



EARTH ENVIRONMENTAL
& GEOTECHNICAL

GeoEnvironmental Investigation

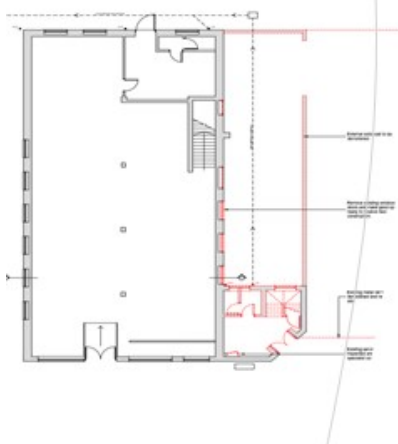
38 Broughton Street

Manchester

August 2020

On behalf of

Risky Clothing Company Ltd



Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

Tel : 0161 975 6088

Email info@earthenvironmental.co.uk
www.earthenvironmental.co.uk

SITE INVESTIGATION
38 BROUGHTON STREET
MANCHESTER
Report Ref: A3434/20
AUGUST 2020

Prepared on Behalf of:

RISKY CLOTHING COMPANY LIMITED

By:

Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

DISTRIBUTION:

1 electronic copy Risky Clothing Company Limited

SITE INVESTIGATION

38 BROUGHTON STREET

Report Reference: A3434/20

Version B.0

Date: 5th August 2020

Prepared for: Risky Clothing Company Limited

Prepared by: Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

Definition of Version Code:

- D. Applied during initial drafting of the report before it has been reviewed.
- C. Applied after the report has been reviewed but before it has been approved by the Project Manager.
- B. Applied after the Project Manager has approved the report ready for issue to the client.
- A. Applied to reports after external/internal review.

The version number starts at "0" and is raised by "1" at each re-type.

Written by:



Daniel Shanks
GeoEnvironmental Consultant



Dr. Shauna McLoughlin
Senior Geo-Environmental Consultant



Approved by:

Adam Czarnecki
Managing Director

TABLE OF CONTENTS

1.0	EXECUTIVE SUMMARY	1
2.0	INTRODUCTION.....	2
2.1	BACKGROUND	2
2.2	PREVIOUS INVESTIGATIONS.....	2
2.3	TERMS OF REFERENCE.....	2
2.4	REPORT SCOPE	2
2.5	LIMITATIONS OF THE STUDY	3
3.0	SITE LOCATION & DESCRIPTION	4
3.1	PROPOSED DEVELOPMENT.....	5
4.0	SITE INVESTIGATION	7
4.1	EXPLORATORY FIELDWORK.....	7
4.2	LABORATORY TESTING	8
4.2.1	<i>Geotechnical Testing</i>	8
4.2.2	<i>Environmental Testing</i>	9
5.0	GROUND CONDITIONS ENCOUNTERED	10
5.1	SOIL PROFILE ENCOUNTERED	10
5.2	OBSERVABLE INDICATIONS OF CONTAMINATION	10
5.3	OBSTRUCTIONS.....	10
5.4	GROUNDWATER.....	10
5.5	LAND GAS.....	11
6.0	ENGINEERING PROPERTIES OF SOILS ENCOUNTERED.....	12
6.1	GENERAL	12
6.2	MADE GROUND	12
6.3	DEVENSIAN TILL (CLAY).....	12
7.0	GEOTECHNICAL ASSESSMENT.....	17
7.1	PROPOSED DEVELOPMENT.....	17
7.2	GROUND CONDITIONS ENCOUNTERED	17
7.3	FOUNDATION CONSIDERATIONS	17
7.3.1	<i>Conventional Shallow Depth Strip/Pad Foundations</i>	17
7.3.2	<i>Ground Improvement</i>	18
7.3.3	<i>Piled Foundations</i>	18
7.4	PAVEMENT DESIGN	18
7.5	CHEMICAL ATTACK ON BURIED CONCRETE	19
7.6	SUITABILITY OF EXCAVATED MATERIALS	19
7.7	TEMPORARY WORKS	20
8.0	SOIL CONTAMINATION RISK ASSESSMENT.....	21
8.1	TIER I HUMAN HEALTH SOIL RISK ASSESSMENT – GROUNDWORKERS DURING DEVELOPMENT.....	21
8.2	TIER I HUMAN HEALTH SOIL RISK ASSESSMENT – FUTURE SITE USERS	21
8.3	SOIL WASTE ASSESSMENT	23
9.0	GROUNDWATER CONTAMINATION RISK ASSESSMENT	24
9.1	ANALYSES OF RESULTS.....	24
10.0	GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT	26
11.0	CONCLUSIONS & RECOMMENDATIONS.....	28
11.1	SOIL CONTAMINATION.....	28
11.2	ASBESTOS	28

11.3	FOUNDATIONS	28
11.4	SOIL DISPOSAL.....	28
11.5	LAND GAS.....	28
11.6	GROUNDWATER.....	29
11.7	RISK TO BURIED (WATER) SERVICES.....	29
11.8	SITE PERSONNEL	29
11.9	OTHER MATTERS	29

LIST OF FIGURES

Figure 1	Aerial Photograph Showing Site Location
Figure 2	General Site Photographs
Figure 3	Proposed Development Plan
Figure 4	Exploratory Hole Location Plan
Figure 5	SPT v Depth Plot
Figure 6	Strength v Depth Plot (Clay)
Figure 7	Plasticity Chart

TABLES

Table 1	Summary of Exploratory Holes Undertaken
Table 2	Summary of Laboratory Geotechnical Tests Undertaken
Table 3	Summary of Ground Conditions Encountered
Table 4	Summary of Laboratory Geotechnical Test Results
Table 5	Summary of Design Parameters (Clay)
Table 6	Comparison of Capping Thickness with and without Geotextile
Table 7	Summary of Guideline Values for Protection of Workers and the General Public During Development of Contaminated Land
Table 8	Soil Results Comparison with C4SL/S4UL Values
Table 9	Summary of Asbestos Encountered
Table 10	Waste Classification of Soils
Table 11	Groundwater Results Comparisons with EQS/Drinking Water Quality Values
Table 12	Modified Ground Gas Classification Table

APPENDICES

Appendix 1	Exploratory Hole Logs
Appendix 2	Monitoring Results
Appendix 3	Geotechnical Testing Results
Appendix 4	Chemical Testing Results
Appendix 5	Soil Waste Assessment
Appendix 6	Report Limitations

1.0 EXECUTIVE SUMMARY

Appointment	A Site Investigation has been commissioned by P4BA Architects Ltd to examine ground conditions for a proposed extension to a commercial property at a site located at 38 Broughton Street, Manchester.
The Investigation	The investigation comprised 3 window sample boreholes with associated sampling, in situ testing, laboratory geotechnical and contamination testing, and ground gas and water monitoring.
The Site	The site is located 2km north of Manchester city centre. The approximate National Grid Reference for the centre of the site is SJ 84021 99997. The site is underlain by Made Ground followed by Devensian till deposits.
Site History	The site was unoccupied until around 1891 a clay pit developed on site. Aside from some development of the clay pits there was no significant change on the site until around 1949, when the clay pits were filled, and a workshop was constructed. The existing commercial building was constructed around 1975.
Ground Conditions Encountered	The exploratory holes encountered Made Ground (up to 3.00m thick) overlying generally stiff to very stiff slightly gravelly clay (to a maximum depth of 7.00m bgl). Groundwater was encountered in all the boreholes between 1.30m and 1.50m.
Geotechnical Assessment	Foundation options are ground improvement, controlled modulus columns and piles. Pavement Design – preliminary design value = 1% in Made Ground Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Risk from contamination to groundworkers during development – Low Risk from soil contamination to future site users – Low Asbestos identified in 1 sample as bundles of chrysotile Risk from asbestos to future site users – Moderate Soil Waste Assessment: 3 samples tested all classified as Non-Hazardous Risk from groundwater contamination to future site users – Low Land Gas & Radon protection measures not required.
<i>This sheet is intended to provide a summary only of the report. It does not provide a definitive engineering analysis for the purposes of costing or construction and is subject to the limitation of the agreed brief.</i>	

2.0 INTRODUCTION

2.1 Background

A Site Investigation has been commissioned by P4BA Architects Ltd on behalf of Risky Clothing Company Ltd to examine ground conditions for a proposed extension to an existing commercial property.

2.2 Previous Investigations

2.2.1 Earth Environmental & Geotechnical Ltd, Phase I GeoEnvironmental Desk Study (A3434/20), dated March 2020.

The desk study highlighted that, historically, the site was unoccupied until around 1891 when an old clay pit, which was part of a brickworks to the north of the site, was developed. Aside from further development of the old clay pits, the site remained mostly unchanged until around 1949 where the old clay pits were filled, and a small workshop was constructed on site. The current commercial building was constructed around 1975 and there has been no significant change since.

The risk from soil contamination to commercial end users was considered to be **MODERATE**. The risk to controlled waters was concluded to be **MODERATE to LOW**. The risk from ground gas to end users was considered to be **MODERATE to LOW**.

An intrusive investigation was recommended in order to carry out geotechnical testing.

2.3 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) have been commissioned by the Client, to undertake a Site Investigation of the site in accordance with proposal A3434/20 dated 27th March 2020. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken including sampling location plan, monitoring geotechnical and chemical testing together with borehole logs*
- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil contaminants identified against current and appropriate published guidelines, in relation to identified receptors, e.g. existing/ future end users and site neighbours.*
- *Classification of soil for offsite disposal.*
- *Assessment of ground conditions for foundation design.*

2.4 Report Scope

This report presents full factual records of the site work carried out, the ground conditions encountered in the exploratory holes, the in situ and laboratory test results. All information collected has been used to provide an interpretation of the ground conditions, with recommendations on geotechnical design and potential ground contamination risks for the proposed development.

2.5 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 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.

3.0 SITE LOCATION & DESCRIPTION

The site is located 2km north of Manchester City Centre. The approximate National Grid Reference for the centre of this site is SJ 84021 99997 (X: 384022, Y: 399995) with the closest postcode being M8 8NN.

The site is a square shaped parcel of land with access via Broughton Street to the southwest. The maximum dimensions of the site are 31m northwest to southeast and 31m northeast to southwest. The site occupies an area of approximately 0.05Ha.

The site is currently occupied by a singular commercial building located on the western side of the property. The remainder of the site is completely covered by concrete. The eastern boundary and part of the north and south boundaries are bordered by palisade fencing. The western border is contained withing the current building walls.

The immediate surrounding area is commercial. There is a garage 100m to the southeast and 160m to the northeast.

The site location is shown in the aerial photograph presented as Figure 1 below.

Figure 1: Aerial Photograph Showing Site Location



Access is from Broughton Street to the south of the site.

General site photographs are presented in Figure 2, overleaf.

Figure 2: General Site Photographs

Photograph taken looking across site looking south



Photograph taken across site during the ground investigation looking south

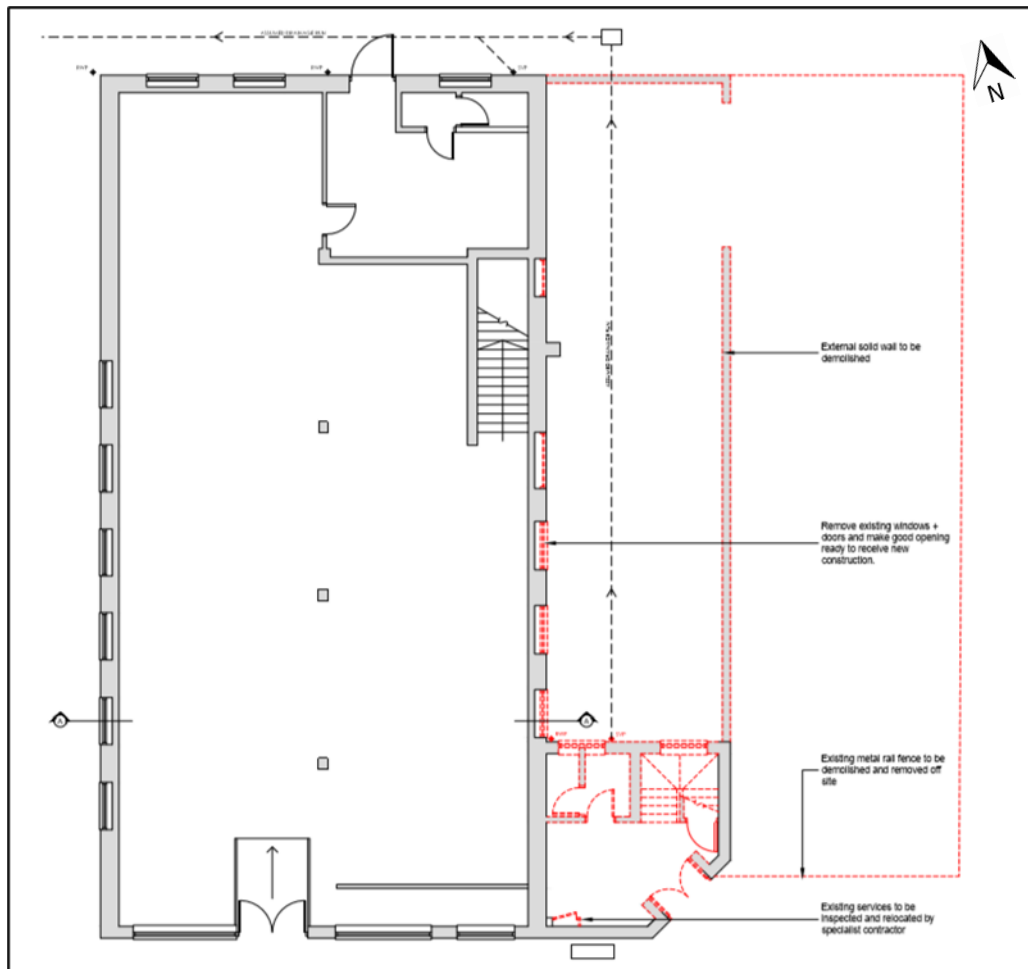


3.1 Proposed Development

It is understood that the Client intends to construct an extension to the existing commercial building on site. Access will be provided via Broughton Street.

The proposed development layout details are shown in Figure 3 below.

Figure 3: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on 10th June 2020 and comprised:

- Three window sample boreholes (designated WS01 to WS03 inclusive) were each sunk to a depth of 7.00m 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. Groundwater observations were noted where possible. These observations relate to the time of the investigation only, and do not necessarily reflect seasonal fluctuations. Exploratory hole logs are included in Appendix 1.
- 50mm diameter standpipes were installed in all window sample boreholes at depths of 6.00m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. EEG carried out groundwater/ground gas monitoring in standpipes after the fieldwork period, the results of which are presented in Appendix 2.

Exploratory hole locations were selected on-site by an EEG engineer based on the proposed development layout and avoiding known services. 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.

On completion, samples recovered from the site were taken to specialist laboratories for chemical and geotechnical 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⁾.

An Exploratory Hole Location Plan is presented as Figure 4 overleaf.

Figure 4: Exploratory Hole Location Plan



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

Table 1: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS01	WS	7.00	10/06/2020	10/06/2020	384031	399996	A
WS02	WS	7.00	10/06/2020	10/06/2020	384028	399991	A
WS03	WS	7.00	10/06/2020	10/06/2020	384032	400002	A

*WS = Window Sample Borehole, TP=Trials Pit
**A=Arising

4.2 Laboratory Testing

4.2.1 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 tests were scheduled by EEG and carried out by Murray Rix. 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 in Table 2 below.

Table 2: Summary of Laboratory Geotechnical Tests Undertaken

TEST	STANDARD	No.
Moisture Content	BS1377:1990 Part 2, Clause 3.2	2
Liquid Limit, Plastic Limit, Plasticity Index	BS1377:1990 Part 2, Clause 4/5	2
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	2
pH value	BS1377:1990 Part 3, Clause 9	2
Particle Size Distribution (wet)	BS1377: 1990 Part2, Clause 9.2	2

The results of the laboratory geotechnical tests are discussed in Section 6 and included in Appendix 3.

4.2.2 Environmental Testing

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

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

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

Chemical analyses were also carried out on two groundwater samples and were submitted for the following suite of determinants:

Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc, Cyanide, Phenol, Sulphate (SO₄), Sulphide, pH, Total Organic Carbon (TOC), Extractable Petroleum Hydrocarbons (EPH), Speciated Petroleum Hydrocarbon and Speciated Polyaromatic Hydrocarbons (PAH).

The results of the laboratory contamination tests are discussed in Sections 8 and 9 and included in Appendix 4.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is underlain by artificial deposits of infilled ground and superficial deposits of Devensian Till comprising Diamicton. The solid geology beneath the site is the Chester Pebble Beds Formation, comprising sandstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** – Variable Made Ground was encountered in all the exploratory holes, comprising:
 - ASPHALT hardstanding.
 - Sandy GRAVEL (containing concrete, clinker, red brick and glass).
 - Gravelly CLAY (containing gravel of red brick, sandstone and concrete).
 - Sandy GRAVEL (containing red brick and ash).
- **Clay** was encountered in all the exploratory holes, comprising:
 - Slightly gravelly CLAY (containing gravel of mudstone).
 - In WS03 silty lenses were found within the clay.

The depths of the various materials encountered in the exploratory holes are summarised in Table 3, below.

Table 3: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m bgl)		GROUNDWATER (m bgl)
	MADE GROUND	CLAY	
WS1	GL-3.00	3.00-7.00	1.50
WS2	GL-3.00	3.00-7.00	1.30
WS3	GL-2.50	2.50-7.00	1.50

5.2 Observable Indications of Contamination

Fine to medium gravel of ash was found in WS03 at approximately 2.00m bgl, suggesting potential contamination.

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

5.3 Obstructions

No man-made obstructions were encountered in any of the excavations carried out during the fieldwork.

5.4 Groundwater

Groundwater was encountered in all the boreholes carried out during the fieldwork. The groundwater was present in WS01 at 1.50m, 1.30m in WS02 and 1.50m in WS03.

Subsequent monitoring in standpipes showed groundwater levels between 1.65m (WS03) and 1.89m (WS01).

5.5 Land Gas

Results obtained during the initial monitoring visit on 25th June 2020 indicated Methane (CH₄) levels of 0.0% by volume, Carbon Dioxide (CO₂) levels ranging from 0.1% to 5.0% by volume, and Oxygen (O₂) levels ranging from 10.8% to 20.3% by volume. An absence of gas flows (-0.1l/hr to 0.0l/hr) were recorded, together with atmospheric pressure of 1012mb.

Results obtained during subsequent monitoring visits on 1st July, 17th July and 24th July 2020 indicated Methane levels ranging of 0.0% by volume, Carbon Dioxide levels ranging from 0.1% to 6.6% by volume, and Oxygen levels ranging from 6.7% to 21.7% by volume. An absence of gas flows (-0.1l/hr to 0.0l/hr) were recorded, together with atmospheric pressure ranging from 998mb to 1014mb.

It should be noted that the concentrations and levels of mobile liquid and gaseous materials are likely to vary with time. The results obtained may therefore be representative of the conditions only at the time of sampling.

6.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED

6.1 General

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.

The results of laboratory geotechnical testing are summarised in the following table.

Table 4: Summary of Laboratory Geotechnical Test Results

Location	Depth (m)	Strata*	CLASSIFICATION									CHEMICAL	
			Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	PSD Cobbles (%)	PSD Gravel (%)	PSD Sand (%)	PSD Silt (%)	PSD Clay (%)	pH Value	Water Soluble Sulphate SO ₄ (mg/l)
WS2	3.20	Clay	21	37	15	22	-	13	14	46	27	7.0	90
WS3	2.60	Clay	18	36	13	23	-	-	47	53	33	7.0	200

6.2 Made Ground

Made Ground was encountered in all the exploratory hole locations between ground level and 3.0m below ground level comprising asphalt, clay and gravel.

SPT tests carried out in the Made Ground resulted in **SPT N values** of between 2 and 7, as shown on the SPT v Depth Plot, in Figure 5, overleaf.

Made Ground is not typically considered to be a suitable founding material, and as such, no geotechnical testing was carried out on the material.

6.3 Devensian Till (Clay)

Clay was encountered in all exploratory hole locations beneath the Made Ground at depths between 2.50m and 7.00m below ground level.

The **water-soluble sulphate** content of two clay samples ranged from 90mg/l to 200mg/l SO₄, together with a **pH value** of 7.0.

Two **Particle Size Distribution** (PSD) tests were carried out on the clay samples. The laboratory generally described the material as a stiff grey brown silty sandy CLAY with (23% to 29% passing the 0.0014mm sieve). Occasional gravel was noted in WS02 at 3.20m.

SPT tests carried out in the clay resulted in **SPT N values** of between 18 and 50, as shown on the SPT v Depth Plot (Figure 5) overleaf. The results suggest the clay is stiff to very stiff.

Figure 6, overleaf, shows the derived shear strength from SPT N values based on correlations by Stroud and Butler⁽¹⁹⁷⁵⁾.

Figure 5: SPT v Depth Plot

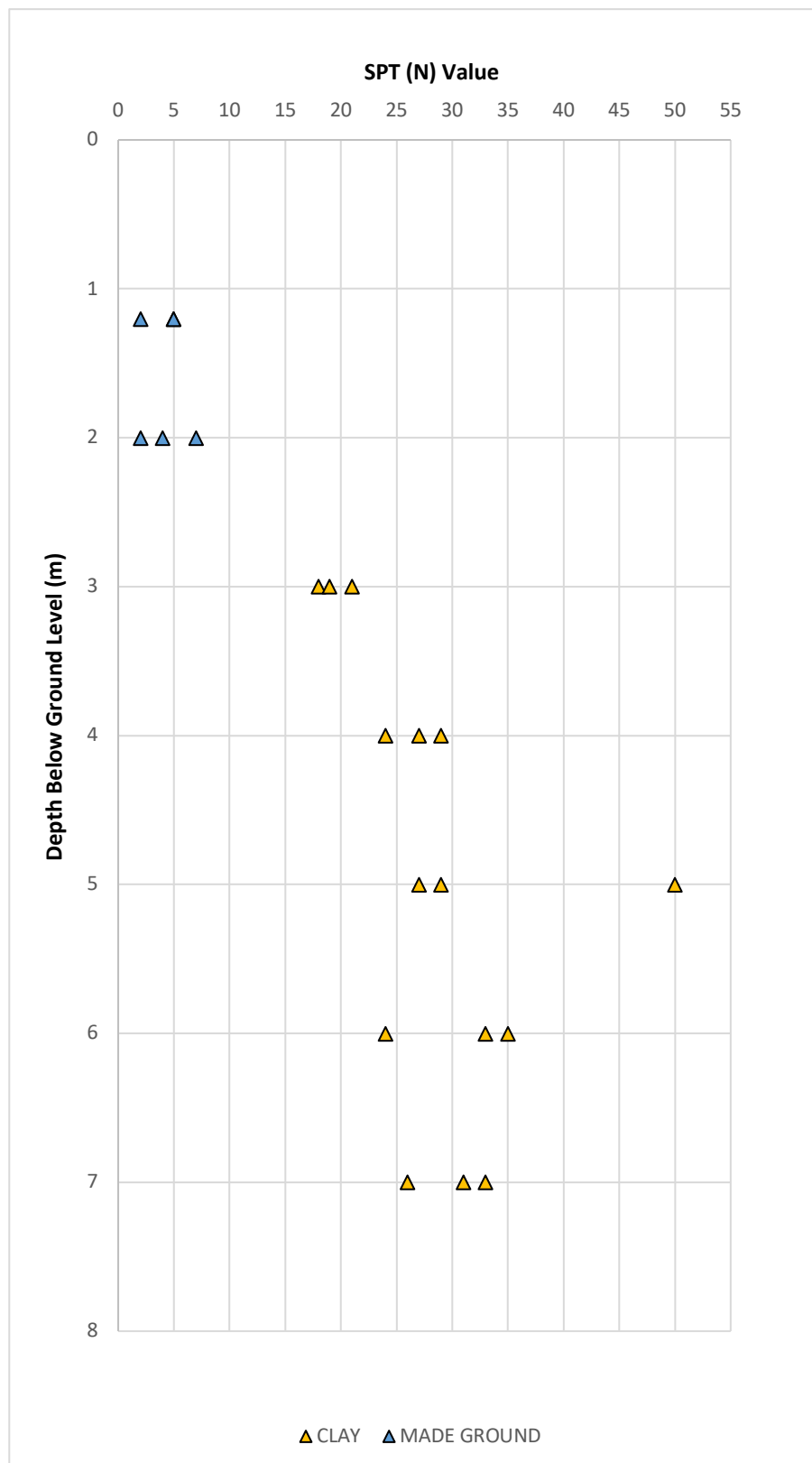
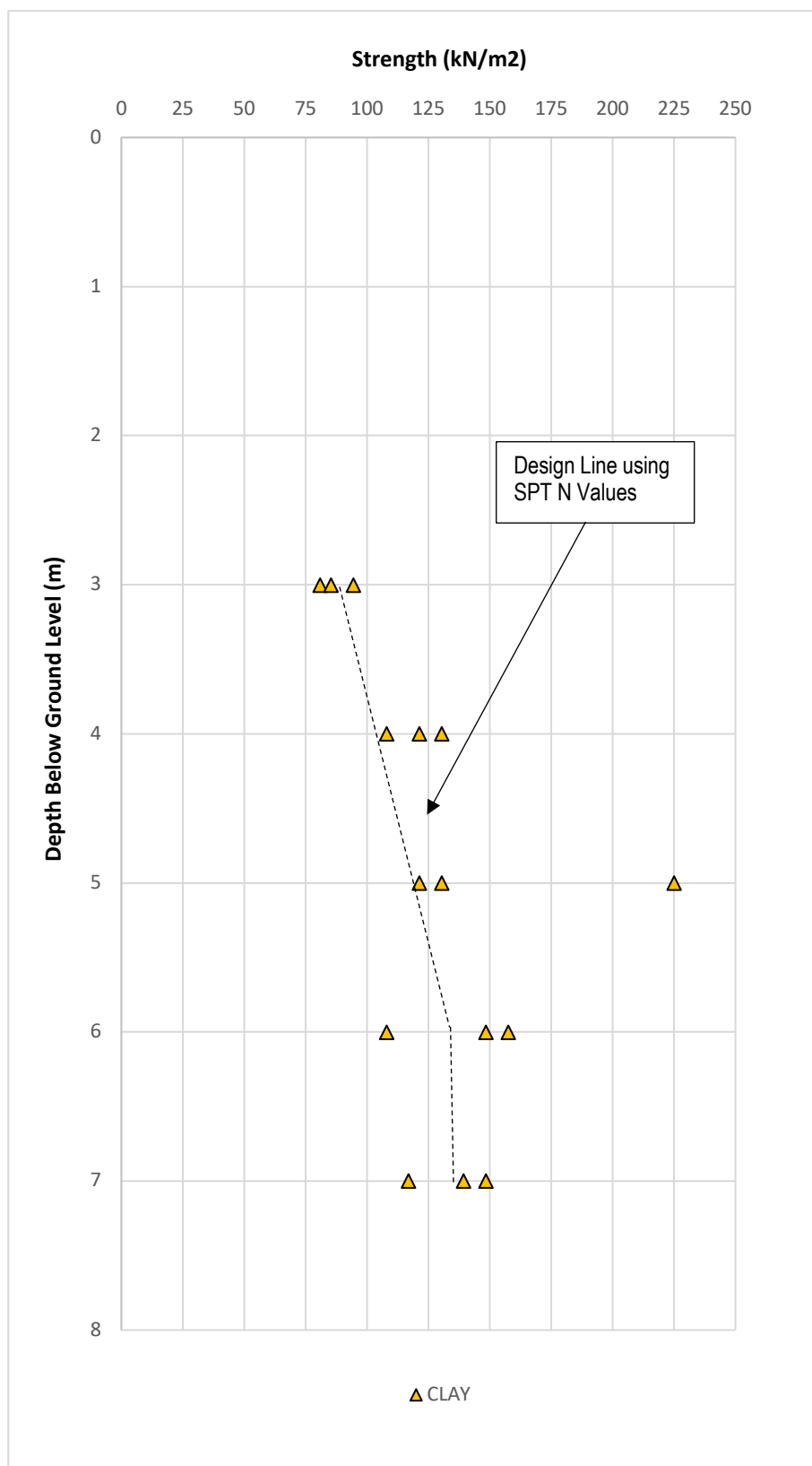


Figure 6: Strength v Depth Plot (Clay)



Recommended N values and derived design values for the cohesive soils are summarised in Table 5, below.

Table 5: Summary of Design Parameters (Clay)

Depth (m)	SPT N Value Range	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
3	18-21	19	83	0.10
4	24-29	26	115	0.08
5	27-50	28	126	0.07
6	24-35	29	128	0.07
7	26-33	29	128	0.07
*based on average value of all results and correlations by Stroud & Butler ⁽¹⁹⁷⁵⁾				
**Based on correlation by Stroud & Butler (1975)				

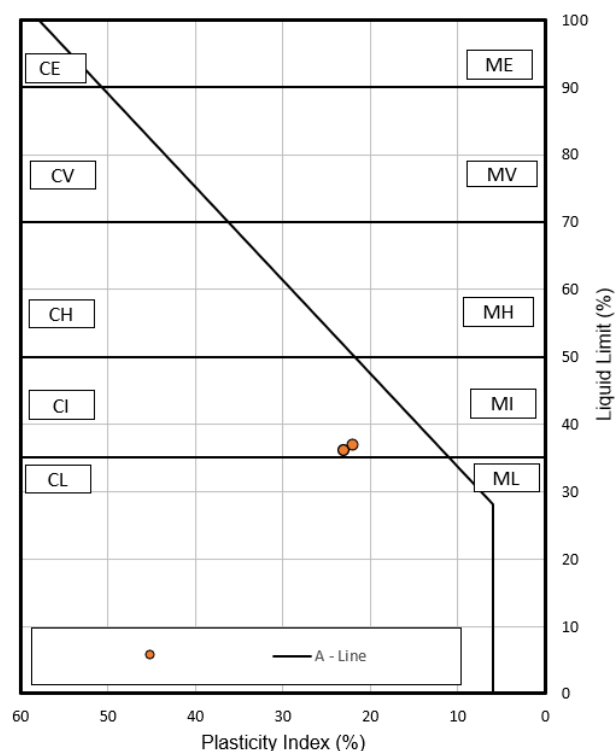
It is recommended that for assessing ultimate bearing capacities, where the lower values are critical, the lower quartile value of N values is used. Based on the N Values in the above table, the equivalent shear strength values were in the range of 83 - 128kN/m².

For design purposes, the following undrained shear strength (Cu) profile is recommended:

- At 3.0m depth Cu = 83kN/m², increasing linearly to 128kN/m² at 6.0m depth.

Atterberg Limit tests were carried out on two samples of the clay. Results of the test reported **liquid limit** values in the range 36% to 37% and **plastic limit** values in the range 13% to 15%, resulting in values of **plasticity index** in the range 22% to 23%. These results suggest the clay to be of intermediate plasticity. Results are shown on the Plasticity Chart in Figure 7, below.

Figure 7 Plasticity Chart



For design purposes, a value of plasticity index = 23% is recommended, based on the upper quartile value of the results.

The **coefficient of volume compressibility (mv)** has been estimated using the following correlation by Stroud and Butler ⁽¹⁹⁷⁵⁾: for a clay with a plasticity index of 23%, $mv = 1 / (0.510 \times N \text{ value})$. This correlation gives values of coefficient of volume compressibility in the range 0.07m²/MN to 0.10m²/MN, as shown in Table 5, above. The results suggest the clay has a **low to medium compressibility**.

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

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

Ip' = modified plasticity index,
Ip = 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 to medium volume change potential**.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the Client intends to construct an extension to the existing commercial property on site. Access will be provided via Broughton Street. Detailed information regarding structural loadings and proposed foundation type was not available at the time of writing this report.

7.2 Ground Conditions Encountered

The exploratory holes generally encountered Made Ground to a maximum depth of 3.00m bgl (WS01 and WS03) overlying Devensian Till Deposits, comprising stiff to very stiff slightly gravelly clay to a maximum depth of 7.00m bgl. Silty lenses were encountered within WS03. Groundwater was encountered in all exploratory hole location at depths of 1.50m in WS01, 1.30m in WS02 and 1.50m in WS03.

7.3 Foundation Considerations

The main consideration for this site is the significant thickness of Made Ground encountered to depths of 2.5m to 3.0m bgl.

Conventional trench fill foundations, placed in the natural strata, (if encountered at foundation depth) may be suitable, depending on allowable bearing pressures, tolerance of structures to settlement and whether excavation support is feasible.

Should the allowable bearing pressure and settlement prove unfavourable, then alternative foundations options will need to be considered, such as ground improvement, controlled modulus columns and piles.

The trench fill footings are discussed below in 7.3.1.

7.3.1 *Conventional Shallow Depth Strip/Pad Foundations*

Trench foundations should be taken down below any Made Ground and placed in the natural Devensian Till Deposits (clay) beneath. 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 at least 150mm into suitable natural strata. In this context attention is drawn to WS01 and WS02 which encountered Made Ground below the foundation level at 3.0m bgl.

Foundations should be placed in materials of similar bearing and consolidation characteristics to avoid potential differential settlement occurring.

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. If foundations cross from granular to cohesive soils, nominal reinforcement should be incorporated.

Should the above anticipated settlements be too high for the proposed structure, alternative foundation options such as ground improvement and piles can be considered, as discussed below.

7.3.2 Ground Improvement

Ground treatment (e.g. vibro displacement) may be an option, subject to environmental and noise/vibration constraints.

For example, vibro stone columns are often used to solve a wide range of static, dynamic and seismic foundation problems by using powerful depth vibrators to densify soils of form stone columns that compact or reinforce soils in situ. Vibro systems can be used to treat granular deposits, fills, made ground and soft clays/silts.

Soils treated by vibro could offer an allowable bearing pressure in the range 100kN/m² to 200kN/m², depending on column spacings and ground encountered.

Once the treatment has been carried out, spread foundations may be adopted across the site, and designed to the loadings given above. Providing that any imported fill material between the tops of the columns and the underside of the floor slab is placed in a controlled manner, floor slabs may be ground bearing. Positive assurances should be sought from an experienced specialist contractor that the proprietary system proposed is capable of providing the required working loads in the ground conditions encountered, with a guarantee on maximum settlement for both footings and floor slabs.

7.3.3 Piled Foundations

The proposed building may be founded on piles taken down to depth to a suitable founding stratum such as the stiff Devensian Till Deposits (Clay) encountered at 3.00m to 7.00m bgl.

A variety of pile types may be used, including bored and continuous flight auger (CFA) piles. Driven piles may be suitable, subject to environmental and noise/vibration constraints.

Because of the various advantages and limitations of each pile type, and the cost implications, advice should be sought from specialist piling contractors to determine the most suitable and cost-effective type. They should also be able to give recommended pile diameters and depths and likely pile capacities, with guaranteed performance. It is recommended a pile test be carried out to confirm pile capacities. In assessing the pile capacities, contractors should make an allowance for the effects of negative skin friction, particularly in the made ground and soft clays.

For preliminary design purposes the design strength profile discussed in Section 6 may be used.

There may be differential settlement between piled structures and the surrounding ground level. Provision should, therefore, be made to make up ground levels at threshold positions, loading bays, vehicle access doorways, etc. Alternatively, these materials should be removed and replaced in a controlled manner by suitable existing materials or imported engineered fill.

It is essential the advice of a specialist piling contractor is sought and that positive assurances are provided by the piling contractor that their proprietary system is capable of providing the required working loads in the ground conditions encountered.

7.4 Pavement Design

Based on the ground conditions encountered a conservative design CBR value of 1% should be adopted as Made Ground was encountered at the subgrade level in all exploratory hole locations.

Consideration should be given to the potential differing ground conditions near surface, which could cause pavements to be constructed on variable made ground. In this context a flexible pavement design may be required.

Consideration should also be given to the use of geotextiles to allow reduction of capping thickness. For examples biaxial geogrids such as Tensar SSLA20 and SSLA30 are often used to reduce capping thickness. The advice of a suitable contractor should be sought as to the most appropriate type of geotextile to use in the ground conditions encountered at this site. For guidance, the following table gives a comparison of granular layer thickness with and without the use of a geotextile, in accordance with the requirement of HA25/94 Part 2.

Table 6: Comparison of Capping Thickness with and without Geotextile

CBR	Unreinforced			Reinforced with Tensar Geogrid				
	Sub-base	Capping	Total	Sub-base	Capping	No. of grids	Total	Thickness saving
0.5%	Design not suitable			200mm	400mm	2	600mm	-
1.0%	150mm	600mm	750mm	400mm	0	1	400mm	350mm
1.5%	150mm	600mm	750mm	310mm	0	1	310mm	440mm
2.0%	150mm	600mm	750mm	260mm	0	1	260mm	490mm
3.0%	150mm	350mm	500mm	210mm	0	1	210mm	290mm
4.0%	150mm	300mm	450mm	175mm	0	1	175mm	275mm
5.0%	150mm	250mm	400mm	160mm	0	1	160mm	240mm
These figures are suitable for light access roads and car parks, based on 1000 standard axles. For heavier loaded pavements the advice of specialist contractor should be sought.								

It should be noted the type of construction will depend on proposed finished pavement levels across the site and it is recommended the pavement design is reviewed once these levels are known. In this context, it is essential further in situ CBR testing is carried out once formation levels are known to confirm design CBR values.

All formation excavations should be examined by a suitably experienced engineer or inspector to check for soft or unsuitable material, which should be removed and replaced with compacted granular fill. Also, to ensure good compaction and remove unevenness, the formation should be compacted with equipment suitable for use in the ground conditions encountered. Careful inspection of this work will also help identify any soft spots at or just below formation level.

7.5 Chemical Attack on Buried Concrete

Chemical tests (see Appendices) show low levels of water-soluble sulphates and near neutral conditions. Based on these conditions, it is recommended that for concrete placed in natural strata 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-1s. The recommendations of BRE Special Digest 1 should be followed for concrete foundations and ground bearing floor slabs.

7.6 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.

Near surface soft natural clays are unlikely to be suitable as structural fill and should be used for landscaping purposes only, providing they are not contaminated.

Granular Made Ground could be suitable for re-use as structural fill, providing it is not contaminated and does not contain excessive amounts of clay and providing moisture contents are controlled during placement. The control of moisture contents will be important as the cohesive content of this stratum is likely to be sensitive to moisture content changes.

7.7 Temporary Works

Formations 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 Made Ground 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 near surface within excavations, particularly during the wetter months of the year. Pumping of excavations from a suitable located sump is likely to be required to keep excavations dry.

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

8.0 SOIL CONTAMINATION RISK ASSESSMENT

8.1 Tier I Human Health Soil Risk Assessment – Groundworkers During Development

To assess the risk of soil contamination to construction and ground workers during development, guidelines from the HSE Document 'Protection of workers and the general public during development of contaminated land'⁽¹⁹⁹¹⁾ are used. The document assesses soil contamination test results and classifies the site as being uncontaminated or contaminated with varying degrees of contamination from 'slight' to 'unusually heavy'. The guideline values and laboratory test results are summarised in the following table:

Table 7: Summary of Guideline Values for Protection of Workers and the General Public During Development of Contaminated Land

Contaminant	Typical Values* for:					Test Results	Class
	Uncontaminated Soils	Slight Contamination	Contaminated	Heavy Contamination	Unusually Heavy Contamination		
	Class A	Class B	Class C	Class D	Class E		
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.8 – 8	A
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	32 – 38	B
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	0.4 – 0.7	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	18 – 20	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	97 – 107	A – B
Lead	0 - 500	500 - 1000	1000 - 2000	2000 – 1%	1.0%	77 – 198	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1 – 1.6	A – B
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	30 – 41	B
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	79 – 167	A
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1	A
Selenium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 3	A
Barium	0 - 500	500 - 1000	1000 - 2000	2000 - 1.0%	1.0%	156 – 216	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	1.4 – 2.1	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	31 - 44	A
Sulphate	0 - 2000	2000 - 5000	5000 – 1%	1% - 5%	5.05%	615 – 926	A
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5	A
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 2	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results the soils are predominantly uncontaminated, except for the copper and mercury concentration which were also slightly contaminated. Therefore, there is a low potential risk from soil contamination to construction workers, ground workers and members of the public during construction. Appropriate measures, such as PPE, site health plans, and appropriate disposal of material arisings will be required to mitigate any risk.

8.2 Tier I Human Health Soil Risk Assessment – Future Site Users

The following section provides a Human Health Soil Assessment for future site users. Based on the proposed development type, the following section compares the results of contamination analyses to residential types of end development as specified by Defra/LQM/CIEH. As part of the contamination assessment, the chemical results obtained by EEG have been screened against accepted compliance criteria, namely:

- Defra C4SL Health Criteria Values (March 2014), where available; and
- Tier 1 assessment values - based on LQM/CIEH Suitable 4 Use Levels⁽²⁰¹⁵⁾ (S4ULs).

The soil chemical testing results are summarised in Table 8, below.

Table 8: Soil Results Comparison with C4SL/S4UL Values

Determinand	C4SL/S4UL Levels Commercial (mg/kg)	WS01 2.20m	WS02 0.40m	WS03 1.70m	No of Exceedances
Metals					
Arsenic	640	38	34	32	0
Beryllium	12	1.4	1.5	2.1	0
Boron	240000	< 1	< 1	< 1	0
Cadmium	410	0.6	0.7	0.4	0
Chromium	8600	18	18	20	0
Chromium VI	49	< 2	< 2	< 2	0
Copper	68000	98	97	107	0
Lead	2300	182	198	77	0
Mercury	58	< 1	1.6	< 1	0
Nickel	980	32	30	41	0
Selenium	12000	< 3	< 3	< 3	0
Vanadium	9000	31	36	44	0
Zinc	730000	167	148	79	0
Petroleum Hydrocarbons					
Benzene	98	<0.002	<0.002	<0.002	0
Toluene	56000	< 0.005	<0.005	<0.005	0
Ethylbenzene	5700	< 0.002	<0.002	<0.002	0
o-xylenes	6600	< 0.002	<0.002	<0.002	0
m-xylenes	62000	< 0.002	< 0.002	< 0.002	0
p-xylenes	5900	< 0.002	< 0.002	< 0.002	0
Aliphatic EC >5-6	3200	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	7800	< 0.05	< 0.05	< 0.05	0
Aliphatic EC >8-10	2000	< 2	< 2	< 2	0
Aliphatic EC >10-12	9700	< 2	2	< 2	0
Aliphatic EC >12-16	59000	< 3	16	< 3	0
Aliphatic EC >16-21	1600000	< 3	10	< 3	0
Aliphatic EC >21-35	1600000	< 10	< 10	< 10	0
Aromatic EC >5-7	26000	< 0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	56000	< 0.05	< 0.05	< 0.05	0
Aromatic EC >8-10	3500	< 2	< 2	< 2	0
Aromatic EC >10-12	16000	4	5	< 2	0
Aromatic EC >12-16	26000	23	44	< 2	0
Aromatic EC >16-21	28000	96	145	< 3	0
Aromatic EC >21-35	28000	257	238	< 10	0
Polycyclic Aromatic Hydrocarbons					
Naphthalene	190	2.14	1.63	0.56	0
Acenaphthylene	83000	0.57	0.91	< 0.1	0
Acenaphthene	84000	1.86	2.95	< 0.1	0
Fluorene	63000	2.44	4.1	< 0.1	0
Phenanthrene	22000	23.2	29.4	0.58	0
Anthracene	520000	6.21	6.37	< 0.1	0
Fluoranthene	23000	31.5	30.1	0.8	0
Pyrene	54000	34.6	31.8	0.84	0
Benzo(a)anthracene	170	17.5	12.7	0.52	0
Chrysene	350	17.8	13.4	0.74	0
Benzo(a)pyrene	76	17.8	9.99	0.7	0
Benzo(b)fluoranthene	44	22.4	11.8	0.99	0
Benzo(k)fluoranthene	1200	7.63	4.98	0.38	0
Indeno(1,2,3-cd)pyrene	500	8.39	4.6	0.48	0
Dibenz(a,h)anthracene	3.5	2.11	1.28	< 0.1	0
Benzo(ghi)perylene	3900	7.49	4.07	0.48	0
Phenols					
Phenol	760	< 2	< 2	< 2	0

Based on the above table, no samples tested contained concentrations of contaminants in exceedance of the screening criteria relevant to a commercial end use.

Asbestos was however identified in one sample, the details of which are summarised in Table 9, below:

Table 9: Summary of Asbestos Encountered

Location	Depth	Sample Matrix	Asbestos Type	Asbestos Quantification
WS02	0.40m	Bundles of chrysotile	Chrysotile	Not Quantified

8.3 Soil Waste Assessment

An assessment of the disposal characteristics of the soil in accordance with Environment Agency guidance WM3.1, edition of June 2018, "Guidance on the classification and assessment of waste" has been carried out on soils recovered from the site, using HazWasteOnline.

The results are summarised in Table 10 below and presented in full in Appendix 5.

Table 10: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	Comments
WS01	2.20	Non-Hazardous	-
WS02	0.40	Non-Hazardous	Asbestos quantification may change classification.
WS03	1.70	Non-Hazardous	-

Table 10 above shows that the three soil samples collected from the window sample boreholes and trial pits were classified as **Non-Hazardous** in accordance with WM3.1.

Further Waste Acceptance Criteria (WAC) testing may prove that this material is acceptable as inert waste.

However, Asbestos can affect the waste classification of soil, if the concentration is greater than 0.1%, the soil will automatically be classified as Hazardous waste. Therefore, further asbestos quantification testing is recommended on sample WS02 to determine the concentration and classification.

9.0 GROUNDWATER CONTAMINATION RISK ASSESSMENT

9.1 Analyses of Results

In the absence of specific UK guidelines regarding groundwater quality in the UK, chemical results obtained by EEG have been compared with the following statutory and non-statutory standards:

- Environmental Quality Standards (EQS); and
- UK Drinking Water standards⁽²⁰⁰⁰⁾.

EQS values have been derived to protect surface water, and the nearest surface water feature is located on-site along the southeast boundary. For the purposes of this report it is considered the most appropriate EQS data for the river are those established for freshwater.

A large number of the EQS values lie just above the method detection limit for particular parameters and as such, are extremely conservative. In the absence of EQS values, Drinking Water Standards have been used for comparison of results. Again, these standards are highly conservative, especially in this site context. A direct comparison was made between the groundwater analyses results and the EQS and Drinking Water Standards, and the results are summarised in Table 11, overleaf.

In general, the laboratory analyses encountered concentrations of contaminants below the EQS and Drinking Water Standards values. Therefore, the levels are considered acceptable and low risk.

Table 11: Groundwater Results Comparisons with EQS/Drinking Water Quality Values

Determinand	EQS Value (1)	Drinking Water Quality (DWQ) Value (2)	WS02	WS03	No. of Exceedances
Arsenic	50	10	< 5	< 5	0
Cadmium	0.9	5	< 0.4	< 0.4	0
Chromium	50	-	< 5	< 5	0
Copper	10	2000	< 5	< 5	0
Lead	1.2 - 14	10	< 5	< 5	0
Mercury	0.07	1.0	< 0.05	< 0.05	0
Selenium	-	10	< 5	< 5	0
Nickel	50 - 200	20	6	6	0
Zinc	75	-	70	10	0
Cyanide	-	50	< 5	< 5	0
Phenol	7.7 - 46	-	< 10	< 10	0
Sulphate	250000	250000	43	48	0
pH	6 - 9	-	7.4	7.3	0
Naphthalene	10	-	< 0.01	< 0.01	0
Anthracene	0.1	-	< 0.01	< 0.01	0
Benzo(a)pyrene	0.27	0.01	< 0.01	< 0.01	0
Benzo(b)fluoranthene	0.017	0.10	< 0.01	< 0.01	0
Benzo(k)fluoranthene	0.017	-	< 0.01	< 0.01	0
Indeno(123cd)pyrene	-	0.10	< 0.01	< 0.01	0
Fluoranthene	0.12	-	0.03	0.03	0
Benzene	10 - 50	-	< 1	< 1	0
Toluene	50 - 380	-	< 5	< 5	0
Ethylbenzene	20 - 200	-	< 5	< 5	0
Xylenes	30	0.10	< 10	< 10	0

*all values in µg/l unless otherwise stated

10.0 GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT

10.1 Radon Gas

The site is not located within a Radon Affected Area as defined by the Health Protection Agency, as less than 1% of properties are above the Action Level of exposure and therefore radon protection measures are not necessary.

10.2 Analyses of Monitoring Results

The potential risk associated with gases being generated in the ground (whether from natural or man-made sources) depends on the concentrations of gas and its flow rate to the surface. These factors are assessed by monitoring of the gas installations in the boreholes. The variable nature of gas generation and the effect of barometric pressure on gas flow, means that the volume of gas potentially reaching the ground surface is normally inconsistent over time.

Four gas monitoring visits have been completed by Earth Environmental & Geotechnical Ltd. The monitoring visits were conducted between the 25th August and 24th July 2020. The results recorded methane (CH₄) levels of 0.0% (v/v) and carbon dioxide (CO₂) levels of 0.1% to 6.6% v/v. Oxygen concentrations of between 6.7% and 21.7% v/v were also recorded.

An absence of flow rates was encountered from the boreholes on site. A gas flow rate of 0.1l/hr has therefore been adopted for the below calculations due to the reporting limit of the flow meter. Atmospheric pressure was recorded to be between 998mb and 1014mb.

Full results of the monitoring to date are presented in Appendix 2.

Table 12 overleaf, adapted from Table 1 of the technical paper Risk and Reliability in Gas Protection Design by Card et al. 2019, shows a summary of the current UK practice with respect to appropriate gas protection measures based upon a Gas Screening Value (GSV).

A GSV for the site has been obtained by multiplying the maximum concentration of gas by the maximum flow rate, which represents worst-case scenario conditions.

- Carbon dioxide: maximum flow rate = 0.1l/hr, max concentration = 6.6%
- Methane: maximum flow rate = 0.1l/hr, max concentration = 0.0%.

Based on the above figures, the GSV is calculated as:

- **Carbon dioxide:** $GSV = 0.1 \times 6.6 / 100 = 0.0066 \text{ litres/hr}$
- **Methane:** $GSV = 0.1 \times 0.0 / 100 = 0.000 \text{ litres/hr}$

The above results suggest the site can be given a Gas Regime A classification, i.e. '**NEGLIGIBLE** to **VERY LOW** risk', in accordance with Table 12, overleaf.

Table 12: Modified Ground Gas Classification Table (Risk and Reliability in Gas Protection Design, 2019)

<i>Characteristic Situation</i>	<i>Pathway vertical permeability (m/s)</i>	<i>GSV CH₄ (l/hr)</i>	<i>GSV CO₂ (l/h)</i>	<i>GSV oxygen deficient gas (Nitrogen) (l/h)</i>	<i>Maximum borehole gauge pressure (Pa)</i>	<i>Limiting sustained gas concentrations in unsaturated zone within 10m of surface</i>	<i>Limitations</i>	<i>Risk level</i>
Gas Regime A	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	< 2 < 1.5 < 1.3	< 12 < 9 < 7	< 217 for all permeability (care when using this value. Usually oxygen deficient gas emissions are sporadic, and monitoring should cover suitable situations)	500 (50mm water) – ASTM (2016)	$< 30\%$ methane $< 21\%$ carbon dioxide No limit on oxygen depletion because it is widespread in natural	No limit on oxygen depletion because it is widespread in natural soils and fill materials due chemical and biological processes	Negligible to very low
Gas Regime B	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	≤ 10 ≤ 7.5 ≤ 6	< 140 < 100 < 85	No Limit	No limit			Low to moderate
Gas Regime C	$\leq 1 \times 10^{-7}$ $1 \times 10^{-7} < k < 1 \times 10^{-5}$ $\geq 1 \times 10^{-5}$	≤ 100 ≤ 75 ≤ 60	No limiting values	No Limit	No limit	No limit	Where oxygen deficient ground gas or carbon dioxide is likely to be emitted from shafts, fractured rock or ground where $k > 1 \times 10^{-4}$ m/s undertake DQRA	Moderate to high
Gas Regime D		N/A	N/A	N/A			DQRA required	Very high

11.0 CONCLUSIONS & RECOMMENDATIONS

11.1 Soil Contamination

There is a low potential risk from soil contamination to construction workers and ground workers during development, and appropriate measures such as PPE, site health plans, appropriate disposal of material arisings will be required to mitigate this risk. The groundworks contractor must provide a soil management plan including methods of dealing with unanticipated soil contamination encountered during groundworks.

Based on the results of the chemical testing, no exceedances in contaminants were encountered in the samples analysed. Therefore, the overall risk to commercial end users is low.

However, the presence of higher levels of contamination on areas of the site not covered by the current exploratory holes should not be discounted and additional spot checks would be prudent, particularly during groundworks. This testing can be carried out as part of the Soil Management Plan for the site.

11.2 Asbestos

Asbestos fibres were detected as bundles of chrysotile in the Made Ground soil sample collected from WS02. Therefore, the overall risk to commercial end users is moderate.

Further Asbestos Quantification testing will determine whether the site requires an Asbestos Management Plan.

11.3 Foundations

Due to depth of the Made Ground, it is recommended that foundations should be placed within the natural stiff clay encountered at 3.0m bgl.

Due to the thickness of Made Ground suspended ground floor slabs should be utilised.

11.4 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. The soils collected from all borehole locations have been classified as Non-Hazardous (See Table 10) for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

However, this classification may change at location WS02, subject to Asbestos Quantification testing.

11.5 Land Gas

Based on results of gas monitoring, the risk of ground gas is considered to be negligible to very low and protection against the ingress of ground gas will not be required at the site.

11.6 Groundwater

Based on the results of the chemical testing, no exceedances in contaminants were encountered in the samples analysed when compared to the recommended DWQ and EQS guideline values. Therefore, the overall risk to commercial end users is low.

11.7 Risk to Buried (Water) Services

It is considered that, due to the absence of contamination, standard materials should be acceptable for new water pipes. Further advice should be sought from the local water company.

Previous guidance on buried water pipes was contained in Water Regulations Advisory Scheme (WRAS) Guidance Note No. 9-04-03⁽²⁰⁰²⁾, however this has been superseded by the UK Water Industry Research Report 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' Ref 10/WM/03/21 (January 2011).

11.8 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.

11.9 Other Matters

Due diligence is required during the construction period, and should any further evidence of contamination be found, appropriate investigation and / or action should be taken. The significance of any contamination not discovered by this investigation is outside the scope of this report.

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

MONITORING RESULTS

APPENDIX 3

GEOTECHNICAL TESTING RESULTS

APPENDIX 4

CHEMICAL TESTING RESULTS

APPENDIX 5

SOIL WASTE ASSESSMENT

APPENDIX 6

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 2020 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.