



LOMAX STREET



DUCIE STREET



EARTH ENVIRONMENTAL
& GEOTECHNICAL

GeoEnvironmental Investigation

Ducie Street

Manchester

September 2021

On behalf of

Urbano Red Limited

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SITE INVESTIGATION

DUCIE STREET

MANCHESTER

Report Ref: A4210/21/SI

SEPTEMBER 2021

Prepared on Behalf of:

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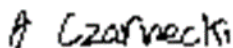


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1.0 EXECUTIVE SUMMARY

Appointment	A site investigation has been commissioned by BDI Structural Solution Ltd, on behalf of Urbano Red Ltd (the 'Client') to examine ground conditions for the proposed residential development to the north of Ducie Street, Manchester.
The Investigation	The investigation comprised 4no. cable percussive boreholes and 6no. window sample boreholes, in situ testing, laboratory geotechnical and contamination testing. A Preliminary Explosive Ordnance Risk Assessment was also conducted prior to the site investigation.
The Site	The site is in Manchester, approximately 1km to the east of Manchester Central Shopping District, at approximate National Grid Reference SJ 85016 98259. The site is underlain by Superficial Deposits of Devensian Till (boulder clay), and the bedrock geology comprises the Chester Formation (sandstone).
Site History	The site has been developed since 1848 and has had multiple phases of recorded development. Historically, terraced houses occupied the north of the site, whilst a machine factory and brewery occupied the south of the site. The terraced houses on the northeast of the site were demolished by 1922. A hotel covered the east of the site, and the machine factory became a brush works by 1932. The remaining terraced houses were demolished by 1953 and the hotel converted into a factory by 1985. All the buildings on site were demolished by 2010 and the area became utilised as a car park to present day.
UXO Risk	The Explosive Ordnance poses a low risk to the proposed site investigation works. However, the planned piling works expose the project to a potential UXO encounter. Therefore, a Stage 2 Detailed Explosive Ordnance Risk Assessment is recommended prior to development.
Ground Conditions Encountered	The exploratory holes encountered Made Ground (to a maximum depth of 3.05m) overlying superficial deposits of Devensian Till comprising firm to very stiff CLAY (to a maximum depth of 16.40m). Beneath which were granular deposits comprising medium dense to very dense SAND (to a maximum depth of 21.0m), and dense to very dense SAND & GRAVEL (to a maximum depth of 21.45m). Groundwater was encountered during the field work at 3.50m (WS2). Subsequent monitoring in the standpipes encountered groundwater at depths between 3.15m-3.30m bgl (WS2) and 1.95m and 3.90m bgl (WS4).
Geotechnical Assessment	Foundation options for the proposed residential development are piles taken down to depth to a suitable founding stratum such as the stiff to very stiff Devensian Till Deposits (boulder clay). Evidence of soil desiccation was observed in seven clay samples. Pavement Design – preliminary design value = 1% Made Ground. Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Contamination Assessment	Risk from contamination to groundworkers during development – Low to Moderate Chemical exceedance in Lead in 1no. soil sample (WS1). Risk from soil contamination to future residential end users – Low due to removal of impacted soils beneath the proposed building. Soil Waste Assessment: 7no. samples tested – 1no. Hazardous and 6no. Non-Hazardous. Asbestos was encountered as bundles of chrysotile fibres in 2no. samples. Asbestos quantified to be between 0.002% (WS2) and 0.003% (CP2). An Asbestos Management Plan will need to be prepared for the site.
Ground Gas Assessment	Based on the gas monitoring results the site can be classified as Gas Regime A and protection measures are therefore not needed.
<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 BDI Structural Solution Ltd, on behalf of Urbano Red Ltd (the 'Client') to examine ground conditions for the proposed residential development to the north of Ducie Street, Manchester.

2.2 Previous Investigations

2.2.1 Lomax Street, Manchester Phase I Desk Study Assessment Report (1702-21), Ltd, Renaissance Ltd, dated May 2018

The desk study highlighted that historically, the site has been developed on since at least 1848, and has been through multiple phases of recorded development. From the historical mapping the site can be seen to have been occupied by terraced houses in the north with a machine factory and brewery in the southern half. By 1908 the brewery was incorporated into the adjacent public house to become a hotel. The terraced houses in the northeastern part of the site had been demolished by 1922. The entire eastern half of the site was covered by the hotel in the 1932 mapping, while the machine factory was converted into a brush works. By 1953 the remaining terraced houses in the northwest of the site had been demolished. By 1985 the hotel had been converted into a factory that covered the entire site. The factory had shut down by 1994. In the 2010 mapping the buildings can be seen to have been demolished with the entire site being used for car parking. The site remains this way until the present-day.

Potential on-site sources of contamination include Made Ground and ground gas associated with on-site and off-site developments including industrial land uses. The site is presently utilised as a car park. Many factories, works, mills, garages, and railway land have been present nearby to the site. Leaks and spillages of fuels and oils such as diesel, lubricants and preservatives may be present from the car parking. Heavy metals, acids, alkalis, fuel/oils, solvents, and metal fines may be present.

The risk to end users from potential soil contamination on the site was concluded to be **MODERATE TO LOW**. The risk to construction workers from Made Ground was concluded to be **HIGH**. These risks are due to the on-site historical industrial land uses likely leaving an environmental legacy of contamination.

The risk to controlled waters was concluded to be **LOW**. Due to the watercourses being distant from the site and clay superficial deposits mitigating contaminant migration.

The risk of ground gas to end users was **MODERATE** due to the potential for significant thicknesses of Made Ground.

A Phase II Geo-Environmental Site Investigation was recommended to assess the risks of any soil or ground gas contamination as well as to examine the ground conditions for foundation design.

2.2.2 Lomax Street, Manchester Flood Risk Assessment Report (1611-12), Ltd, Renaissance Ltd, dated May 2018

The site is located within a Flood Risk Zone 1 and was considered appropriate under Planning Practice Guidance.

The site was considered to have a very low risk of flooding from surface water.

The site was not considered to be at risk of flooding from reservoirs.

The surface water run-off was specified to be accommodated on-site up to and including the 1 in 100-year critical event with an allowance for climate change. Flows will discharge to the existing sewer on Lomax Street with the lowest practical discharge rate of 5l/s.

Foul flows from the development will be discharged to the existing sewer within Lomax Street subject to Section 106 agreement.

2.2.3 Proposed Development Lomax Street, Manchester Archaeological Desk Based Assessment, Kathryn Sather & Associates, dated April 2018

There are no designated Scheduled Ancient Monuments within the study area. There are no entries in the Historic Environment Record within the study area. However, areas of interest were identified within the historical mapping.

Due to the nature of the proposed development, the works will have a large impact upon any buried archaeological remains that survive within the study area.

It was recommended that the extent, nature, and condition of these potential remains should be established, and further archaeological works undertaken if required, to mitigate the loss of the archaeological remains. It was also recommended that the site would require further archaeological investigation through a programme of evaluation trenching to establish the presence or absence of archaeological remains. If present, the extent and significance of the remains would be assessed and if warranted, an open area excavation may be required to mitigate the loss of the buried remains.

2.2.4 Lomax Street, Manchester Air Quality Assessment, Idom Merebrook Ltd, dated April 2018

The site was reported to be set within an Air Quality Management Area (AQMA) declared in respect of annual mean concentrations of NO₂. Concentrations of NO₂ in representative locations in the vicinity of the site were below but close to the Air Quality Objectives (AQO) of 40 µg.m⁻³.

Traffic-related emissions were expected to be the main source of pollution in the vicinity of the site due to its central location. A diecasting works was also located on the opposite side of Ducie Street.

The risk of dust impacts during the construction phase was assessed as 'low' in the absence of mitigation. Provided appropriate mitigation is employed throughout the construction phase the overall effect on local air quality was assessed as 'not significant'.

The scheme was anticipated to result in a decrease in traffic on the local road network because of the change in use. Heating will be via electrical radiator panels and hot water supply via an

immersion heater (electrical) therefore there will be no onsite point sources of emissions. The operational development is assessed as having a negligible impact on local air quality and the overall effect of the scheme is judged to be 'not significant'.

2.2.5 Ecological Assessment at Lomax Street, Manchester, Urban Green, dated June 2018

Ashton Mersey and Rochdale Canal SBI sites were deemed not likely to be affected by the development on site. There was no hydrological or ecological connectivity between the site and these designated sites. In addition, the development site is relatively small and fragmented, and so any temporary disturbance caused by works will be relatively isolated and confined to a small geographical area and will be contained via suitable onsite pollution management.

The site comprised mostly hardstanding, which is not a priority habitat of ecological relevance. Due to this low ecological value, there was much scope within the new development to easily achieve a net gain in biodiversity by implementing ecological enhancements.

The risk of harming roosting bats because of the proposed site development was concluded to be low. However, it was recommended that a lighting scheme be implemented that is designed not to disturb bats and other nocturnal wildlife.

2.2.6 Preliminary Explosive Ordnance Risk Assessment, Ducie Street, Manchester, Impartial Assessments Ltd, dated July 2021.

The Preliminary Risk Assessment was written in accordance with CIRIA C681(2009) and C785 (2019) guidelines on UXO risk assessment.

The risk associated with shallow buried Explosive Ordnance (EO) has likely been mitigated, however any deep buried German unexploded bomb (UXB) contamination could have persisted up to the present day.

The site is located within the WW2-era County Borough of Manchester which sustained 27.0 bombs / 1,000 acres which is considered a 'moderate' bombing density.

Luttwaffe target maps showing several bombing targets within 1km of the site, the closest record is London Road Good Station located 190m to the southwest of the site.

Pre-WW2 buildings in the north of the site were demolished by the late 1940s which could indicate potential bomb damage.

The Explosive Ordnance poses a low risk to the proposed site investigation works. However, the planned piling works expose the project to a potential UXO encounter. Therefore, a Stage 2 Detailed Explosive Ordnance Risk Assessment is recommended prior to development.

A copy of the Preliminary Explosive Ordnance Risk Assessment is included in Appendix 1.

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 A4210/21 dated 9th June 2021. The objectives of this investigation are as follows:

- *Provide information on the work undertaken including sampling location plan, borehole logs, chemical and geotechnical testing.*
- *Integrated UXO desk study.*
- *Assessment of ground conditions for foundation design purposes.*
- *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 surplus soils 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 considering 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 in Manchester approximately 1km to the east of Manchester Central Shopping District. The approximate National Grid Reference for the centre of the site is SJ 85016 98259 (X: 385016 Y: 398259) with the closest postcode being M1 2JP.

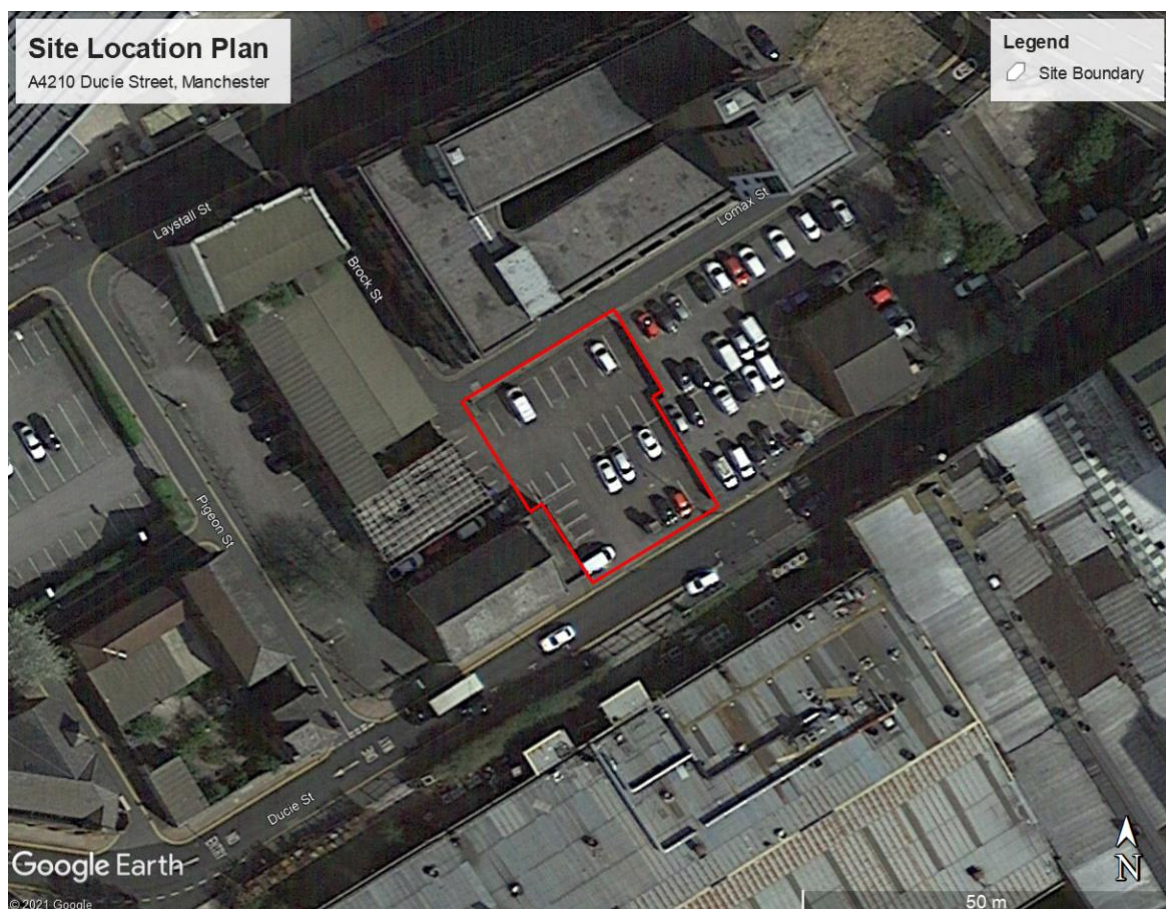
The site is a near rectangular shaped parcel of land with current access via Ducie Street to the southeast and Lomax Street to the northwest. The proposed development area encompasses an area of approximately 0.1hectares. The site has a gently sloping topography with a decrease in elevation from 49m AOD in the northwest to 48m AOD in the southeast.

The site currently comprises a car park entirely covered in asphalt hardstanding with an attendant's booth adjacent to the southeast boundary. The site is open to the northwest and southeast with a wooden panelled fence in the northeast and a brick wall in the south east.

The site is located within an urban area with the general vicinity comprising industrial, commercial, and residential properties. Adjacent to the northeast of the site is another car park, to the southeast is Ducie Street with an industrial building beyond, to the southwest are commercial properties and to the northwest is Lomax Street with a residential apartment building beyond.

The site location is shown in Figure 1, below.

Figure 1: Site Location Plan



Site photographs are presented in Figures 2 to 5 below.

Figure 2 View Facing Southeast Showing the Window Sampling Setup



Figure 3 View Facing Northwest Showing the Cable Drilling in the Northern Portion of the Site



Figure 4 View Facing Southeast Showing the Cable Drilling in the Southern Portion of the Site



Figure 5 Made Ground and Superficial Deposits Encountered in the Window Sample Boreholes



3.1 Proposed Development

It is understood that the Client intends to construct a 7 to 8 storey residential apartment building that is proposed to include 41 apartments. The development will include a communal roof garden, and street tree planting. The site will be accessed via Lomax Street to the north of the site.

The proposed development layout details are shown in Figure 6, below.

Figure 6: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on Monday 2nd to Thursday 5th August 2021. The fieldwork comprised:

- Four cable percussive boreholes (designated CP1, CP2, CP2A and CP2B) were drilled to a maximum depth of 21.45m below existing ground level. Two boreholes had to be terminated early due to the presence of solid concrete obstructions. The rig consists essentially of a mechanised drop-weight that repeatedly falls onto an anvil, driving attached sample tubes or probe rods into the ground. The method can therefore be classified as a form of drive sampling, in which a tube or split tube sampler having a short cutting edge at its lower end is forced into the ground by dynamic impact (BS 5930:1999). Although the rig operates primarily as a soil sampling tool, the rig is also capable of conducting Standard Penetration Tests to BS 1377: Part 9: 1990. The rig has the facility to drive casing into the ground, simultaneously with a soil sample tube. Using this system means that any overburden/loose ground can be sampled without hole collapse, ensuring that successive samples are accurate from the depth taken and consequently minimising cross-contamination of both in situ strata & samples. Groundwater observations were noted where possible. These observations relate to the time of the investigation only, and do not necessarily reflect seasonal fluctuations. Cable percussive borehole logs are included in Appendix 2.
- Six window sample boreholes (designated WS1 - WS3, WS3A, WS3B and WS4 inclusive) were each sunk to a maximum depth of 5.0m below existing ground level). Four boreholes had to be terminated early due to the presence of solid concrete obstructions. 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. 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. Window sample borehole logs are included in Appendix 2.
- 50mm diameter standpipes were installed in three window sample boreholes (WS1, WS2 and WS4) up to a depth of 5.00m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. There are two existing monitoring standpipes installed on site from a previous investigation (labelled BH1 and BH3) up to a depth of 15.40m bgl. EEG carried out groundwater/ground gas monitoring in standpipes after the fieldwork period, the results are included in Appendix 3.

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

Table 1 overleaf indicates appropriate features targeted.

Table 1: Sampling Location Justification

Exploratory Hole	Sampling Location
CP1	Proposed residential apartment building footprint
CP2	Proposed residential apartment building footprint
CP2A	Proposed residential apartment building footprint
CP2B	Proposed residential apartment building footprint
WS1	Proposed residential apartment building footprint
WS2	Proposed residential apartment building footprint
WS3	Proposed residential apartment building footprint
WS3A	Proposed residential apartment building footprint
WS3B	Proposed residential apartment building footprint
WS4	Proposed residential apartment building footprint

Each exploratory location was scanned using a Cable Avoidance Tool (CAT) 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. All the samples were labelled and stored in cool boxes prior to being collected by courier at the end of the day for delivery to the DETS laboratory.

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 Ltd.

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 handheld 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.

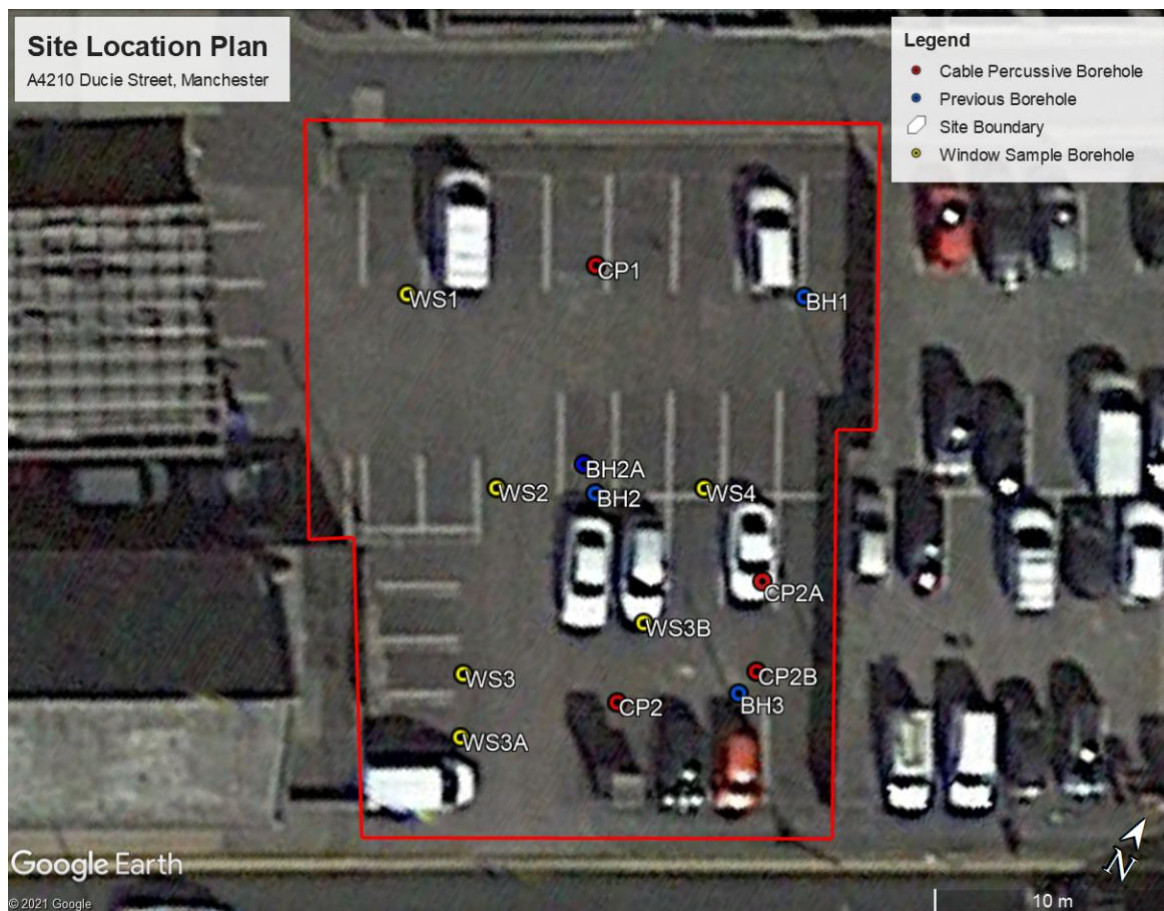
The descriptive terminologies such as firm, etc formerly used within older versions of BS5930 to describe strength now solely relate to consistency. Shear strength is now defined related to results obtained in the field (using a hand vane for example) or in the laboratory (from triaxial tests), as detailed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

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	130 to 300
Extremely High Strength	300 to 600

An Exploratory Hole Location Plan is presented as Figure 7, below.

Figure 7: Exploratory Hole Location Plan



A summary of exploratory holes undertaken during the investigation are presented in Table 3, overleaf.

Table 3: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
CP1	CP	21.45	02/08/2021	03/08/2021	385013	398264	A
CP2	CP	2.40	03/08/2021	03/08/2021	385023	398249	A
CP2A	CP	0.70	03/08/2021	03/08/2021	385026	398257	A
CP2B	CP	19.95	04/08/2021	05/08/2021	385027	398254	A
WS1	WS	2.00	03/08/2021	03/08/2021	385007	398259	SP
WS2	WS	5.00	03/08/2021	03/08/2021	385014	398254	SP
WS3	WS	0.50	03/08/2021	03/08/2021	385017	398247	A
WS3A	WS	0.37	03/08/2021	03/08/2021	385018	398245	A
WS3B	WS	0.73	03/08/2021	03/08/2021	385022	398253	A
WS4	WS	5.00	03/08/2021	03/08/2021	385021	398259	SP
*CP = Cable Percussive Borehole, WS = Window Sample Borehole							
**A=Arisings, SP=Standpipe							

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	12
Liquid Limit, Plastic Limit, Plasticity Index	BS1377:1990 Part 2, Clause 4/5	12
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	10
pH value	BS1377:1990 Part 3, Clause 9	10
Triaxial tests	BS1377:1990 Part 7, Clause 9	8
"Quick" undrained with multistage loading		

The results of the laboratory geotechnical tests are discussed in Section 6 and included in Appendix 4.

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 Ltd a UKAS and MCERTS accredited laboratory.

Chemical analyses were carried out on seven 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, Speciated Polycyclic Aromatic Hydrocarbons (PAH) and Speciated Petroleum Hydrocarbons (TPH).

In addition, two of the soil samples were also submitted for asbestos quantification.

Chemical analyses were also carried out on one groundwater sample (WS2) which was 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 (TPH) and speciated Polyaromatic Hydrocarbons (PAH).

The results of the laboratory contamination tests are discussed in Sections 8 to 9 and included in Appendix 5.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is underlain by superficial deposits of Devensian Till, comprising diamicton, commonly known as Boulder Clay. The solid geology beneath the site is shown to be the Chester Formation, comprising sandstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** – Variable Made Ground was encountered in all exploratory hole locations to a maximum depth of 3.05m bgl, comprising:
 - A covering of TARMACADAM is present across the site.
 - Gravelly SAND containing concrete, red brick, sandstone, limestone, glass fragments and metal fragments.
 - Clayey sandy GRAVEL containing red brick, concrete, limestone, sandstone, glass, and metal fragments.
 - SAND & GRAVEL containing concrete, red brick, sandstone, limestone, slate, rebar, tarmac, metal, plastic, and glass fragments. With varying silt and clay content.
 - Sandy gravelly COBBLES of concrete.
 - Sandy gravelly CLAY containing red brick, concrete, limestone, sandstone, slate metal, glass, and pottery fragments.
 - CONCRETE.
- **Superficial Deposits** - were encountered in all the exploratory holes to a maximum depth of 21.45m bgl, comprising:
 - Firm to stiff sandy gravelly CLAY containing sandstone and mudstone, with occasional sand lenses.
 - Firm to very stiff silty sandy gravelly CLAY containing sandstone and mudstone.
 - Very stiff sandy CLAY with abundant sand lenses.
 - Medium dense to very dense clayey gravelly SAND containing sandstone and mudstone.
 - Dense silty gravelly SAND containing sandstone. Abundant clay lenses.
 - Dense to very dense SAND & GRAVEL containing sandstone.

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

5.2 Observable Indications of Contamination

During the ground investigation, variable Made Ground containing concrete, glass fragments, metal nails, rebar, pottery fragments, plastic and red brick were observed in the exploratory holes.

No other visual or olfactory signs of contamination were observed.

Table 5: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m)							Ground water (m bgl)
	MADE GROUND				SUPERFICIAL DEPOSITS			
	MACADAM	CONCRETE	COHESIVE	GRANULAR	CLAY	SAND	SAND & GRAVEL	
CP1	GL-0.15	2.90-3.00	-	0.15-2.90	3.00-16.40	16.40-21.00	21.00-21.45	-
CP2	GL-0.15	0.50-0.85 2.30-2.40	-	0.15-0.50 0.85-2.30	-	-	-	-
CP2A	GL-0.15	0.60-0.70	-	0.15-0.60	-	-	-	-
CP2B	GL-0.15	-	1.50-2.10	0.15-1.50 2.10-3.05	3.05-17.20	17.20-18.00 19.50-19.95	18.00-19.50	-
WS1	GL-0.15	1.90-2.00	-	0.15-1.90	-	-	-	-
WS2	GL-0.15	-	1.10-1.90	0.15-1.10	1.90-5.00	-	-	3.50m
WS3	GL-0.15	0.50+	-	0.15-0.50	-	-	-	-
WS3A	GL-0.15	0.37+	-	0.15-0.37	-	-	-	-
WS3B	GL-0.15	0.73+	-	0.15-0.73	-	-	-	-
WS4	GL-0.15		0.30-1.90	0.15-0.30	1.90-5.00	-	-	-

5.3 Obstructions

Man-made obstructions were encountered at most locations during the site investigation (CP1, CP2, CP2A, WS1, WS3, WS3A and WS3B).

This was present as concrete at shallow (<1m bgl) and greater depths (1.90m to 3.00m bgl). The shallow concrete was encountered in CP2, CP2A, WS3, WS3A, WS3B. The deeper concrete was present in CP1, CP2 and WS1.

5.4 Groundwater

Groundwater was encountered in exploratory hole location WS2 at approximately 3.50m during the field work.

Subsequent monitoring in the standpipes encountered groundwater at depths between 3.15m-3.30m bgl in WS2. Groundwater was also encountered in WS4 at depths of between 1.95m and 3.90m bgl. No groundwater was encountered in monitoring standpipes WS1 and WS4.

No groundwater was encountered in the monitoring standpipes installed during a previous investigation labelled BH1 and BH3, however BH3 was wet at the base.

5.5 Land Gas

Ground gas monitoring was undertaken using a Geotechnical Instruments G5000 plus in accordance with the monitoring protocol outlined in CIRIA C665.

Results obtained during the initial monitoring visit on 13th August 2021 indicated Methane (CH₄) levels ranging from 0.0% to 0.1% by volume, Carbon Dioxide (CO₂) levels ranging from 0.1% to 2.0% by volume, and Oxygen (O₂) levels ranging from 17.8% to 20.9% by volume. A peak gas flow of 0.0l/hr was recorded, together with atmospheric pressure of 1000mb.

Results obtained during subsequent monitoring visits on 18th, 27th and 31st August 2021 indicated Methane levels of 0.1% by volume, Carbon Dioxide levels ranging from 0.1% to 2.8% by volume,

and Oxygen levels ranging from 17.9% to 18.4% by volume. A peak gas flow of 0.7l/hr was recorded, together with atmospheric pressure of 1000mb.

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 the laboratory geotechnical testing are summarised in Table 6, below.

Table 6: Summary of Laboratory Geotechnical Test Results

Location	Depth (m)	Strata	CLASSIFICATION							STRENGTH	CHEMICAL	
			Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Modified Plasticity Index (%)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)		pH Value	Water Soluble Sulphate SO ₄ (mg/l)
CP1	3.00-3.45	CLAY	16	37	14	23	22	2.17	1.87	131-138	-	-
CP1	6.00-6.45	CLAY	14	38	14	24	24	2.21	1.94	173-175	7.0	150
CP1	7.50-7.95	CLAY	17	37	14	23	22	-	-	-	-	-
CP1	10.50-10.95	CLAY	11	39	13	26	26	2.33	2.10	231-246	7.0	110
CP1	13.50-13.95	CLAY	14	37	15	22	21	-	-	-	-	-
CP1	16.50-16.95	SAND	-	-	-	-	-	-	-	-	6.9	180
CP2B	4.50-4.95	CLAY	14	35	13	22	21	2.18	1.96	181-193	7.0	100
CP2B	7.50-7.95	CLAY	-	-	-	-	-	2.24	1.98	137-148	7.0	160
CP2B	10.50-10.95	CLAY	-	-	-	-	-	2.34	2.13	153-175	-	-
CP2B	12.00-12.45	CLAY	11	36	12	24	24	2.22	2.00	110-125	7.1	130
CP2B	13.50-13.95	CLAY	15	39	14	25	25	2.17	1.89	118-131	-	-
CP2B	15.45-15.95	CLAY	18	41	15	26	26	-	-	-	-	-
CP2B	18.00-18.45	SAND & GRAVEL	-	-	-	-	-	-	-	-	6.7	270
WS1	1.80	MG	-	-	-	-	-	-	-	-	6.6	350
WS2	2.50	CLAY	11	37	13	24	23	-	-	-	7.0	210
WS4	2.00	CLAY	13	38	13	25	24	-	-	-	-	-
WS4	3.50	CLAY	22	40	16	24	23	-	-	-	7.0	140

6.2 Made Ground

Made Ground was encountered in all exploratory hole locations between ground level and a maximum depth of 3.05m below ground level (CP2B) and varied between exploratory hole locations.

SPT tests carried out in the Made Ground material resulted in **SPT N values** of between 6 and 50, as shown on the SPT v Depth Plot, in Figure 8 (overleaf). The refusals (N=50) were encountered in the concrete.

The **water-soluble sulphate** content of one Made Ground sample was 350mg/l SO₄, with a **pH value** of 6.6.

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

6.3 Superficial Deposits

As discussed in Section 5, superficial soils were encountered across the site predominantly as Devensian Till Deposits comprising CLAY. Granular soils comprising SAND & GRAVEL, and SAND were also encountered at significant depth.

6.3.1 CLAY

Clay was encountered in all exploratory hole locations beneath the Made Ground at depths between 1.90m and 17.20m below ground level.

The **water-soluble sulphate** content of eight clay samples ranged from 100mg/l to 210mg/l SO₄, with a **pH value** of between 7.0 and 7.1.

SPT tests carried out in the clay resulted in **SPT N values** of between 14 and 43, as shown on the SPT v Depth Plot, in Figure 8 (overleaf). The results suggest the clay is firm to very stiff.

The **undrained shear strength** in triaxial compression (U100) was carried out on eight samples of the clay. Results of the test showed shear strength values in the range 110kN/m² to 246kN/m² at depths of between 3.0m and 13.95m, suggesting the clay tested is high to very high strength.

In-situ **hand penetrometer** (HP) tests were carried out on the recovered soils, the results of which generally ranged between 96kPa (kN/m²) to >215kPa, suggesting the clay tested is high to very strength.

In-situ **hand shear vane** (HSV) measurements were also carried out on the recovered soils, the results of which generally ranged between 64kPa (kN/m²) to 192kPa, suggesting the clay tested is medium to very high strength.

For design purposes, the more conservative SPT N values were used. Recommended N values and derived design values for cohesive soils are summarised in Table 7, below.

Table 7: Summary of Design Parameters (Clay)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Shear Strength** (kN/m ²)	Measured Undrained Triaxial Shear Strength (kN/m ²)	Coefficient of Volume Compressibility* (mv)
2.0	14-15	15	14	64 (medium strength)	-	0.14
3.0	28-30	29	29	128 (high strength)	131-138	0.07
4.0-4.5	18-40	27	20	90 (high strength)	181-193	0.10
5.0	35-38	37	36	161 (very high strength)	-	0.06
6.0	20	20	20	90 (high strength)	173-175	0.10
7.5	24	24	24	108 (high strength)	137-148	0.08
9.0	22-23	23	22	100 (high strength)	-	0.09
10.5	-	-	-	-	153-246	-
12.0	21	21	21	95 (high strength)	110-125	0.10
13.5	43	43	43	194 (very high strength)	118-131	0.05
15.0	25-34	30	27	123 (high strength)	-	0.07
16.5	27	27	27	122 (high strength)	-	0.07

*Based on lower quartile N value and correlations by Peck Hanson and Thornburn (1974)

**Based on correlation by Stroud & Butler (1975)

Figure 8 SPT v Depth Plot

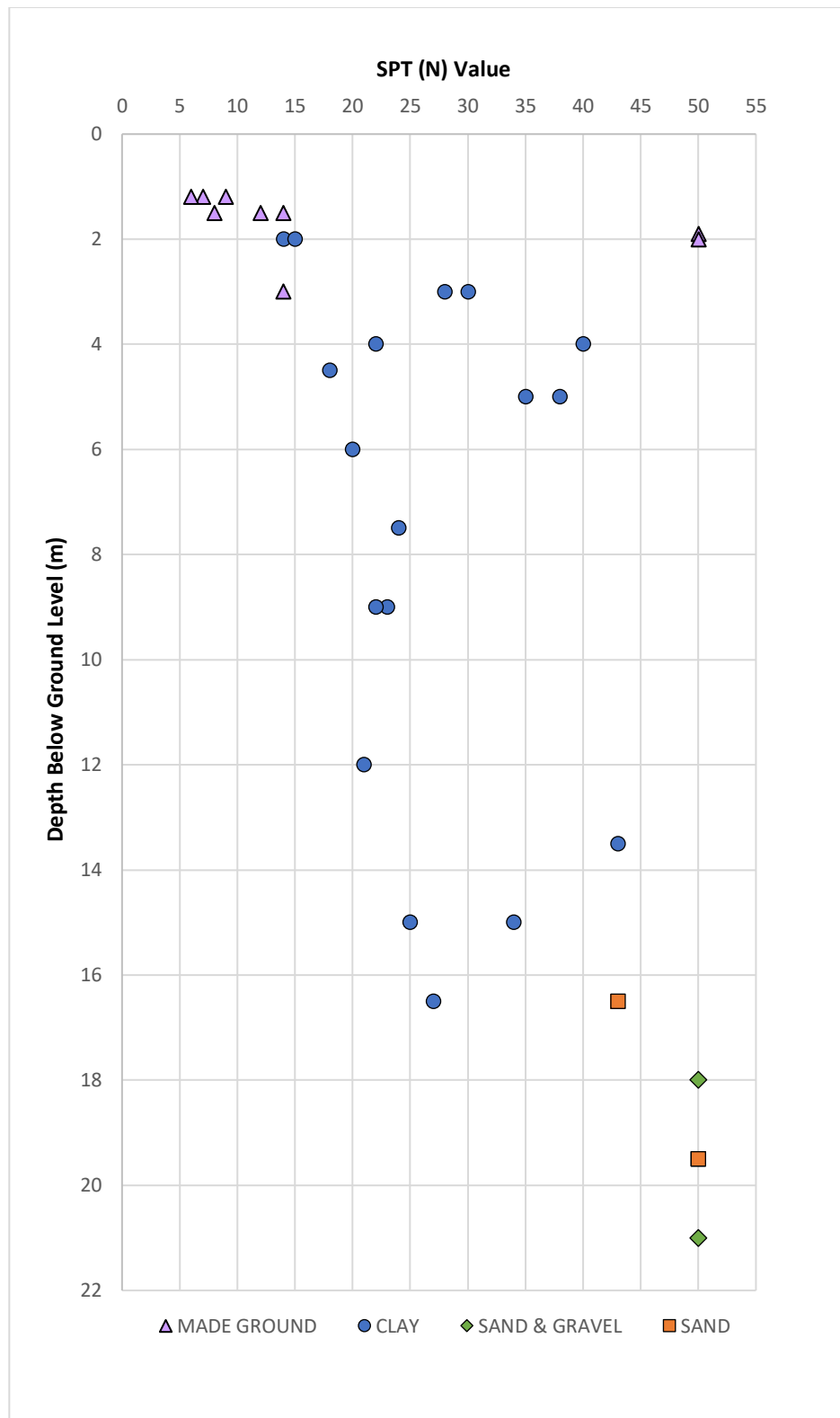
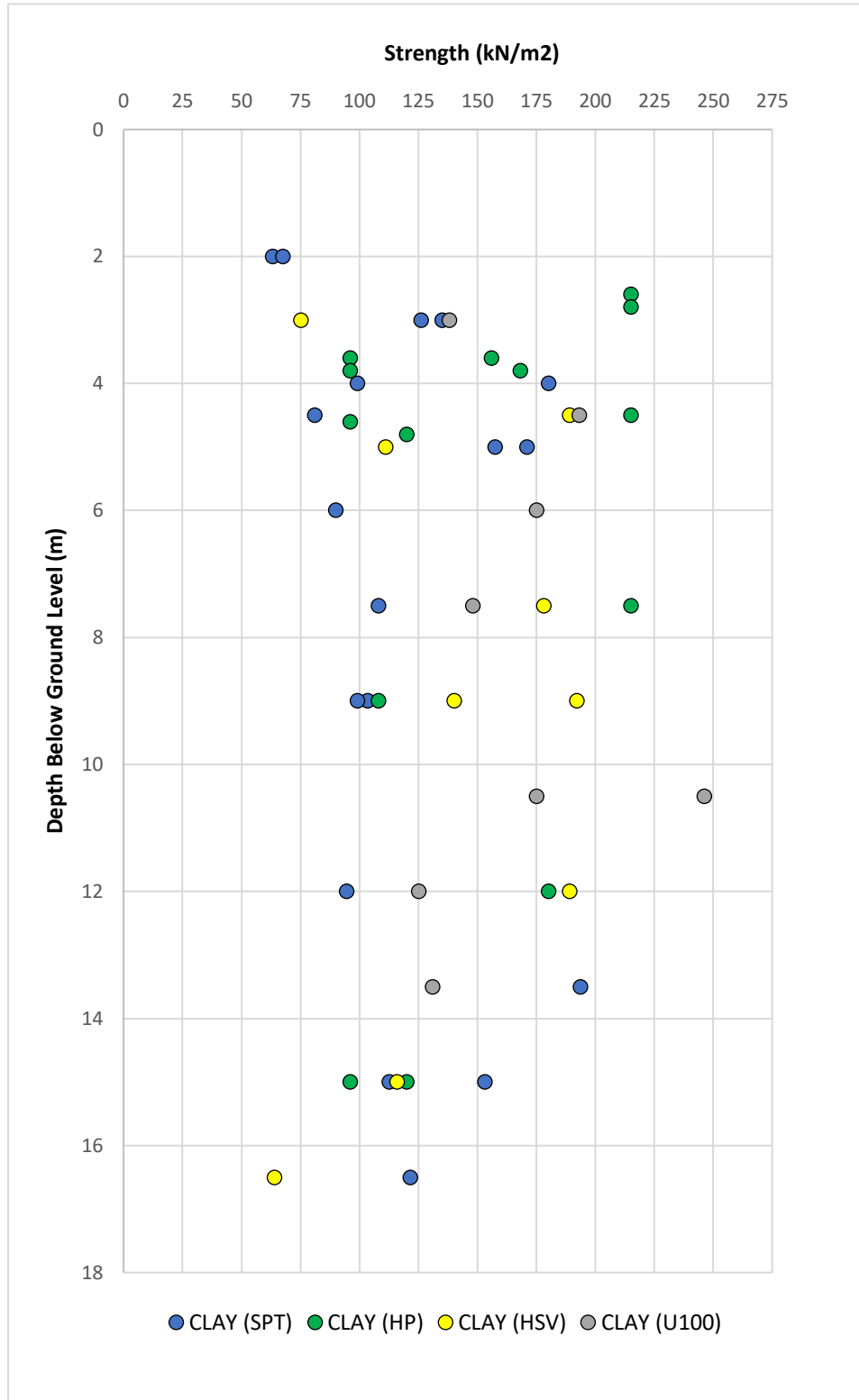


Figure 9, below, shows the derived undrained shear strength of the Clay based on in-situ hand penetrometer tests and hand shear vane measurements, alongside equivalent shear strength from SPT N values based on correlations by Stroud and Butler ⁽¹⁹⁷⁵⁾.

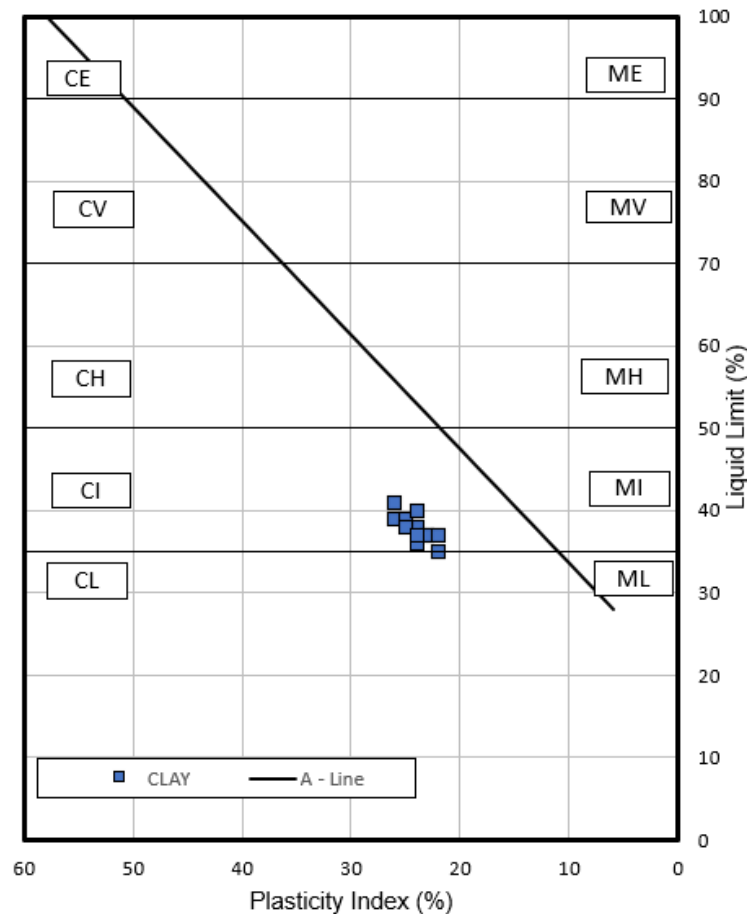
Figure 9 Strength v Depth Plot (Clay)



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 Table 7, the equivalent shear strength values are in the range of 64kN/m² to 194kN/m², suggesting the clay is medium to very high strength.

Atterberg Limit tests were carried out on three samples of the clay. Results of the test reported **liquid limit** values in the range of 35% to 41% and **plastic limit** values in the range of 12% to 16%, resulting in values of **plasticity index** in the range of 22% to 26%. These results suggest the clay to be of **intermediate plasticity**. Results are shown on the Plasticity Chart in Figure 10, below.

Figure 10 Plasticity Chart



For design purposes, a value of plasticity index = 25% 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 25%, $mv = 1 / (0.50 \times N \text{ value})$. This correlation gives values of coefficient of volume compressibility in the range of 0.05m²/MN to 0.14m²/MN as shown in Table 7. 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:

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

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 **medium 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, below.

Table 8: Soil Desiccation Indicators in the Clay

Location	Depth (m)	Liquid Limit (%)	40% Liquid Limit (%)	Natural Moisture Content (%)	Desiccation
CP1	3.00-3.45	37	15	16	No
CP1	6.00-6.45	38	15	14	Yes
CP1	7.50-7.95	37	15	17	No
CP1	10.5-10.95	39	16	11	Yes
CP1	13.5-13.95	37	15	14	Yes
CP2B	4.50-4.95	35	14	14	No
CP2B	12.00-12.45	36	14	11	Yes
CP2B	13.50-13.95	39	16	15	Yes
CP2B	15.45-15.95	41	16	18	No
WS2	2.50	37	15	11	Yes
WS4	2.00	38	15	13	Yes
WS4	3.50	40	16	22	No

The results in the above table show seven clay samples collected between 2.00m and 13.95m bgl show evidence of desiccation.

6.3.2 SAND

Sand was encountered in both cable percussive boreholes (CP1 and CP2B) beneath the clay, and sand & gravel at depths between 16.5m and 19.5m below ground level.

The **water-soluble sulphate** content of one sand sample was 180mg/l SO_4 , with a **pH value** of 6.9.

SPT tests carried out in the sand resulted in **SPT N values** of between 43 and 50, as shown on the SPT v Depth Plot, in Figure 9 (above). The results suggest the sand is dense to very dense.

Recommended N values and derived design values for the granular soils are summarised in Table 9, overleaf.

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)**
16.5	43	43	43	Dense	39
19.5	50	50	50	Dense to very dense	41
*Based on lower quartile N value					
**Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾					

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 correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾, this gives an **angle of shearing resistance** of $\phi=39$ at 16.5m bgl.

For assessing settlements average ground conditions will give a more realistic value of settlements, the average of N values should be used.

6.3.3 SAND & GRAVEL

Gravel was encountered beneath the sand material at depths between 18.0m and 21.45m below ground level.

SPT tests carried out in the gravel resulted in **SPT N values** of 50, as shown on the SPT v Depth Plot, in Figure 9 (above). The results suggest the gravel is dense to very dense.

Recommended N values and derived design values for the granular soils are summarised in Table 10, below.

Table 10: Summary of Design Parameters (Sand & Gravel)

Depth	SPT N Value Range	Average N Value	Design N Value*	Equivalent Soil Density	Angle of Internal Friction (degrees ^o)**
18.0	50	50	50	Dense to very dense	41
21.0	50	50	50	Dense to very dense	41
*Based on lower quartile N value					
**Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾					

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 correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾, this gives an **angle of shearing resistance** of $\phi=41$ at 18.0m bgl.

For assessing settlements average ground conditions will give a more realistic value of settlements, the Average of N values should be used.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the Client intends to construct a 7 to 8 storey residential apartment building that is proposed to include 41 apartments. The development will include a communal roof garden, and street tree planting. The site will be accessed via Lomax Street to the north of the site.

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 3.05m bgl (CP2B).

Underlying the Made Ground were superficial deposits of Devensian Till comprising firm to very stiff CLAY to a maximum depth of 16.40m bgl. Beneath which were granular deposits comprising medium dense to very dense SAND to a maximum depth of 21.0m bgl, and dense to very dense SAND & GRAVEL to a maximum depth of 21.45m bgl.

Groundwater was encountered in location WS2 at approximately 3.50m bgl during the field work. Subsequent monitoring in the standpipes encountered groundwater at depths between 3.15m-3.30m bgl in WS2. Groundwater was also encountered in WS4 at depths of between 1.95m and 3.90m bgl.

7.3 Foundation Considerations

Based on the ground conditions encountered, conventional shallow strip/pad foundations are not considered suitable for the proposed development. The main consideration is the significant thickness of Made Ground encountered across the site (up to 3.05m thickness in places).

Therefore, alternative methods such as pile foundations are considered more suitable for the development. Pile foundations are discussed below in section 7.3.1.

7.3.1 Piled Foundations

The proposed building may be founded on piles taken down to depth to a suitable founding stratum such as the stiff to very stiff Devensian Till Deposits (boulder clay).

A variety of pile types may be used, including bored and continuous flight auger (CFA) piles. Driven piles may be suitable, subject to environmental constraints. Friction piles would be the best choice and the pile length can be increased to bring settlement within limit.

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 clays.

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. Alternatively, these materials should be removed and replaced in a controlled manner by suitable existing materials or imported engineered fill.

Careful consideration should be given to piling directly above any services. Service plans show buried water, gas, and electricity services across large areas of the site and relict buried services are considered likely to remain in-situ.

A stage 2 detailed explosive ordnance risk assessment is also required prior to development works.

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 can provide the required working loads in the ground conditions encountered.

7.4 Pavement Design

The ground investigation identified the soil type at subgrade level to typically be 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.

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. Table 11 below 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 11: 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.								

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 Appendix 4) showed low concentrations 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.

Any cohesive Made Ground is unlikely to be suitable as structural fill and should be used for landscaping purposes only, providing it is 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 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 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 12: 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	-	-
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.7 - 8.3	A - B
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	8 - 22	A
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 0.2 - 0.7	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	13 - 24	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	24 - 377	A - C
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	27 - 589	A - B
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1 - 3.1	A - C
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	8 - 25	A - B
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	54 - 170	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%	135 - 314	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5 - 0.9	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	20 - 29	A
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	738 - 5304	A - C
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5 - 21	A - C
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 soil classification ranges from uncontaminated to contaminated. Therefore, there is a **MODERATE to 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 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 commercial 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 13, overleaf.

Table 13: Soil Results Comparison with C4SL/S4UL Values

Determinand	C4SL/S4UL Levels Residential (mg/kg)	WS1 0.60m MG	WS2 0.25m MG	WS3 0.30m MG	WS4 0.80m MG	CP1 0.40m MG	CP1 1.00m MG	CP2 0.80m MG	No of Exceedances
Metals									
Arsenic	40	9	16	11	8	13	22	11	0
Beryllium	1.7	< 0.5	< 0.5	< 0.5	0.8	0.5	0.9	< 0.5	0
Boron	11000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0
Cadmium	150	0.3	0.7	0.4	< 0.2	0.2	0.5	0.3	0
Chromium	910	15	17	18	24	22	19	13	0
Chromium VI	21	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Copper	7100	27	120	35	24	33	377	112	0
Lead	310	589	199	171	27	157	287	164	1
Mercury	56	1.5	< 1	1.3	< 1	3.1	1.2	< 1	0
Nickel	180	9	12	10	25	13	15	8	0
Selenium	430	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0
Vanadium	1200	20	21	21	27	23	29	23	0
Zinc	40000	143	166	90	54	78	170	86	0
Petroleum Hydrocarbons									
Benzene	0.38	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
Toluene	880	0.006	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005	0
Ethylbenzene	83	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
o-xylenes	88	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
m-xylenes	82	0.004	< 0.002	0.002	0.002	< 0.002	0.004	0.002	0
p-xylenes	79	0.004	< 0.002	0.002	0.002	< 0.002	0.004	0.002	0
Aliphatic EC >5-6	42	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	100	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aliphatic EC >8-10	27	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >10-12	130	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >12-16	1100	31	< 3	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >16-21	65000	647	6	6	< 3	< 3	< 3	5	0
Aliphatic EC >21-35	65000	1131	102	85	< 10	< 10	< 10	143	0
Aromatic EC >5-7	370	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	860	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aromatic EC >8-10	47	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >10-12	250	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >12-16	1800	4	< 2	3	< 2	< 2	10	7	0
Aromatic EC >16-21	1900	299	5	11	< 3	< 3	33	35	0
Aromatic EC >21-35	1900	930	113	132	< 10	< 10	62	263	0
Polycyclic Aromatic Hydrocarbons									
Naphthalene	2.3	0.21	0.14	0.34	< 0.1	0.39	0.32	0.22	0
Acenaphthylene	2900	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthene	3000	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.95	0.31	0
Fluorene	2800	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.52	0.2	0
Phenanthrene	1300	0.46	0.63	0.74	0.13	0.54	6.06	2.02	0
Anthracene	31000	< 0.1	0.13	0.15	< 0.1	< 0.1	1.11	0.45	0
Fluoranthene	1500	0.5	1.02	1.19	< 0.1	0.58	6.27	1.51	0
Pyrene	3700	0.56	1.05	1.17	< 0.1	0.59	6.43	1.57	0
Benzo(a)anthracene	11	0.45	0.52	0.68	< 0.1	0.28	2.69	0.87	0
Chrysene	30	0.36	0.43	0.54	< 0.1	0.27	3.09	1.01	0
Benzo(a)pyrene	5.3	0.39	0.47	0.67	< 0.1	0.3	2.77	2.02	0
Benzo(b)fluoranthene	3.9	0.45	0.6	0.78	< 0.1	0.39	3.09	1.62	0
Benzo(k)fluoranthene	110	0.14	0.23	0.3	< 0.1	0.17	1.29	0.69	0
Indeno(1,2,3-cd) pyrene	45	0.22	0.28	0.37	< 0.1	0.19	1.61	0.71	0
Dibenz (a, h) anthracene	0.31	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.25	0.12	0
Benzo(ghi)perylene	390	0.22	0.28	0.4	< 0.1	0.2	1.49	0.71	0
Phenols									
Phenol	750	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0

Based on the results shown in Table 13, one soil sample tested contained concentrations of contaminants in exceedance of the screening criteria relevant to a Residential End Use without plant uptake:

- Sample WS1 at 0.60m bgl has an elevated level of **Lead** (589mg/kg).

Asbestos was identified in two samples, the details of which are summarised in Table 14 below.

Table 14: Summary of Asbestos Encountered

Location	Depth	Sample Matrix	Asbestos Type	Concentration
WS2	0.25m	Bundles of fibres	Chrysotile	0.002
CP2	0.80m	Bundles of fibres	Chrysotile	0.003

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 15, below and presented in full in Appendix 6.

Table 15: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification
WS1	0.60	Hazardous
WS2	0.25	Non-Hazardous
WS3	0.30	Non-Hazardous
WS4	0.80	Non-Hazardous
CP1	0.40	Non-Hazardous
CP1	1.00	Non-Hazardous
CP2	0.80	Non-Hazardous

Table 15 above shows that one soil sample collected from WS1 at 0.60m bgl was classified as **Hazardous** in accordance with WM3.1 due to an elevated concentration of Total Petroleum Hydrocarbons (TPH – C6 to C40).

The remaining six soil samples collected from the window sample boreholes and cable percussive boreholes 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.

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. The asbestos concentrations observed in WS2 and CP2 ranged from 0.002%-0.003%, therefore the soils are still classified as Non-Hazardous.

9.0 GROUNDWATER CONTAMINATION RISK ASSESSMENT

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 118m to the south of the site and refers to the Ashton Canal. For the purposes of this report, it is considered the most appropriate EQS data for the canal are those established for freshwater.

Many of the EQS values lie just above the method detection limit for 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 groundwater sample was retrieved from borehole location WS2. Groundwater was also encountered in WS4; however, no sample could be retrieved following purging of the borehole. No groundwater was encountered in the remaining monitoring wells. The nearest active groundwater abstraction license is located 1.4km to the west of the site.

A direct comparison was made between the groundwater analyses results and the EQS and Drinking Water Standards, and the results are summarised in Table 16, overleaf.

In general, the laboratory analyses encountered no levels of contamination above the EQS and Drinking Water Standards.

Table 16 Groundwater and Surface Water Results Comparisons with EQS/Drinking Water Quality Values

Determinand	EQS Value (1)	Drinking Water Quality (DWQ) Value (2)	WS2 Groundwater	No. of Exceedances
Arsenic	50	10	< 5	0
Cadmium	0.9	5	< 0.4	0
Chromium	4.7	50	< 5	0
Copper	10	2000	< 5	0
Lead	1.2 - 14	10	< 5	0
Inorganic Mercury	0.07	1	< 0.05	0
Selenium	-	10	< 5	0
Nickel	4-34	20	< 5	0
Zinc	10.9	-	< 2	0
Total Cyanide	1 - 5	50	< 5	0
Phenol	7.7 - 46	-	< 10	0
Sulphate	400000	250000	284	0
pH	6 - 9	-	8.1	0
Naphthalene	2 - 130	-	0.03	0
Anthracene	0.1	-	< 0.01	0
Benzo(a)pyrene	0.27	0.01	< 0.01	0
Benzo(b)fluoranthene	0.017	-	< 0.01	0
Benzo(k)fluoranthene	0.017	-	< 0.01	0
Indeno(123cd) pyrene	-	0.10	< 0.01	0
Fluoranthene	0.0063 - 0.12	-	0.04	0
Benzene	10 - 50	1	< 1	0
Toluene	74 - 380	-	< 5	0
Ethylbenzene	-	300 (WHO)	< 5	0
Xylenes	30	-	< 10	0
Total Petroleum Hydrocarbons Aro C6-C8	-	10 (WHO)	< 10	0
Total Petroleum Hydrocarbons Aro C8-C10	-	700 (WHO)	< 10	0
Total Petroleum Hydrocarbons Aro C10-C12	-	300 (WHO)	< 10	0
Total Petroleum Hydrocarbons Aro C12-C16	-	90 (WHO)	< 10	0
Total Petroleum Hydrocarbons Aro C16-C21	-	90 (WHO)	< 10	0
Total Petroleum Hydrocarbons Aro C21-C35	-	90 (WHO)	< 10	0
Total Petroleum Hydrocarbons Ali C6-C8	-	15000 (WHO)	< 10	0
Total Petroleum Hydrocarbons Ali C8-C10	-	15000 (WHO)	< 10	0
Total Petroleum Hydrocarbons Ali C10-C12	-	300 (WHO)	< 10	0
Total Petroleum Hydrocarbons Ali C12-C16	-	300 (WHO)	< 10	0

*All values in µg/l unless otherwise stated, WHO=World Health Organization guide values.

10.0 GROUND GAS RISK ASSESSMENT

10.1 Radon Gas

The site is not located in a Radon Affected Area as defined by the Health Protection Agency as less than 1% of properties are above the Action Level of exposure. Therefore, no radon protection measures are necessary for new properties.

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 carried out between the 13th and 31st August 2021. The results recorded methane (CH₄) levels of between 0.0 and 0.1% (v/v) and carbon dioxide (CO₂) levels of 0.1% to 2.8% v/v. Oxygen concentrations of between 17.4% to 21.5% v/v were also recorded.

Gas flow rates ranged from -2.5l/hr to 0.7l/hr and a maximum flow rate of 0.3l/hr has been adopted for the below calculations. Atmospheric pressure was recorded to be 1000mb.

Full results of the monitoring visits are presented in Appendix 3.

Table 17 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 = 0.7l/hr, max concentration = 2.8%
- Methane: maximum flow rate = 0.7l/hr, max concentration = 0.1%.

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

- **Carbon dioxide:** $GSV = 0.7 \times 2.8 / 100 = \mathbf{0.0196 \text{ litres/hr}}$
- **Methane:** $GSV = 0.7 \times 0.1 / 100 = \mathbf{0.0007 \text{ litres/hr}}$

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 17, overleaf.

Table 17: 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 conditions)	500 (50mm water) – ASTM (2016)	$< 30\%$ methane $< 21\%$ carbon dioxide Not applicable where municipal solid waste landfills, mine workings or similar credible sources with credible pathways for migration are present. Not applicable where potential ground gas reservoirs are connected to buildings.	No limit on oxygen depletion because it is widespread in natural soils and fill materials due chemical and biological processes Consider whether pressurisation could realistically occur and over what timescales where potential ground gas reservoirs are connected to buildings.	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 moderate to 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, an exceedance in Lead was encountered in one soil sample (WS1 at 0.60m).

However, the contaminated soils are located beneath the proposed building footprint. Therefore, there will be a low risk, due to the removal of the pollutant linkage during development.

11.2 Asbestos

Asbestos was encountered as bundles of Chrysotile fibres in two soil samples. Further Asbestos Quantification testing detected a concentration of between 0.002% (WS2) and 0.003% (CP2).

Therefore, an Asbestos Management Plan will need to be prepared for the site.

11.3 Foundations

Conventional shallow strip/pad foundations are not considered suitable for the proposed development site due to the depth of Made Ground (encountered to depths of 3.05m bgl).

The proposed building may be founded on piles taken down to depth to a suitable founding stratum such as the stiff to very stiff Devensian Till Deposits (boulder clay).

11.4 Soil Disposal

Soils should be disposed of at a suitable site, registered to take the levels of contamination encountered. One soil sample collected from WS1 (0.60m) has been classified as Hazardous for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1.

The remaining soil samples have been classified as Non-Hazardous for the purpose of off-site disposal in accordance with Environment Agency guidance WM3.1. Further Waste Acceptance Criteria (WAC) testing may prove that this material is acceptable as inert waste.

11.5 Groundwater Contamination

Based on the results of the chemical testing, no contaminant exceedances were encountered in the groundwater sample retrieved from WS2. Therefore, the risk is considered very low.

11.6 Land Gas

The gas monitoring results recorded methane (CH₄) levels between 0.0% to 0.1% volume (v/v) and carbon dioxide (CO₂) levels ranging from 0.1% to 2.8% v/v. Oxygen concentrations of between 17.4% and 21.5% v/v were also recorded.

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

11.7 UXO Risk

The Preliminary Explosive Ordnance Risk Assessment concluded the planned piling works expose the project to a potential UXO encounter.

Therefore, a Stage 2 Detailed Explosive Ordnance Risk Assessment is recommended prior to development.

11.8 Risk to Buried (Water) Services

It is considered that, due to the absence of any significant petroleum hydrocarbon 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).

11.9 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.

11.10 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.

11.11 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.

11.12 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

PRELIMINARY EXPLOSIVE ORDNANCE RISK ASSESSMENT

APPENDIX 2

EXPLORATORY HOLE LOGS

APPENDIX 3

MONITORING RESULTS

APPENDIX 4

GEOTECHNICAL TESTING RESULTS

APPENDIX 5

CHEMICAL TESTING RESULTS

APPENDIX 6

SOIL WASTE ASSESSMENT

APPENDIX 7

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd based on 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 2021 and should be read considering 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.