUVIAL DEPOSITS					
			Sandy Gravelly CLAY	SAND and GRAVEL	Silty SAND	Gravelly SAND	Silty CLAY	
WS1	GL-0.30		0.30-0.90	0.90-4.00	4.00 -5.00	-	-	3.0
WS2	GL-0.40		-	0.40-4.00	-	-	-	2.8
WS3	GL-0.40		0.40-0.80	-	-	0.80-6.00	-	2.0
WS4	GL-0.40		-	0.40-4.00	-	-	-	3.0
WS5	GL-0.30	0.30-1.30		1.90-5.00	-	0.30-1.30	-	3.0
TPA	GL-0.20		0.20-1.60	1.60-3.10	-	-	-	-
TPB	GL-0.30		-	0.30-2.10	-	-	-	-
TPD	GL-0.20		-	0.20-2.00	-	-	-	-
TPE	GL-0.20		-	1.70-3.00	-	0.20-1.70	-	-
TPG	GL-0.20		-	1.60-2.30	-	0.20-1.60	-	-
TPH	GL-0.20		-	0.20-2.50	-	-	-	-
TPJ	GL-0.20		-	0.20-1.50	2.60-3.40	1.50-2.60	-	-
TPN	GL-0.20		0.90-2.40	0.20-0.90	-	-	-	-
				2.40-2.80				
TPO	GL-0.20		-	0.20-2.00	-	-	-	-
TPR	GL-0.20		-	1.50-2.20	-	0.20-1.50	-	-
TPS	GL-0.20		-	0.20-2.80	-	-	-	-
TPU	GL-0.30		-	-	-	0.30-3.00	-	-
TPV	GL-0.20		-	0.30-2.10	-	-	1.90-3.10	-

Figure 13 2D Cross Section Plan

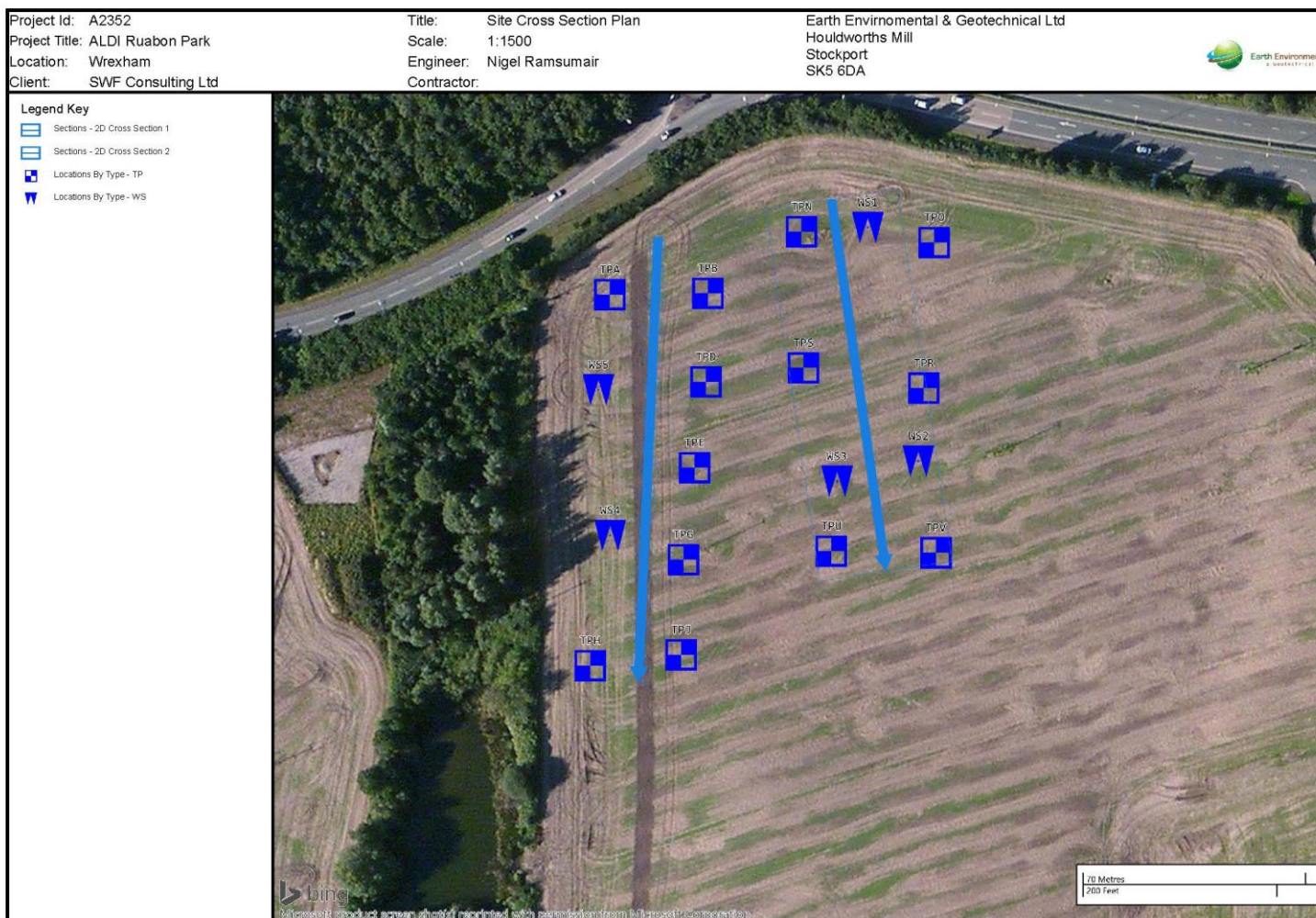


Figure 14 2D Cross Section 1

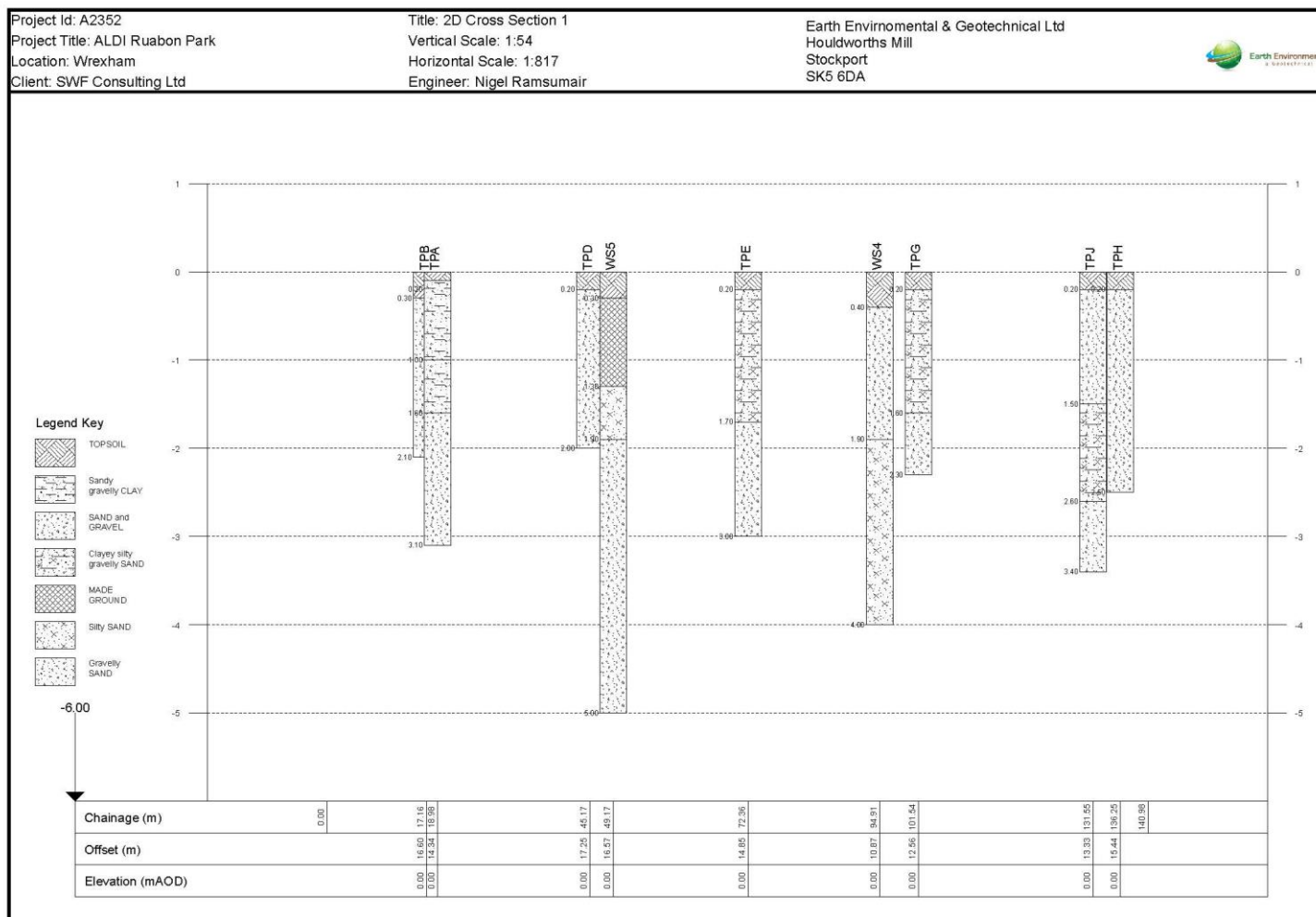
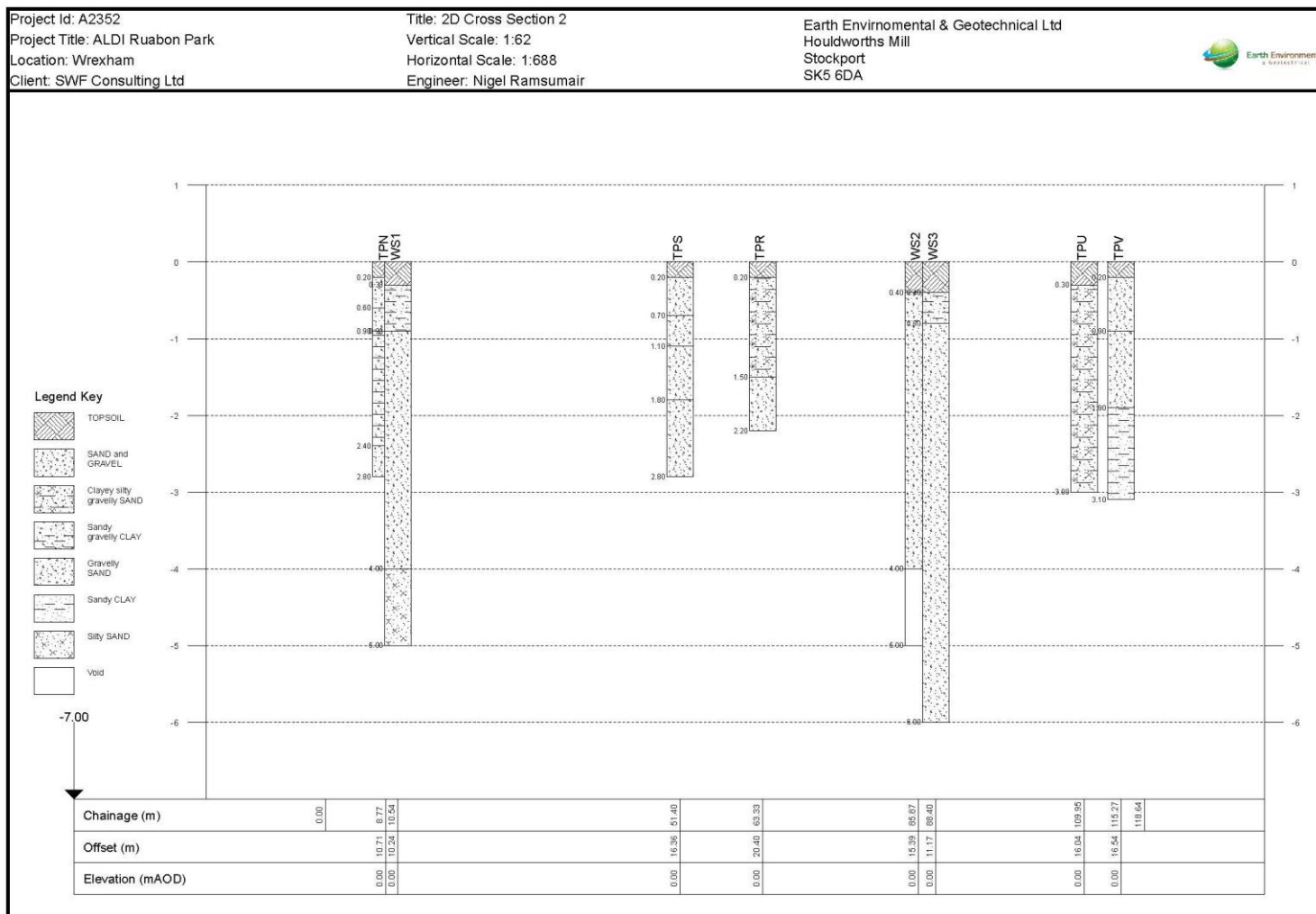


Figure 15 2D Cross Section 2



4.2 Observable Indications of Contamination

No visual or olfactory evidence of contamination was identified during the investigation.

4.3 Obstructions

Underground man-made obstructions were not encountered during the fieldwork.

4.4 Groundwater

Subsequent monitoring of groundwater in standpipes indicated groundwater levels at depths ranging between 2.00m^(WS3) and 3.00m^(WS1).

4.5 Ground Gas/Water Monitoring

Ground gas and water monitoring was not required during this ground investigation.

5.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED

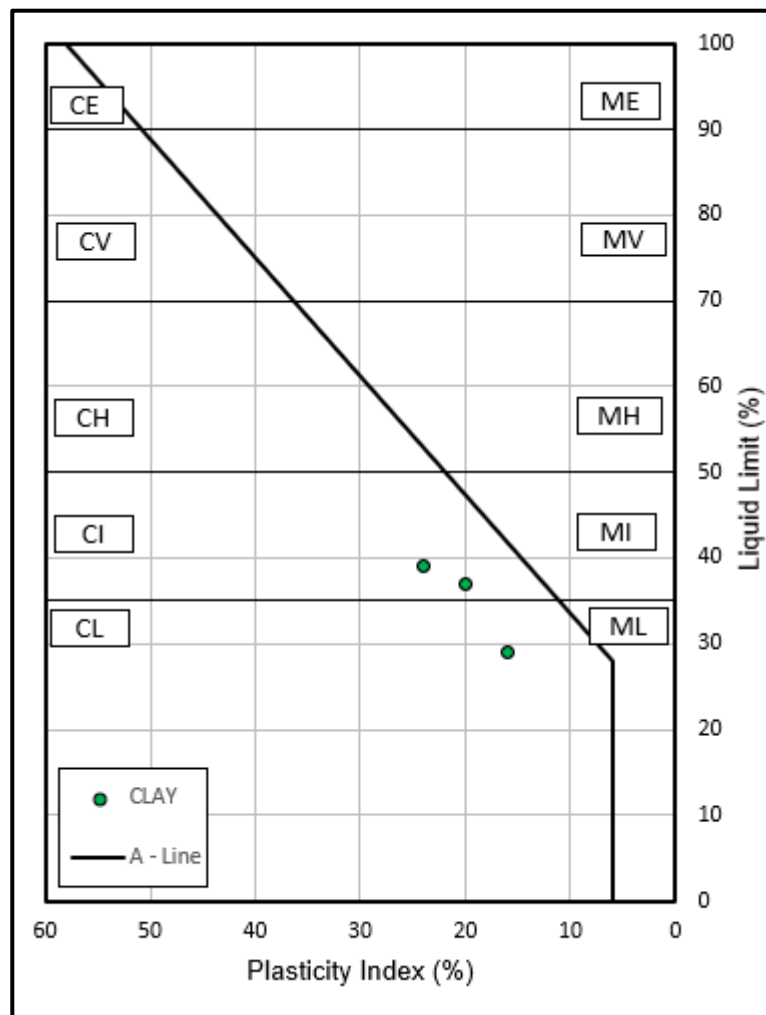
The following sections discuss the engineering properties of the strata encountered, based on results of in situ testing and laboratory testing obtained during this investigation.

Laboratory tests have given values of **water soluble sulphate** (SO_4) 0.24g/l to 0.38g/l, together with **pH Values** in the range 6.8 to 7.2.

5.1 Devensian Till (Clay)

Atterberg Limit tests have given values of **liquid limit** in the range 29% to 39% and **plastic limit** values in the range 13% to 17%, resulting in values of **plasticity index** in the range 16% to 24%. These results suggest the samples tested are either clay of low or intermediate plasticity as shown on the Plasticity Chart below. For design purposes, a value of plasticity index = 20% is recommended, based on the average of the results.

Figure 16 Plasticity Chart



In accordance with NHBC Chapter 4.2 Building Near Trees ⁽²⁰⁰³⁾ soils can be classified in terms of volume change potential, using the relationship:

$$I_p' = I_p \times \frac{\% \text{ less than } 425\mu\text{m}}{100\%}$$

....where I_p' = modified plasticity index, I_p = plasticity index.

Based on the laboratory test results, the above relationship and Table 1 of NHBC Chapter 4.2, the samples of clay are shown to have **low volume change potential**.

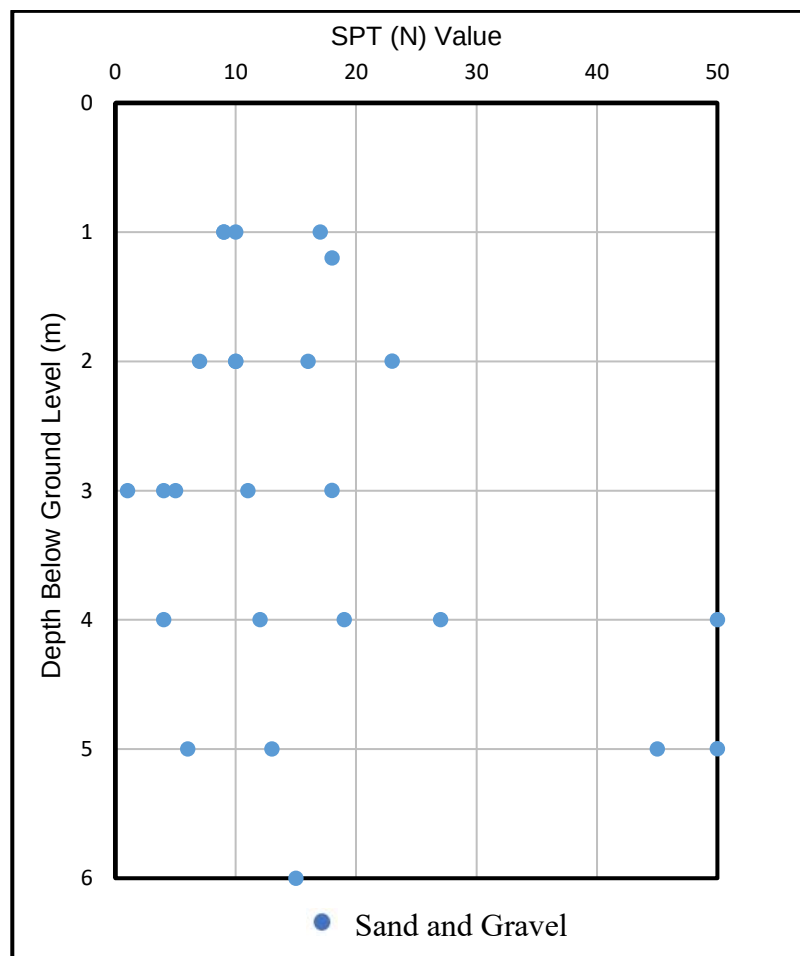
The coefficient of volume compressibility (m_v) may also be estimated from a correlation by Stroud and Butler (1975): for a clay with a plasticity index of 20%, $m_v = 1 / (450 \times N \text{ value})$.

5.2 Devensian Till (Sand)

Laboratory **particle size distribution** (PSD) tests suggest the samples tested are silty sand or gravel. Results are included in Appendix 4.

SPT N values range from 1 to 50, as can be seen from the SPT v Depth Plot, below. These results suggest the granular material is very loose to very dense.

Figure 17 SPT v Depth Plot



It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the average N values are used. For assessing settlements average ground conditions will give a more realistic value of settlements, and the average of N values should be used (i.e. N = 12.6 at 1.00m, N = 12.8 at 2.00m and N = 7.8 at 3.00m).

Recommended N values and derived design values are summarised in the following table:

Table 3 : Summary of Design Parameters (Sand and Gravel)

Depth	N Value Range	Design N Value	Phi(Degrees)**
1.0m-1.5m	9-18	12.6	31
2.0m-2.5m	8-23	12.8	31
3.0m-3.5m	1-18	7.8	29
* Based on average value of results			
**based on correlations by Stroud and Butler ⁽¹⁹⁷⁵⁾			

5.3 In Situ Test Results

Soil infiltration rates have been derived from soakaway testing in the test pits. Results are included in Appendix 2.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Development

The current proposed development of the land includes an ALDI retail store with 141 car parking spaces including 6 disabled and 9 parent and child spaces to the west. A Costa drive thru with 42 car spaces including 2 disabled and 1 waiting space to the north east and a fuelling station with a shop and carwash with associated 18 car parking spaces including 2 disabled and 2 fast charging points.

6.2 Ground Conditions Encountered

The exploratory holes have encountered interbedded firm to stiff thin horizons of clays followed by very loose to very dense sand and gravel. Subsequent monitoring of groundwater in standpipes indicated groundwater levels at depths ranging between 2.00m^(WS3) and 3.00m^(WS1, 4, 5).

6.3 Foundation Considerations

Conventional strip/pad foundations are suitable at this site, depending on anticipated structural loadings and tolerance of structures to settlement.

For the purposes of this report the following foundation option is discussed:

- a) Conventional Strip Footings.
- b) Pad Foundations

The above is discussed in the following section.

6.3.1 *Strip/Pad Foundations*

Conventional shallow depth strip foundations will be suitable at this site, taken down to a minimum 1.0m depth and into the natural medium dense clayey sand. If any Made Ground, particularly loose or soft material is encountered at foundation level this should be excavated and replaced with suitable granular fill or the foundation extended to suitable strata.

The following table summarises anticipated allowable bearing pressures for strip/pad foundations placed at different depths in the sand and gravel. The bearing capacities are calculated based on Hansen's⁽¹⁹⁷⁸⁾ method and assuming a factor of safety against bearing capacity failure of 3. Groundwater is assumed to be at 2.00m.

Table 4 : Summary of Allowable Bearing Pressures (Strip/Pad Foundations)

Foundation Depth	Design Value (Section 5)	Foundation Type	Foundation Size	Allowable Bearing Pressure
1.0m	$\phi=31^\circ$	Strip	0.6m	88kN/m ²
			0.75m	90kN/m ²
			0.90m	92kN/m ²
		Pad	1.0mx1.0m	125kN/m ²
			1.5mx1.5m	127kN/m ²
			2.0mx2.0m	131kN/m ²
2.0m	$\phi=31^\circ$	Strip	0.6m	169kN/m ²
			0.75m	170kN/m ²
			0.90m	172kN/m ²
		Pad	1.0mx1.0m	252kN/m ²
			1.5mx1.5m	250kN/m ²
			2.0mx2.0m	250kN/m ²
3.0m	$\phi=29^\circ$	Strip	0.6m	200kN/m ²
			0.75m	201kN/m ²
			0.90m	202kN/m ²
		Pad	1.0mx1.0m	297kN/m ²
			1.5mx1.5m	294kN/m ²
			2.0mx2.0m	291kN/m ²

Assuming materials beneath foundations are homogeneous over the depth of influence of the foundation loading for a foundation loading of 75kN/m².

Settlements for other bearing pressures may be estimated on a pro-rata basis but bearing pressures should not exceed the allowable net bearing pressure based on ultimate bearing capacity.

If trees are to be planted as part of the redevelopment, foundations should be designed in accordance with NHBC Chapter 4.2, where foundations are constructed within the zone of influence of any trees. In this context soils beneath the site should be considered as having low to medium volume change potential.

Floor slabs should be designed as suspended where located within the zone of influence of a tree or where made ground is of 600mm thickness or greater.

All foundation excavations should be inspected by a suitable qualified engineer to prove that the founding strata is suitable and uniform along the length of the foundation, and capable of taking the anticipated structural loadings.

6.4 Chemical Attack on Buried Concrete

Chemical tests (see Appendix 3) show low levels of water soluble sulphates and near neutral conditions. Based on these conditions, it is recommended that for foundations the Design

Sulphate Class for the site, as defined in BRE Special Digest 1⁽²⁰⁰⁵⁾, be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1. The recommendations of BRE Special Digest 1 should be followed for concrete foundations and ground bearing floor slabs.

6.5 Suitability of Excavated Materials

Acceptability criteria and testing, and methods of compaction/placement will depend on the type of contract and specification used for the construction of the proposed development and it is recommended that earthworks specifications are reviewed by a suitably qualified engineer, once these have been prepared by the relevant parties.

The clay is likely to be suitable as structural fill and should be used for landscaping purposes only, providing it is not contaminated. The natural sand could be re-used as structural fill, depending on additional compliance testing and provided it is not contaminated.

6.6 Temporary Works

Formations in the natural clay and sand will be susceptible to damage both by weather and trafficking, and should be protected immediately on exposure, particularly in areas where construction plant will access the site.

Excavations in the natural sand and near surface soft clay are likely to be unstable and should be battered back to an angle of 1 in 2, or a system of close sheeting and shoring adopted to ensure stability, and in particular where personnel are required to enter excavations.

All excavations should be adequately supported where personnel are required to enter.

Groundwater seepages could be encountered in excavations, depending on depth. If required pumping of excavations from a suitable located sump should be adequate to keep excavations dry.

All natural materials on site should be capable of being excavated using conventional excavating machinery.

7.0 SOIL CONTAMINATION RISK ASSESSMENT

7.1 General

The following sections provide a Human Health Soil Assessment for groundworkers during development and future site users.

At a Tier I stage the long term (chronic) human health toxicity of the soil has been assessed with reference to DEFRA/Environment Agency Contaminated Land Exposure Assessment (CLEA) Soil Guideline Values (SGV) for generic site land uses, soils and exposure. Where Environment Agency generic guidance is absent, reference has been made to the Chartered Institute of Environmental Health (CIEH) S4ULs for human health risk assessment.

In the case of arsenic, cadmium, hexavalent chromium, lead and benzo(a)pyrene DEFRA Category 4 Screening levels have been adopted.

The soil chemical testing results are presented in Appendix 3 and summarised in Table 5.

Table 5 : Assessment of Soil Chemical Data

Parameter	WS1 0.20mbgl	WS1 0.50mbgl	WS2 0.20mbgl	WS2 0.80mbgl	WS3 0.20mbgl	WS3 0.50mbgl	WS4 0.20mbgl	WS4 0.70mbgl	WS5 0.50mbgl	WS5 1.50mbgl	Assessment Criteria (mg/kg)
Arsenic	4	< 2	7	< 2	6	< 2	5	4	2	< 2	640
Boron	84	49	102	48	106	32	129	60	79	27	240000
Beryllium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	12
Cadmium	0.5	< 0.2	1.1	< 0.2	1.6	< 0.2	1.1	0.3	< 0.2	< 0.2	410
Chromium	21	23	26	18	31	18	26	18	14	17	8600
Free Cyanide	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	34
Hexavalent Chromium	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	49
Copper	25	20	31	18	32	14	35	21	16	13	68000
Lead	105	54	140	55	146	46	146	106	65	34	2330
Mercury	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1100
Nickel	14	21	19	20	19	27	20	23	17	20	980
Selenium	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	12000
Vanadium	28	27	36	17	46	19	35	23	17	17	9000
Zinc	107	69	179	42	208	79	201	81	51	64	730000
pH	7.2	7.4	7.6	7.7	7.4	7.5	7.3	7.5	7.4	7.4	N/A
Naphthalene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	190
Acenaphthylene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	83000
Acenaphthene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	84000
Fluorene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	63000
Phenanthrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	22000
Anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	520000
Fluoranthene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.14	< 0.1	< 0.1	< 0.1	23000
Pyrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.12	< 0.1	< 0.1	< 0.1	54000
Benzo(a)anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	170
Chrysene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.12	< 0.1	< 0.1	< 0.1	350

Parameter	WS1 0.20mbgl	WS1 0.50mbgl	WS2 0.20mbgl	WS2 0.80mbgl	WS3 0.20mbgl	WS3 0.50mbgl	WS4 0.20mbgl	WS4 0.70mbgl	WS5 0.50mbgl	WS5 1.50mbgl	Assessment Criteria (mg/kg)
Benzo(b)fluoranthene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.14	< 0.1	< 0.1	< 0.1	44
Benzo(k)fluoranthene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1200
Benzo(a)pyrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	77
Indeno(1,2,3-cd)pyrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	500
Di-benz (a,h) anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3.5
Benzo(ghi)perylene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	320
Aliphatic >C5 - C6	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3200
Aliphatic >C6 - C8	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	7800
Aliphatic >C8 - C10	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	2000
Aliphatic >C10 - C12	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	9700
Aliphatic >C12 - C16	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	59000
Aliphatic >C16 - C21	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	1600000
Aliphatic >C21 - C34	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1600000
Aromatic >C5 - C7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	26000
Aromatic >C7 - C8	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	56000
Aromatic >C8 - C10	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	3500
Aromatic >C10 - C12	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	16000
Aromatic >C12 - C16	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	36000
Aromatic >C16 - C21	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	28000
Aromatic >C21 - C35	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	28000
Benzene	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	90
Toluene	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	56000
Ethylbenzene	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	5700
o-Xylene	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	6600
Asbestos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001%

Notes for Table 8

Concentrations in **red** above assessment criteria, **ND** = Not Detected, **D** = Detected

No contaminants have been identified with respect to the long term protection of human health, when compared to commercial assessment criteria.

Asbestos has not been identified in any of the samples tested.

8.0 REVIEW OF CONCEPTUAL MODEL

The table considers whether a pollution linkage is potentially present and provides a preliminary qualitative assessment of risk based on the information currently available. Where a possible linkage is identified, it does not necessarily mean that a significant risk exists, but indicates that further information is required through appropriate site investigation to substantiate the conceptual model.

The Conceptual Model is based on a proposed commercial end use.

Table 6 : Conceptual Model

Source	Pathway	Receptor	Linkage	Comment
Based on the environmental testing results the likelihood of significant ground contamination sources being present at the site is considered LOW .	Direct contact, ingestion of soil, dermal contact, dust exposure pathways.	Current Site Users	Unlikely	The risk to current site users via direct exposure is considered to be LOW .
		Adjacent land users	Unlikely	The risk is considered LOW , although usual dust control measures should be implemented as part of good site working practices during construction.
		Future land users	Unlikely	There are proposed garden areas, therefore the risk to future site users via direct exposure is considered to be LOW .
		Construction Workers	Unlikely	Assuming appropriate Health and Safety measures are adopted during the works, a LOW preliminary risk to construction workers is identified.
Considering the land use of the site and immediate surrounding area, the likelihood of significant sources of soluble and/or liquid and therefore mobile contaminants occurring at the site is considered LOW	Direct downward migration through leaching and/or mobile liquids.	Groundwater	Possible	No significant sources of mobile contamination are identified on the site and the site lies upon a principal aquifer. The perceived risk to groundwater is considered LOW .
	Off-site migration in groundwater or surface water flow.	Surface water	Unlikely	No significant sources of mobile contamination are identified on the site. There are no surface water features in the area. The perceived risk to surface water is considered LOW .
		Groundwater / surface water abstractions	Possible	No significant sources of mobile contamination are identified on the site. There are no abstraction licences nearby, the perceived risk to water abstractions is considered NEGLECTABLE .
		Adjacent Properties	Unlikely	No significant sources of mobile contaminants associated with the site, the preliminary risk to adjacent properties is considered LOW .

Source	Pathway	Receptor	Linkage	Comment
		Ecology	Unlikely	No significant sources of mobile contaminants associated with the site, yet the absence of sensitive ecological receptors in the vicinity, the risk to ecology is LOW .
The likelihood of significant volatile contaminants occurring at the site is considered LOW .	Inhalation of harmful vapours (indoor and outdoor airspaces)	Current Site Users	Unlikely	Recognising the nature of the site, it is unlikely that there will be a build-up of any harmful gases or vapours. The risk associated with current site users is considered to be LOW .
		Future site Users	Unlikely	No significant sources of volatile contamination are identified on the site. Modern construction practices will provide a barrier and ventilation. The risk associated with future site users is considered to be LOW .
		Adjacent Properties	Unlikely	The potential risk to adjoining site users is considered NEGLIGIBLE .
The likelihood of degradable materials with the potential to generate hazardous ground gas is LOW .	Emissions from the ground collecting in confined spaces and excavations	Construction/ services maintenance workers	Unlikely	Considering the potential for exposure the preliminary risk is LOW .
	Migration of gases on/off site and collecting in confined spaces on/off site.	Adjoining site users	Possible	The potential risk to adjoining site users associated with the site is considered LOW .
		Current/future site users	Possible	The proposed residential end use represents sensitive receptors. The potential risk is considered LOW .
Chemicals which could prove aggressive to construction materials may be present on site. LOW	Direct contact	Construction concrete, plastic water pipes.	Unlikely	Risks to construction materials can be identified via site investigation prior to the proposed construction works. The perceived risk is considered LOW .

9.0 CONCLUSIONS AND RECOMMENDATIONS

The following section provides a summary of the conclusions and recommendations based on the findings of the contamination testing and gas monitoring.

9.1 Contamination

Based on available soil contamination test results there is a low potential risk from soil contamination to construction workers, ground workers and members of the public, and appropriate measures, such as PPE, site health plans, appropriate disposal of material arisings will mitigate this risk.

As discussed in the above sections, the contamination tests indicate generally low concentrations of the potential contaminants compared to commercial end use criteria. It is therefore considered that, based on the information available, remedial action will not be required at this site.

9.2 Site Personnel

As with all construction sites, personnel working on the site during the construction period should be encouraged to maintain a high standard of personal hygiene and on site washing facilities should be available.

9.3 Foundations

Shallow strip or pad foundations are considered to be suitable for the site. These will need to be deepened within the area of retained and felled trees and hedges.

9.4 Soakaways

Infiltration testing indicates that soakaways are feasible for the site due to the permeable existing geology.

9.5 Surplus Material

Excavated material during construction work would largely be natural material and therefore can be used on site as construction fill or taken offsite.

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

SOAKAWAY TEST RESULTS

APPENDIX 3

CHEMICAL TESTING RESULTS

APPENDIX 4

GEOTECHNICAL TESTING RESULTS

APPENDIX 5

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd on the basis of a defined programme and scope of works and terms and conditions agreed with the client. This report was compiled with all reasonable skill, and care, bearing in mind the project objectives, the agreed scope of works, the prevailing site conditions, the budget and staff resources allocated to the project.

Other than that expressly contained in the above paragraph, Earth Environmental & Geotechnical Ltd provides no other representation or warranty whether express or implied, is made in relation to the services. Unless otherwise agreed this report has been prepared exclusively for the use and reliance of the client in accordance with generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon, or transferred to, by any other party without the written agreement of a Director of Earth Environmental & Geotechnical Ltd.

If a third party relies on this report, it does so wholly at its own and sole risk and Earth Environmental & Geotechnical Ltd disclaims any liability to such parties.

It is Earth Environmental & Geotechnical Ltd understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was an important factor in determining the scope and level of the services. Should the purpose for which the report is used, or the proposed use of the site change, this report will no longer be valid and any further use of, or reliance upon the report in those circumstances by the client without Earth Environmental & Geotechnical Ltd review and advice shall be at the client's sole and own risk.

The report was written in 2018 and should be read in light of any subsequent changes in legislation, statutory requirements and industry best practices. Ground conditions can also change over time and further investigations or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of Earth Environmental & Geotechnical Ltd. In the absence of such written advice of Earth Environmental & Geotechnical Ltd, reliance on the report in the future shall be at the client's own and sole risk. Should Earth Environmental & Geotechnical Ltd be requested to review the report in the future, Earth Environmental & Geotechnical Ltd shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between Earth Environmental & Geotechnical Ltd and the client.

The observations and conclusions described in this report are based solely upon the services that were provided pursuant to the agreement between the client and Earth Environmental & Geotechnical Ltd. Earth Environmental & Geotechnical Ltd has not performed any observations, investigations, studies or testing not specifically set out or mentioned within this report.

Earth Environmental & Geotechnical Ltd is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, Earth Environmental & Geotechnical Ltd did not seek to evaluate the presence on or off the site of electromagnetic fields, lead paint, radon gas or other radioactive materials.

The services are based upon Earth Environmental & Geotechnical Ltd observations of existing physical conditions at the site gained from a walkover survey of the site together with Earth

Environmental & Geotechnical Ltd interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst Earth Environmental & Geotechnical Ltd have no reason to doubt the accuracy and that it has been provided in full from those it was requested from, the items relied on have not been verified.

No responsibility can be accepted for errors within third party items presented in this report. Further Earth Environmental & Geotechnical Ltd was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the services. Earth Environmental & Geotechnical Ltd is not liable for any inaccurate information, misrepresentation of data or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Earth Environmental & Geotechnical Ltd and including the doing of any independent investigation of the information provided to Earth Environmental & Geotechnical Ltd save as otherwise provided in the terms of the contract between the client and Earth Environmental & Geotechnical Ltd.

Where field investigations have been carried out these have been restricted to a level of detail required to achieve the stated objectives of the work. Ground conditions can also be variable and as investigation excavations only allow examination of the ground at discrete locations. The potential exists for ground conditions to be encountered which are different to those considered in this report. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and Earth Environmental & Geotechnical Ltd] based on an understanding of the available operational and historical information, and it should not be inferred that other chemical species are not present.

The groundwater conditions entered on the exploratory hole records are those observed at the time of investigation. The normal speed of investigation usually does not permit the recording of an equilibrium water level for any one water strike. Moreover, groundwater levels are subject to seasonal variation or changes in local drainage conditions and higher groundwater levels may occur at other times of the year than were recorded during this investigation.

Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.