



Earth Environmental
& Geotechnical

Remediation Strategy

Victoria Avenue East

Moston

May 2023

On behalf of



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Report A3469/23/RMS

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Figure 2	Site Location Plan
Figure 3	Exploratory Hole Location Plan (A3469/21/SI, April 2022)

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Table 1	Gas Protection Point Score Required (BS8485:2019)
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Historical Information

Historically, a road was located through the centre of the site in 1948. The site was then occupied by a sports field in 1932. Restaurants were constructed on site in 2001, followed by a car park to the north in 2001. Currently, the restaurants are derelict, and there is a small area of soft landscaping to the north-western corner of the site adjacent the car park.

Objective

The Remediation Strategy is intended to build on the site characterisation information and provide details on the remediation objectives necessary to protect potential receptors and render the site suitable for the proposed development.

In summary this document presents the technical detail behind the proposed remedial activities at the site and includes:

- Design of ground gas remedial measures

This report has been prepared for the purpose of satisfying the requirements of the Local Planning Authority. Earth Environmental & Geotechnical Ltd reserves the right to amend this Remediation Strategy in the light of further information which may become available or future changes in contaminated land guidance, prior to site activities.

Sources of Information

The following reports have previously been prepared for the site by Earth Environmental & Geotechnical Ltd and should be read in conjunction with this Remediation Strategy:

- Earth Environmental & Geotechnical Ltd, Phase I Desk Study Report (reference A3469/21, March 2020).
- Earth Environmental & Geotechnical Ltd, Phase II GeoEnvironmental Site Investigation (reference A3469/21/SI, April 2022).

2.0 SITE LOCATION AND DESCRIPTION

The site is located 1.6km north of the centre of Moston. The approximate National Grid Reference for the centre of the site is SD 88213 03383 (X: 388213, Y: 403383) with the closest postcode being M9 7GH.

The site is an irregular shaped parcel of land with maximum dimensions of approximately 127m northeast to southwest and 124m northwest to southeast. The area of the site is 0.68hectares with a flat and level topography.

Currently on site are 2no. restaurant style businesses in the southwestern section. There is an outdoor seating area associated with these businesses. The north eastern area is a large macadam car park. There is an oblong shaped area in the northern most part of the site covered with grass and trees.

A location plan is shown below as Figure 2.

Figure 2: Site Location Plan



3.0 PREVIOUS SITE INVESTIGATIONS

As mentioned in Section 1, two reports have been prepared for the site by EEG Ltd.

The recommendations in this Remediation Strategy are based primarily on the findings of the Phase II Geo-Environmental Site Investigation (A3469/21/SI, April 2022) which is summarised below.

3.1 Earth Environmental & Geotechnical Ltd, Phase II Geo-Environmental Site Investigation, A3469/21/SI, April 2022

Scope of Works

The site investigation was conducted on the 5th and 6th January 2022 and comprised:

- Two cable percussive boreholes (CP1 and CP2) to a maximum depth of 15.00m bgl;
- Ten window sample boreholes (WS01 – WS10 inclusive) to a maximum depth of 6.00m bgl;
- 50mm diameter standpipes were installed in all of the window sample boreholes at depths up to 6.00m below ground level.

Standard Penetration Tests (SPTs) were conducted in the window sampler boreholes, and soil samples were retrieved from the exploratory holes at regular intervals for geotechnical and chemical analysis. Soils were logged by an on-site engineer.

An exploratory hole location plan is presented as Figure 3, below.

Figure 3: Exploratory Hole Location Plan (A3469/21/SI, April 2022)



Ground Conditions

The recorded ground conditions are summarised as follows:

- **Made Ground** – to a maximum depth of 1.30m bgl;
 - A covering of TARMAC is present across the site
 - Clayey sandy gravelly TOPSOIL containing sandstone, mudstone, and red brick
 - SAND & GRAVEL containing limestone and concrete
 - Sandy clayey GRAVEL containing red brick, concrete, clinker, and ash
 - Sandy GRAVEL containing sandstone
 - Gravelly SAND containing concrete, sandstone, red brick, and clinker occasional cobbles of red brick
 - Silty gravelly SAND containing sandstone, red brick clinker and timber
 - Sandy gravelly CLAY containing concrete, red brick, sandstone rare wire and glass
- **Superficial Deposits** – to a maximum depth of 15.00m bgl;
 - Very soft to soft amorphous/fibrous/pseudo-fibrous PEAT
 - Sandy gravelly peaty CLAY containing mudstone
 - Soft to firm silty CLAY
 - Soft to stiff sandy CLAY
 - Stiff silty sandy CLAY
 - Soft to stiff sandy gravelly CLAY containing mudstone and sandstone with occasional sand bands
 - Firm to stiff gravelly CLAY containing occasional cobbles of mudstone
 - Soft to stiff sandy SILT
 - Loose to very dense silty SAND with occasional clay bands
 - Loose silty gravelly SAND containing mudstone
 - Medium dense gravelly SAND containing sandstone
 - Very dense SAND & GRAVEL containing sandstone and quartz

Soil Contamination Assessment

Thirteen soil samples were retrieved from the site for chemical analysis.

Samples were analysed for the following suite of contaminants: Asbestos, 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.

None of the soil samples tested were found to contain concentrations of contaminants in exceedance of assessment criteria values relevant to a commercial end use with plant uptake.

Asbestos was identified in one of the samples collected from the site – WS05 at 0.55m.

Soils were predominantly classified as Non-Hazardous for the purpose of off-site disposal. However, one of the samples was classified as exceeding hazardous and one of the samples was classified as stable non-reactive hazardous.

Water Contamination Assessment

Four water samples were retrieved from the site for chemical analysis.

Samples were analysed for the following suite of contaminants: 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).

Three of the soil samples tested were found to contain concentrations of contaminants in exceedance of assessment criteria values.

Ground Gas Assessment

Ground gas monitoring has been carried out on the site and has proved the presence of elevated gas levels on the site.

The Carbon Dioxide GSV was calculated to be 0.0189 litres/hour, with the Methane GSV calculated as 0.0042 litres/hour. These results suggested that the site can be given a Characteristic Situation 2, low risk.

Remedial Recommendations

Soil Contamination

Based on the results of the chemical testing, no exceedances of assessment criteria for contaminants were observed in any locations across the site.

It was concluded that no remedial action should be required at this site.

Asbestos was encountered in one location; however, this was identified to be a low concentration and an asbestos management plan was not considered a requirement for the site.

Water Contamination

Based on the results of the chemical testing, exceedances of assessment criteria for contaminants were observed in three of the samples taken across the site.

However, it was concluded that no remedial action should be required at the site due to only slight exceedances in contaminants and the proposed commercial end use.

It was also stated that due to an absence of nearby surface water features and groundwater abstractions, remediation is not required.

Ground Gas

The report concluded that the monitoring dataset indicated the site would fall in Characteristic Situation 2 (CS2) ('low' gas risk) due to elevated carbon dioxide and methane being recorded. It was concluded that ground gas protection measures were considered necessary at the site, in accordance with CIRIA C735.

The site investigation report is present ed in Appendix 1 and should be read in conjunction with this report.

4.0 LICENCES & APPROVALS

Various licences, permits and approvals are required at various stages before certain works can commence. Some activities can start before all such approvals are in place.

- (i) Approval of this Remediation Method Statement;
- (ii) All documentation in accordance with the CDM 2015 Regulations;
- (iii) Site Waste Management Plan;
- (iv) A signed declaration by qualified person of the Material Management Plan (MMP) in accordance with CL: AIRE Waste Code of Practice, Version 2, March 2011. This would allow for reuse of excavated soils after demonstration of suitability for use;
- (v) General condition survey of boundary features.

5.0 PROPOSED WORKS

Aims

The remediation aims are to resolve contamination issues to protect human and environmental receptors and render the site suitable for the proposed end use and satisfy the requirements of the Local Planning Authority and Insurance bodies (NHBC).

The remediation strategy for the site has been developed following review and assessment of the site investigation reports previously prepared for the site.

Ground Gas

Gas Protection Measures - Specification

The gas protection measures installed must comply with a Characteristic Situation 2 in accordance with BS8485:2019.

A scoring system is referred to within BS 8485:2019, whereby each protection measure has an individual score, as summarised in Table 1 below.

Table 1: Gas Protection Point Score Required (BS8485:2019)

Characteristic Situation	Minimum gas protection score (points)			
	High Sensitivity		Medium	Low
	Type A building (private housing)	Type B building (multiple occupancy private or commercial)	Type C building (single occupancy commercial)	Type D building (large industrial)
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4.0	3.0	2.5
4	6.5	5.5	4.5	3.5
5			5.5	4.5

The proposed development is for a commercial development, therefore would be classified as Type C building (medium risk). The combined score for such a development must equal or exceed a **gas protection score of 2.5 for Characteristic Situation 2**.

A Type C building is typically a commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).

The required 2.5 points must be achieved by installation of a suitable combination of measures. Reference should be made to BS8485:2019 for details, however, as a minimum the following would be expected:

Structural Barrier

- Cast in-situ ground bearing floor slab (**Score – 0.5**).

Visqueen Gas Barrier Membrane

- Minimum 0.40mm thick reinforced membrane meeting all the following criteria (**Score – 2**):
 - Sufficiently impervious to gases with a methane gas transmission rate $<40.0\text{ml/day/m}^2/\text{atm}$ (average) tested in accordance with BS ISO 15105-1, for sheet and joints;
 - Sufficiently durable to last for the anticipated life of the building and duration of gas emissions;
 - Sufficiently strong to withstand in-service stresses and installation process together with ongoing construction until covered.
 - All penetrations and joints sealed (welded not glued) to achieve complete integrity across entire building footprint.

After installation, the membrane should be capable of providing a complete barrier to gas entry.

Service entry locations and physical penetrations through the subfloor pose a potentially high risk to the continuity and integrity of any waterproofing and/or gas protection system. The reduction of service penetrations through a slab by relocation through the outer wall above ground level will reduce the detailing required if laying a membrane and therefore reduce the risk of failure.

The gas membrane should be installed correctly by a competent contractor. Appropriate specification, supervision and control will be needed during design and construction, including validation and verification of the construction accordance with CIRIA C735.

The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints.

For example, a minimum 0.40mm thickness (equivalent to 370g/m^2 for polyethylene) reinforced membrane (virgin polymer) will meet the performance criteria opposite.

If a membrane is installed that does not meet all the criteria opposite, then the “score” is zero.

An example of a suitable CS2 gas membrane is provided in Appendix 2.

Gas Protection Measures –Verification & Validation

During the installation process, clear evidence that the recommended ground gas protection measures have been suitably installed in line with the above specification and appropriate guidance (CIRIA C735) will be provided.

Verification will be carried out by an appropriate independent person and a Verification Report will be prepared, which will provide the following:

- Description of the visual inspection regime
- Description of the elements of the ground gas protection system
- Dates of inspection, inspection staff present, weather conditions and surrounding site activities
- Specifics relating to the level of training, competency, and accuracy of the installation team
- Photographic record of gas protection system installed, including any observed defects and/or repairs
- Details of any areas unable to be inspected and the reasons explained.

It should be noted that no installation of gas protection measures should be carried out at the site without prior approval of this Remediation Strategy by the Local Planning Authority and any deviation to works away from the agreed Remediation Strategy should be agreed in writing with the Local Planning Authority prior to installation.

6.0 SITE WORKS

Outlined below are some of the main task and activities associated with the remediation works.

Site Organisation

Site works will be supervised throughout by a suitably qualified Engineer, who will report to a Project Manager. Supervision may be part-time for certain activities but will be full-time during the removal of any contaminated soil/fill and any placement of fill to an engineering specification.

Welfare Facilities/Security

Initial mobilisation works will include the establishment of appropriate office and welfare facilities. Such facilities may include but are not restricted to; office accommodation, canteen facilities, washroom/drying room, toilets, wheel wash, car parking, stores, and security unit.

The site should be secured by fencing to prevent unauthorised access onto the site during the enabling works.

Health & Safety

All site personnel will undergo a site-specific health and safety induction prior to commencement of work on site.

The Engineer will be informed prior to any proposed entry of a confined space or deep excavation. Entry will be restricted to suitably qualified and equipped personnel.

Works will be carried out about current statutory requirements and guidance by the Health & Safety Executive "Protection of workers and the general public during the redevelopment of contaminated land." Protective clothing, footwear and gloves will be required with hand washing and boot-washing facilities made available. Smoking will be limited to designated areas.

Site Clearance

Any trees currently under a preservation order should be identified and agreed with relevant authorities prior to the commencement of the works. All trees subject to a Tree Preservation Order should be clearly identified and protected by chestnut paling with fluorescent tape.

The site should then be cleared of all residual debris, fly tipped materials, any vegetation, shrubs, bushes, and unprotected trees as instructed by the client.

Excavation of Subsurface Obstructions

During the site investigation, obstructions were not identified within the made ground, which could pose obstacles during excavations and construction.

Any material identified as potentially contaminated should be stockpiled on a non-permeable membrane, and tested for suitability for either re-use on site, or offsite disposal.

Should the material be removed from site, waste acceptance criteria testing should be undertaken, and the material disposed of in a suitably licensed facility. The development of a

Materials Management Plan (MMP) in line with the CL: AIRE Code of Practice may be required to remove or re-use soils.

Unexpected Contamination

If during site clearance works or other excavations, material with visual or olfactory evidence of previously unrecorded contamination is encountered, the principal contractor should contact Earth Environmental & Geotechnical.

These soils should be then sampled, and chemical analysis carried out. The environmental consultant shall decide upon the chemical suitability of the material, to either remain on site or if it is likely to present a risk to receptors.

If the soils present a risk, the materials should be removed from site or remediated as per the specification in Section 5.0.

Any excavated material identified as potentially contaminated should be stockpiled on a non-permeable membrane, and tested for suitability for either re-use on site, or disposed offsite.

If prolonged stockpiling is unavoidable, these soils should be covered with a non-permeable membrane at the end of each working day, to prevent the possibility of leachate migrating from the soils due to infiltration.

Should the material be removed from site, waste acceptance criteria testing should be undertaken, and the material disposed of in a suitably licensed facility. The development of a Materials Management Plan (MMP) in line with the CL:AIRE Code of Practice may be required to remove or re-use soils.

Backfill of Excavations

All excavations shall, prior to backfilling, be surveyed to ascertain their spatial extent and depth. Excavations (to remove relict structures, contamination etc) should be backfilled with suitable materials as agreed with the Engineer and subjected to nominal compaction.

However, where an excavation conflicts with the footprint of a proposed highway, compaction in general accordance with the Specification for Highway Works Table 6/1 will be required.

Control of Perched Groundwater

The regional groundwater table is unlikely to be encountered during remediation earthworks; however, discontinuous perched groundwater may be present within Made Ground. If encountered during the excavation works, this perched water will be recovered by pumping from open excavations. Dependant on volumes recovered, some form of temporary storage may also be required.

Provision should be made for pumping from sumps and appropriate excavation support for all excavations.

7.0 ENVIRONMENTAL MONITORING & CONTROLS

General

All works should be carried out in a manner that minimises impact on the environment and generates adequate and accurate records to demonstrate remediation works have been carried out to the required standard and in accordance with all applicable legislation. All such records should be collated on contract completion (or sooner as required) and included within the contract completion report. Appropriate progress reports should be provided in a format and at a frequency as agreed with the client and project manager including on-going monitoring/validation information.

Comprehensive records should be maintained throughout the project. These should be collated on contract completion into a completion and validation report, which should be submitted to the appropriate regulators for approval. It will be presented in an appropriate manner to allow interested third parties to fully understand the whole remediation process.

The records should include correspondence with the regulators & other third parties, environmental monitoring data, validation testing, comprehensive as-built drawings, photographs, collation of all site investigation reports, operational method statements & risk assessments, construction phase health & safety plan and confirmation of post remediation considerations especially in respect of interaction with initial construction (groundwork's).

Noise Control

Earthworks will only take place during normal working hours 8.00am – 6.00pm Monday to Friday and 8.00am to 13:00pm on Saturdays with no working on Sundays or Bank Holidays. The site manager shall assess noise and its impact upon neighbours through the working day and to ensure the following mitigation measures are being utilised:

All plant and machinery will be fitted with adequate silencers and will not be operated unless in good condition.

Noise levels will be as per normal for a project of this nature. Pneumatic breakers will be used but location and hours of use controlled whenever possible.

Should residents make any complaints regarding noise associated with the works, the site manager shall investigate. Such investigation may include the use of portable monitoring equipment to record noise levels at the location of the complainant. The nature of the complaint and findings of the investigation shall be discussed with the local EHO. If the complaint is upheld appropriate remedial action shall be taken. Such action may include the adjustment of working hours or the alteration of site practices and working methods.

Odour Control

Works may produce odours, but good site practice and associated mitigation measures should ensure fugitive odours are kept to an absolute minimum. Such controls may include:

- Additional covers will be applied to stockpiles if they are contributing to fugitive odours.
- Areas of excavation i.e., area of exposed contaminated soils, will be kept to a minimum and covered/re-instated as soon as is practicably possible.

- Odour suppressing equipment shall be utilised at appropriate locations at appropriate times.

If a complaint is made regarding odours from nearby residents, the site manager shall respond by attending the complainant's property to assess the nature and level of odour nuisance including monitoring where appropriate. Appropriate mitigation measures as described herein shall then be enforced including, if necessary, suspension of excavation works until the prevailing weather conditions become more favourable.

Dust Control

Earthworks may produce dust during prolonged periods of dry weather. The site manager shall assess dust and its impact upon neighbours through the working day and ensure the following mitigation measures are being utilised to control dust:

- The use and maintenance of good quality site roads;
- Enforcing speed limits of site plant and;
- Dust suppression via water applied by towed bowser, particularly in the vicinity of locations where trace asbestos fibres have been detected in soils.

8.0 VALIDATION REPORT

A Validation Report would be developed for installation of the ground gas protection measures.

The validation of the gas membrane will be by Earth Environmental & Geotechnical prior to the laying of the screed horizon. The installation will be validated in accordance with a Manchester City Council gas protection validation record template.

The ground gas element of validation report should include:

- 🌍 a description of any measures installed – this could be presented in textual form, as photographic records or by as-built construction drawings (any variations to the pre-construction design should be fully detailed and justification(s) presented);
- 🌍 details of who installed the measures;
- 🌍 details of who inspected or verified the installation/s and a description of how this took place, together with any constraints (i.e., areas that could not be inspected or tested) or other issues of uncertainty;
- 🌍 verification test results, outcome of inspections and compliance data should be provided, either within the main text or as an Annex to the report; and
- 🌍 any defects identified, together with corrective actions and subsequent verification checks. Where appropriate, the report content should also include:
- 🌍 copies of regulatory correspondence/sign off;
- 🌍 manufacturers' specifications, warranties and/or guarantees;
- 🌍 personnel details (such as relevant qualifications); and
- 🌍 maintenance requirements and/or limitations of the system.

The report should provide a concluding comment about the suitability (or otherwise) of installed gas measures and include the name of the author, company details and date of issue.

APPENDIX 1

EEG PHASE II GEOENVIRONMENTAL SITE INVESTIGATION REPORT, APRIL 2022



EARTH ENVIRONMENTAL
& GEOTECHNICAL

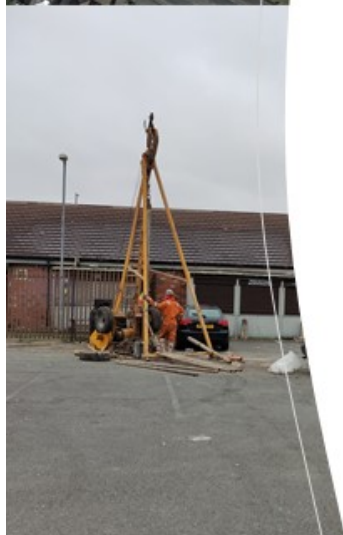
GeoEnvironmental Investigation

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Prepared on Behalf of:

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ALDI VICTORIA AVENUE EAST, MOSTON

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Definition of Version Code:

- D. Applied during initial drafting of the report before it has been reviewed.
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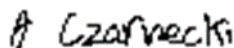
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1.0 EXECUTIVE SUMMARY

Appointment	A site investigation has been commissioned by SWF Consulting Ltd, on behalf of ALDI Stores UK (the 'Client') to examine ground conditions for the proposed commercial development at Victoria Avenue East, Moston.
The Investigation	The site investigation comprised 2no. cable percussive boreholes, 10no. window sample boreholes, in situ testing, laboratory geotechnical and contamination testing. Groundwater sampling and gas monitoring have not been completed at the time of writing this report.
The Site	The site is located approximately 1.6km to the north of the centre of Moston, Manchester, at approximate National Grid Reference SD 88213 03383. The site is underlain by superficial deposits of Devensian Till (boulder clay) and Peat. The solid geology is shown to be the Pennine Middle Coal Measures Formation, comprising mudstone, coal seams, siltstone and sandstone.
Site History	Historically, a road was located through the centre of the site in 1948. The site was then occupied by a sports field in 1932. Restaurants were constructed on site in 2001, followed by a car park to the north in 2001. Currently, the restaurants are derelict, and there is a small area of soft landscaping to the north-western corner of the site adjacent the car park.
Ground Conditions Encountered	The exploratory holes generally encountered Made Ground (to a maximum depth of 1.3m bgl), beneath the Made Ground was superficial deposits of Devensian Till comprising low to high strength CLAY (to a maximum depth of 10.0m bgl). Superficial deposits of Peat (to a maximum depth of 5.0m bgl) and loose to very dense SAND (to a maximum depth of 15.00m bgl) was also encountered at most locations. Small horizons of SILT were encountered in WS02 and WS03 (to a maximum depth of 4.60m bgl). SAND & GRAVEL was also encountered in CP01 and CP02 (to a maximum depth of 10.50m bgl). Groundwater was encountered during the field work between 1.50m and 6.20m bgl (WS04, WS07, WS08, CP01 and CP02).
Geotechnical Assessment	Foundation options for the proposed commercial development are anticipated to be pile foundations, bearing into the high strength boulder clay or very dense sand & gravel encountered beneath. Shallow foundations are not considered suitable for the site due to the peat deposits and low strength clay encountered. Pavement Design – preliminary design value = 1% Made Ground, 3-5% natural clay. Design Sulphate Class = DS-1 ACEC Site Classification = AC-1s
Ground Gases	Ground Gas protection measures are required on site. Radon protection measures are not required.
Contamination Assessment	Risk from contamination to groundworkers during development – Moderate to Low No soil chemical exceedance when compared to a commercial end use. Risk from soil contamination to commercial end users – Low Asbestos was encountered in 1no. soil sample – Bundles of Chrysotile fibres (0.001%) Soil Waste Assessment: 13no. samples tested – All Non-Hazardous. WAC testing - 3no. samples classified as Inert, 1no. sample Stable Non-Reactive Hazardous, and 1no. sample exceeds Hazardous. Marginal groundwater exceedances in 4no. samples when compared to EQS and DWQ values.
<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 SWF Consulting Ltd, on behalf of ALDI Stores UK (the 'Client') to examine ground conditions for the proposed commercial development at Victoria Avenue East, Moston.

2.2 Previous Investigations

2.2.1 Earth Environmental & Geotechnical Ltd *Phase I GeoEnvironmental Desk Study Report, Victoria Avenue, Moston reference: A3469/21, dated March 2020.*

The desk study highlighted that historically the site was undeveloped, apart from a road through the centre of the site dating to 1848. The site became part of a large sports field in 1932 and restaurants developed on the south of the site in 2001, followed by a car park to the north in 2003. The two restaurants are currently derelict and there is a small area of soft cover with trees on the north-western corner of the site adjacent the car park.

Potential on-site sources of contamination include Made Ground from various phases of development, infilled features along the boundary and land associated with the M60 motorway. Asbestos containing materials (ACM) may be present in existing structures. Finally, ground gas associated with deposits of peat, a nearby historical landfill, deep Made Ground and nearby infilled features.

The overall risk from soil contamination to commercial end users and construction workers was concluded to be **LOW**.

The risk to controlled waters was concluded to be **LOW** based on the underlying cohesive geology and absence of a nearby abstraction.

Given the anticipated extent and age of the made ground the risk from ground gas to end users was considered to be **MODERATE to LOW**.

An intrusive site investigation was recommended to examine the ground conditions for the design of foundations, floor slabs, and pavement construction for the proposed development. As part of the geotechnical investigation, it was recommended that soil samples are recovered for contamination testing.

2.3 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) have been commissioned by the Client, to undertake a Site Investigation of the site in accordance with proposal A3469/21 dated 15th December 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.*
- *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 located 1.6km north of the centre of Moston. The approximate National Grid Reference for the centre of the site is SD 88213 03383 (X: 388213, Y: 403383) with the closest postcode being M9 7GH.

The site is an irregular shaped parcel of land with maximum dimensions of approximately 127m northeast to southwest and 124m northwest to southeast. The area of the site is 0.68hectares with a flat and level topography.

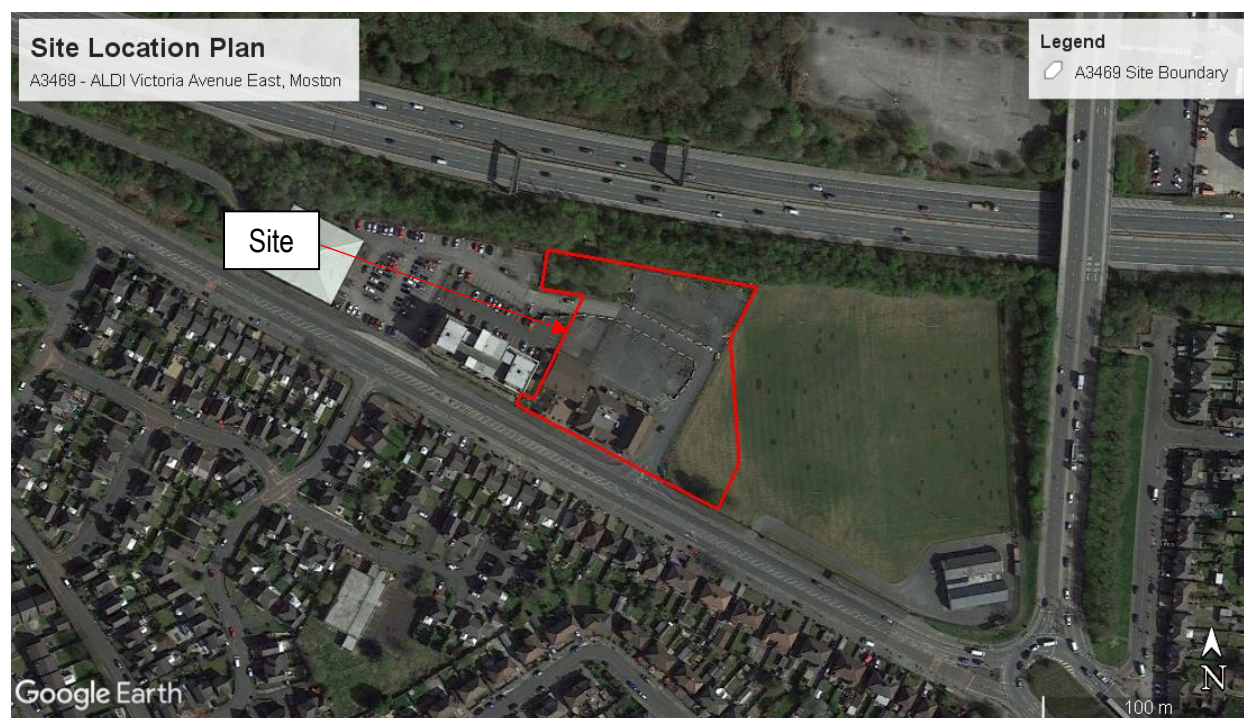
Currently on site are 2no. restaurant style businesses in the southwestern section. There is an outdoor seating area associated with these businesses. The north eastern area is a large macadam car park. There is an oblong shaped area in the northern most part of the site covered with grass and trees.

The boundaries to the north and east are made of metal fencing. The southern boundary is made up by the building. The western most boundary is partially open and partially made up of a restaurant building on site.

Immediately north of the site is a wooded area containing an unspecified concrete block housing manhole covers and vents. Beyond that is the M60. To the east is a sports field. South of the site is Victoria Avenue East. Directly west of the site is an apartment block, just north of which are the associated macadam parking facilities. Past that to the west is a gym with parking.

The site location is shown in Figure 1, below.

Figure 1: Site Location Plan



Site photographs are presented in Figures 2 to 5, overleaf.

Figure 2 View Facing Southeast Showing the Former Pub Garden



Figure 3 View Facing South Showing the Cable Percussive Borehole Rig Setup



Figure 4 Topsoil and Peat Deposits Encountered in WS09



Figure 5 Peat Deposits and Devensian Till Deposits Encountered in WS08

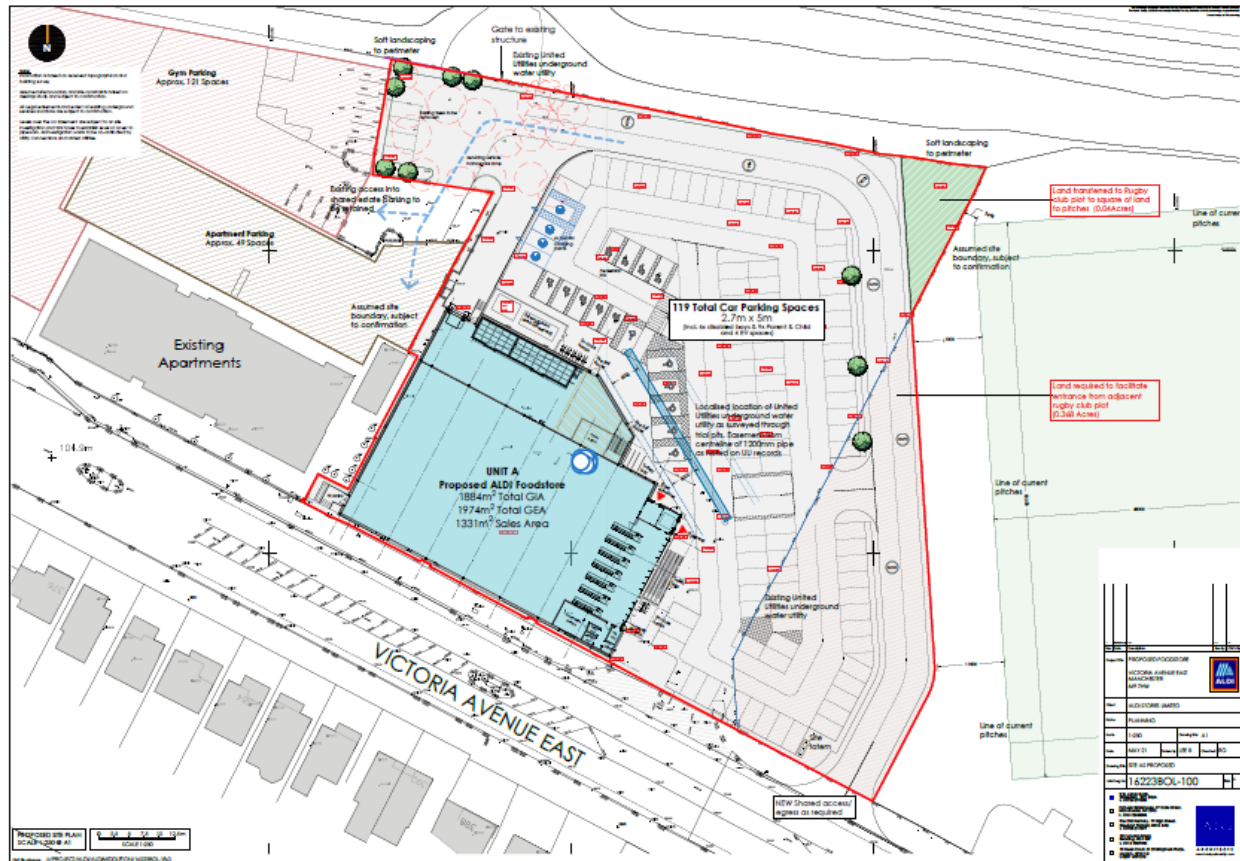


3.1 Proposed Development

It is understood that the Client intends to erect a retail store with associated vehicle parking facilities. The store will cover a total area of 1974m² and there will be 119 parking spaces. Access will be provided via Victoria Avenue East. Land to the northeast corner will be transferred to the adjacent rugby club.

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 Wednesday 5th and Thursday 6th January 2022. The fieldwork comprised:

- Two cable percussive boreholes (designated CP1 and CP2) were drilled to a maximum depth of 15.00m below existing ground level. 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 1.
- Ten window sample boreholes (designated WS01 to WS10 inclusive) were each sunk to a maximum depth of 6.0m below existing ground level). Window sampler boring is carried out with a small, track-mounted rig, which uses a chain-driven trip hammer to drive sampling tubes or penetrometers into the ground. These tools are coupled to the anvil of the hammer by solid drill rods. Sampling tubes comprise “windowless samplers”, which are plain sampler tubes in which a continuous disturbed sample is recovered within a semi-rigid plastic liner. 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 1.
- 50mm diameter standpipes were installed in all ten window sample boreholes (WS01 to WS10) up to a depth of 6.00m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. EEG carried out groundwater/ground gas monitoring in standpipes after the fieldwork period, the results are included in Appendix 2. Prior to groundwater sampling all boreholes will be purged (three well volumes) by use of a water bailer.

Exploratory hole locations were chosen based on the proposed development and located on-site by an EEG engineer avoiding known services and an exclusion zone within proximity of underground aqueduct.

Table 1 overleaf indicates appropriate features targeted.

Table 1: Sampling Location Justification

Exploratory Hole	Sampling Location
WS01	Proposed ALDI building footprint
WS02	Proposed ALDI building footprint
WS03	Existing soft landscaped area and proposed car park
WS04	Proposed loading bay route
WS05	Proposed car parking area
WS06	Internal road in proposed car park
WS07	Internal road in proposed car park
WS08	Main access road into car park
WS09	Main access road into car park
WS10	Existing car park to be transferred to rugby club
CP01	Proposed ALDI building footprint
CP02	Proposed ALDI 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 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	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, below and overleaf.

Table 3: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS01	WS	6.00	05/01/2022	05/01/2022	388167	403360	SP
WS02	WS	6.00	05/01/2022	05/01/2022	388196	403378	SP
WS03	WS	6.00	05/01/2022	05/01/2022	388176	403422	SP
WS04	WS	6.00	05/01/2022	05/01/2022	388188	403403	SP
WS05	WS	6.00	05/01/2022	05/01/2022	388209	403419	SP
WS06	WS	6.00	05/01/2022	05/01/2022	388238	403396	SP
WS07	WS	6.00	05/01/2022	05/01/2022	388235	403330	SP

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS08	WS	6.00	05/01/2022	05/01/2022	388253	403349	SP
WS09	WS	6.00	05/01/2022	05/01/2022	388254	403373	SP
WS10	WS	6.00	05/01/2022	05/01/2022	388260	403413	SP
CP01	CP	15.00	05/01/2022	05/01/2022	388181	403390	A
CP02	CP	13.50	06/01/2022	06/01/2022	388207	403372	A

* WS=Window Sample Borehole, CP=Cable Percussive 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	8
Liquid Limit, Plastic Limit, Plasticity Index	BS1377:1990 Part 2, Clause 4/5	8
Sulphate content of 2:1 soil: water extract	BS1377:1990 Part 3, Clause 5	8
pH value	BS1377:1990 Part 3, Clause 9	8
Triaxial tests	BS1377:1990 Part 7, Clause 9	
“Quick” undrained with multistage loading		3
“Quick” undrained with single stage loading		2

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

4.2.2 Environmental Testing

The environmental chemistry of the ground was investigated by specialist chemical analysis of selected samples, scheduled by EEG, and carried out by DETS Ltd a UKAS and MCERTS accredited laboratory.

Chemical analyses were carried out on thirteen 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.

In addition, four of the soil samples were also submitted for Waste Acceptance Criteria testing (WAC).

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

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

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

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is not underlain by artificial deposits, however made ground is found 3m to the north of the site. The site is underlain by superficial deposits of Devensian Till (boulder clay) and Peat. The solid geology beneath the site is shown to be the Pennine Middle Coal Measures Formation, comprising mudstone, coal seams, siltstone and 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 1.30m bgl, comprising:
 - A covering of TARMAC is present across the site
 - Clayey sandy gravelly TOPSOIL containing sandstone, mudstone and red brick
 - SAND & GRAVEL containing limestone and concrete
 - Sandy clayey GRAVEL containing red brick, concrete, clinker and ash
 - Sandy GRAVEL containing sandstone
 - Gravelly SAND containing concrete, sandstone, red brick and clinker occasional cobbles of red brick
 - Silty gravelly SAND containing sandstone, red brick clinker and timber
 - Sandy gravelly CLAY containing concrete, red brick, sandstone rare wire and glass
- **Superficial Deposits** - were encountered in all the exploratory holes, to the base of the boreholes at a maximum depth of 15.0m bgl, comprising:
 - Very soft to soft amorphous/fibrous/pseudo-fibrous PEAT
 - Sandy gravelly peaty CLAY containing mudstone
 - Soft to firm silty CLAY
 - Soft to stiff sandy CLAY
 - Stiff silty sandy CLAY
 - Soft to stiff sandy gravelly CLAY containing mudstone and sandstone with occasional sand bands
 - Firm to stiff gravelly CLAY containing occasional cobbles of mudstone
 - Soft to stiff sandy SILT
 - Loose to very dense silty SAND with occasional clay bands
 - Loose silty gravelly SAND containing mudstone
 - Medium dense gravelly SAND containing sandstone
 - Very dense SAND & GRAVEL containing sandstone and quartz

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

Table 5: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m)									Ground water (m bgl)
	MADE GROUND				SUPERFICIAL DEPOSITS					
	TOPSOIL	TARMAC	GRANULAR	COHESIVE	CLAY	SILT	PEAT	SAND	SAND & GRAVEL	
WS01	-	GL-0.08	0.08-0.70	0.70-1.00	1.00-1.45 2.60-6.00	-	1.45-2.15	2.15-2.60	-	-
WS02	-	GL-0.20	0.20-0.80	-	2.80-6.00	1.70-2.80	0.80-1.70	-	-	-
WS03	GL-0.20	-	0.20-1.10	-	1.10-2.40 2.65-3.00 3.80-4.00 4.60-6.00	3.00-3.60 4.50-4.60	-	2.40-2.65 3.60-3.80 4.00-4.50	-	-
WS04	-	GL-0.20	0.20-0.80	-	0.80-1.30 1.50-1.75 2.65-3.00 3.35-4.00 4.90-5.00 5.70-6.00	-	-	1.30-1.50 1.75-2.65 3.00-3.35 4.80-4.90 5.60-5.70	-	3.00
WS05	GL-0.25		0.25-1.30	-	1.30-6.00	-	-	-	-	-
WS06	-	GL-0.15	0.15-0.60	0.60-1.15	1.40-4.50 5.70-6.00	-	1.15-1.40	4.50-5.70	-	-
WS07	GL-0.40	-	0.40-0.80	-	0.80-1.50 3.85-4.00 5.50-6.00	-	1.50-3.85 4.90-5.00	-	-	1.50
WS08	GL-0.15	-	0.15-0.55	-	0.55-0.90 3.40-6.00	-	0.90-3.40	-	-	4.00
WS09	GL-0.20	-		-	2.00-6.00	-	0.20-2.00	-	-	-
WS10	-	GL-0.10	0.10-0.90	0.90-1.10	1.10-4.15 4.40-5.00 5.80-6.00	-	-	4.15-4.40 5.00-5.80	-	-
CP01	-	GL-0.20	0.20-0.60	0.60-1.20	1.20-1.60 1.70-9.00	-	-	1.60-1.70 10.20-15.00	9.00-10.20	1.50 6.20
CP02	-	GL-0.30	0.30-1.30		2.00-10.00	-	1.30-2.00	10.50-13.50*	10.00-10.50	5.80
*Refusal										

5.2 Observable Indications of Contamination

During the ground investigation, variable Made Ground containing gravel of concrete, red brick and clinker were observed in the exploratory holes. Ash was also encountered within the Made Ground at location WS08. Rare glass and wire were encountered within the Made Ground at locations WS06 and WS10.

No olfactory signs of contamination were observed.

5.3 Obstructions

No man-made obstructions were encountered in the exploratory hole locations. However, cobbles of red brick were encountered in the hand pits at locations WS01, WS04, CP01 and CP02.

5.4 Groundwater

Groundwater was encountered in exploratory hole locations WS04, WS07, WS08, CP01 and CP02 at depths between 1.50m and 6.20m bgl.

Subsequent monitoring in the standpipes encountered groundwater at depths between 0.40m bgl (WS9) and 5.10m bgl (WS6).

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 8th February 2022 indicated Methane (CH₄) levels ranging from 0.0% to 4.2% by volume, Carbon Dioxide (CO₂) levels ranging from 0.3% to 18.9% by volume, and Oxygen (O₂) levels ranging from 4.5% to 21.7% by volume. A peak gas flow of 1.9l/hr was recorded, together with atmospheric pressure of 999mb.

Results obtained during subsequent monitoring visits between the 17th and 30th March 2022 indicated Methane levels ranging from 0.0% to 0.1% by volume, Carbon Dioxide levels ranging from 0.0% to 7.0% by volume, and Oxygen levels ranging from 10.0% to 21.9% by volume. A peak gas flow of 0.0l/hr was recorded, together with atmospheric pressure of 1008mb.

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 (%)		pH Value	Water Soluble Sulphate SO ₄ (mg/l)
WS01	2.70	CLAY	23	35	14	21	21	-	6.9	180
WS01	3.60-4.00	CLAY	14	-	-	-	-	54	-	-
WS01	4.80	CLAY	17	38	14	24	24	-	7.0	150
WS01	5.60-6.00	CLAY	18	-	-	-	-	204	-	-
WS02	2.80	CLAY	24	36	13	23	23	-	7.0	170
WS02	3.70	CLAY	21	37	16	21	20	-	7.0	130
CP101	1.50-1.95	CLAY	20	36	17	19	19	-	7.0	111
CP101	3.00-3.45	CLAY	15	37	13	24	24	-	7.1	140
CP101	4.50-4.95	CLAY	19	-	-	-	-	71-76	-	-
CP102	4.50-4.95	CLAY	11	35	13	22	22	-	6.9	100
CP102	6.00-6.45	CLAY	18	-	-	-	-	81-89	-	-
CP102	7.50-7.95	CLAY	15	36	13	23	23	-	6.9	90
CP102	9.00-9.45	CLAY	15	-	-	-	-	106-117	-	-

6.2 Made Ground

Made Ground was encountered in all exploratory hole locations between ground level and a maximum depth of 1.30m below ground level (WS05 and CP02) and varied between exploratory hole locations.

SPT tests carried out in the Made Ground resulted in **SPT N values** of between 3 and 10, as shown on the SPT v Depth Plot, in Figure 8 (overleaf).

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 Peat Deposits and Devensian Till Deposits (Boulder Clay).

6.3.1 PEAT

Peat was encountered in WS01, WS02, WS06-WS09 and CP02 beneath the Made Ground or clay at depths between 0.20m and 5.00m below ground level.

SPT tests carried out in the peat resulted in **SPT N values** of between 3 and 8, as shown on the SPT v Depth Plot, in Figure 8 (overleaf).

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

6.3.2 CLAY

Clay was encountered in all exploratory hole locations beneath the Made Ground at depths between 0.55m and 10.00m below ground level.

The **water-soluble sulphate** content of eight clay samples ranged from 90mg/l to 180mg/l SO₄, with a **pH value** of between 6.9 and 7.1.

SPT tests carried out in the clay resulted in **SPT N values** of between 3 and 28, as shown on the SPT v Depth Plot, in Figure 8 (overleaf). The results suggest the clay is very soft to stiff.

The **undrained shear strength** in triaxial compression (U100) was carried out on five samples of the clay. Results of the test showed shear strength values in the range 54kN/m² to 117kN/m² at depths of between 3.6m and 9.45m, suggesting the clay tested is medium to high strength.

In-situ **hand penetrometer** (HP) tests were carried out on the recovered soils, the results of which generally ranged between 12kPa (kN/m²) to 215kPa, suggesting the clay tested is very low to very high strength.

For design purposes, the more conservative SPT N values were used, as the gravel content of the clay can affect the hand penetrometer readings. 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*	Measured Undrained Triaxial Shear Strength (kN/m ²)	Equivalent Shear Strength** (kN/m ²)	Coefficient of Volume Compressibility** (mv)
1.2	5-9	7	7	-	36 (Low Strength)	0.28
2.0	3-17	10	9	-	46 (Medium Strength)	0.22
3.0-4.0	9-28	15	9	54	46 (Medium Strength)	0.22
4.0-4.95	14-24	19	17	71-76	87 (High Strength)	0.12
5.0-6.0	15-25	21	19	204	38 (Low Strength)	0.10
6.0-6.45	13-24	20	18	81-89	89 (High Strength)	0.11
7.5	17-18	18	17	-	88 (High Strength)	0.12

*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 (Clay)

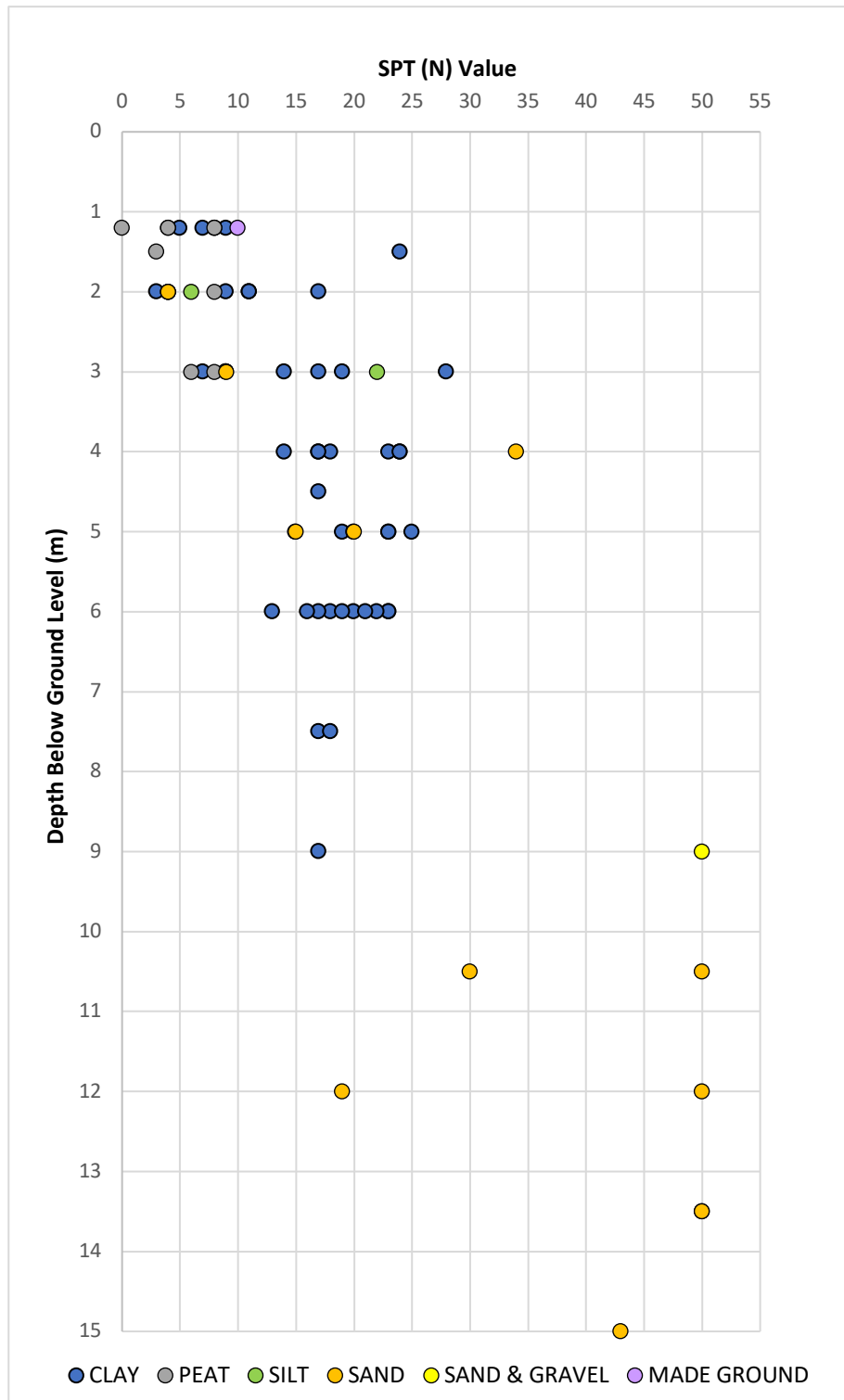
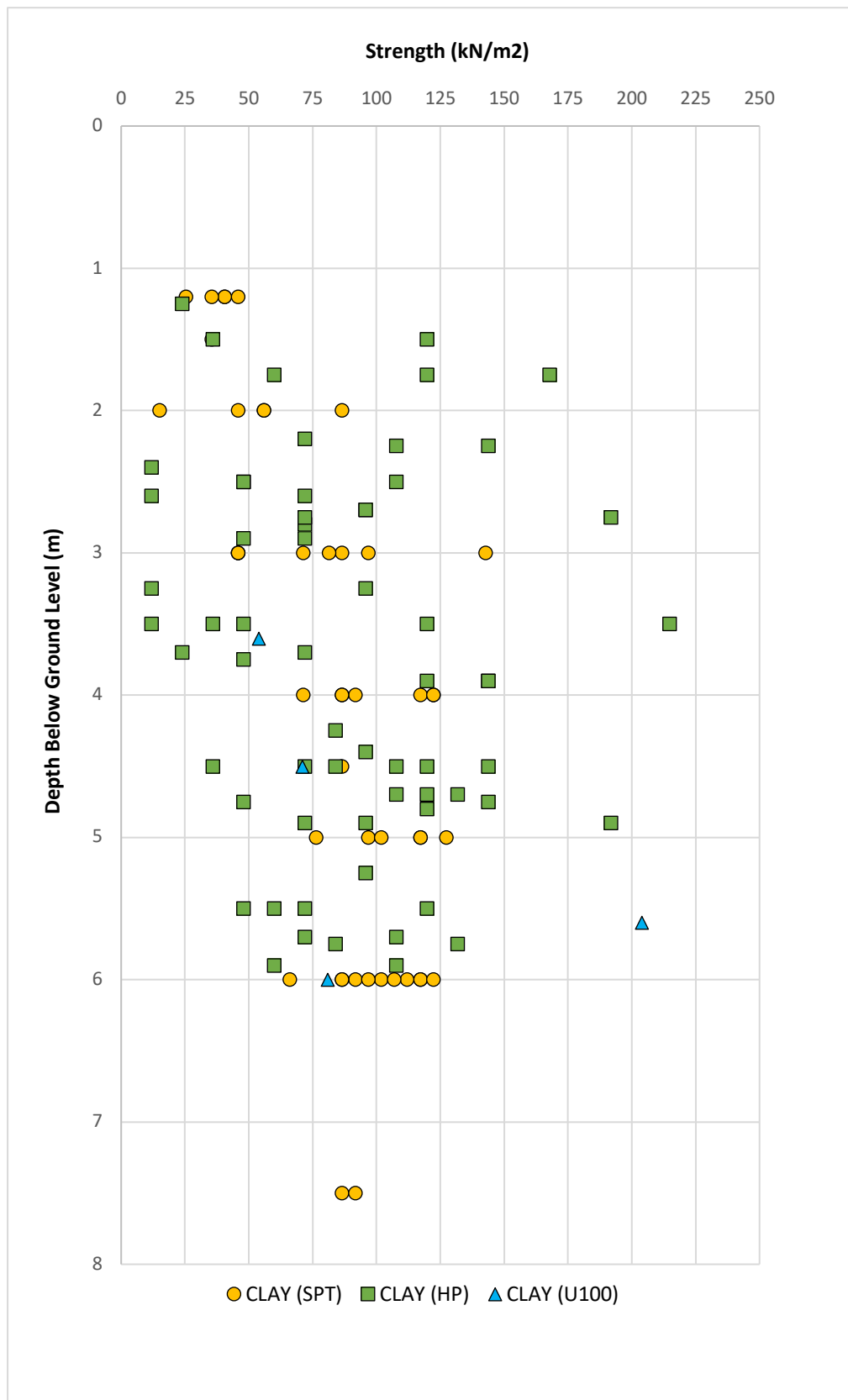


Figure 9 overleaf shows the derived undrained shear strength of the Clay based on laboratory testing and in-situ hand penetrometer tests, alongside equivalent shear strength from SPT N values based on correlations by Stroud and Butler ⁽¹⁹⁷⁵⁾.

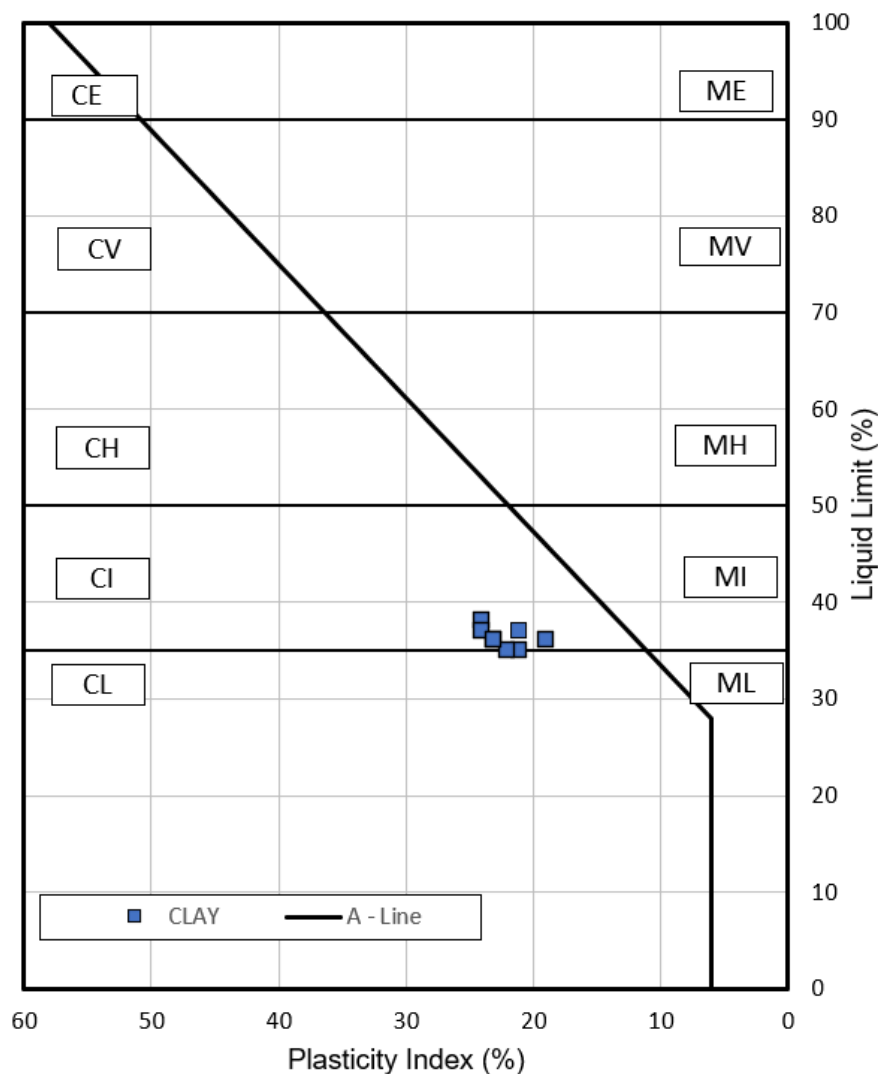
Figure 9 Strength v Depth Plot (Clay)



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 Table 7, the equivalent **shear strength** values are in the range of 36kN/m² to 89kN/m² suggesting the clay is low to high strength.

Atterberg Limit tests were carried out on eight samples of the clay. Results of the test reported **liquid limit** values in the range of 35% to 38% and **plastic limit** values in the range of 13% to 17%, resulting in values of **plasticity index** in the range of 19% to 24%. These results suggest the clay to be **low to 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 = 23% is recommended, based on the upper quartile value of the results.

The **coefficient of volume compressibility (mv)** has been estimated using the following correlation by Stroud and Butler ⁽¹⁹⁷⁵⁾: for a clay with a plasticity index of 23%, $mv = 1 / (0.51 \times N \text{ value})$. This correlation gives values of coefficient of volume compressibility in the range of

0.10m²/MN to 0.22m²/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 **low to 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
WS01	2.70	35	14	23	No
WS01	4.80	38	15	17	No
WS02	2.80	36	14	24	No
WS02	3.70	37	15	21	No
CP101	1.50-1.95	36	14	20	No
CP101	3.00-3.45	37	15	15	No
CP102	4.50-4.95	35	14	11	Yes
CP102	7.50-7.95	36	14	15	No

The results in the above table show one clay sample collected between 4.50-4.95m bgl showed evidence of desiccation.

6.3.3 SILT

Silt was encountered in exploratory hole locations WS02 and WS03 beneath the peat, clay and sand at depths between 1.70m and 4.60m below ground level.

SPT tests carried out in the silt resulted in **SPT N values** of between 6 and 22, as shown on the SPT v Depth Plot, in Figure 8 (above). The results suggest the silt is soft to stiff.

6.3.4 SAND

Sand was encountered in exploratory hole locations WS01, WS03, WS04, WS06, WS10, CP01 and CP02, below the clay and peat at depths between 1.30 and 15.00m below ground level.

SPT tests carried out in the sand resulted in **SPT N values** of between 4 and 50, as shown on the SPT v Depth Plot, in Figure 8 (above). The results suggest the sand is very loose to very dense.

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

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 $\phi=27.9$ at 2.0m bgl.

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°)**
2.0	4	4	4	Very loose to loose	27.9
3.0	9	9	9	Loose	29.6
4.0	34	34	34	Dense	37.1
5.0	15	15	15	Medium dense	31.6
10.5	30-50	40	35	Dense	37.4
12.0	19-50	35	27	Medium dense	35.2
13.5	50	50	50	Very dense	35.2
15.0	43	43	43	Dense	39.4
*Based on lower quartile N value					
**Based on the correlation by Peck, Hanson and Thornburn ⁽¹⁹⁷⁴⁾					

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

6.3.5 SAND & GRAVEL

Sand & gravel was encountered in exploratory hole locations CP01 and CP02, directly below the clay at depths between 9.00 and 10.50m below ground level.

SPT tests carried out in the sand & gravel resulted in a **SPT N value** of 50, as shown on the SPT v Depth Plot, in Figure 8 (above). The results suggest the sand & gravel is very dense.

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 9.0m bgl.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Proposed Development

It is understood that the Client intends to erect a food store with associated vehicle parking facilities. The store will cover a total area of 1974m² and there will be 119 parking spaces. Access will be provided via Victoria Avenue East.

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 1.30m bgl (WS05 and CP02).

Underlying the Made Ground in all exploratory hole locations was superficial deposits of Devensian Till comprising low to high strength CLAY at depths between 0.55m and 10.0m bgl.

Deposits of PEAT were encountered in most exploratory hole locations at depths between 0.20m and 5.00m bgl. Loose to very dense SAND was also encountered between 1.30m bgl and 15.00m bgl.

Small horizons of SILT were encountered in WS02 and WS03 at depths between 1.70m and 4.60m bgl. SAND & GRAVEL was also encountered in CP01 and CP02 at depths between 9.00m and 10.50m bgl.

Groundwater was encountered in exploratory hole locations WS04, WS07, WS08, CP01 and CP02 at depths between 1.50m and 6.20m bgl. Subsequent monitoring in the standpipes encountered groundwater at depths between 0.40m bgl (WS9) and 5.10m bgl (WS6).

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 Peat encountered across the site (up to 2.50m thickness in places). Low strength cohesive soils were also encountered at shallow foundation depths.

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 high strength clay or very dense sand & gravel encountered beneath.

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 so as 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 areas of the site. An aqueduct is present beneath the site in close proximity to the proposed building footprint.

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

7.4 Pavement Design

The ground investigation identified the soil type at subgrade level to typically be Made Ground or peat 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.

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 10 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 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 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 3) 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 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	5.7-6.6	A-B
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	7.1-10.2	A-D
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	< 2-46	A-B
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	< 2-54	A
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	< 4-136	A-B
Lead	0 - 500	500 - 1000	1000 - 2000	2000 - 1%	1.0%	< 5-558	A-B
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	<1-1.3	A-B
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	< 3-59	A-C
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	20-144	A
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1-1.6	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%	73-389	A
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5-4.8	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	1-90	A
Sulphate	0 - 2000	2000 - 5000	5000 - 1%	1% - 5%	5.05%	<200-6114	A-C
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5-7	A
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 2-17	A-C
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results the soils concentrations range from uncontaminated to heavy contamination values. 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 commercial land use 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 LEEG 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.

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

Table 12: Soil Results Comparison with C4SL/S4UL Values

Determinand	C4SL/S4UL Levels Commercial (mg/kg)	WS01 0.35m MG	WS01 0.50m MG	WS02 0.30m MG	WS02 1.20m MG	WS03 0.70m MG	WS04 0.60m MG	WS05 0.55m MG	WS06 1.10m MG	WS07 0.45m MG	WS07 2.20 MG	WS08 0.40m MG	WS09 1.30m PEAT	WS10 0.80m MG	No of Exceedances
Metals															
Arsenic	640	< 2	6	< 2	< 2	13	13	11	15	46	4	27	11	< 2	0
Beryllium	12	< 0.5	< 0.5	< 0.5	< 0.5	0.7	0.6	0.6	0.8	4.8	1.2	1.4	0.8	< 0.5	0
Boron	240000	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.5	< 1	1.6	< 1	0
Cadmium	410	0.7	0.4	0.4	< 0.2	0.3	0.7	0.3	< 0.2	< 0.2	< 0.2	0.4	< 0.2	< 0.2	0
Chromium	8600	< 2	11	6	12	20	46	15	21	24	54	18	42	9	0
Chromium VI	49	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Copper	68000	< 4	25	5	58	35	41	36	33	136	42	79	48	5	0
Lead	2300	5	94	8	12	64	104	135	558	116	18	70	31	16	0
Mercury	1100	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.3	< 1	< 1	< 1	< 1	< 1	0
Nickel	980	< 3	7	6	13	19	38	13	13	59	37	25	32	10	0
Selenium	12000	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0
Vanadium	9000	1	17	14	12	28	21	28	30	90	18	60	29	10	0
Zinc	730000	71	144	20	31	93	105	162	64	91	32	89	41	30	0
Petroleum Hydrocarbons															
Benzene	27	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
Toluene	56000	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0
Ethylbenzene	5700	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
o-xylenes	6600	< 0.002	0.006	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
m-xylenes	62000	< 0.002	0.008	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
p-xylenes	5900	< 0.002	0.008	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0
Aliphatic EC >5-6	3200	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aliphatic EC >6-8	7800	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aliphatic EC >8-10	2000	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >10-12	9700	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aliphatic EC >12-16	59000	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >16-21	1600000	< 3	< 3	< 3	< 3	3	4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0
Aliphatic EC >21-35	1600000	< 10	< 10	274	< 10	16	94	< 10	< 10	< 10	< 10	< 10	< 10	15	0
Aromatic EC >5-7	26000	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Aromatic EC >7-8	56000	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0
Aromatic EC >8-10	3500	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >10-12	16000	< 2	3	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >12-16	26000	< 2	9	< 2	< 2	< 2	7	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
Aromatic EC >16-21	28000	< 3	23	< 3	< 3	7	38	10	< 3	< 3	< 3	4	< 3	< 3	0
Aromatic EC >21-35	28000	< 10	26	427	< 10	22	212	19	< 10	< 10	< 10	< 10	< 10	< 10	0

<i>Polycyclic Aromatic Hydrocarbons</i>															
Naphthalene	190	< 0.1	1.66	< 0.1	< 0.1	< 0.1	0.41	0.28	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthylene	83000	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Acenaphthene	84000	< 0.1	0.61	< 0.1	< 0.1	< 0.1	0.68	0.22	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Fluorene	63000	< 0.1	1.07	< 0.1	< 0.1	< 0.1	0.5	0.14	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Phenanthrene	22000	< 0.1	4.69	0.11	< 0.1	0.8	4.63	1.57	< 0.1	0.19	< 0.1	0.41	< 0.1	< 0.1	0
Anthracene	520000	< 0.1	1.17	< 0.1	< 0.1	0.17	0.97	0.31	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Fluoranthene	23000	< 0.1	4.12	< 0.1	0.2	1.21	5.52	1.83	0.13	0.58	< 0.1	0.67	< 0.1	< 0.1	0
Pyrene	54000	< 0.1	4.31	< 0.1	< 0.1	1.14	4.9	1.52	0.14	0.54	< 0.1	0.63	< 0.1	< 0.1	0
Benzo(a)anthracene	170	< 0.1	1.45	< 0.1	< 0.1	0.47	2.28	0.63	< 0.1	0.28	< 0.1	0.25	< 0.1	< 0.1	0
Chrysene	350	< 0.1	1.94	< 0.1	< 0.1	0.58	2.42	0.73	< 0.1	0.35	< 0.1	0.33	< 0.1	< 0.1	0
Benzo(a)pyrene	76	< 0.1	1.27	< 0.1	< 0.1	0.44	2.22	0.54	< 0.1	0.32	< 0.1	0.24	< 0.1	< 0.1	0
Benzo(b)fluoranthene	44	< 0.1	1.52	< 0.1	< 0.1	0.57	2.56	0.73	< 0.1	0.44	< 0.1	0.32	< 0.1	< 0.1	0
Benzo(k)fluoranthene	1200	< 0.1	0.7	< 0.1	< 0.1	0.15	0.82	0.2	< 0.1	0.15	< 0.1	< 0.1	< 0.1	< 0.1	0
Indeno(1,2,3-cd) pyrene	500	< 0.1	0.66	< 0.1	< 0.1	0.24	0.95	0.27	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	0
Dibenzo (a, h) anthracene	3.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Benzo(ghi)perylene	3900	< 0.1	0.64	< 0.1	< 0.1	0.24	0.96	0.28	< 0.1	0.19	< 0.1	< 0.1	< 0.1	< 0.1	0
<i>Phenols</i>															
Phenol	760	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0
MG = Made Ground															

Based on the results shown in Table 12 above, no soil samples tested contained concentrations of contaminants in exceedance of the screening criteria relevant to a Commercial End Use.

Asbestos was however identified in one sample, the details of which are summarised in Table 13, below.

Table 13: Summary of Asbestos Encountered

Location	Depth	Sample Matrix	Asbestos Type	Asbestos Quantification
WS05	0.55m	Fibre bundles	Chrysotile	0.001

However, 2no. soil samples have elevated levels of **Total Petroleum Hydrocarbons (TPH)** in the range of 355mg/kg to 701mg/kg.

Hydrocarbons tend to be a mixture of various organic compounds and are characterised by the length of their carbon chain, the 'C' value. For the purposes of this report, a speciated TPH analysis has been carried out using the GC-FID method. This method allows the characterisation of different 'C' values within each soil sample. Typical 'C' values are summarised as follows:

Analytical Request	Carbon Range	Products
Petroleum/gasoline range organics	C ₅ - C ₁₀	Petrol
Diesel range organics	C ₁₀ - ca. C ₂₀	Diesel, paraffin, and heating oils
Mineral range organics	ca. C ₂₀ - C ₄₀	Lubricating oil, higher boiling fuel oils

Based on the laboratory results, the TPH encountered would appear to be predominantly in the C20-C40 range suggesting the elevated hydrocarbons are likely to be due to the presence of lubricating oils and fuel oils (C20-C40).

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 14, below and presented in full in Appendix 5.

Table 14: Waste Classification of Soils

Location	Depth (m bgl)	WM3.1 Classification	WAC Testing
WS01	0.35	Non-Hazardous	Inert
WS01	0.50	Non-Hazardous	-
WS02	0.30	Non-Hazardous	Stable Non-Reactive Hazardous
WS02	1.20	Non-Hazardous	-
WS03	0.70	Non-Hazardous	-
WS04	0.60	Non-Hazardous	-
WS05	0.55	Non-Hazardous	Inert
WS06	1.10	Non-Hazardous	-
WS07	0.45	Non-Hazardous	-
WS07	2.20	Non-Hazardous	-
WS08	0.40	Non-Hazardous	Exceeds Hazardous
WS09	1.30	Non-Hazardous	-
WS10	0.80	Non-Hazardous	Inert

Table 14 above shows the 13no. soil samples collected from WS01 to WS10 were classified as Non-Hazardous in accordance with WM3.1.

For Waste Acceptance Criteria (WAC) testing, EEGL have compared solid waste and leachate values with guideline values in Landfill Regulations. The following table summarises the results of the solid waste analysis and leachate testing, together with limit values for Non-Hazardous waste and Hazardous waste as described in the Landfill Regulations.

Table 15: Summary of WAC Test Results

Determinand	Landfill Regulations Limits (mg/kg unless otherwise indicated)			WS01 0.35m (mg/kg)	WS02 0.30m (mg/kg)	WS05 0.55m (mg/kg)	WS08 0.40m (mg/kg)	WS10 0.80m (mg/kg)
	Inert Waste	Stable Non-Reactive non-hazardous waste	Hazardous Waste					
TOC (%)	3%	5%	6%	2.9	4	3	13.5	0.4
Loss on ignition (%)	-	-	10%	0.36	4.40	5.50	19.10	1.70
BTEX (mg/kg)	6	-	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sum of PCBs (mg/kg)	1	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Mineral Oil (mg/kg)	500	-	-	< 10	436	< 10	< 10	17
Total PAH (mg/kg)	100	-	-	< 1.7	< 1.7	9.5	2.9	< 1.7
pH (units)	-	>6	-	8.6	8.4	8.3	7.1	8.1
Acid Neutralisation Capacity (mol/kg)	-	To be evaluated		6.3	1.6	1.1	< 1	< 1
Arsenic	0.5	2	25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium	20	100	300	0.8	< 0.2	0.2	0.2	< 0.2
Cadmium	0.04	1	5	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	0.5	10	70	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Copper	2	50	100	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Mercury	0.01	0.2	2	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Molybdenum	0.5	10	30	< 0.01	0.02	0.02	0.02	0.01
Nickel	0.4	10	40	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07
Lead	0.5	10	50	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Antimony	0.06	0.7	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	0.1	0.5	7	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Zinc	4	50	200	0.11	0.05	< 0.05	0.08	< 0.05
Chloride	800	15000	25000	30	30	39	25	15
Fluoride	10	150	500	< 5	< 5	< 5	< 5	< 5
Sulphate	1000	20000	50000	15	20	63	25	13
Total Dissolved Solids	4000	60000	100000	610	510	680	580	470
Phenol Index	1	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
DOC	500	800	1000	85.3	141	205	162	89.3

The results summarised in Table 15, above show that the soil sample retrieved from WS02 at 0.30m bgl had concentrations of contaminants above the recommended level for Inert Waste. The elevated contaminant was Total Organic Carbon (TOC). Therefore, the soils from this area of the site will be accepted at a **Stable Non-Reactive Hazardous Waste Facility**.

The soil sample retrieved from WS08 at 0.40m bgl had concentrations of contaminants above the recommended level for **Hazardous Waste**. The elevated contaminants were Total Organic Carbon (TOC) and Loss on Ignition. It should be noted that clinker and ash were observed in these samples.

The remaining 3no. samples had concentrations of contaminants within the recommended levels for 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 concentration in WS05 at 0.55m was 0.001% therefore the soils are still classified as Inert Waste.

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. For the purposes of this report, it is considered the most appropriate EQS data 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.

It should be noted, there are no surface water features identified within 250m of the site and there are no groundwater abstraction licenses within 2km of the site.

Groundwater samples were retrieved from four monitoring wells installed in window sample boreholes WS02, WS06, WS08 and WS10. No groundwater could be obtained from the remaining boreholes due to low water levels.

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 levels of contamination more than the EQS and Drinking Water Standards in a total of 3no. samples, as summarised below.

- WS6 has slightly elevated levels of **lead** (27µg/l) above the associated recommended EQS and DWQ values. Also, **Zinc** (26µg/l) above the associated recommended EQS value.
- WS8 has slightly elevated levels of **copper** (21µg/l) and **lead** (28µg/l) above the associated recommended EQS and DWQ values. Also, **Zinc** (122µg/l) above the associated recommended EQS value and **TPH Aromatic C16-C21** (103µg/l) above the WHO value.
- WS9 has slightly elevated levels of **lead** (21µg/l) above the associated recommended EQS and DWQ values. Also, **Zinc** (28µg/l) above the associated recommended EQS value.

However, these groundwater contaminants were not elevated in the Made Ground soils located on site. Given these guidelines are particularly stringent, it is considered, based on the type of proposed development and end use, these levels are considered acceptable and low risk.

The results also show WS8 to have significantly elevated level of **Extractable Petroleum Hydrocarbons** (EPH) = 848µg/l.

There are methods of remediation for hydrocarbons in groundwater including, removal of source (i.e., removal of hydrocarbon affected soils) and bio-remediation. However, based on the

type of end development it is considered remediation of the groundwater will not be required, particularly due to the absence of nearby surface water features and groundwater abstractions.

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

Determinand	EQS Value (1)	Drinking Water Quality (DWQ) Value (2)	WS02	WS06	WS08	WS09	No. of Exceedances
Arsenic	50	10	< 5	7	6	< 5	0
Cadmium	0.9	5	< 0.4	< 0.4	0.5	< 0.4	0
Chromium	4.7	50	< 5	< 5	< 5	< 5	0
Copper	10	2000	< 5	< 5	21	7	1 (1)
Lead	1.2 - 14	10	< 5	27	28	21	3 (1) + (2)
Inorganic Mercury	0.07	1	< 0.05	< 0.05	< 0.05	< 0.05	0
Selenium	-	10	< 5	< 5	< 5	< 5	0
Nickel	4-34	20	< 5	8	7	9	0
Zinc	10.9	-	8	26	122	28	3 (1)
Total Cyanide	1 - 5	50	< 5	< 5	< 5	< 5	0
Phenol	7.7 - 46	-	< 10	< 10	< 10	< 10	0
Sulphate	400000	250000	9	13	3	< 1	0
pH	6 - 9	-	6.8	7	6.7	6.4	0
Naphthalene	2 - 130	-	0.06	0.05	0.07	0.07	0
Anthracene	0.1	-	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(a)pyrene	0.27	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(b)fluoranthene	0.017	-	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzo(k)fluoranthene	0.017	-	< 0.01	< 0.01	< 0.01	< 0.01	0
Indeno(123cd) pyrene	-	0.10	< 0.01	< 0.01	< 0.01	< 0.01	0
Fluoranthene	0.0063 - 0.12	-	< 0.01	< 0.01	< 0.01	< 0.01	0
Benzene	10 - 50	1	< 1	< 1	< 1	< 1	0
Toluene	74 - 380	-	< 5	< 5	< 5	< 5	0
Ethylbenzene	-	300 (WHO)	< 5	< 5	< 5	< 5	0
Xylenes	30	-	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C6-C8	-	10 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C8-C10	-	700 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C10-C12	-	300 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Aro C12-C16	-	90 (WHO)	< 10	14	60	< 10	0
Total Petroleum Hydrocarbons Aro C16-C21	-	90 (WHO)	< 10	25	103	< 10	1 (WHO)
Total Petroleum Hydrocarbons Aro C21-C35	-	90 (WHO)	< 10	< 10	28	< 10	0
Total Petroleum Hydrocarbons Ali C6-C8	-	15000 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C8-C10	-	15000 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C10-C12	-	300 (WHO)	< 10	< 10	< 10	< 10	0
Total Petroleum Hydrocarbons Ali C12-C16	-	300 (WHO)	< 10	< 10	64	< 10	0

*All values in µg/l unless otherwise stated, WHO=World Health Organization guide values.
Values in red are elevated above the recommended guidance value.

10.0 GROUND GAS AND RADON GAS CONTAMINATION RISK ASSESSMENT

10.1 Radon Gas

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

10.2 Analyses of Monitoring Results

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

A total of four gas monitoring visits have been completed by Earth Environmental & Geotechnical Ltd. The monitoring visits were carried out between the 8th February and 30th March 2022. The results recorded methane (CH₄) levels of between 0.0% to 4.2% v/v and carbon dioxide (CO₂) levels of between 0.0% to 18.9% v/v. Oxygen concentrations of between 4.5% and 21.9% v/v were also recorded.

With regard to flow rates, for the purposes of the ground gas risk assessment BS8485 2015+A1 2019 states that *'steady state flow rates, rather than brief peak values on opening, should be used in screening risk assessment if these are considered to be representative of the conceptual site model'*.

Low flow rates were locally recorded at the site, with a maximum peak flow rate of 1.9litres/hour recorded in WS10 on the first monitoring visit only. However, steady values are more representative of the ground gas regime at the site.

For our initial assessment purposes, we have adopted a steady flow rate of 0.1litres/hour (i.e., the limit of detection of the monitoring device). It should be noted the steady flow rate was recorded as 0.0litres/hour on most monitoring visits. Atmospheric pressure was recorded to be between 990mb and 1015mb.

Full results of the monitoring are presented in Appendix 2.

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 steady flow rate of 0.1l/h adopted for assessment purposes.

- Carbon dioxide: steady flow rate = 0.1l/hr, max concentration = 18.9%
- Methane: steady flow rate = 0.1l/hr, max concentration = 4.2%.

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

- **Carbon dioxide:** $GSV = 0.1 \times 18.9 / 100 = 0.0189 \text{ litres/hr}$
- **Methane:** $GSV = 0.1 \times 4.2 / 100 = 0.0042 \text{ litres/hr}$

Table 17: 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 mineworkings
4	Moderate to High	<15	Quantitative risk assessment	Mineworkings 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

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 18 above, as the methane concentration was >1% and the carbon dioxide concentration was >5%.

Protection Measures

Based on the foregoing preliminary assessment, ground gas protection measures are considered necessary at the site in accordance with BS8485:2015 + A1 2019. This should comprise a proprietary ground gas resistant membrane. The membrane should be installed to effectively prevent ground gases from entering the footprint of the proposed buildings. The membrane should be extended across wall cavities and any joints sealed (typically heat-welded) with appropriate overlapping. Any service penetrations should be appropriately sealed to the membrane.

In accordance with CIRIA C735, any gas protection membrane should be validated by a suitably qualified inspector. Any membrane installed without verification may be classified as not offering suitable protection to the proposed building.

Table 18 (below) extracted from BS8485:2015+A1:2019 (Code of Practice for the design of protective measures for methane and carbon-dioxide ground gases for new buildings) shows differing gas protection measures for different building types.

Table 18 Gas Protection Point Score Required (BS8485:2015 + A1 2019)

Characteristic Situation	Minimum gas protection score (points)			
	High Sensitivity		Medium	Low
	Type A building (private housing)	Type B building (multiple occupancy private or commercial)	Type C building (single occupancy commercial)	Type D building (large industrial)
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4.0	3.0	2.5
4	6.5	5.5	4.5	3.5

The proposed development is for a Type C building (commercial), a medium sensitivity risk. The combined score for such a development must equal or exceed a **gas protection score of 2.5 for Characteristic Situation 2**.

The required 3.5 points must be achieved by installation of a suitable combination of measures. Reference should be made to BS8485:2015 + A1 2019 for details. These should include a combination of two or more of the following three types of protection measures, which should be used to achieve the required score:

- The structural barrier of the floor slab, or of the basement slab and walls if a basement is present;
- Ventilation measures; and
- Gas resistant membrane.

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, no chemical exceedances were encountered when compared to the assessment criteria for a Commercial End Use. Therefore, the risk is considered low and remedial action should not be required at this site.

11.2 Asbestos

Asbestos was encountered in 1no. soil sample as bundles of chrysotile fibres which were quantified to be 0.001%.

Due to the low concentration, an asbestos management plan is not required for the site. However, the following rules should be adhered to within the vicinity of asbestos contamination:

- Site personnel have the risk communicated to them at the induction stage.
- Ensure personnel have suitable training and PPE.

11.3 Foundations

Conventional shallow strip/pad foundations are not considered suitable for the proposed development site due to the peat deposits and low strength cohesive soils encountered.

The proposed building may be founded on piles taken down to depth to a suitable founding stratum such as the high strength clays or dense sand and gravels encountered beneath.

11.4 Land Gas

Based on results of the gas monitoring, the site has been given a Characteristic Situation 2 and the risk of ground gas is low. Therefore, protection against the ingress of ground gas will be required at the site.

A remediation strategy is recommended which will outline the ground gas protection measures required.

Radon protection measures are not required at the site.

11.5 Soil Disposal

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

However, further Waste Acceptance Criteria (WAC) showed that WS08 at 0.40m contains concentrations of contaminants which exceed the level for Hazardous Waste. Sample WS02 at 0.30m will be accepted at a Stable Non-Reactive Hazardous Landfill site. The remaining samples will be accepted at an Inert Waste Facility.

11.6 Groundwater Contamination

Based on the results of the chemical testing, there were slight exceedances in copper, lead, zinc and TPH aromatic (C16-C21) in 4no. borehole locations.

Given these EQS and DWQ guidelines are particularly stringent, it is considered, based on the proposed commercial end use, these levels are considered acceptable and low risk.

There is an absence of nearby surface water features and groundwater abstractions and therefore remediation is not required.

11.7 Risk to Buried (Water) Services

It is considered that, due to the presence of elevated hydrocarbons, non-standard materials may be required for new water pipes. Further advice should be sought from the local water company.

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

11.8 Site Personnel

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

11.9 Other Matters

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

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

MONITORING RESULTS

APPENDIX 3

GEOTECHNICAL TESTING RESULTS

APPENDIX 4

CHEMICAL TESTING RESULTS

APPENDIX 5

SOIL WASTE ASSESSMENT

APPENDIX 6

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd 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.

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APPENDIX 2

EXAMPLE OF APPROPRIATE CS₂ GAS MEMBRANE SPECIFICATION

Visqueen Gas Barrier

Features and benefits

- BBA certified - third party accreditation
- Complies with BS 8485:2015 + A1:2019 - industry standard for methane and carbon dioxide protection
- Flexible - easy to detail and install on site
- Multi functional - also acts as a radon and damp proof membrane
- Dual jointing methods - lap joints can be taped or heat welded

Product description

Visqueen Gas Barrier is a multi-layer reinforced polyethylene gas barrier with a 20 micron aluminium foil. The barrier is coloured blue on the upper surface and silver on the reverse. The product is supplied in single wound rolls (not folded), 2m x 50m.

Approvals and standards

- Third party accreditation (BBA 13/5069)
- Conforms to the specification requirements of BS 8485:2015 + A1:2019
- Suitable for all Characteristic Gas Situation (CS) ground gas regimes
- Conforms to the specification requirements of NHBC Amber 1 and Amber 2 applications
- Conforms to the specification requirements of BR 211:2015
- CE Mark EN 13967:2017
- Quality Management System ISO 9001:2015
- Occupational Health and Safety System ISO 45001:2018
- Environmental Management System ISO 14001:2015

Usage

Visqueen Gas Barrier is suitable for use in all types of buildings to prevent the ingress of harmful levels of ground gases e.g. methane, carbon dioxide and radon.

The barrier can be positioned above or below a solid concrete ground floor slab or above a precast suspended segmental ground floor system, e.g. beam and block floor.

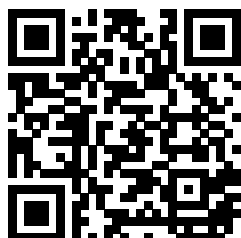
The barrier can also be used as a high performance radon membrane and/or damp proof membrane.

The product is not intended for use where there is a risk of hydrostatic pressure.

System components

- VisqueenPro Double Sided Jointing Tape, 50mm x 10m
- Visqueen Gas Resistant Foil Lap Tape, 75mm x 50m
- Visqueen GR Lap Tape, 150mm x 10m
- Visqueen Ultimate Top Hat Units
- Visqueen Preformed Units
- VisqueenPro Detailing Strip, 300mm x 10m, 500mm x 10m
- Visqueen TreadGUARD 300, 2m x 75m
- Visqueen TreadGUARD 1500, 1m x 2m

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Visqueen Gas Barrier

Storage and handling

Visqueen Gas Barrier should be stored horizontally, under cover in its original packaging.

Care should be taken when handling the product in line with current manual handling regulations.

Preparation

Visqueen Gas Barrier should be installed on a smooth continuous surface e.g. grouted beam and block floor, a compacted blinding layer e.g. 50mm thick sand blinding, or smooth concrete blinding. The substrate should be free from irregularities such as voids or protrusions.

The barrier can be cut with a sharp retractable safety knife or robust scissors.

When installing the membrane in demanding site conditions, use Visqueen GR Lap Tape in place of Visqueen Gas Resistant Foil Lap Tape.

Installation

Visqueen Gas Barrier should be loose laid on the substrate with the blue side up so as to avoid sunlight glare.

The barrier should be clean and dry at the time of jointing. It should be overlapped by at least 150mm, bonded with Visqueen Pro Double Sided Jointing Tape and sealed with Visqueen Gas Resistant Foil Lap Tape.

Alternatively lap joints can be heat welded to achieve an effective seal. Welded lap joints can be less than 150mm provided the joint integrity is not compromised.

Airtight seals should be formed around all service entry points. Visqueen Preformed Top Hat Units should be used for sealing service entry pipes. The base of the top hat and the upstand should be bonded using Visqueen Pro Double Sided Jointing Tape and sealed with Visqueen Gas Resistant Foil Lap Tape. The upstand should be secured with the supplied jubilee clip.

Forming an effective barrier to gases may give rise to complex three-dimensional detailing where, it is recommended Visqueen Preformed Units are used e.g. corners. Alternatively Visqueen Pro Detailing Strip can be used to seal awkward junctions.

If the barrier is punctured or perforated a patch of the same material should be lapped at least 150mm beyond the limits of the puncture and bonded with Visqueen Pro Double Sided Jointing Tape and sealed with Visqueen Gas Resistant Foil Lap Tape. Alternatively a patch can be formed using Visqueen Pro Detailing Strip and lapped at least 150mm beyond the extents of the puncture.

Long periods of exposure to ultraviolet light will reduce the effectiveness of the membrane. The membrane should be covered by a protective layer immediately after installation to prevent damage from following trades, ultraviolet light, etc. Care should be taken to ensure that the membrane is not punctured, stretched or displaced when applying a screed or final floor covering. A minimum thickness of 50mm screed is recommended. When reinforced concrete is to be laid over the barrier the wire reinforcements and spacers must be prevented from puncturing the barrier. Where there is a high risk of potential damage, the barrier should be covered with Visqueen TreadGuard protection, screed, or other approved protection material before positioning the reinforcement.

Usable temperature range

It is recommended that Visqueen Gas Barrier and all associated system components should not be installed below 5°C.

Additional information

When used in accordance BS8485:2015 + A1:2019 a subfloor ventilation system or pressure relief maybe required
Where hydrocarbon or VOC contamination is present use Visqueen Ultimate VOC or HC Blok gas protection systems
To assist build sequencing, Visqueen GR DPC is available for gas protection through the wall constructions
For suspended beam and block floor detailing see GB-01
Visqueen Preformed Top Hat Units should be used at service pipe penetrations see GB-51
For internal and external corners Visqueen Ultimate Preformed Units should be used see PFU-553
To seal around steel columns use Visqueen Pro Detailing Strip see GB-52
For additional detailing information, contact Visqueen Technical Services +44 (0) 333 202 6800

The information in this datasheet was correct at the time of publication. It is the user's responsibility to obtain the latest version of the datasheet as it is updated on a regular basis. The information contained in the latest datasheet supersedes all previously published editions.

Visqueen Gas Barrier

Property	Test method	Units	Compliance criteria	Result
Dimensions	EN 1848-2	m		2 x 50
Overall thickness including scrim mesh	EN 1849-2	mm	+/-10%	0.52
Mass	EN 1849-2	g/m ²	-0%/+5%	400
Tensile strength - MD	EN 12311	N	MLV	350
Tensile strength - CD	EN 12311	N	MLV	350
Tensile elongation - MD	EN 12311	%	MLV	20
Tensile elongation - CD	EN 12311	%	MLV	21
Joint strength	EN 12317-2	N	MLV	332
Watertightness 2kPa	EN 1928	-	Pass/Fail	Pass
Resistance to impact	EN 12691	mm	MDV	150
Dart impact	BS 2782	g	MDV	731
Low temperature flexibility	EN 495-5	°C	MDV	-40
Durability against ageing	EN 1296 and EN 1928	-	Pass/Fail	Pass
Durability chemical resistance	EN 1847	-	Pass/Fail	Pass
Resistance to tearing (nail shank) CD	EN 12310-1	N	MDV	358
Resistance to tearing (nail shank) MD	EN 12310-1	N	MDV	368
Resistance to static loading	EN 12730	kg	MLV	20
Water vapour transmission - resistance	EN 1931	MNs/g	MDV	7000
Water vapour transmission - permeability	EN 1931	g/m ² /d	MDV	0.03
Visible defects	EN 1850 -2	-	Pass/Fail	Pass
Reaction to fire	EN 13501-1	Class	MDV	F
BS 8485:2015 + A1:2019 testing requirements				
Mass	EN 1849-2	g/m ²	Average >370	400
Methane permeability	ISO 15105-1	mls/m ² /d/atm	Pass/Fail	<0.15
Puncture CBR	BS EN ISO 12236	N	MDV	1114
Tensiles yield strength MD	ASTM D4885-01	kN/m	MDV	12.5
Tensiles yield strength CD	ASTM D4885-02	kN/m	MDV	7.3
Resistance to static loading	EN 12730	kg	>MLV	20
Yield elongation CD	ASTM D4885-04	%	MDV	19
Tear resistance - trouser method A - MD	BS ISO 34-1	kN/m	MDV	48.2
Tear resistance - trouser method A - CD	BS ISO 34-1	kN/m	MDV	44.8
Tear resistance - angle method B - MD	BS ISO 34-1	N	MDV	53.5
Tear resistance - angle method B - CD	BS ISO 34-1	N	MDV	60.6

Health and safety information

Refer to the Visqueen Gas Barrier material safety datasheet (MSDS).

Visqueen Gas Barrier

About Visqueen

The Visqueen name has long been recognised as one of the leading manufacturers of high quality advanced membrane technologies and design based solutions by specifiers, distributors, builders merchants and contractors throughout the UK and Europe.

For further guidance on the Visqueen services shown below, please refer to the relevant section of the Visqueen website (www.visqueen.com) or contact Visqueen Technical Services on +44 (0) 333 202 6800 or enquiries@visqueen.com

Complete Range, Complete Solution



Structural
Waterproofing



Gas
Protection



Damp Proof
Membrane



Tapes



Damp Proof
Course



Stormwater



Vapour
Control

Visqueen Technical Support

Visqueen combine an extensive product portfolio with industry leading levels of service and support which includes guidance over the phone, bespoke CAD drawings to help with complex detailing, electronic NBS specifications and access to a dedicated team of highly knowledgeable and experienced field based Technical Support Managers.

Visqueen Technical Support is available to all our customers including architects, specifiers, distributors, builders merchants, contractors and end users. All of our technical team have been awarded the industry recognised qualification Certificated Surveyor in Structural Waterproofing (CSSW).

Visqueen CPD Seminars

The Visqueen Continuing Professional Development (CPD) Seminars provide up-to-date information on changes within Building Regulations/Building Standards and nationally recognised industry guidance affecting damp proofing, water vapour control, hazardous ground gas protection and below ground structural waterproofing.

The one hour seminars have been produced for design specialists within the construction sector and are delivered by our team of Technical Support Managers.

Visqueen PI designs and special projects

From initial design to the completed project, Visqueen are with you every step of the way. Whether it be hazardous ground gas protection and/or below ground waterproofing protection employing barrier, structurally integral or drained systems, Visqueen can offer professional indemnity (PI) insurance for bespoke Visqueen design solutions.

Visqueen Technical Support Managers work with all stakeholders to provide cost effective Visqueen solutions offering complete peace of mind throughout the construction phase and beyond.

Visqueen Training Academy

Based at our manufacturing facility in Derbyshire, the Visqueen Training Academy is available to support Visqueen customers throughout the UK by providing a wide range of both theory and practical skills related training.

Courses include one day product awareness training for our distributors and builders merchants to help them in their day-to-day jobs, through to intensive three day courses giving detailed hands-on training in the practical skills required for safe and robust product installation.

APPENDIX 3

REPORT LIMITATIONS

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.

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