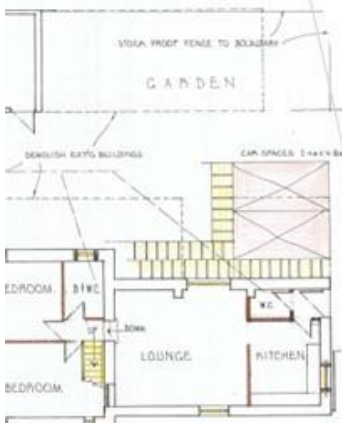




EARTH ENVIRONMENTAL
& GEOTECHNICAL

GeoEnvironmental Site Investigation Report

Moorgate Farm East

Rochdale

December 2023

On behalf of

Morris Construction

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

**GEOENVIRONMENTAL
SITE INVESTIGATION
REPORT**

MOORGATE FARM EAST

ROCHDALE

Report Ref: A5635/23/SI

DECEMBER 2023

Prepared on Behalf of:

MORRIS CONSTRUCTION

By:

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

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GEOENVIRONMENTAL SITE INVESTIGATION REPORT

MOORGATE FARM EAST, ROCHDALE

Report Reference: A5635/23/SI

Version B.0

Date: 5th December 2023

Prepared for: Morris Construction

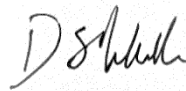
Prepared by: Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

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Written by:



Daniel Shanks
Senior GeoEnvironmental Consultant

Approved by:



Adam Czarnecki
Managing Director

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1.0 EXECUTIVE SUMMARY

Appointment	A site investigation has been commissioned by Morris Construction (the Client), to examine ground conditions for a proposed conversion of the existing barn at Moorgate Farm East, Broad Lane, Rochdale, OL16 4QL, to a 2-storey residential dwelling.
The Investigation	The investigation comprised four windowless sample boreholes, three of which installed with combined ground gas and groundwater monitoring standpipes, with associated sampling and in situ testing, laboratory geotechnical and contamination testing.
The Site	The site is located approximately 2.3km northwest of Shaw & Crompton centre, and approximately 3km southeast of Rochdale town centre. The approximate National Grid Reference for the centre of the site is SD 92007 10449 (X: 392007, Y: 410449) with the closest postcode being OL16 4QL. The site is underlain by superficial Hummocky (moundy) Glacial Deposits, comprising Diamicton. The solid geology beneath the site is recorded as the Pennine Lower Coal Measures Formation, comprising mudstone, siltstone, and sandstone.
Ground Conditions Encountered	The exploratory holes generally encountered variable made ground below a concrete slab, to a maximum depth of 0.40m bgl. Variable superficial deposits, largely comprising soft to firm clay with interbedded layers of soft silt and loose to medium dense sand, were encountered underlying the made ground to a maximum depth of 5.00m bgl. Groundwater was encountered during the fieldwork, exclusively in WS4 at 3.00m bgl. Subsequent groundwater monitoring identified water in all installed borehole locations, at depths between 0.26m - 2.91m bgl.
Geotechnical Assessment	Pavement Design – preliminary design value = 1% in Made Ground (shallow subgrade level), a CBR value of 1 to 3% in clay, 20 - 40% in sand (deeper subgrade level). Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Risk from contamination to groundworkers during development - Low Risk from contamination to future residential end users - Moderate to Low PAH exceedances identified in two locations. No asbestos was identified in the samples analysed. Development of a remediation strategy recommended. Soil Waste Assessment: 5 samples tested, all classified as Non-Hazardous in accordance with WM3.1.
Ground Gas Assessment	Detailed assessment of the data, with specific reference to gas ratios shows that the ground gas composition generally resembles air, not landfill or harmful gas. The risk from ground gas is therefore considered “very low” with a characteristic situation of CS1, with gas 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 Morris Construction (the Client), to examine ground conditions for a proposed conversion of the existing barn at Moorgate Farm East, Broad Lane, Rochdale, OL16 4QL, to a 2-storey residential dwelling.

2.2 Existing Planning Applications

2.2.1 Planning Application to Rochdale Borough Council, 21/00003/FUL, dated February 2021.

A planning application has been submitted for the site to Rochdale Borough Council (Reference: 21/00003/FUL) for the proposed conversion of the existing barn into one residential dwelling, including the demolition of the attached and detached stable buildings. The application was approved with conditions in October 2021.

2.3 Previous Investigations

2.3.1 GeoEnviro Solutions Ltd, Phase I GeoEnvironmental Desk Study (2466-22 PI), dated October 2022.

The report highlights that historically the site has been occupied by a single main building in the southeast since the start of historical mapping in 1851, with multiple other, smaller buildings constructed and demolished across the site until the early 1990's. Since the 1990's, no further significant change has occurred on site.

The site is underlain by superficial deposits of Hummocky (Moundy) Glacial Deposits, comprising 'rock debris, clayey till and poorly to well stratified sand and gravel' (Secondary A Aquifer), and solid geology of the Pennine Lower Coal Measures Formation (Secondary A Aquifer).

The risk from soil contamination to construction workers and future end users was considered to be **LOW to VERY LOW**. The risk from ground gas to end users was considered to be **LOW** due to the anticipated low risk of gas generation in the made ground deposits below the site.

The risk to controlled waters was concluded to be **VERY LOW**.

An intrusive investigation was recommended to establish geotechnical parameters for the design of foundations, floor slabs and pavement construction. As part of the geotechnical investigation, it was recommended that samples are recovered for contamination testing.

2.4 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 A5635/23 dated 23rd September 2023. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken including sampling location plan, borehole logs, geotechnical and chemical testing.*
- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil, water and ground gas contaminants identified against*

current and appropriate published guidelines, in relation to identified receptors, e.g., existing/ future end users and site neighbours.

- *Classification of soils for offsite disposal.*
- *Assessment of ground conditions for foundation design.*

2.5 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.

2.6 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.

3.0 SITE LOCATION & DESCRIPTION

The site is located approximately 2.3km northwest of Shaw & Crompton Centre, and approximately 3km southeast of Rochdale town centre. The approximate National Grid Reference for the centre of the site is SD 92007 10449 (X: 392007, Y: 410449) with the closest postcode being OL16 4QL.

The site is a rectangular shaped parcel of land with access via Broad Lane to the southeast. The maximum dimensions of the site are approximately 47m north to south and 46m east to west. The site occupies an area of approximately 0.1 hectares.

The site is currently occupied by a vacant barn, with two sets of stables, both disused. The site is currently used for the storage of materials and tools, assumed to be associated with the proposed build. The site is entirely covered by hardstanding comprising cast in-situ concrete.

The immediate surrounding area is generally agricultural land, with residential properties situated along Broad Lane.

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

Figure 1: Aerial Photograph Showing Site Location



General site photographs are presented in Figure 2 overleaf.

Figure 2: General Site Photographs

Photograph taken viewing the rear of the existing barn, facing southwest



Photograph taken viewing the rear of the existing barn and the partially demolished sections of the barn, facing south



Photograph taken viewing the existing site access from Broad Lane, facing north



Photograph showing representative superficial soils (WS2)

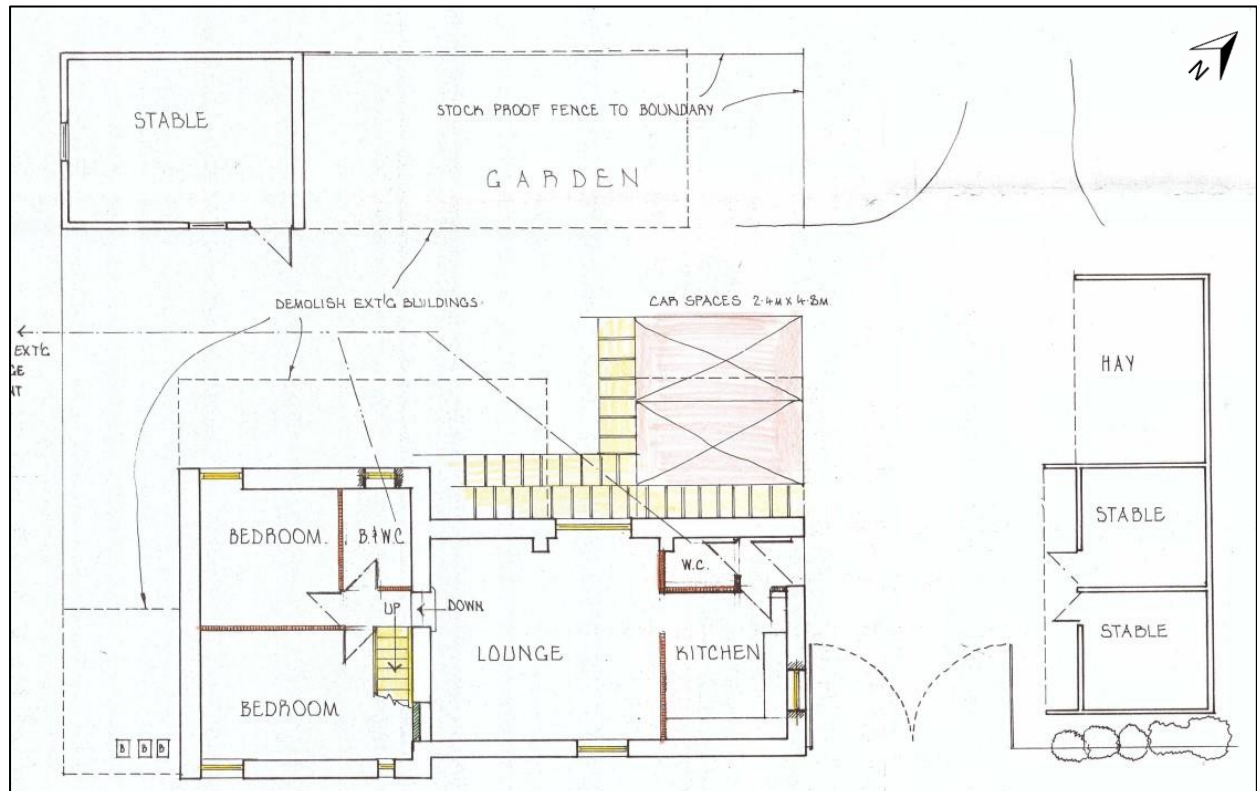


3.1 Proposed Development

It is understood that the client wishes to demolish the existing external extensions to the barn, along with the partial demolition of the northern most stable and convert the existing barn into a 2-storey, 3-bedroom residential dwelling.

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 the 3rd of October 2023 and comprised:

- Four window sample boreholes (designated WS1 - WS4 inclusive) were each sunk to depths between 4.00m to 5.00m below existing ground level. The boreholes were drilled with the intention of reaching 6.00m bgl however were terminated early in all locations due to refusals in very stiff clay and very dense sand. 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 three of the boreholes to depths between 4.00m and 5.00m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. EEG carried out ground gas monitoring in standpipes after the fieldwork period, the results of which are presented in Appendix 5.

Exploratory hole locations were selected prior to the site works by EEG Ltd based on the proposed development and avoiding known services.

Table 1 below indicates the appropriate features targeted.

Table 1: Sampling Location Justification

Exploratory Hole	Sampling Location
WS1, WS2, WS4	Adjacent to existing barn that is to be converted for geotechnical parameters
WS3	Proposed garden area for chemical testing

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.

Soil samples were recovered in 250g glass amber jars and 1kg plastic tubs. If collection was not possible the same day, then samples were stored in the sample storage fridge at the EEG offices below 4°C.

Samples were tracked using appropriate Chain of Custody forms provided by DETS.

It should be noted that hexavalent chromium soil is analysed using the USEPA recommended method of alkaline leach. This method limits chromium (VI) reduction to chromium (III).

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+A1:2020) 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⁾.

All sampling locations were surveyed by use of a hand-held Trimble GeoXH GPS instrument that is capable of surveying to an accuracy of less than 10mm depending on satellite coverage, proximity to trees and building structures.

The descriptive terminologies such as firm, etc formerly used within older versions of BS5930 to describe strength now solely relate to consistency. Shear strength is now defined related to results obtained in the field (using a hand vane for example) or in the laboratory (from triaxial tests), as detailed in Table 2 below.

Table 2: Shear Strength Definitions

Term based on measurement	Undrained Strength (c_u) definition in kN/m^2 (from BS EN ISO 14688-2: 2004, 5.3, Table 5)
Extremely Low Strength	<10
Very Low Strength	10 to 20
Low Strength	20 to 40
Medium Strength	40 to 75
High Strength	75 to 150
Very High Strength	150 to 300
Extremely High Strength	300 to 600

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 3 below.

Table 3: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS1	WS	4.00	03/10/2023	03/10/2023	392020	410449	A
WS2	WS	5.00	03/10/2023	03/10/2023	392009	410450	MW
WS3	WS	4.00	03/10/2023	03/10/2023	392005	410459	MW
WS4	WS	5.00	03/10/2023	03/10/2023	392003	410438	MW
*WS = Window Sample Borehole **A = Arisings, MW= Monitoring Well							

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 4, below.

Table 4: 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
Particle size distribution (wet)	BS1377:1990 Part 2, Clause 9.2	1
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	2
pH value	BS1377:1990 Part 3, Clause 9	2

The results of the laboratory geotechnical tests are discussed in Section 6 and included in Appendix 2.

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, a UKAS and MCERTS accredited laboratory.

Chemical analyses were carried out on five 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), and Speciated Polyaromatic Hydrocarbons (PAH).

Full results of the laboratory contamination tests are discussed in Section 8 and included in Appendix 3.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is underlain by superficial Hummocky (moundy) Glacial Deposits, comprising Diamicton. The solid geology beneath the site is recorded as the Pennine Lower Coal Measures Formation, comprising mudstone, siltstone, and sandstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** - Variable made ground was encountered in all exploratory holes to a maximum depth of 0.40m bgl, comprising:
 - Concrete.
 - Slightly silty, gravelly SAND, containing gravel of red brick, concrete, and rare clinker.
 - Sandy GRAVEL of red brick and concrete.
- **Superficial Deposits** - Variable superficial deposits were encountered in all exploratory hole locations to a maximum depth of 5.00m bgl, comprising:
 - CLAY with varying quantities of silt, sand and gravel of quartzite and sandstone.
 - SAND with varying quantities of clay, silt and gravel of quartzite and sandstone.
 - SILT with varying quantities of clay, sand and gravel of quartzite and sandstone.

The depths of the various materials encountered in the exploratory holes are summarised in Table 5, below.

Table 5: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m bgl)				GROUNDWATER STRIKE (m bgl)	MONITORING GROUNDWATER (m bgl)
	MADE GROUND	SUPERFICIAL DEPOSITS				
		CLAY	SAND	SILT		
WS1	GL - 0.40	0.40 - 2.00 3.00 - 3.80 3.90 - 4.00	3.80 - 3.90	-	-	-
WS2	GL - 0.40	0.40 - 2.00 2.70 - 4.00 4.50 - 5.00	4.00 - 4.50	2.00 - 2.70	-	1.68 - 2.91
WS3	GL - 0.40	0.40 - 1.00 1.20 - 2.00 2.20 - 3.00 3.40 - 3.90	3.90 - 4.00	1.00 - 1.20 2.00 - 2.20 3.00 - 3.40	-	0.26 - 1.04
WS4	GL - 0.30	0.90 - 1.90 4.60 - 5.00	0.30 - 0.90 1.90 - 2.60 2.80 - 4.00	2.60 - 2.80 4.00 - 4.60	3.00	1.10 - 2.40

5.2 Observable Indications of Contamination

Variable made ground was encountered in all exploratory boreholes, including gravel of red brick, concrete, and rare clinker.

No further visual or olfactory indication of contamination were encountered during the site investigation

5.3 Obstructions

No man-made obstructions were encountered in any of the exploratory hole locations.

5.4 Groundwater

Groundwater was encountered during the fieldwork, exclusively in WS4 at 3.00m bgl.

Subsequent groundwater monitoring identified water in all installed borehole locations, at depths between 0.26m - 2.91m bgl.

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 6: Summary of Laboratory Geotechnical Test Results

Location	Depth (m)	Strata*	CLASSIFICATION									CHEMICAL	
			Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Modified Plasticity Index (%)	PSD Gravel (%)	PSD Sand (%)	PSD Silt (%)	PSD Clay (%)	pH Value	Water Soluble Sulphate SO ₄ (mg/l)
WS1	1.00	CLAY	18.7	36	15	21	18	5	40	55	-	7.5	150
WS4	1.50	CLAY	17.2	39	14	25	23	3	43	32	22	7.3	120

6.2 Superficial Deposits

As discussed in Section 5, soils interpreted to represent the superficial deposits were encountered as variable CLAY, SAND and SILT.

6.2.1 Cohesive

Cohesive superficial deposits were encountered in all exploratory hole locations at depths between 0.40m - 5.00m bgl.

SPT tests carried out in the cohesive material resulted in **N values** of between 0 and 50, as shown on the SPT v Depth Plot in Figure 5 (overleaf). The results suggest the cohesive soils are very soft to very stiff.

The **water-soluble sulphate** content of two clay samples ranged between 120mg/l and 150mg/l SO₄, with **pH values** of between 7.3 and 7.5.

Atterberg Limit tests were carried out on two samples of the clay. Results of the tests reported **liquid limit** values of 36% and 39% and **plastic limit** values of 14% and 15%, resulting in values of **plasticity index** values of 21% and 25%. These results suggest the samples of clay tested are of **intermediate plasticity** as shown on the Plasticity Chart in Figure 6, overleaf.

Recommended N values and derived design values for the cohesive soils are summarised in Table 7, overleaf.

Table 7: Summary of Design Parameters (Cohesive)

Depth	SPT N Value Range	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
1.20	0 - 8	0.75	4 (Extremely Low Strength)	2.64 (Very High Compressibility)
2.00	8 - 9	8.25	42 (Medium Strength)	0.24 (Medium Compressibility)
3.00	4 - 16	6	30 (Low Strength)	0.32 (High Compressibility)
4.00	24 - 50	30.5	154 (Very High Strength)	0.06 (Low Compressibility)
5.00	50	50	252 (Very High Strength)	0.04 (Very Low Compressibility)
*Based on lower quartile N value and correlations by Peck Hanson and Thornburn ⁽¹⁹⁷⁴⁾				
**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 range between 4kN/m² and 252kN/m², suggesting the clay is of extremely low strength to very high strength at the depths tested, in accordance with Table 2.

For design purposes, a value of plasticity index = 24% is recommended, based on the upper quartile 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 24%, $mv = 1 / (0.505 \times N \text{ value})$.

This correlation gives values of the coefficient of volume compressibility between 2.64m²/MN and 0.04m²/MN, as shown in Table 7, above. The results suggest the clay has a **very high to very low 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:

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

$I_{p'}$ = 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 a **medium to low volume change potential**.

The **Natural Moisture Content (NMC)** and **Liquid Limit (LL)** of the soil can be used to give an indication of **soil desiccation**, i.e., where the NMC is less than 40% of the LL, the soil is inferred to be desiccated, as summarised in Table 8, overleaf.

Table 8: Soil Desiccation Indicators in Clay

Location	Depth (m)	Liquid Limit (%)	40% Liquid Limit (%)	Natural Moisture Content (%)	Desiccation
WS1	1.00	36	14	18.7	No
WS4	1.50	39	16	17.2	No

The results in the above table show that none of the tested samples show evidence of desiccation.

6.2.2 Sand

Sand was encountered within all exploratory hole locations, generally interbedded with the cohesive deposits.

SPT tests carried out in the sand resulted in SPT **N values** between 4 and 50, as shown on the SPT v Depth Plot in Figure 5 (overleaf). This result suggests the sand material is loose to very dense.

For design purposes, N values of between 4 - 20 have been adopted. Based on the correlation by Peck, Hanson and Thornburn⁽¹⁹⁷⁴⁾, this gives an **angle of shearing resistance** between $\phi=28$ - 33° .

Table 9: Summary of Design Parameters (Sand)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Soil Density	Angle of Internal Friction (degrees ^o)**
2.00	4	4	4	Loose	28
3.00	8	8	8	Loose	29
4.00	10 - 50	30	20	Medium Dense	33
*Based on lower quartile N value					
**Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾					

Figure 5: SPT v Depth Plot

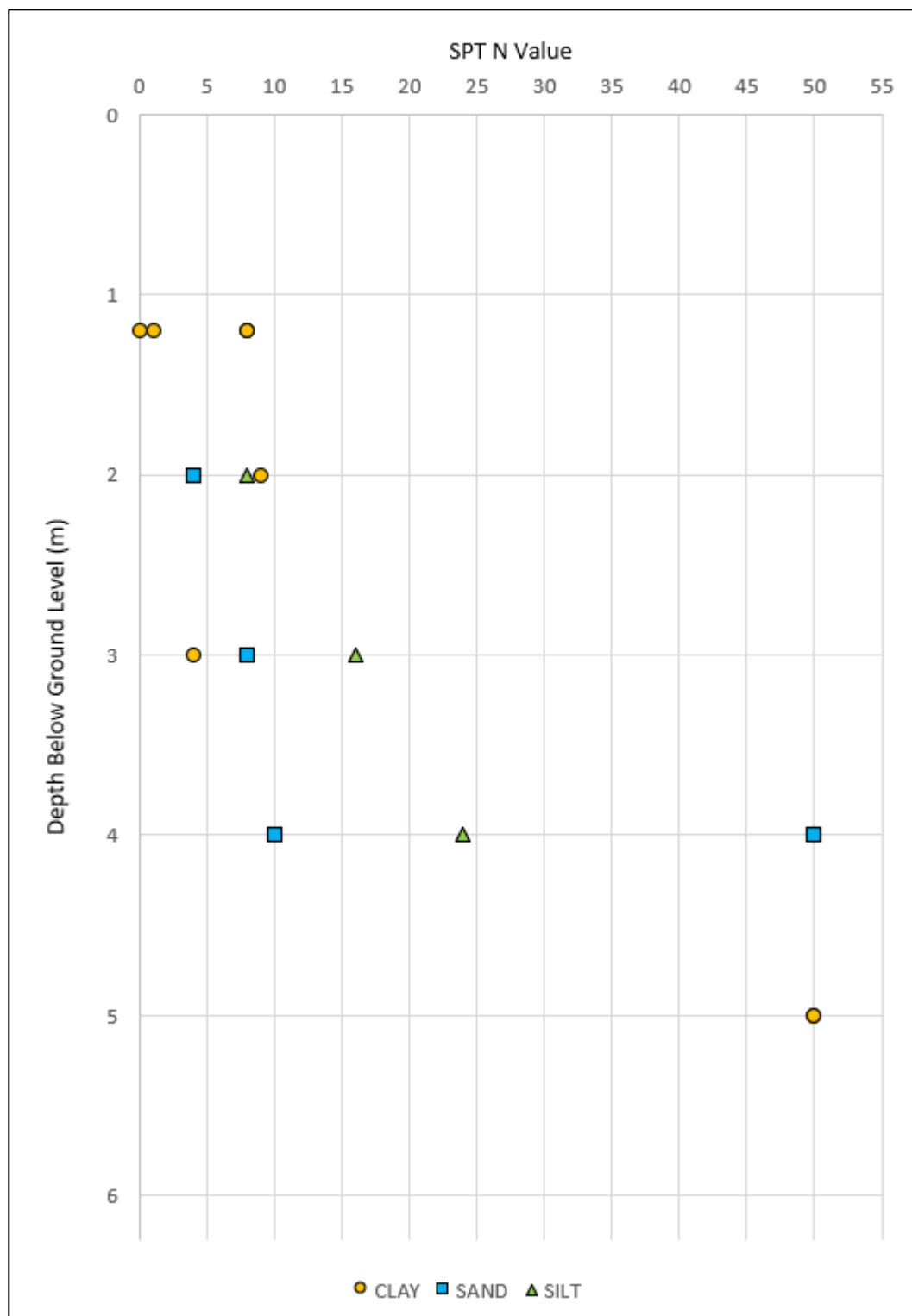
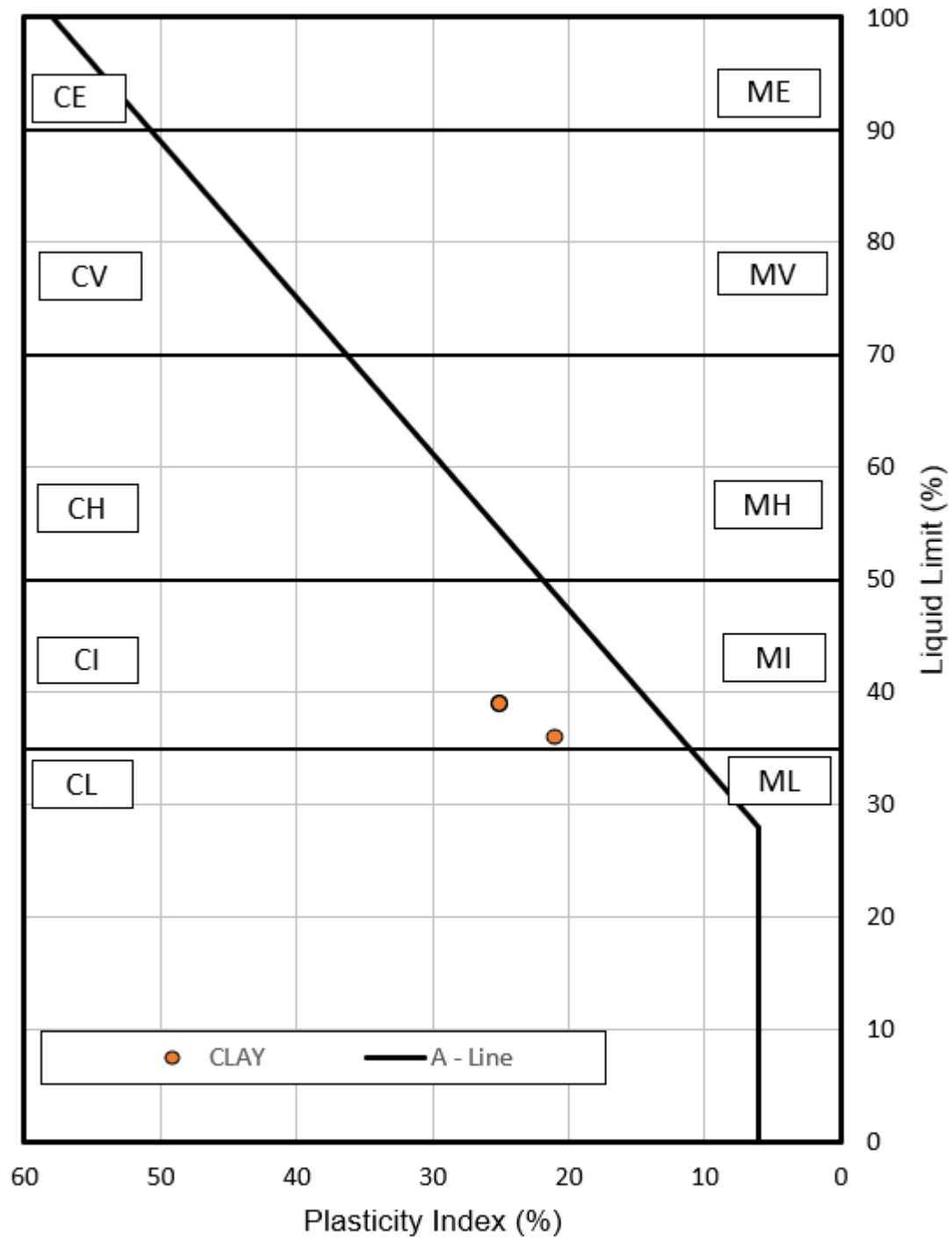


Figure 6: Plasticity Chart



7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the client wishes to demolish the existing external extensions to the barn, along with the partial demolition of the northern most stable and convert the existing barn into a 2-storey, 3-bedroom residential dwelling.

7.2 Ground Conditions Encountered

The exploratory holes generally encountered variable made ground below a concrete slab, to a maximum depth of 0.40m bgl.

Variable superficial deposits, largely comprising soft to firm clay with interbedded layers of soft silt and loose to medium dense sand, were encountered underlying the made ground to a maximum depth of 5.00m bgl.

Groundwater was encountered during the fieldwork, exclusively in WS4 at 3.00m bgl.

Subsequent groundwater monitoring identified water in all installed borehole locations, at depths between 0.26m - 2.91m bgl.

7.3 Pavement Design

The ground investigation identified the soil type at the subgrade level to typically be made ground underlain by clay and sand. Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), a conservative design CBR value of 1% should be adopted in areas where made ground is encountered at subgrade level, with 3 - 5% used where clay is encountered and 20 - 40% for sand.

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.

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.

Table 10: 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 axes. For heavier loaded pavements, the advice of specialist contractor should be sought.								

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.

7.4 Chemical Attack on Buried Concrete

Chemical tests (see Appendices) show low levels of water-soluble sulphates and 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.

7.5 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.

Granular made ground and natural sand 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.

7.6 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 11: 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 (acid)	6 - 7	5 - 6	4 - 5	2 - 4	<2	6.9	A
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.1 - 7.3	A
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	4 - 23	A
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 0.2 - 0.2	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	7 - 14	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	9 - 62	A
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	9 - 90	A
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	5 - 19	A
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	18 - 115	A
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1 - 1.1	A
Selenium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 2	A
Barium	0-500	500-1000	1000-2000	2000-1.0%	1.0%	19 - 79	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5 - 1	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	12 - 37	A
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	< 200 - 1057	A
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5 - 40	A - C
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 1	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results, the soils range from uncontaminated to 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 further mitigate this 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 contaminated land guidance has recently changed the evaluation of risk from 'minimal' (SGVs) to 'low' (referred to as Lowest Level of Toxicological Concern (LLTCs)). The policy companion document and supporting letter by DEFRA, states that C4SLs 'could be used under the planning regime, as well as within Part 2A'.

Based on these comments EEG considers the justifications and assumptions used to generate 'low' risk are suitable for the planning regime.

Where no C4SLs have been generated EEG will use the LQM S4ULs. Similar assumptions and land use to C4SLs have been used. However, toxicological information has been based on 'minimal risk' as per previous guidelines and assumptions. If contaminants are not present as C4SLs or S4ULs then EEG will use CL:AIRE GACs. These follow the 'minimal' risk principal and more stringent exposure parameters and will be conservative.

EEG consider the main risk drivers for PAHs are benzo(a)pyrene (B(a)P) and naphthalene. This is due to B(a)P possibly being a carcinogen and most toxic of the PAHs and naphthalene the most volatile and soluble. The new C4SLs indicate B(a)P as a surrogate marker for carcinogenic PAHs, since the risk from other non-carcinogenic PAHs are considered negligible. Naphthalene will be treated separately using the LQM S4ULs.

As a preliminary screening assessment, all results have been compared to a residential end use criterion.

The soil chemical testing results are summarised in Table 12, overleaf.

Table 12: Soil Results Comparison with C4SL/S4UL Values

Determinand	C4SL/S4UL Levels Resi w/ HP SOM 6% (mg/kg)	WS1 0.20m	WS2 0.60m	WS3 0.20m	WS3 0.50m	WS4 0.30m	No of Exceedances
Metals							
Arsenic	37	23	4	15	6	6	0
Beryllium	1.7	1	< 0.5	0.6	< 0.5	< 0.5	0
Boron	290	< 1	< 1	< 1	< 1	1.1	0
Cadmium	22	< 0.2	< 0.2	0.2	< 0.2	< 0.2	0
Chromium	910	11	14	11	10	7	0
Chromium VI	21	< 2	< 2	< 2	< 2	< 2	0
Copper	2400	62	15	39	10	9	0
Lead	200	50	24	90	13	9	0
Inorganic Mercury	40	< 1	< 1	< 1	< 1	< 1	0
Nickel	130	19	10	17	6	5	0
Selenium	250	< 2	< 2	< 2	< 2	< 2	0
Vanadium	410	37	16	24	17	12	0
Zinc	3700	42	29	115	52	18	0
Polycyclic Aromatic Hydrocarbons							
Naphthalene	13	< 0.1	< 0.1	1.15	< 0.1	7.25	0
Acenaphthylene	920	< 0.1	< 0.1	< 0.1	< 0.1	0.32	0
Acenaphthene	1100	< 0.1	< 0.1	0.59	< 0.1	10.2	0
Fluorene	860	< 0.1	< 0.1	0.34	< 0.1	7.04	0
Phenanthrene	440	0.13	< 0.1	1.03	< 0.1	6.25	0
Anthracene	11000	< 0.1	< 0.1	0.71	< 0.1	1.89	0
Fluoranthene	890	< 0.1	< 0.1	6.04	< 0.1	8.68	0
Pyrene	2000	< 0.1	< 0.1	4.87	< 0.1	7.19	0
Benzo(a)anthracene	13	< 0.1	< 0.1	3.14	< 0.1	3.95	0
Chrysene	27	< 0.1	< 0.1	2.75	< 0.1	3.21	0
Benzo(a)pyrene	5	< 0.1	< 0.1	3.98	< 0.1	4.56	0
Benzo(b)fluoranthene	3.7	< 0.1	< 0.1	4.17	< 0.1	4.83	2
Benzo(k)fluoranthene	100	< 0.1	< 0.1	1.38	< 0.1	1.54	0
Indeno(1,2,3-cd)pyrene	41	< 0.1	< 0.1	2.2	< 0.1	2.32	0
Dibenz(a,h)anthracene	0.3	< 0.1	< 0.1	0.59	< 0.1	0.54	2
Benzo(ghi)perylene	350	< 0.1	< 0.1	1.48	< 0.1	1.66	0
Phenols							
Phenol	380	< 2	< 2	< 2	< 2	< 2	0

Based on the above table, contaminant concentrations were found in exceedance of the screening criteria relevant to a residential end use in two borehole locations. The exceedances refer to benzo(b)fluoranthene and dibenz(a,h)anthracene in both WS3 at 0.20m bgl and WS4 at 0.30m bgl.

No asbestos fibres or fragments were identified in the soil samples analysed.

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 13 overleaf and presented in full in Appendix 4.

Table 13: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	Comments
WS1	0.20	Non-Hazardous	-
WS2	0.60	Non-Hazardous	-
WS3	0.20	Non-Hazardous	-
WS3	0.50	Non-Hazardous	-
WS4	0.30	Non-Hazardous	-

The above table shows that all the tested samples collected from the site have been classified as **Non-Hazardous** in accordance with WM3.1.

9.0 GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT

9.1 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.

9.2 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 monitoring visits were conducted between the 13th of October and the 8th of November 2023. The results recorded methane (CH₄) levels of 0.1% to 1.0% v/v with carbon dioxide (CO₂) levels of 0.1% to 6.6% v/v. Oxygen concentrations of between 21.7% and 12.7% v/v were also recorded.

A maximum flow rate of 0.4 litres/hour was encountered from a single borehole (WS2) on site, with a minimum flow rate recorded as 0.1 litres/hour. For assessment purposes, the steady detection flow rate of 0.1 litres/hour has been used.

Atmospheric pressure was recorded to be between 955mb and 973mb.

Full results of the monitoring are presented in Appendix 5.

Table 14 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 steady flow rate of 0.4l/h adopted for assessment purposes.

- Carbon dioxide: maximum flow rate = 0.4 l/hr, max concentration = 6.6%
- Methane: maximum flow rate = 0.4 l/hr, max concentration = 1.0%.

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

- **Carbon Dioxide:** $GSV = 0.1 \times 6.6 / 100 = 0.0066 \text{ litres/hour}$
- **Methane:** $GSV = 0.1 \times 1.0 / 100 = 0.001 \text{ litres/hour}$

The CIRIA guidance document notes that ‘...the GSV is a guideline value and not an absolute threshold’.

The above results suggest the site can be given a Characteristic Situation 2, i.e., ‘low risk’, in accordance with Table 14 overleaf, due to slightly elevated carbon dioxide levels.

Table 14: Characteristic Situation (Wilson et al 2006/2007 modified from Wilson and Card, 1999)

Characteristic Situation	Risk Classification	Gas Screening Value CH_4 or CO_2 (l/hr)	Additional Factors	Typical source of generation
1	Very Low	<0.07	Typically, < 1% methane Typically, < 5% carbon dioxide	Typical made ground
2	Low	<0.7	Borehole air flow rate to not exceed 70l/hr otherwise consider increase to Characteristic Situation 3	Typical made ground
3	Moderate	<3.5		Old landfill, inert waste, flooded mine workings
4	Moderate to High	<15	Quantitative risk assessment	Mine workings susceptible to flooding, completed landfill
5	High Risk	<70		Mineworking unflooded inactive with shallow workings near surface
6	Very High Risk	>70		Recent landfill site

Detailed Assessment

EEG have made reference to *Ground Gas Information Sheet No.1, Using Ternary Plots for Interpretation of Ground Gas Monitoring Results (July 2018)*, which reports that carbon dioxide is widespread in the sub-surface environment at concentrations of up to 21% and is generated by microbial and geochemical processes. Elevated carbon dioxide concentrations are commonly elevated in Glacial Till, Chalk, River Terrace Gravel, Thanet Sand, Lambeth Group and Made Ground.

It is reported that when monitoring wells are installed in these materials, small volumes of organic material are exposed to oxygen, which results in biological respiration or oxidation of the material, resulting in the production of carbon dioxide. Weathering of pyrites and subsequent reactions of

acidic pore water with carbonate material can also cause increased concentrations of carbon dioxide in the monitoring well headspace.

Organic material in Made Ground can also degrade to produce carbon dioxide and or methane, in which case the carbon dioxide may be generated so slowly that it will not be emitted from the ground surface in quantities or at a rate that is sufficient to pose a risk to overlying development.

Based on the above information, the gas monitoring data from this investigation has been analysed in respect of methane, carbon dioxide, oxygen, and nitrogen gas ratios, to deduce the potential source of the ground gas, as shown in Figures 7 to 9 below/ overleaf.

Figure 7: Gas Ratios Ternary Plot

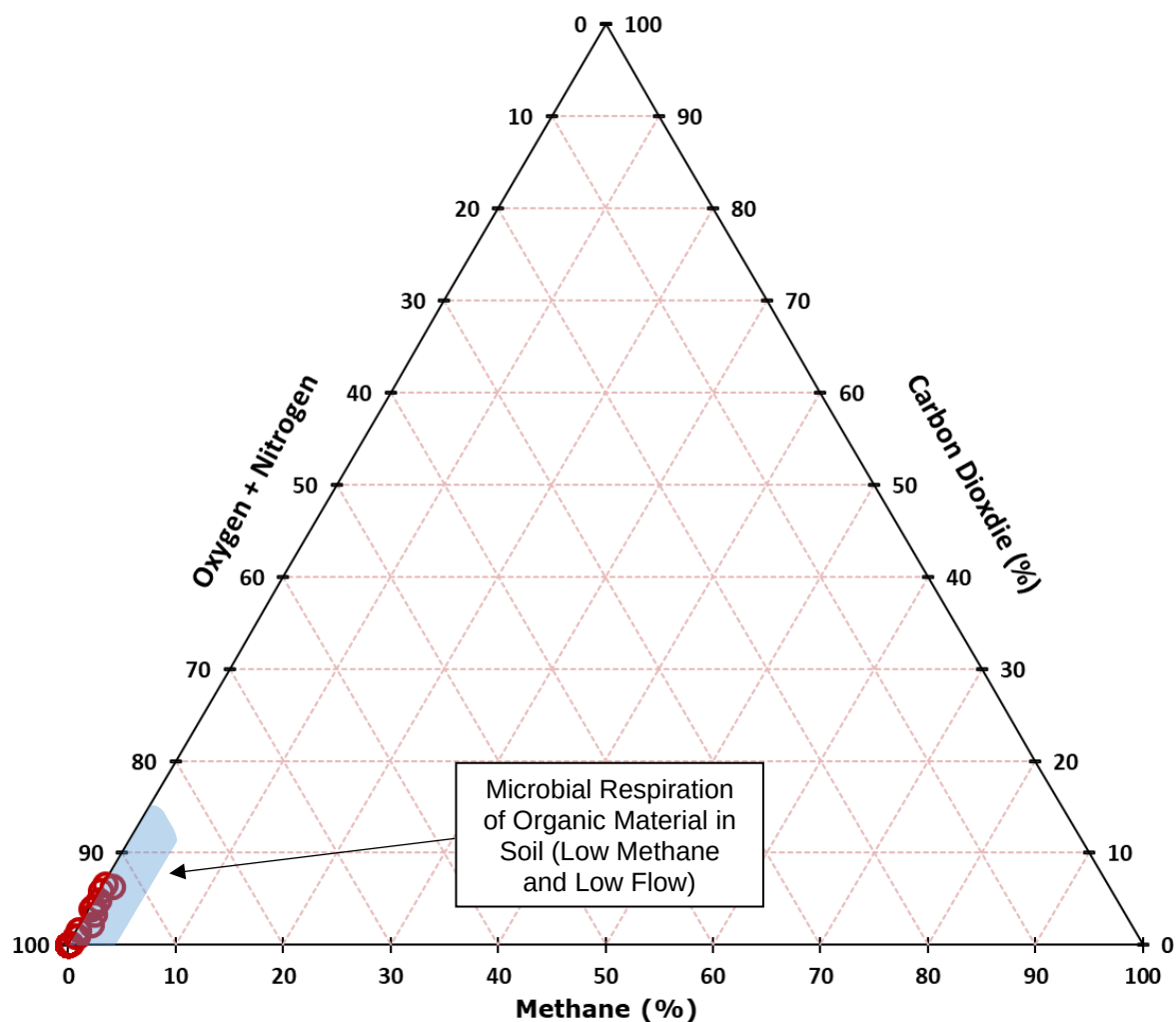


Figure 7 shows the ground gas monitoring results from this site investigation plotted within a ternary plot, adapted from Teasdale et al. 2015. The results show that the gas composition within the monitoring wells plot in the zone of microbial respiration.

Figure 8: Carbon Dioxide: Oxygen Ratio Plot

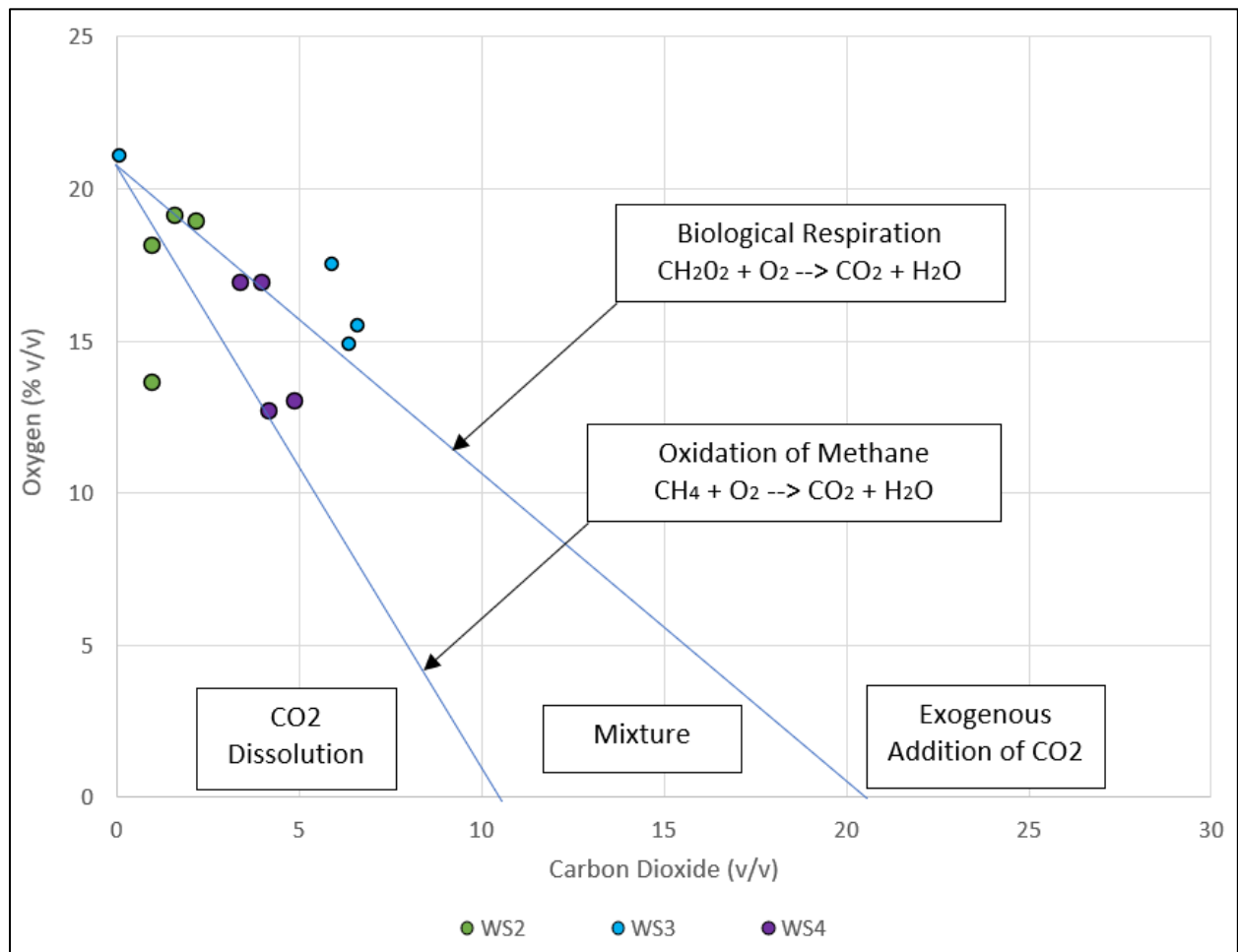


Figure 8 shows that the points that plot to the left of the biological respiration and oxidation of methane lines are caused by dissolution of gas from the ground (or pore) water and from reaction of rainwater with soil. The points to the right of the biological respiration line are caused by biological respiration (i.e., oxidation of organic material in the soil).

The majority of the data plots to the right of the oxidation of methane line and to the right of the biological respiration line, indicating a mixture of sources. Therefore, carbon dioxide being produced is potentially via microbial respiration.

Figure 9: Nitrogen/Oxygen: Carbon Dioxide Ratio Plot

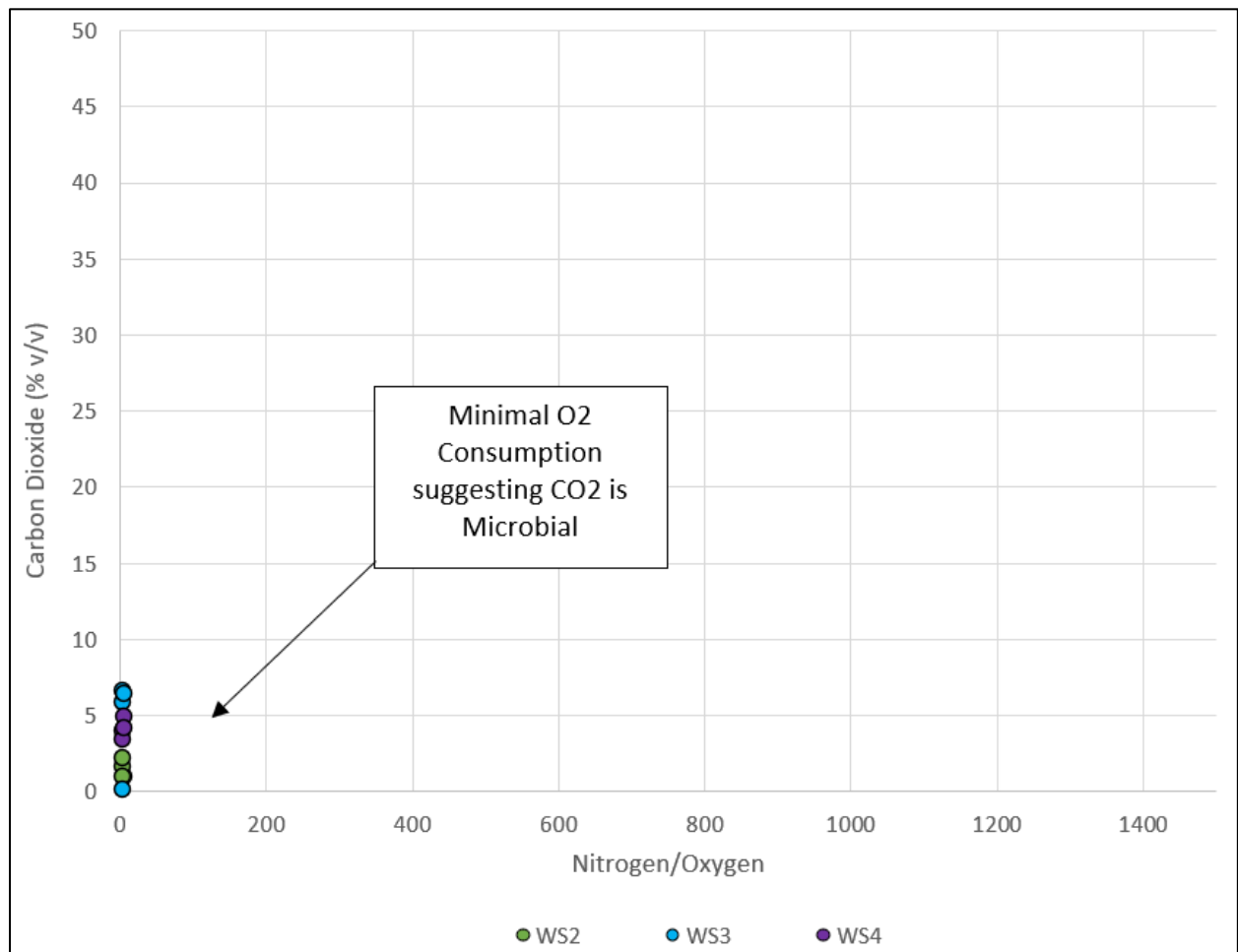


Figure 9 presents an assessment of the nitrogen/oxygen and carbon dioxide ratios. The figure shows all the monitoring results plotted to the left side of the graph, which represents minimal oxygen consumption. There is no data plotting towards the right side of this figure which would suggest methane oxidation.

The gas ratios therefore indicate that the carbon dioxide concentrations in the glacial deposits are naturally occurring from biological respiration, and it is therefore considered that the site as a whole should be classified as Characteristic Situation 1, i.e., 'very low risk'.

Based on the foregoing detailed assessment, ground gas protection measures are not considered necessary at the site.

10.0 CONCLUSIONS & RECOMMENDATIONS

10.1 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.

Based on the results of the chemical testing, contaminant concentrations were found in exceedance of the screening criteria relevant to a residential end use in two locations, referring to benzo(b)fluoranthene and dibenz(a,h)anthracene in both WS3 at 0.20m bgl and WS4 at 0.30m bgl.

Therefore, there is a **MODERATE to LOW** risk from soil contamination to future residential end users. The development of a remediation strategy detailing the implementation of a cover system in the proposed rear garden area, is recommended to mitigate this risk.

10.2 Asbestos

Asbestos fibres or fragments were not identified in any of the samples tested during this investigation.

10.3 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. All soil samples collected have been classified as Non-Hazardous for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

Further WAC testing on this material may prove it to be classified as inert waste.

10.4 Pavement Design

Based on the findings of the site investigation, the soil type at subgrade level was typically made ground. Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), a conservative design CBR value of 1% should be adopted in areas where made ground is encountered at subgrade level.

If pavement design is altered so that the subgrade comprises natural strata (typically at depths in the region of 1.20m bgl), a CBR value of 3 - 5% should be adopted for the clay and 20 - 40% for sand.

10.5 Land Gas

Detailed assessment of the data, with specific reference to gas ratios shows that the ground gas composition generally resembles air, not landfill or harmful gas. No oxidation of methane is occurring at the site. The source is likely to be biological respiration (i.e., the oxidation of organic material in the soil) that has been disturbed and released during the drilling process.

Based on this analysis and the low flow rates recorded in the window sample boreholes, the risk of ground gas can be considered “very low” with a characteristic situation of CS1.

Therefore, ground gas protection measures are not necessary in the proposed buildings on this site.

10.6 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.

10.7 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

GEOTECHNICAL TESTING RESULTS

APPENDIX 3

SOIL CHEMICAL TESTING RESULTS

APPENDIX 4

SOIL WASTE ASSESSMENT

APPENDIX 5

GROUND GAS MONITORING DATA

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 2023 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.