

EARTH ENVIRONMENTAL & GEOTECHNICAL

Phase II GeoEnvironmental Investigation

Manchester College Openshaw

Manchester

May 2019

On behalf of

LTE group®
Learning | Training | Employment

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

Tel : 0161 975 6088

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

PHASE II GEOENVIRONMENTAL INVESTIGATION

MANCHESTER COLLEGE OPENSHAW

Report Ref: A2876/19/B.0

May 2019

Prepared on Behalf of:

LTE Group

By:

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

www.earthenvironmental.co.uk

DISTRIBUTION:

1 electronic copy Building Design Partnership

PHASE II GEOENVIRONMENTAL INVESTIGATION

MANCHESTER COLLEGE, OPENSHAW

Report Reference: A2876/18

Version B.0

Date: 26th May 2019

Prepared for: LTE Group

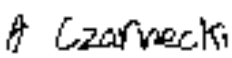
Prepared by: Earth Environmental & Geotechnical Ltd
Houldsworth Mill Business & Arts Centre
Houldsworth Street
Stockport
SK5 6DA

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

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



Written by: **Nigel Ramsumair**
Operations Manager



Approved by:

Adam Czarnecki
Managing Director

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 BACKGROUND 1
1.2 PREVIOUS INVESTIGATIONS 1
1.2.1 Earth Environmental & Geotechnical Ltd Phase I Desk Study A2876/19, dated May 2018) 1
1.3 TERMS OF REFERENCE 1
1.4 LIMITATIONS OF THE STUDY 1

2.0 SITE LOCATION & DESCRIPTION 3

2.1 SITE DESCRIPTION 3
2.2 PROPOSED DEVELOPMENT 9

3.0 SITE INVESTIGATION 10

3.1 EXPLORATORY FIELDWORK 10
3.2 LABORATORY TESTING PROGRAMME 14
3.2.1 Geotechnical Testing 14
3.2.2 Environmental Testing 14

4.0 GROUND CONDITIONS ENCOUNTERED 15

4.1 SOIL PROFILE ENCOUNTERED 15
4.2 OBSERVABLE INDICATIONS OF CONTAMINATION 16
4.3 OBSTRUCTIONS 17
4.4 DYNAMIC CONE PENETROMETER TESTING 17
4.5 GROUNDWATER 18

5.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED 19

5.1 MADE GROUND 19
5.2 DEVENSIAN TILL 19

6.0 GEOTECHNICAL ASSESSMENT 24

6.1 PROPOSED DEVELOPMENT 24
6.2 GROUND CONDITIONS 24
6.3 FOUNDATION CONSIDERATIONS 24
6.4 GROUND FLOOR SLABS 25
6.5 PAVEMENT DESIGN 25
6.6 SOIL INFILTRATION RATES 26
6.6.1 Soakaways in Trial Pits 26
6.6.1 Falling head tests in Boreholes 27
6.7 CHEMICAL ATTACK ON BURIED CONCRETE 27
6.8 SUITABILITY OF EXCAVATED MATERIALS 28
6.9 TEMPORARY WORKS 28

7.0 SOIL CONTAMINATION RISK ASSESSMENT 29

7.1 TIER I HUMAN HEALTH SOIL RISK ASSESSMENT – GROUNDWORKERS DURING DEVELOPMENT 29
7.2 TIER I HUMAN HEALTH SOIL RISK ASSESSMENT – FUTURE SITE USERS 30
7.3 SOIL WASTE ASSESSMENT 32

8.0 GROUNDWATER CONTAMINATION RISK ASSESSMENT 33

9.0 GROUND GAS RISK ASSESSMENT 35

10.0 REVIEW OF CONCEPTUAL MODEL 37

10.1 SOURCES OF CONTAMINATION 38
10.2 RECEPTORS 38
10.3 POLLUTANT PATHWAYS 38

11.0 CONCLUSIONS AND RECOMMENDATIONS 41

11.1 SOIL CONTAMINATION 41
11.2 SOIL WASTE ASSESSMENT 41
11.3 GROUNDWATER CONTAMINATION 41
11.4 GROUND GAS 41
11.5 SOAKAWAY TESTING 42
11.6 FOUNDATION RECOMMENDATIONS 42
11.7 SITE PERSONNEL 42

LIST OF FIGURES

Figure 1 Site Location Plan
Figure 2 Cable percussive drilling of BH1
Figure 3 Cable percussive drilling of BH2
Figure 4 Cable percussive drilling of BH3
Figure 5 Windowless sample rig at WS2
Figure 6 Soil profile encountered at WS2
Figure 7 Soil profile encountered at WS3
Figure 8 Soil profile encountered at WS10
Figure 9 Soil profile encountered at WS6
Figure 10 Soil profile encountered at WS7
Figure 11 Soil profile encountered at WS8
Figure 12 Development Layout Plan
Figure 13 Exploratory Hole Location Plan
Figure 14 DCP Location Plan
Figure 15 SPT vs Depth Plot
Figure 16 Strength vs Depth Plot
Figure 17 Plasticity Chart
Figure 18 Locations of detected Asbestos

TABLES

Table 1 Summary of Exploratory Holes Undertaken
Table 2 Summary of Ground Conditions Encountered
Table 3 Soil Desiccation Indicators in the Sandy Gravelly Clay
Table 4 Assessment of Allowable Bearing Capacity
Table 5 Summary of Recorded CBR %
Table 6 Soakaway Infiltration Rates
Table 7 Falling head Infiltration Rates
Table 8 Summary of Guideline Values for Protection of Workers and the General Public During Development of Contaminated Land
Table 9 Assessment of Soil Chemical Data
Table 10 Waste Classification of Soils
Table 11 Assessment of Groundwater Chemical Data
Table 12 Modified Wilson & Card Classification (CIRIA Report 665)
Table 13 Consequence, Probability and Risk
Table 14 Estimation of Level of Risk
Table 15 Revised Conceptual Model

APPENDICES

Appendix 1 Exploratory Hole Logs
Appendix 2 Chemical Testing Results
Appendix 3 Geotechnical Testing Results
Appendix 4 Soil Waste Assessment
Appendix 5 Dynamic Cone Penetration Testing
Appendix 6 Soakaway Results
Appendix 7 Monitoring Data
Appendix 8 Report Limitations

1.0 INTRODUCTION

1.1 Background

A Site Investigation has been commissioned by the Building Design Partnership on behalf of the LTE Group (the Client) to examine ground conditions for a new sport facility development at Manchester College, which will also include 4G artificial pitch and associated car parking.

1.2 Previous Investigations

1.2.1 Earth Environmental & Geotechnical Ltd Phase I Desk Study A2876/19, dated May 2018)

In summary, the report identified from historical mapping that the northern part of the site formed part of a bleach works and an engineering works previously occupied the south of the site, together with an associated railway/tram network and several chimneys. The site was later cleared and gradually redeveloped as a college from the early 1960s onwards.

It was therefore considered possible that potentially contaminated made ground may be present beneath the site, associated with former land uses and various phases of development.

The risk to end users from potential soil and groundwater contamination on the site was generally concluded to be **LOW** based on the proposed commercial end use (school) due to the coverage of proposed buildings and hardstanding across the site.

The risk to controlled waters was concluded to be **MODERATE to LOW,** with the risk from ground gas considered to be **MODERATE** due to probable deep Made Ground beneath the site and the former bleachworks and engineering works.

1.3 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) was commissioned by the Client to undertake a Geo-Environmental Investigation of the site in accordance with a proposal A2876 dated 6th January 2019.

The objectives of this investigation are as follows:

- *Assess the presence and likely extent of any potential environmental hazards (soil, ground gas and groundwater contamination) associated within the areas of the site investigated.*
- *Assess the ground conditions for design of foundations.*
- *Assess the ground conditions for pavement design.*
- *Classify the soils for offsite disposal purposes.*

1.4 Limitations of the Study

The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information, improved practices or changes in legislation may require a reinterpretation of the report in whole or in part. EEG reserve the right to amend either

conclusions or recommendations in light of any further information that may become available. The report is provided for the sole use by the client and is confidential to them.

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

2.0 SITE LOCATION & DESCRIPTION

2.1 Site Description

The site is located in the east of Manchester city centre approximately 1.6km east of Ardwick and approximately 4.3km west of Audenshaw. The approximate National Grid Reference for the centre of the site is SJ 87525 97341 (X: 387525, Y: 397341) with the closest postcode being M11 2WH.

The site is an irregular shape. The main portion is roughly rectangular shape that “dog legs” east towards the main Manchester city College building. The overall maximum dimensions of the site are 170m east-west by 200m north-south occupying an area of approximately 2.1ha.

The site is currently an active college consisting of multi-storey buildings, soft verge, hardstanding (asphalt and concrete), car parking and access roads.

The study site is part of an industrial estate that spans further to the east and west. Directly south of the site is an area of forestry consisting of tall mature trees, providing a noise barrier for the railway line (running east to west) further to the south. Directly north of the site are residential housing estate.

This report focuses on the area of the proposed development and not the whole college campus as shown in Figure 1, below.

Figure 1 Site Location Plan



Site photographs are presented in Figures 2 to 11 below.

Figure 2 Cable percussive drilling of BH1



Figure 3 Cable percussive drilling of BH2



Figure 4 Cable percussive drilling of BH3



Figure 5 Windowless sample rig at WS2



Figure 6 Soil profile encountered at WS2



Figure 7 Soil profile encountered at WS3



Figure 8 Soil profile encountered at WS10



Figure 9 Soil profile encountered at WS6



Figure 10 Soil profile encountered at WS7



Figure 11 Soil profile encountered at WS8

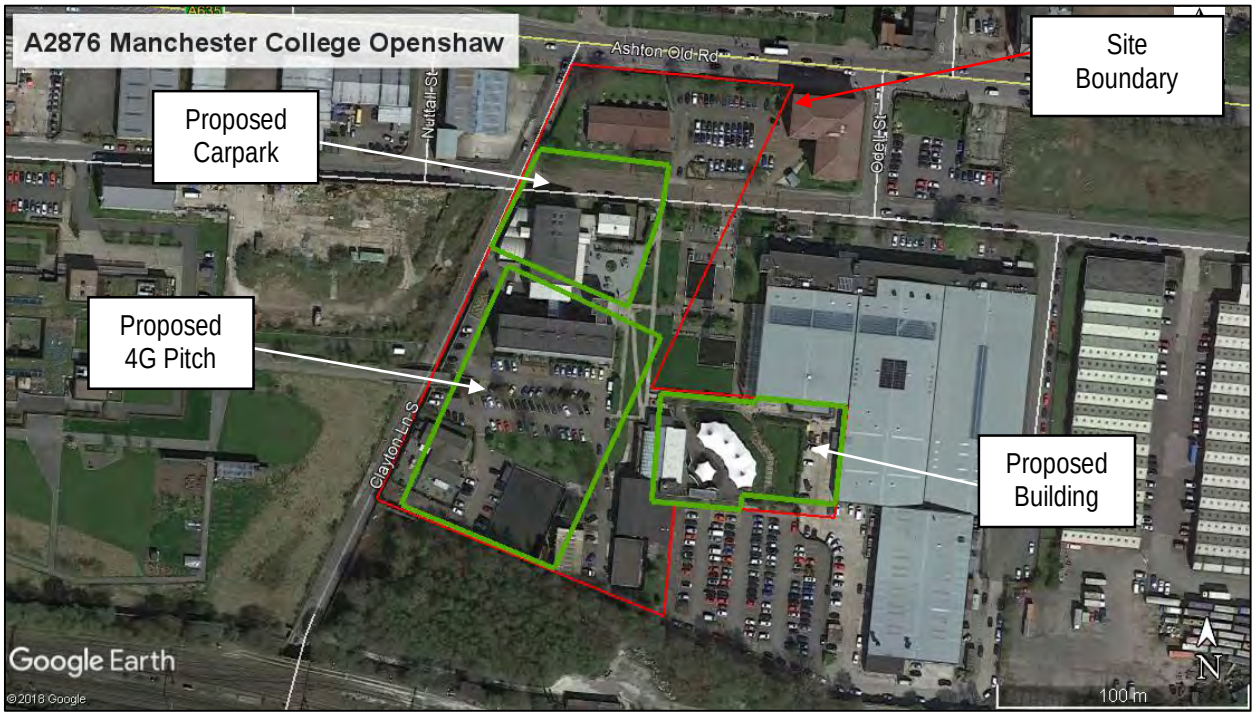


2.2 Proposed Development

It is understood that the client intends to further develop existing workshop and classroom facilities within the main Whitworth House block. The scheme will involve the demolition of a number of existing buildings to allow for the construction of a new adjoining block containing sports hall, gym and changing facilities, together with a new 4G pitch and additional car parking.

Figure 12, below, shows an extract from the proposed development plan.

Figure 12 Development Layout Plan



3.0 SITE INVESTIGATION

3.1 Exploratory Fieldwork

The fieldwork was carried out by EEG between the 8th and 12th April 2019 and comprised:

- Ten window sample boreholes (designated WS1 to WS10 inclusive) were each initially hand dug to 1.20m (where possible) and then progressed using the window sampling rig to depths of between 1.30m and 5.00m below existing ground level (bgl). Window sampler boring is carried out with a small, track-mounted rig, which uses a chain driven trip hammer to drive sampling tubes or penetrometers into the ground. These tools are coupled to the anvil of the hammer by solid drill rods. Sampling tubes comprise "windowless samplers", which are plain sampler tubes in which a continuous disturbed sample is recovered within a semi-rigid plastic liner. In order to reduce friction within the borehole, sampling tubes of progressively smaller diameter are used as the borehole depth increases. Sampler diameters generally range from between approximately 90mm to 50mm. Standard Penetration Tests (SPTs) were undertaken in the boreholes in accordance with accordance with BS EN ISO 22476-3.

- 50mm diameter standpipes were installed in five of the Window Sampler boreholes (WS1, WS3, WS4, WS7 & WS9) to depths of between 3.5m and 5.0m bgl.

- Eighteen dynamic cone penetrometer (DCP) tests (designated DCP1 to DCP18) were undertaken in areas of proposed hard-standing and 4G pitch. DCP tests use an 8kg free fall hammer dropper over a distance of 575mm to drive a 60˚ nose cone from ground level to depths of between 84mm and 920mm bgl. Locations were positioned across the site in areas of soft verge in order to minimize disturbance of the existing hard-standing.

- Ten trial pits (designated TP1- TP9 & IP2) were excavated to depths of between 0.90m and 3.20m bgl, using a wheeled excavator. Representative disturbed samples were recovered from the excavated material as pitting proceeded. Trial pits were backfilled immediately on completion of sampling and testing.

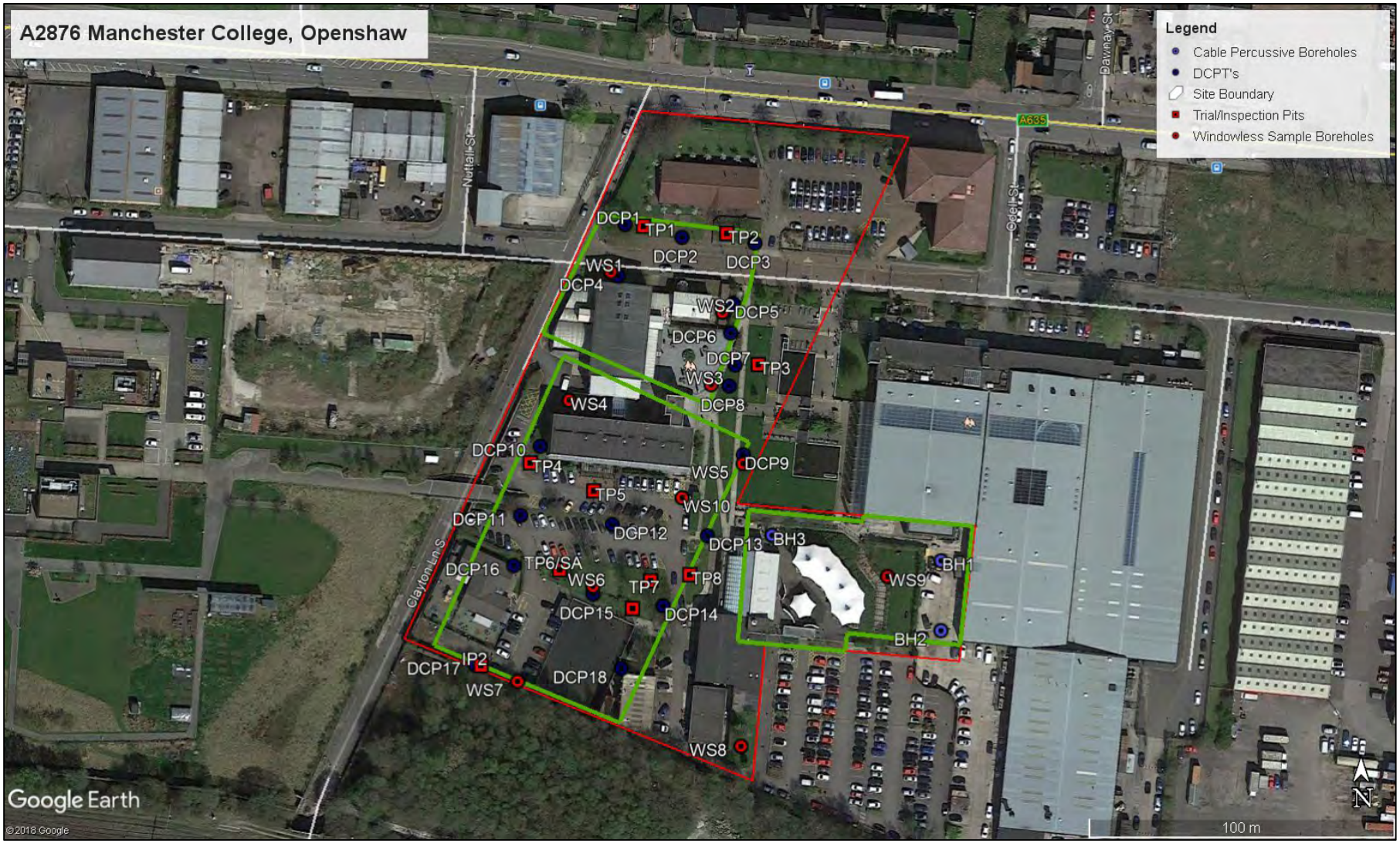
- In-situ soakaway testing was carried out in two of the trial pits prior to backfilling (TP6 and TP9), generally in accordance with the methods described in BRE Digest 365$^{(2007)}$ in order to determine an infiltration rate for the in-situ soils.

- Three cable percussive boreholes (designated BH1 and BH3) were drilled to depths of 15.0m bgl. 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.

The exploratory hole locations were determined on site by BDP & EEG based on the proposed development plan and to target potential sources of contamination identified in the Phase I Desk Study report (Reference A2876, dated May 2019) and are shown on the Exploratory Hole Location Plan (Figure 13) overleaf. Exploratory Hole logs are included in Appendix 1.

The in-situ DCP test results are presented in Appendix 5 and the soakaway test results are presented in Appendix 6.

Figure 13 Exploratory Hole Location Plan



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

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

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

All locations and elevations were surveyed by use of a hand-held Trimble GPS with antennae, capable of achieving an accuracy of less than 10cm, depending on the prevailing satellite coverage and obscuring by trees and structures.

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

Table 1: Summary of Exploratory Holes Undertaken

Hole	Type	Depth (m)	Date Started	Date Finished	Backfill Details
WS1	WS	2.00	10/04/2019	10/04/2019	SP
WS2	WS	4.00	10/04/2019	10/04/2019	A
WS3	WS	2.50	10/04/2019	10/04/2019	SP
WS4	WS	5.00	10/04/2019	10/04/2019	SP
WS5	WS	1.20	10/04/2019	10/04/2019	A
WS6	WS	5.00	10/04/2019	10/04/2019	A
WS7	WS	5.00	10/04/2019	10/04/2019	SP
WS8	WS	5.00	10/04/2019	10/04/2019	A
WS9	WS	5.00	10/04/2019	10/04/2019	SP
WS10	WS	2.70	10/04/2019	10/04/2019	A
TP1	TP	1.10	12/04/2019	12/04/2019	A
TP2	TP	2.00	12/04/2019	12/04/2019	A
TP3	TP	1.80	12/04/2019	12/04/2019	A
TP4	TP	0.90	11/04/2019	11/04/2019	A
TP5	TP	1.40	11/04/2019	11/04/2019	A
TP6	TP	3.20	11/04/2019	11/04/2019	A
TP7	TP	1.10	11/04/2019	11/04/2019	A
TP8	TP	1.10	11/04/2019	11/04/2019	A
TP9	TP	2.60	11/04/2019	11/04/2019	A
IP2	TP	2.00	11/04/2019	11/04/2019	A
BH1	BH	15.00	08/04/2019	08/04/2019	A
BH2	BH	15.00	09/04/2019	09/04/2019	A
BH3	BH	15.00	10/04/2019	10/04/2019	A
WS=Window Sample Borehole, TP=Trial Pit, BH= Cable Percussive Borehole A=Arisings, SP=Standpipe					

3.2 Laboratory Testing Programme

3.2.1 *Geotechnical Testing*

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

TEST	STANDARD (BS1377:1990)	No.
Liquid Limit, Plastic Limit, Plasticity Index	Part 2, Clause 3.2, 4.4 & 5.3	8
Multi-stage Triaxial	Part 7, Clause 9	8
Sulphate content of 2:1 soil: water extract	Part 3,	4
pH value	Part 3,	4

The results of the laboratory geotechnical tests are discussed in Section 5 and included in Appendix 3.

3.2.2 *Environmental Testing*

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

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

Asbestos Screen, Arsenic, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc, Cyanide, Thiocyanate, Phenol, Sulphate (SO_4), Sulphide, pH, Sulphur, Soil Organic Matter and speciated Polyaromatic Hydrocarbons (PAH), Speciated Petroleum Hydrocarbons (TPH) and WAC Testing.

Chemical analysis on two water samples has also been proposed for the following suite of determinants:

pH, Total Sulphate, Sulphide, Total Cyanide, As, Cr, Cr (vi), Cu, Pb, Se, Zn, Cd, Hg, Ni, Vanadium, Barium, Beryllium, WS Boron, Mono Phenol, Speciated PAH and Speciated TPH.

No groundwater was encountered in WS1 & 7 and therefore could not be sampled. After purging, the recharge of WS3 was too poor to sample.

The results of the laboratory contamination tests are discussed in Section 7 and included in Appendix 2.

4.0 GROUND CONDITIONS ENCOUNTERED

4.1 Soil Profile Encountered

The BGS mapping for the area indicates the site to be underlain by superficial 'Drift' deposits comprising Glacial Till Deposits of silt and clay. The solid geology underlying the site is shown to comprise of the Etruria Formation (Sandstone and Mudstone), Pennine Coal Measures Formation (Mudstone, Siltstone and Sandstone) and the Chester Pebble Beds Formation (Sandstone).

The sequence of strata encountered beneath the site was:

- **Surface Cover –** Asphalt/Paving Stone/Topsoil/Grass.
- **Made Ground –** Encountered in each exploratory location with variable composition across the site but generally:
    - Greyish brown, slightly silty sand.
    - Dark brown gravel or gravelly sand with variable inclusions of concrete, clinker, building stone, brick, sandstone and ash.
    - Dark grey, slightly sandy, slightly gravelly clay with inclusions of brick, concrete, clinker, sandstone and ash.
- **Glacial Till Deposits –**
    - Stiff, brown, slightly sandy, slightly gravelly clay.
    - Sandy, Gravelly Clay - Stiff brown, occasionally mottled grey, slightly sandy, slightly gravelly clay with gravel mudstone and sandstone, which becomes very stiff and fissured with depth, with frequent silty sand partings.
    - Silty Sand - brown, silty fine to medium sand with occasional mudstone gravel and clay lenses.

The depths of the various materials encountered in each of the exploratory holes are summarised in Table 2 overleaf.

Table 2: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m)										GROUND WATER (mbgl)
	Topsoil	Made Ground							DEVENSIAN TILL		
		CONCRETE	ASPHALT	Silty SAND	Gravelly SAND	Sandy COBBLES & BOULDERS	Sandy GRAVEL	Sandy Gravelly CLAY	Sandy Gravelly CLAY	Gravelly SAND	
BH1	-	GL-0.25	-	-	0.25-1.60	-	-	1.60-2.20	2.20-6.30 6.70-15.00	6.30-6.70	6.30
BH2	-	GL-0.25	-	-	0.25-1.80	-	-	1.80-2.60	2.60-15.00	-	-
BH3	-	-	GL-0.20	-	0.20-0.30	0.30-0.60	0.60-4.20	-	-	4.20-15.00	-
WS1	GL-0.20	-	-	-	0.20-0.90	-	-	0.90-2.00	-	-	-
WS2	-	-	GL-0.10	-	0.35-0.70	-	0.10-0.35	-	0.70-4.00	-	-
WS3	-	GL-0.05	-	0.05-0.30	-	-	0.30-0.85	-	0.85-2.50	-	-
WS4	-	-	GL-0.10	-	0.10-0.90	-	-	0.90-2.00	2.00-5.00	-	-
WS5	GL-0.20	-	-	-	-	-	0.20-1.30	-	-	-	-
WS6	GL-0.40	-	-	-	1.20-2.20 -	-	-	0.40-1.20 2.20-2.70	2.70-5.00	-	-
WS7	-	-	GL-0.20	-	0.20-1.00	-	1.90-5.00	1.00-1.90	-	-	-
WS8	GL-0.30	-	-	-	0.30-0.60 1.40-4.40	-	-	0.60-1.40 -	4.40-5.00	- -	- -
WS9	GL-0.15	-	-	-	0.15-1.10	-	-	1.10-1.60	1.60-5.00	-	-
WS10		-	GL-0.10	-	0.10-0.60	-	-	0.60-2.40	2.40-2.70	-	-
TP1	GL-0.10	-	-	-	-	-	0.10-1.10	-	-	-	-
TP2	GL-0.10	-	-	-	-	-	0.10-1.50	-	1.50-2.00	-	-
TP3	GL-0.10	-	-	-	-	-	0.10-1.60	-	1.60-1.80	-	-
TP4	GL-0.20	-	-	-	-	0.20-0.90	-	-	-	-	-
TP5	GL-0.35	-	-	-	-	0.35-1.40	-	-	-	-	-
TP6	GL-0.40	-	-	-	0.40-2.80	-	-	-	2.80-3.20	-	-
TP7	GL-0.60	-	-	-	0.60-1.10	-	-	-	-	-	-
TP8	GL-0.40	0.75-0.80	-	-	0.40-0.75 0.80-1.10	-	-	- -	-	-	-
TP9	GL-0.40	-	-	-	0.40-1.60	-	-	-	1.60-2.60	-	2.60
IP2	-	-	GL-0.10	-	-	-	0.10-2.00	-	-	-	-

*Perched water seepage at interface of made ground/topsoil and underlying clay.

4.2 Observable Indications of Contamination

BH1 & 2 was located adjacent the existing Whitworth building where there was a small amount of dark staining with a slight hydrocarbon odour.

In BH1 & 2, WS4, 6, 7, 8, 9 & 10, TP5 & 9 the made ground was also observed to contain coal/charcoal and clinker fragments.

In TP's 6 & 7 the made ground was also observed to contain asbestos tiles that appeared to be covered with a cleaner looking topsoil layer. During the excavation of all trial pits, any potential clean cover was kept separate from the impacted made ground, ensuring that any clean cover was reinstated.

Inclusions of concrete, brick, slate, pottery, tile and glass were also noted within the made ground encountered at the site. These particular inclusions are considered generally inert and unlikely to present a risk of contamination.

No other visual or olfactory evidence of contamination was observed.

4.3 Obstructions

A historic land drain was encountered in TP4 at 0.90m bgl and it is considered likely that other land drains are likely to cross the site.

Relict foundation and building materials were encountered as cobble sized blocks of brick and concrete in WS1, 5 & 7 and in TP1, 4, 5. In WS5 and TP6 the material was loosely compacted.

A water service was encountered in TP8 at 1.00m bgl that halted any further excavation.

4.4 Dynamic Cone Penetrometer Testing

Dynamic Cone Penetrometer (DCP) tests were undertaken at 18 locations across the site (DCP1 to DCP18) to determine CBR values in the proposed new car park and new proposed 4G pitch.

CBR values have been determined from the DCP results on the basis of the following correlation:

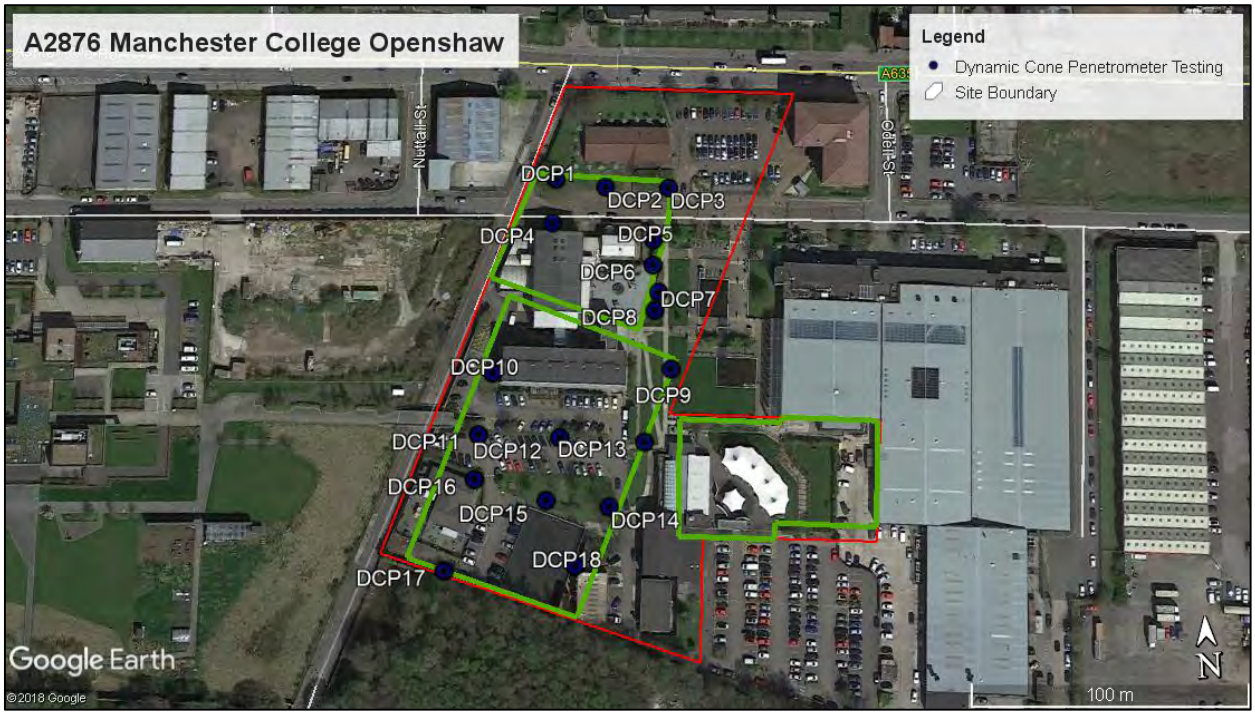
$$\text{Log10 (CBR)} = 2.480 - 1.057 \times \text{Log10 (penetration / mm)}$$

It should be noted that made ground was encountered at a depth of 0.70m bgl at its shallowest.

Full results of the DCP tests including the calculated CBR values are presented in Appendix 5.

Figure 14 below shows the locations of the DCP tests in relation to the proposed development.

Figure 14 DCP Location Plan



4.5 Groundwater

Groundwater seepages encountered during the fieldwork within the natural soils at depths of 6.30m bgl in BH1.

Perched groundwater was encountered in TP9 at depths of 2.60m bgl.

Groundwater levels were recorded to be between 0.45m and 2.10m bgl during subsequent monitoring visits (WS3, 4 & 9). No groundwater was encountered in WS1 & 7 and therefore could not be sampled. After purging, ground levels were in line with the depth at which natural clay were encountered, indicating that ground water is perched on top on the underlying natural strata.

5.0 ENGINEERING PROPERTIES OF SOILS ENCOUNTERED

The following sections discuss the engineering properties of the strata encountered within the footprint of the proposed new building (WS9 and BH1 to BH3), based on results of in-situ testing obtained during this investigation.

5.1 Made Ground

Made Ground

Both cohesive and granular made ground was encountered in each of the exploratory holes to depths of between 2.20m bgl (BH1) and 4.20m bgl (BH3). Made ground is not typically considered to be a suitable founding material, and as such, no geotechnical testing was carried out on the material.

Standard Penetration Tests (SPTs) were carried out within the Made Ground material. The SPT tests resulted in **SPT N values** ranging from 4 to 13. The variation in results indicates that the Made Ground is heterogenous and of variable strength.

Sulphate content and pH value determination tests were carried out on four samples of the Made Ground by the chemical laboratory. The **water-soluble sulphate** content of the samples ranged between 270 mg/l SO_4 to 340 mg/l SO_4 with **pH values** of 6.9 to 7.0.

5.2 Devensian Till

As discussed in Section 4.1, the Devensian Till was found to vary in composition vertically and laterally. The Glacial Till was encountered as a Silty Sandy Gravelly Clay and in rare horizons Clayey, Silty, Gravelly Sand.

Natural clay inferred to represent Glacial Lacustrine Deposits was encountered in all of the boreholes beneath the Made Ground within the proposed building area.

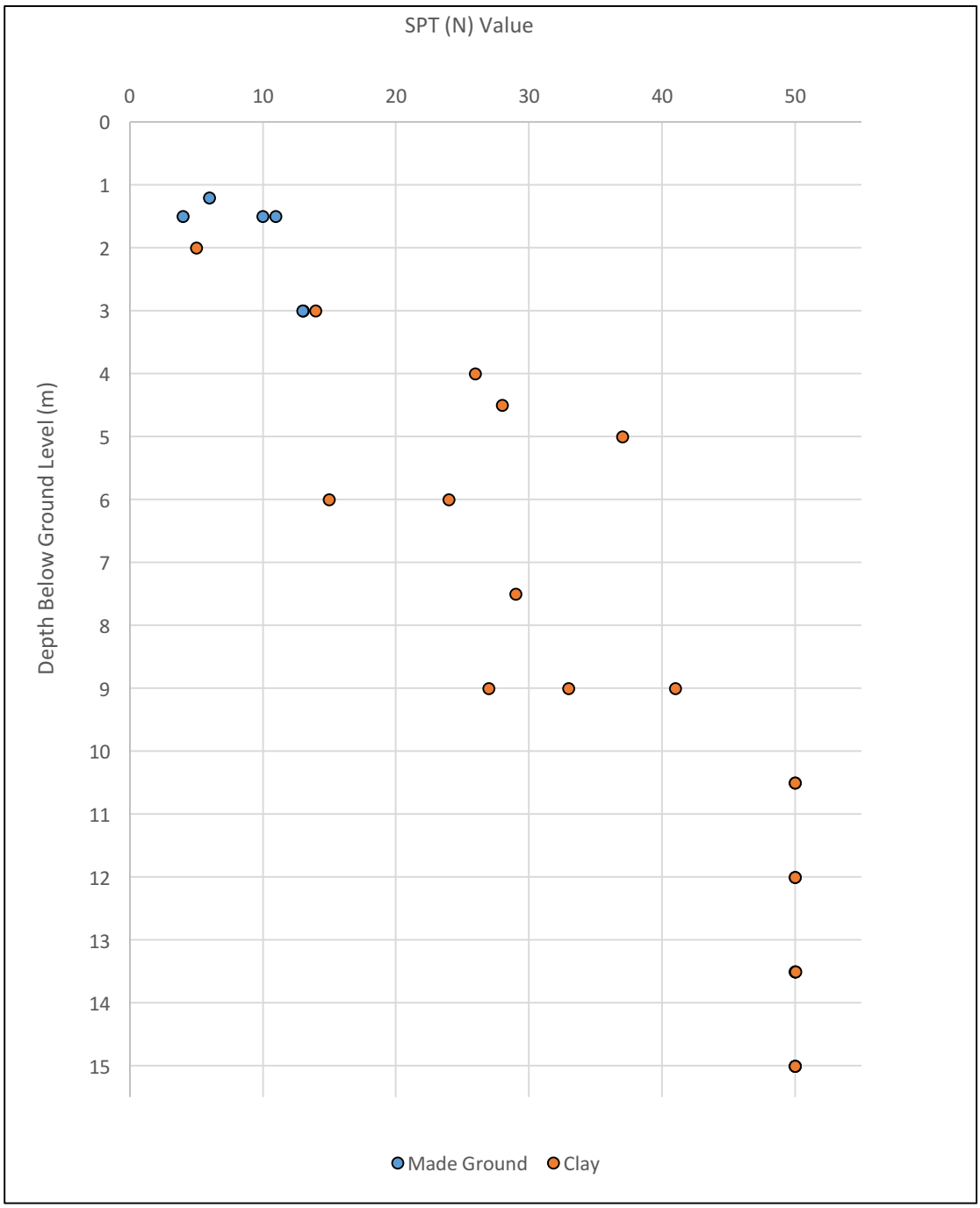
SPT tests carried out in the Clay resulted in SPT N values of between 5 and 50, as shown on the SPT v Depth Plot below (Figure 15). These results suggest the Clay is soft to very stiff.

Sulphate content and pH value determination tests were carried out on four samples of the Made Ground by the chemical laboratory. The **water-soluble sulphate** content of the samples ranged between 300 mg/l SO_4 to 380 mg/l SO_4 with **pH values** of 7.0 to 7.2.

In-situ hand vane (HV) tests were carried out on the recovered soils. The results of the HV tests in the Silty Sandy Gravelly Clay ranged between 58kN/m^2 to >130kN/m^2, with an average shear strength value of 115kN/m^2.

The results of the HV testing and laboratory testing are included in the Strength vs Depth Plot presented as Figure 16 in the following section.

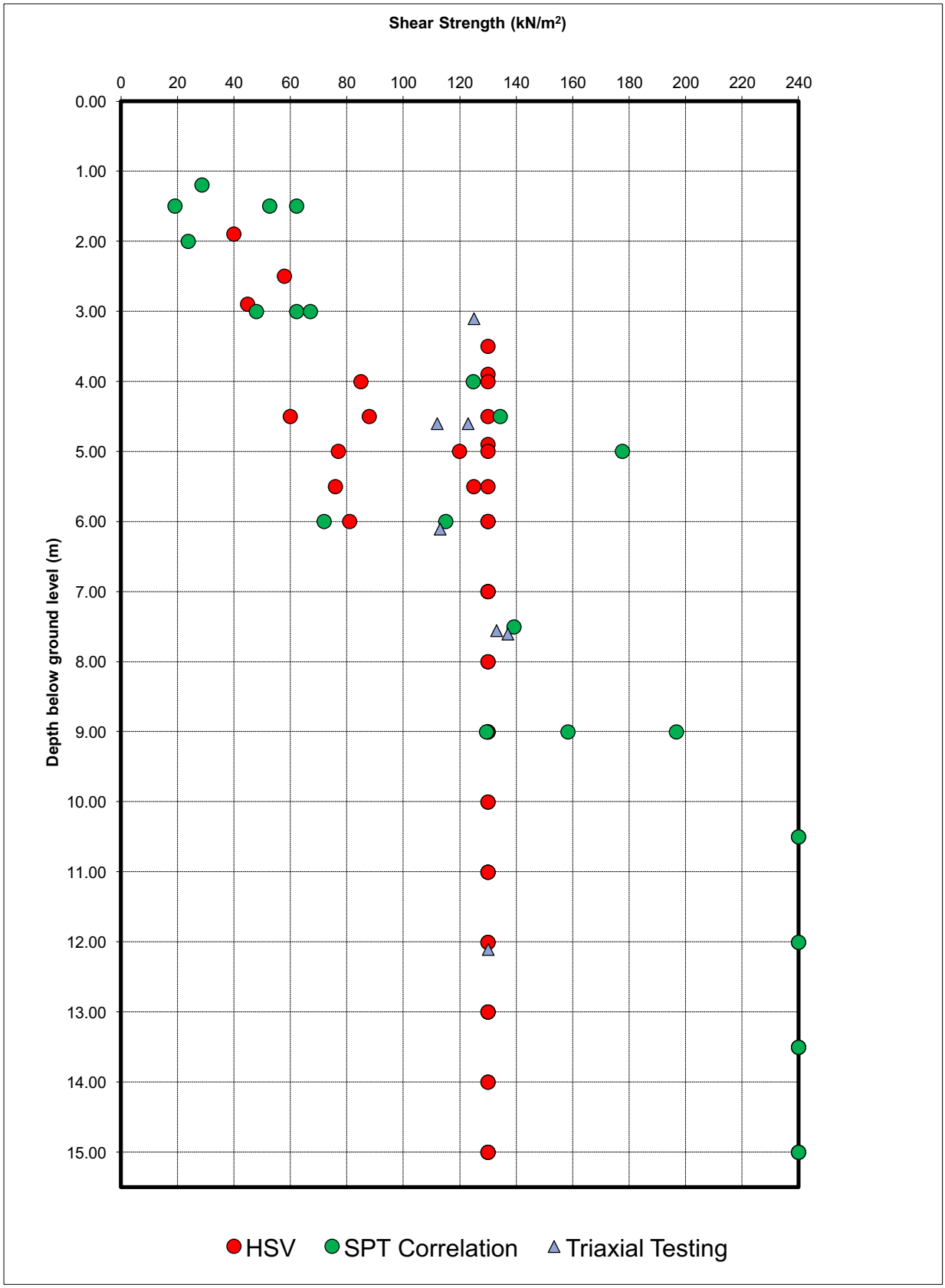
Figure 15 SPT vs Depth Plot



The SPT plot indicates a gradual increase in shear strength with depth. In situ hand vane (HV) tests were also carried out on the recovered soils. The results of the HV tests range between 58kN/m^2 to >130kN/m^2.

Figure 15, overleaf, shows the results of the HV and triaxial testing plotted alongside equivalent shear strength values derived from SPT N values, based on correlations by Stroud and Butler (1975).

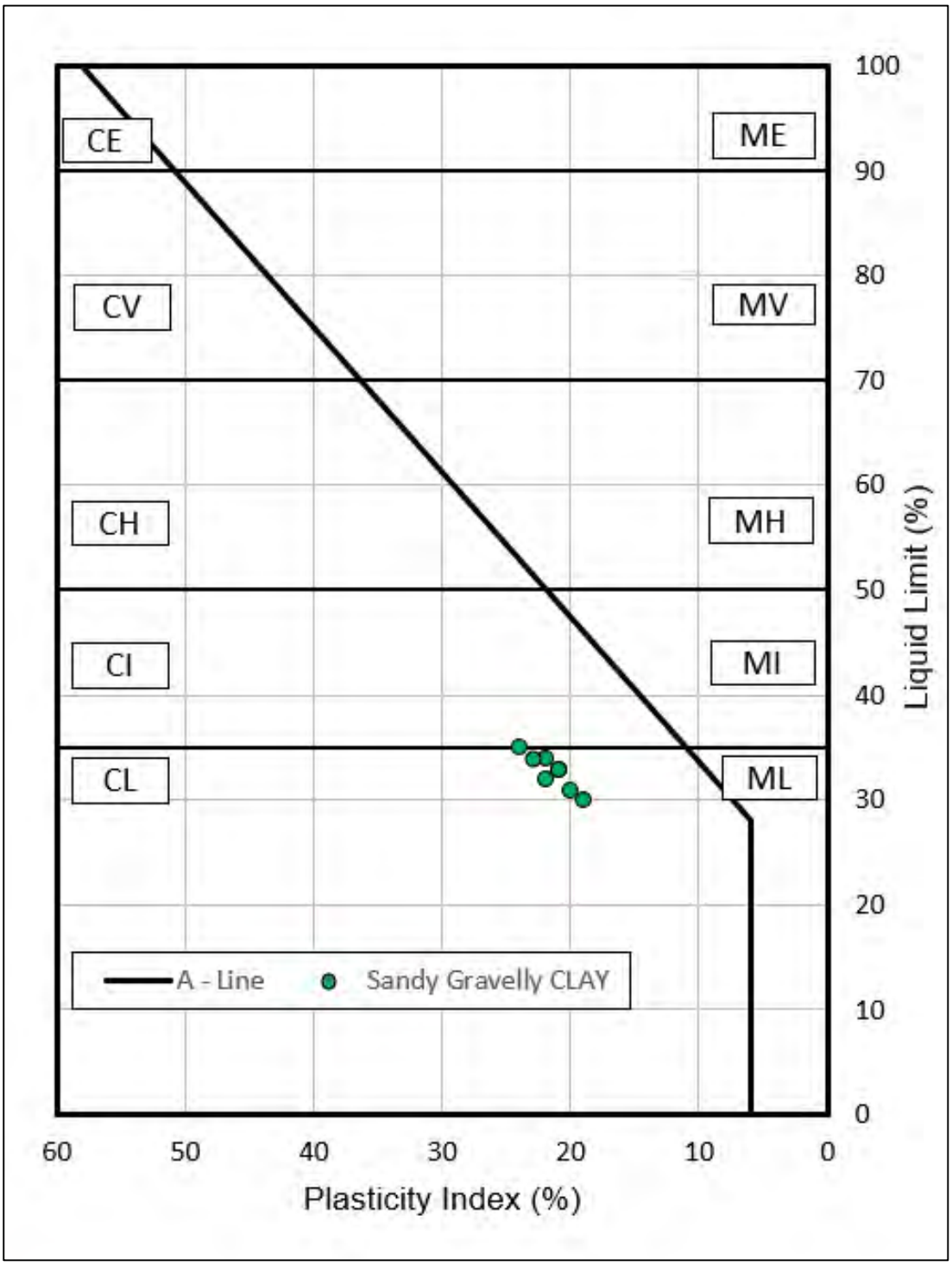
Figure 16 Strength vs Depth Plot



Atterberg Limit tests were carried out on four samples of the Sandy Gravelly Clay. Results of the tests reported **liquid limit** values of between 30% and 35%, and **plastic limit** values of between 10% and 12%, resulting in **plasticity index** values of 19% to 24%. These results suggest the Sandy Gravelly Clay to be of **low to intermediate plasticity**.

Results are shown on the Plasticity Chart below. Full test results are included in Appendix 3.

Figure 17 Plasticity Chart



For design purposes, a value of plasticity index = 21.5% is recommended, based on the average of the results.

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

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

Ip' = modified plasticity index
Ip = plasticity index.

Based on the laboratory test results, the above relationship and Table 1 of NHBC Chapter 4.2, the samples of Sandy Gravelly Clay have a **low volume change potential**.

In some locations, the soils appeared very stiff and dry, indicative of potential desiccation. 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 3 below.

Table 3: Soil Desiccation Indicators in the Sandy Gravelly Clay

Location	Depth (m)	Liquid Limit (%)	40% Liquid Limit (%)	Natural Moisture Content (%)	Desiccation
BH1	3.80	34	13.6	17	No
BH1	5.50	34	13.6	17	No
BH1	10.00	30	12.0	5.6	Yes
BH2	5.00	33	12.2	14	No
BH2	2.60-3.00	35	14.0	17	No
BH2	10.50-11.00	32	12.8	10	Yes
BH3	12.00	31	12.4	13	No
BH3	4.00-4.45	33	13.4	14	No

The results in the above table show that the soils in BH1 (10.00m) and BH2 (10.50-11.00m) present evidence of desiccation.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Development

It is understood that the client intends to further develop existing workshop and classroom facilities within the main Whitworth House block. The scheme will involve the demolition of a number of existing buildings to allow for the construction of a new adjoining block containing sports hall, gym and changing facilities, together with a new 4G pitch and additional car parking.

6.2 Ground Conditions

The exploratory holes within the area of the proposed building (WS9 & BH1-3) encountered Made Ground (to a maximum depth of 4.20m bgl) over firm/stiff natural clays.

A groundwater seepage was encountered during the fieldwork within the natural soils at depth of 6.30 bgl.

6.3 Foundation Considerations

Conventional shallow strip/pad foundations are considered suitable for the site, however deep made ground has been found at BH3, which could be associated with a retaining wall. Further investigation of ground conditions is recommended within this area.

A Characteristic Value of uncorrected SPT N value has been calculated measured in the cable percussive and window sampling boreholes within the Sports Block and Workshop building areas.

The Characteristic N value is 33.72, which converts to an undrained shear strength, based on Stroud and Butler (1975) of 151kN/m^2.

Laboratory undrained triaxial testing has been conducted on seven U100 samples and has recorded values varying from 105KN/m^2 to 128kN/m^2, for a depth range of 3m to 12m. An average value of 116kN/m^2 has been estimated.

The laboratory undrained triaxial test data has been used to make an estimate of the soil allowable bearing capacity. Table 4 (below) provides a summary of the estimates based on Hansens Method using an overall factor of Safety of 3, and average undrained triaxial value of 116kN/m^2.

Table 4: Assessment of Allowable Bearing Capacity

Pad Foundation Width (m)	Depth (m)	Allowable Bearing Capacity (kN/m^2)	Average Consolidation Settlement for Column Loading of 1200KN (mm)
1.0	2.5	365	52
1.5	2.5	350	58
2.0	2.5	338	70
2.5	2.5	327	88

The coefficient of volume compressibility (m_v) has been estimated from Stroud and Butler 1975 using a Characteristic SPT N value of 33.72. The average plasticity index of the clay soils is 29%.

The average mv is estimated to be 1x (440 x Average SPT N) which is 0.0673 $m^{2/}MN$, which is consistent with as value for an overconsolidated glacial clay.

Average consolidation settlement has been estimated for depth range of 1.5 x foundation width. The foundation settlement varies from 52mm to 88mm depending on the foundation width.

It should be noted that a previous geotechnical assessment by Allied Exploration & Geotechnics Ltd, dated January 2004, established an allowable bearing capacity of $250kN/m^2$.

Settlement calculations were also made for foundation pressures of $100kN/m^2$ to $250kN/m^2$, with values of 15.4mm to 38.6mm.

Foundations should be designed in accordance with NHBC Chapter 4.2, where constructed within the zone of influence of any trees. In this context soils beneath the site should be considered as having low volume change potential.

If any Made Ground, particularly loose or soft material is encountered at foundation level this should be excavated and replaced with suitable granular fill or the foundation extended to suitable strata. Floor slabs may be designed as ground bearing where Made Ground is excavated and replaced with suitable granular fill.

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

6.4 Ground Floor Slabs

Floor slabs should be designed as ground bearing subject to proof rolling of the formation and removal of any hots-spots.

6.5 Pavement Design

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

Based on the recommendations for design CBR values provided in Interim advice note 73/06, Revision 1 (2009), a CBR value for the underlying strata would need to achieve 4%.

A conservative design CBR value of 1% should be adopted in areas where Made Ground is encountered at subgrade level.

However, the results of the in-situ DCP testing carried out at the site indicated much higher CBR values at likely subgrade level across the site. The results are summarised in the following table:

Table 5: Summary of Recorded CBR %

Location (In Relation to Proposed Development)	DCP Test No.	Average CBR %
Car Park	DCP1	35.41*
	DCP2	35.62
	DCP3	48.71
	DCP4	13.79
	DCP5	26.26*
	DCP6	19.50*
	DCP7	53.31*
	DCP8	29.21*
4G Pitch	DCP9	81.66*
	DCP10	33.50
	DCP11	23.41
	DCP12	146.79*
	DCP13	28.91
	DCP14	32.49
	DCP15	16.68
	DCP16	33.38
	DCP17	27.44
	DCP18	44.46
*Test refused on cobble associated with historic demolition fill.		

Full results are presented in Appendix 5.

Once formation level for the new road pavements has been achieved, 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.

Exposed subgrades are likely to deteriorate rapidly on exposure to wet weather and should be shaped to shed water. Subbase should be placed as soon as possible to minimise the exposure of subgrade to adverse weather conditions.

6.6 Soil Infiltration Rates

6.6.1 Soakaways in Trial Pits

Two soakaway pits (TP6 & TP9) were excavated within the area of the proposed 4G football pitch, however due to the depth of made ground, the natural strata was only encountered in TP9 (at a depth of 1.60m bgl).

Due to the presence of deep made ground and slow rate of infiltration observed across the area, the infiltration rates for the two tests were unable to be calculated.

Table 6 (below) provides a summary of each of the soakaway infiltration rate results.

Table 6 Soakaway Infiltration Rates

Location/Test	Infiltration Rate (m/s)
TP6/SA01	Disregarded due to deep made ground
TP9/SA02	Infiltration too slow to calculate

6.6.1 Falling head tests in Boreholes

Five falling head tests (WS1,3,4,7 & 9) were carried, however due to the depth of made ground, the natural strata was only encountered in WS3, 4 & 9.

Due to the presence of deep made ground and slow rate of infiltration observed across the area, the infiltration rates for all tests had to be disregarded.

Table 7 (below) provides a summary of each of the soakaway infiltration rate results.

Table 7 Falling head Infiltration Rates

Location/Test	Infiltration Rate (m/s)
WS1	Disregarded due to deep made ground
WS2	Disregarded due to perched water table on top of glacial till displaying poor permeability
WS4	Disregarded due to perched water table on top of glacial till displaying poor permeability
WS7	Disregarded due to deep made ground
WS9	Disregarded due to perched water table on top of glacial till displaying poor permeability

Soakaway and failing head testing has proven that soakaways are not suitable onsite as a means of drainage. This is due to the presence of deep made ground and the nature of the impermeable underlying glacial till.

6.7 Chemical Attack on Buried Concrete

Chemical testing of a sample taken from beneath the site show low levels of water-soluble sulphates and near neutral conditions.

Based on these conditions, it is recommended that for foundations the Design Sulphate Class for the site, as defined in BRE Special Digest 1(2005), be taken as DS-1, and the Aggressive Chemical Environment for Concrete (ACEC) site classification be taken as AC-1.

The recommendations of BRE Special Digest 1 should be followed for concrete foundations and ground bearing floor slabs.

6.8 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.

Demolition rubble may be re-used as structural fill, providing it is not contaminated and subject to processing (breaking down etc.). Granular Made Ground could be suitable as structural fill providing it is not contaminated and does not have excessive amounts of clay.

The material could be used a backfill to retaining walls with an assumed angle of internal friction of thirty degreed and K_a 0.30. K_o 0.46 and K_p 3.35.

6.9 Temporary Works

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

Excavations in Made Ground are likely to be unstable and should be battered back to an angle of 1 in 2, or a system of close sheeting and shoring adopted to ensure stability, and in particular where personnel are required to enter excavations. All excavations should be adequately supported where personnel are required to enter.

Groundwater seepages could be encountered near surface within excavations, particularly during the wetter months of the year. Pumping of excavations from a suitable located sump is likely to be required to keep excavations dry.

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

7.0 SOIL CONTAMINATION RISK ASSESSMENT

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

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

The guideline values and laboratory test results are summarised in the following table:

Table 8: Summary of Guideline Values for Protection of Workers and the General Public During Development of Contaminated Land

Contaminant	Typical Values* for:					Test Results	Class
	Uncontaminated Soils	Slight Contamination	Contaminated	Heavy Contamination	Unusually Heavy Contamination		
	Class A	Class B	Class C	Class D	Class E		
pH (alkaline)	7 - 8	8 - 9	9 - 10	10 - 12	12	72.-10.1	A-D
Arsenic	0 - 30	30 - 50	50 - 100	100 - 500	500	5-37	A-B
Cadmium	0 - 1	1 - 3	3 - 10	10 - 50	50	< 0.2-0.4	A
Chromium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	7-179	A-B
Copper	0 - 100	100 - 200	200 - 500	500 - 2500	2500	6-333	A-C
Lead	0 - 500	500 - 1000	1000 - 2000	2000 – 1%	1.0%	39-874	A-B
Mercury	0 - 1	1 - 3	3 - 10	10 - 50	50	< 1	A
Nickel	0 - 20	20 - 50	50 - 200	200 - 1000	1000	5-195	A-C
Zinc	0 - 250	250 - 500	500 - 1000	1000 - 5000	5000	18-263	A-B
Boron	0 - 2	2 - 5	5 - 50	50 - 250	250	< 1-2.1	A-B
Beryllium	0 - 5	5 - 10	10 - 20	20 - 50	50	< 0.5-4.5	A
Vanadium	0 - 100	100 - 200	200 - 500	500 - 2500	2500	10-302	C
Sulphate	0 - 2000	2000 - 5000	5000 – 1%	1% - 5%	5.05%	273-3011	A-B
Sulphide	0 - 10	10 - 20	20 - 100	100 - 500	500	< 5	A
Cyanide (free)	0 - 1	1 - 5	5 - 50	50 - 100	100	< 2	A
Phenol	0 - 2	2 - 5	5 - 50	50 - 250	250	< 2	A

Based on the above results the soils are classified as a combination of non-contaminated, slightly contaminated, contaminated and anomaly of heavy contamination.

The overall potential risk from soil contamination to construction workers, ground workers and members of the public during construction is therefore considered moderate to low.

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

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

At a Tier I stage the long term (chronic) human health toxicity of the soil has been assessed with reference to DEFRA/Environment Agency Contaminated Land Exposure Assessment (CLEA) Soil Guideline Values (SGV) for generic site land uses, soils and exposure relevant to a Commercial end use.

Where Environment Agency generic guidance is absent, reference has been made to the Chartered Institute of Environmental Health (CIEH) S4ULs for human health risk assessment.

In the case of arsenic, cadmium, hexavalent chromium, lead and benzo(a)pyrene DEFRA Category 4 Screening levels have been adopted. A conservative Soil Organic Matter (SOM) of 1% has been adopted for organic chemicals for the purposes of the initial assessment. A SOM of 6% has been adopted for inorganic chemicals as detailed in 'The LQM / CIEH S4ULS for human health assessment', (2015).

The soil chemical testing results are presented in Appendix 2 and summarised in Table 9, overleaf.

Table 9: Assessment of Soil Chemical Data

Parameter	TP2 0.50m MG	TP5 1.20m MG	TP6 1.00m MG	TP7 0.40m MG	TP7 1.00m MG	TP8 0.70m MG	TP9 0.50m MG	BH2 0.60m MG	BH3 3.00m MG	WS1 0.50m MG	WS3 0.50m MG	WS4 0.60m MG	WS6 1.30m MG	WS10 1.30m MG	IP2 0.70m MG	BH1 1.50m MG	Assessment Criteria (mg/kg)
Arsenic	15	23	22	10	37	7	19	15	18	12	5	10	23	7	22	14	640
Boron	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.1	240000
Beryllium	0.9	< 0.5	1.2	0.5	3.4	0.6	4.5	1.3	2.1	0.9	< 0.5	1	1.1	1	1.7	1.2	12
Cadmium	0.3	< 0.2	< 0.2	0.2	0.4	< 0.2	< 0.2	0.4	0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	0.3	< 0.2	410
Chromium III	17	61	29	16	61	14	16	13	31	17	7	15	24	17	179	19	8600
Free Cyanide	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	34
Chromium VI	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	49
Copper	55	189	137	52	176	21	148	74	174	38	6	57	333	33	288	42	68000
Lead	122	348	501	125	307	53	103	89	874	95	12	472	88	39	297	455	2300
Mercury	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1100
Nickel	18	106	97	33	120	12	43	32	52	14	5	19	37	25	194	24	980
Selenium	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	12000
Vanadium	27	34	31	16	62	14	50	29	29	21	10	23	25	21	302	37	9000
Zinc	112	108	158	83	239	57	98	112	201	121	18	74	96	241	263	36	73000
pH	7.6	7.7	7.3	7.2	7.3	7.5	7.4	8.4	9	8	8.1	10.1	8.8	8.1	8.1	7.5	N/A
Naphthalene	0.19	0.19	0.51	0.26	2.23	0.12	1.08	0.68	0.57	0.65	< 0.1	1.63	10.6	0.34	0.97	0.21	190 (76.4) [sol]
Acenaphthylene	< 0.1	< 0.1	0.2	< 0.1	0.18	< 0.1	0.13	0.18	0.14	< 0.1	< 0.1	< 0.1	0.35	< 0.1	0.51	< 0.1	84000 (57.0) [sol]
Acenaphthene	0.2	< 0.1	0.32	< 0.1	0.25	< 0.1	< 0.1	0.18	0.31	0.69	< 0.1	2.59	0.57	0.21	0.6	0.41	83000 (86.1) [sol]
Fluorene	0.22	0.14	0.37	< 0.1	0.38	0.2	0.21	0.23	0.31	0.54	0.18	1.56	0.59	0.29	1.1	0.37	63000 (30.9) [sol]
Phenanthrene	1.38	1.07	2.27	0.71	3.68	0.98	1.38	1.99	2.04	4.69	0.32	9.68	3.19	1.49	6.41	2.87	22000
Anthracene	0.33	0.29	0.87	0.14	0.95	0.29	0.36	0.49	0.55	1.01	< 0.1	2.29	0.74	0.31	1.72	0.65	520000
Fluoranthene	2.28	2.01	3.79	1.05	4.25	1.46	1.48	3.28	3.02	5.68	< 0.1	9.85	3.06	1.69	9.6	4.46	23000
Pyrene	2.04	1.76	3.62	0.99	3.69	1.31	1.18	2.84	2.53	4.89	0.15	10.2	2.3	1.6	7.46	4.41	54000
Benzo(a)anthracene	1.19	1.16	2.72	0.58	2.24	0.76	0.92	1.45	1.55	2.33	< 0.1	6.22	1.42	0.91	4.91	2.37	170
Chrysene	1.02	1.05	2.35	0.57	2.05	0.53	0.72	1.22	1.26	2.32	< 0.1	6.69	1.23	0.89	4.07	2.22	350

Parameter	TP2 0.50m MG	TP5 1.20m MG	TP6 1.00m MG	TP7 0.40m MG	TP7 1.00m MG	TP8 0.70m MG	TP9 0.50m MG	BH2 0.60m MG	BH3 3.00m MG	WS1 0.50m MG	WS3 0.50m MG	WS4 0.60m MG	WS6 1.30m MG	WS10 1.30m MG	IP2 0.70m MG	BH1 1.50m MG	Assessment Criteria (mg/kg)
Benzo(b)fluoranthene	1.47	1.54	2.97	0.81	2.67	0.76	1.05	1.66	1.87	2.95	< 0.1	7.03	1.67	0.98	5.63	1.94	44
Benzo(k)fluoranthene	0.54	0.57	1.05	0.22	0.91	0.33	0.43	0.58	0.67	0.94	< 0.1	2.13	0.52	0.29	1.75	0.5	1200
Benzo(a)pyrene	1.18	1.01	2.14	0.46	1.48	0.6	0.59	1.29	1.34	2.55	< 0.1	5.86	0.92	0.7	3.33	1.29	35
Indeno(1,2,3-cd) pyrene	0.92	0.87	1.44	0.31	0.97	0.41	0.49	0.93	0.95	1.38	< 0.1	2.49	0.52	0.33	1.63	0.74	500
Di-benz (a,h)anthracene	0.14	0.14	0.28	< 0.1	0.19	< 0.1	< 0.1	0.13	0.15	0.22	< 0.1	0.49	< 0.1	< 0.1	0.32	0.15	3.5
Benzo(ghi)perylene	0.72	0.71	1.3	0.24	0.73	0.28	0.34	0.75	0.74	1.19	< 0.1	2.39	0.47	0.36	1.3	0.58	3900
Phenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	760
Benzene	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.005	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.004	< 0.002	27
Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.009	< 0.005	< 0.005	< 0.005	56000 (869)^{vap}
Ethylbenzene	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.010	< 0.002	< 0.002	< 0.002	< 0.002	5700 (518) ^{Vap}
Xylene	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.011	< 0.005	< 0.002	< 0.002	< 0.002	6600 (478) ^{sol}
Aliphatic >C5 - C6	< 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	< 0.01	< 0.01	< 0.01	3200 (304)^{sol}
Aliphatic >C6 - C8	< 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	< 0.05	< 0.05	< 0.05	7800 (144)^{sol}
Aliphatic >C8 - C10	< 2	< 2	< 2	< 2	< 2	< 2	10	< 2	< 2	< 2	59	< 2	< 2	< 2	< 2	62	2000 (78)^{sol}
Aliphatic >C10 - C12	< 2	< 2	< 2	< 2	< 2	< 2	3	< 2	< 2	< 2	266	< 2	< 2	< 2	< 2	84	9700 (48)^{sol}
Aliphatic >C12 - C16	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	1086	< 3	< 3	59	< 3	81	59000 (24)^{sol}
Aliphatic >C16 - C21	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	4	< 3	489	< 3	< 3	199	3	< 3	1,600,000
Aliphatic >C21 - C34	< 10	82	< 10	< 10	< 10	< 10	< 10	50	74	< 10	52	81	48	712	75	< 10	1,600,000
Aromatic >C5 - C7	< 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	< 0.01	< 0.01	< 0.01	26000 (1220)^{sol}
Aromatic >C7 - C8	< 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	< 0.05	< 0.05	< 0.05	56000 (869)^{Vap}
Aromatic >C8 - C10	< 2	< 2	< 2	< 2	5	< 2	< 2	< 2	< 2	< 2	7	< 2	7	< 2	< 2	11	3500 (613)^{Vap}
Aromatic >C10 - C12	< 2	< 2	< 2	< 2	4	< 2	< 2	< 2	< 2	< 2	44	< 2	25	< 2	< 2	26	16000 (364)^{sol}
Aromatic >C12 - C16	8	< 2	4	< 2	22	< 2	5	3	3	7	415	24	38	29	12	43	36000 (169)^{sol}
Aromatic >C16 - C21	16	9	20	< 3	52	< 3	10	16	15	28	321	90	57	175	46	32	28000
Aromatic >C21 - C35	86	79	99	< 10	135	< 10	45	257	126	139	95	346	179	924	162	62	28000
Asbestos	D	ND	ND	ND	D	D	ND	ND	ND	D	ND	D	D	ND	D	ND	<0.001%

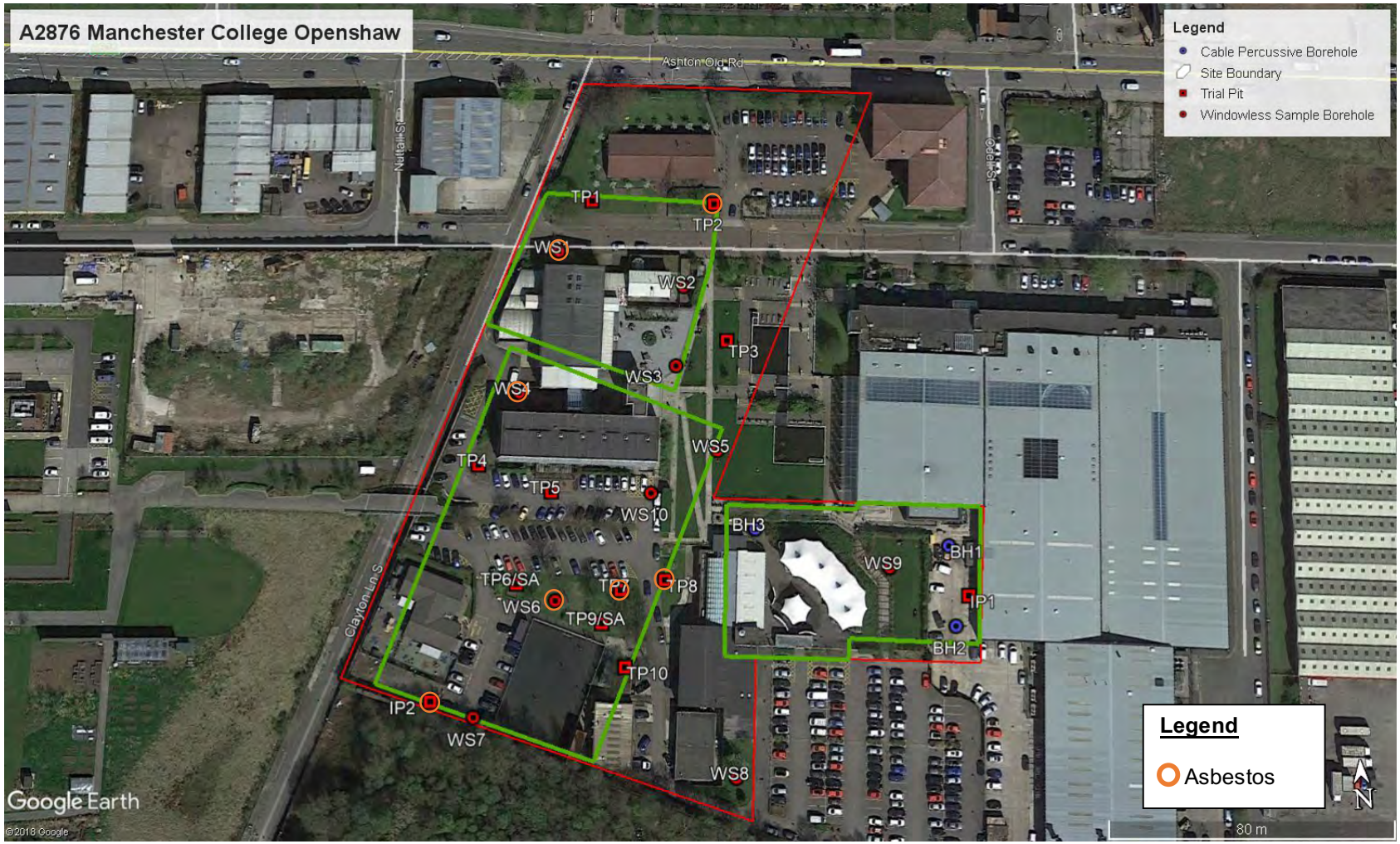
Notes for Table 9
All units in mg/kg
Assessment criteria based on Commercial/Industrial end use (1% SOM).
Concentrations in red above assessment criteria
ND = Not Detected, D = Detected

As shown in Table 8, none of the samples analysed contained concentrations of the contaminants tested for in exceedance of their screening criteria relevant to commercial end use.

However, asbestos was detected in seven samples. The asbestos was identified to be bundles of chrysotile fibres in TP7, TP8, WS1, WS6 and IP2) and bundles of amosite fibres in WS4 and TP2).

Further quantification testing of the asbestos fibres is required in order to provide a more robust risk assessment.

Figure 18 Locations of detected Asbestos



7.3 Soil Waste Assessment

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

Based on this assessment, the soil samples tested have been classified as a mixture of Hazardous and Non-Hazardous.

Additional Waste Acceptance Criteria testing was also carried out on five of the soil samples to determine whether they could be classified as inert. The results of which are presented in Table 10 below.

The results are summarised below and presented in full in Appendix 4.

Table 10: Waste Classification of Soils

Location	Depth (m bgl)	HazWasteOnline Classification	WAC Classification
TP2	0.50	Non-Hazardous	-
TP5	1.20	Non-Hazardous	Non-Hazardous
TP6	1.00	Non-Hazardous	-
TP7	0.40	Non-Hazardous	-
TP7	1.00	Non-Hazardous	-
TP8	0.70	Non-Hazardous	-
TP9	0.50	Non-Hazardous	-
BH1	1.50	Non-Hazardous	-
BH2	0.60	Non-Hazardous	Inert
BH3	3.00	Non-Hazardous	Non-Hazardous
WS1	0.50	Non-Hazardous	-
WS3	0.50	Hazardous	-
WS4	0.60	Non-Hazardous	Inert
WS6	1.30	Non-Hazardous	-
WS10	1.30	Hazardous	-
IP2	0.70	Non-Hazardous	Non-Hazardous

It should be noted that a reassessment may be required on receipt of the asbestos quantification results. Concentrations on asbestos >0.1% would reclassify the soil as Hazardous.

8.0 GROUNDWATER CONTAMINATION RISK ASSESSMENT

All wells were purged prior to sampling using a dedicated bailer and string at each location to prevent cross contamination.

Two groundwater samples were retrieved from the monitoring standpipes within WS4 and WS9.

All water samples were placed in dark amber bottles jars and stored in a cool box for transport to the chemical laboratory.

Chemical testing has been performed by DETS Environmental a UKAS and MCERTS accredited laboratory (report number: 19-06010.1) for a wide range of analytes including:

pH, Total Sulphate, Sulphide, Total Cyanide, As, Cr, Cr (vi), Cu, Pb, Se, Zn, Cd, Hg, Ni, Vanadium, Barium, Beryllium, WS Boron, Mono Phenol, Speciated PAH and speciated TPH.

The results from the groundwater testing have been compared to UK Drinking Water Standards, Environmental Quality Standards (for the protection of ecology in waters) and World Health Organisation Standards. The assessment criteria should therefore be viewed as very conservative.

Full results are included in Appendix 2 and summarised in Table 11, below.

Table 11: Assessment of Groundwater Chemical Data

Parameter	WS4	WS9	Assessment Criteria (µg/l)	Source
Arsenic, Dissolved	< 5	< 5	10	EQS/UK DWS
Barium, Dissolved	56	121	700	
Beryllium, Dissolved	< 3	< 3	No Standard	
Boron	66	135	1000	UK DWS
Cadmium, Dissolved	< 0.4	< 0.4	5	UK DWS
Chromium, Dissolved	< 5	< 5	50	UK DWS
Hexavalent Chromium	< 20	< 20	50	EQS Freshwater
Copper, Dissolved	11	< 5	2000	UK DWS
Lead, Dissolved	< 5	< 5	10	UK DWS
Mercury, Dissolved	< 0.05	< 0.05	1	UK DWS
Nickel, Dissolved	6	< 5	20	UK DWS
Selenium, Dissolved	6	< 5	10	UK DWS
Vanadium, Dissolved	< 5	< 5	20	EQS Freshwater
Zinc, Dissolved	27	186	3000	UK DWS
Benzo(a)pyrene	< 0.01	< 0.01	0.03	EQS Freshwater
Cyanide	< 5	< 5	50	UK DWS
Fluoranthene	0.01	< 0.01	0.2	EQS Freshwater
Naphthalene	< 0.01	0.04	10	EQS Freshwater
pH	7.1	7	6.5-9.5	UK DWS
Phenol	< 10	< 10	No Standard	EQS Freshwater

Parameter	WS4	WS9	Assessment Criteria (µg/l)	Source
Total PAH^^	0.01	0.01	<0.1	UK DWS
Toluene	< 5	< 5	700	WHO Drinking Water Guideline
Benzene	< 1	< 1	10	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C5 - C6	< 10	< 10	10	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C6 - C8	< 10	< 10	10	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C8 - C10	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C10 - C12	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C12 - C16	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C16 - C21	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aliphatic >C21 - C34	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aromatic >C5 - C7	< 10	< 10	10	WHO Drinking Water Guideline
TPH CWG - Aromatic >C7 - C8	< 10	< 10	700	WHO Drinking Water Guideline
TPH CWG - Aromatic >C8 - C10	< 10	< 10	300	WHO Drinking Water Guideline
TPH CWG - Aromatic >C10 - C12	< 10	< 10	90	WHO Drinking Water Guideline
TPH CWG - Aromatic >C12 - C16	< 10	< 10	90	WHO Drinking Water Guideline
TPH CWG - Aromatic >C16 - C21	< 10	< 10	90	WHO Drinking Water Guideline
TPH CWG - Aromatic >C21 – C35	< 10	< 10	90	WHO Drinking Water Guideline

Notes for Table 10
Concentrations in **red** above assessment criteria
UKDWS: United Kingdom Drinking Water Standards
EQS Freshwater: Environment Agency Environmental Quality Standard for Freshwater
All assessment criteria derived from EA Chemical Standards Database & CL:AIRE Petroleum Hydrocarbons in Water, Version 1.1, 29th March 2017 and EA Chemicals Standards Database
^^ based on sum of benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(12,3-c,d)pyrene

From the above it appears that each of the samples tested contained no concentrations of contaminants of concern in excess of conservative drinking water and ecological standards.

9.0 GROUND GAS RISK ASSESSMENT

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

Four gas monitoring visits have been completed by Earth Environmental & Geotechnical Ltd.

The monitoring visits were conducted at the site between 25th April and 15th May 2019 and the results obtained recorded methane (CH_4) levels of between 0.0% and 0.4% by volume (v/v) and carbon dioxide (CO_2) levels ranging from 0.0% to 1.3% v/v. Oxygen concentrations of between 1.7% and 20.3% v/v were also recorded.

Gas flow rates were recorded using a dedicated flow meter. A maximum flow rate of 0.6l/hr was detected in the boreholes. Atmospheric pressure was recorded to be between 986mb and 1021mb.

Full results of the monitoring to date are presented in Appendix 7.

Table 8.5 of CIRIA Report 665 (2007), presented below as Table 12, provides information on current UK practice with respect to appropriate gas protection measures based upon a Gas Screening Value (GSV). A GSV for the site has been obtained by multiplying the maximum concentration of gas by the maximum flow rate, which represents worst-case scenario conditions.

- Carbon dioxide: maximum flow rate = 0.6/hr, max concentration = 1.3%
- Methane: maximum flow rate = 0.6/hr, max concentration = 0.4%.

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

- **Carbon dioxide**: GSV = 0.6 x 1.3 / 100 = **0.0078litres/hr**
- **Methane**: GSV = 0.6 x 0.4 / 100 = **0.0024litres/hr**

The above results suggest the site can be given a Characteristic Situation-1 (CS-1), i.e. ‘very low risk’ classification, in accordance with the table overleaf.

NHBC Guidance on Carbon Dioxide and Methane’ (2007) requires the gassing regime to be assessed in accordance with the traffic-light classification system. The site would be classified as Green.

Table 12: Modified Wilson & Card Classification (CIRIA Report 665)

Characteristic Situation (CIRIA Report 149)	*Risk Classification*	*GSV (CH_4 or CO_2) (l/hr)*	*Additional Factors*	*Typical Source of Generation*
1	Very Low Risk	<0.07	Typically, methane ≤1%v/v and/or carbon dioxide ≤5% v/v. Otherwise consider increase to Situation 2.	Natural Soils with low organic content. "Typical" Made Ground.
2	Low Risk	<0.7	Borehole flow rate not to exceed 70l/hr. Otherwise increase to Situation 3.	Natural soil, high peat/organic content. "Typical" Made Ground.
3	Moderate Risk	<3.5		Old landfill, inert waste, mineworking flooded.
4	Moderate to High Risk	<15	Quantitative risk assessment required to evaluate scope of measures required.	Mineworking susceptible to flooding, completed landfill (WMP 26B criteria)
5	High Risk	<70		Mineworking unflooded inactive with shallow workings near surface.
6	Very High Risk	>70		Recent landfill site.

10.0 REVIEW OF CONCEPTUAL MODEL

A Revised Conceptual Model has been prepared for the site and is presented as Table 15, overleaf. The Revised Conceptual Model reviews the Preliminary Conceptual Model (PCM) presented as Table 5 in Section 6.0 of EEG Phase 1 GeoEnvironmental Investigation report (Reference: A2876/19, dated May 2019) using the information obtained during this site investigation and considers the source-pathway-receptor linkages present alongside the likelihood, severity and risk level as defined within Table 13 and Table 14 below. The assessment of probability, a modified risk table, and certain consequence definitions are based on CIRIA C552 and CLR11.

Table 14 considers whether a pollution linkage is present and provides a preliminary qualitative assessment of risk based on the information currently available. Where a possible linkage is identified, it does not necessarily mean that a significant risk exists but indicates that further information is required through appropriate site investigation to substantiate the conceptual model.

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

Table 13: Consequence, Probability and Risk

Probability	Consequence	Risk
High Likelihood- There is a pollution linkage and an event either appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution	Very High – acute risk to the human health likely to result in significant harm. Risk of severe or irreversible effect on ground/surface water quality. Catastrophic damage to buildings / property.	Very High – there is a high potential that the source-pathway-receptor scenarios may give rise to harm to human health or the environment and remedial action is likely to be required.
Likely – there is a pollution linkage and all the elements are present, which means that it is probable an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.	High – Severe or irreversible effect on human health. Temporary severe or irreversible effect on ground/surface water quality. Reduction of water quality rendering groundwater or surface water unfit to drink and/or substantial adverse impact on groundwater dependant environmental receptors.	High – it is likely that the source-pathway-receptor scenarios may give rise to an impact on human health or the environment, which may require remediation and/or control measures to mitigate risks
Low likelihood– there is a pollutant linkage and circumstances are possible for an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term	Moderate – Long term or short term moderate effect on human health. Moderate effect on ground/surface water quality, reversible with time. Reduced reliability of a supply at a groundwater or surface water abstraction source	Moderate – it is possible that the source-pathway-receptor scenarios may give rise to an impact on human health or the environment, however it is either relatively unlikely that such are would be severe, or if any harm were to occur it is more likely that harm would be mild.
Unlikely – there is a pollution linkage but circumstances are such that it is doubtful that an event would occur even in the very long term.	Low – Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.) Slight effect on ground/surface water quality, reversible with time. Marginal reduced reliability of a supply at a groundwater or surface water abstraction source.	Low – it is possible that harm could arise at the source, however it is likely that the risk would at worst be mild.
		Very Low – it is unlikely that the source-pathway-receptor scenarios will give rise to an impact on human health or the environment.

Table 14: Estimation of Level of Risk

		Consequence			
		High	Moderate	Low	Very low
Probability	High Likelihood	Very High	High risk	Moderate risk	Moderate to low risk
	Likely	High risk	Moderate risk	Moderate to low risk	Low risk
	Low Likelihood	Moderate risk	Moderate to low risk	Low risk	Very low risk
	Unlikely	Moderate to low risk	Low risk	Very low risk	Very low risk

10.1 Sources of Contamination

The Phase I Desk Study report for the site outlined the potential for the presence of soil and groundwater contamination associated with:

Previous developments on site including; a bleach works, engineering works and housing. Since the establishment of the college there has been numerous redevelopments of the site for college building. All of these are potential sources of made ground onsite.

Potential contaminants are likely to include: Heavy metals, Hydrocarbons, Inorganic Compounds, Asbestos).

The site investigation identified the following:

- Made Ground to a maximum depth of 4.20m bgl.
- Seven of the Made Ground soil samples contained concentrations of asbestos.

10.2 Receptors

The following receptors have been considered for the construction and operational stages of the proposed redevelopment.

- Current site users
- Adjacent land users
- Future land users
- Construction workers during site development works
- Underlying Groundwater/on site surface water course

10.3 Pollutant Pathways

The following pathways have been considered for the construction and operational stages of the proposed redevelopment.

- Direct contact via dermal contact, ingestion, inhalation of potentially contaminated soils.
- Downward vertical migration of contaminants to shallow groundwater and lateral migration to on-site drainage ditch.
- Vertical and lateral migration of ground gas associated with Made Ground soils.

Table 15: Revised Conceptual Model

Source	Pathway	Receptor	Probability	Consequence	Risk	Comment
Made Ground (Exceedances of Asbestos)	Dermal contact, ingestion and inhalation of soils dust	Current Site Users	Unlikely	Moderate	Low Risk	The site is currently covered in clean topsoil or hardstanding. The risk to current site users from potential contamination is considered to be LOW.
		Adjacent land users	Unlikely	Moderate	Low Risk	The site is currently covered in clean topsoil or hardstanding. The risk is considered LOW and usual dust control measures should be implemented as part of good site working practices during construction to reduce dust generation.
		Future land users	Unlikely	Moderate	Low Risk	Asbestos has been encountered in Made Ground soils at the site. The proposed development will include a building, 4G artificial pitch and carpark breaking the pathway from the receptor. The risk to future site users via direct exposure is therefore considered to be LOW. Appropriate remediation in the form of clean capping in proposed soft verge areas must be adapted.
		Construction Workers	Likely	Moderate	Moderate Risk	Construction workers are likely to be exposed to contaminated soils during construction works, however, assuming appropriate health and safety measures are adopted (in line with CDM and other relevant health and safety guidance) a LOW risk to construction workers is anticipated.
	Downward vertical/lateral leaching and migration of contaminants	Underlying shallow groundwater	Low Likelihood	Moderate	Moderate to Low Risk	Shallow groundwater was encountered beneath the site with no chemical exceedances. The underlying superficial soils are predominantly cohesive with generally low permeability which will inhibit migration to the underlying Secondary A and Principal aquifers. The risk to controlled waters is therefore considered LOW.

Source	Pathway	Receptor	Probability	Consequence	Risk	Comment
	Vertical or lateral migration of ground gas	Current Site Users	Unlikely	Moderate	Low risk	Based on monitoring data obtained to date, low concentration of CO_2 and CH_4 have been recorded at the site. Furthermore, the cohesive low permeability nature of the underlying superficial deposits will act as a barrier to ground gas migration. The risk to current site users from ground gas is therefore considered LOW.
		Adjacent land users	Unlikely	Moderate	Low risk	Based on monitoring data obtained to date, low concentration of CO_2 and CH_4 have been recorded at the site. Furthermore, the cohesive low permeability nature of the underlying superficial deposits will act as a barrier to ground gas migration. The risk to adjacent site users from ground gas is therefore considered LOW.
		Future land users	Unlikely	Moderate	Low risk	Based on monitoring data obtained to date, low concentration of CO_2 and CH_4 have been recorded at the site. The risk to future site users from ground gas is therefore considered LOW..
		Construction Workers	Low Likelihood	Moderate	Moderate to Low risk	Depleted oxygen as low as 1.7% has been recorded at the site. Construction workers may be exposed low oxygen conditions in confined spaces and excavations, however, the duration will be short term. The risk to construction is considered MODERATE to LOW.
Asbestos	Inhalation of fibres	Current/ Future/ Adjacent site users	Unlikely	High	Moderate to Low risk	Asbestos fibres were detected in seven of the soil samples tested. Due to the nature of the existing development and proposed development. The risk of direct contact with receptors is therefore considered LOW. Dust control measures must be implemented as part of good site working practices during construction.
		Construction Workers	Likely	High	High Risk	Asbestos fibres were detected in seven of the soil samples tested. Due to the nature of the existing development and proposed development. Dust control measures and appropriate health and safety measures should be adopted in line with CDM and other relevant health and safety guidance.

11.0 CONCLUSIONS AND RECOMMENDATIONS

The following section provides a summary of the conclusions and recommendations based on the findings of the site investigation.

11.1 Soil Contamination

None of the samples analysed contained concentrations of the contaminants tested for in exceedance of their screening criteria relevant to commercial end use.

However, asbestos was detected in seven samples. The asbestos was identified to be bundles of chrysotile fibres in TP7, TP8, WS1, WS6 and IP2) and bundles of amosite fibres in WS4 and TP2).

Further quantification testing of the asbestos fibres is required in order to provide a more robust risk assessment.

All the positively ID'd asbestos was located in areas of proposed hardstanding, so there is reduced risk of direct contact between end users and contaminated soils. However, a remediation strategy will be required for the removal of any material from these areas.

It should be noted that if the proposed layout is altered, these recommendations will need to be revised.

The overall potential risk from soil contamination to construction workers, ground workers and members of the public during construction is considered **MODERATE to LOW**.

11.2 Soil Waste Assessment

The soils have been classified as Non-Hazardous and Hazardous in accordance with Environment Agency guidance WM3.1. Further Waste Acceptance Criteria testing has classified the sample from BH1 (0.60m) & WS4 (0.60m) as inert.

However, it should be noted that a reassessment may be required on receipt of the asbestos quantification results. Concentrations on asbestos >0.1% would reclassify the soil as Hazardous.

11.3 Groundwater Contamination

Based on the results of the chemical testing, it appears that each of the samples tested contained no concentrations of contaminants of concern in excess of conservative drinking water and ecological standards.

11.4 Ground Gas

Based on the results of the gas monitoring, there is considered to be a **LOW** risk from ground gas at the site.

The site has been given a classification of CS-1, with no gas protection measures required.

11.5 Soakaway Testing

Soakaway and failing head testing have proven that soakaways are not suitable onsite as a means of drainage. This is due to the presence of deep made ground and the nature of the impermeable underlying glacial till.

11.6 Foundation Recommendations

Conventional shallow strip/pad foundations are considered suitable for the site, however deep made ground has been found at BH3, which could be associated with a retaining wall. Further investigation of ground conditions is recommended for this area.

11.7 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 onsite washing facilities should be available.

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

CHEMICAL TESTING RESULTS

APPENDIX 3

GEOTECHNICAL TESTING RESULTS

APPENDIX 4

SOIL WASTE ASSESSMENT

APPENDIX 5

DYNAMIC CONE PENETRATION TESTING

APPENDIX 6

SOAKAWAY RESULTS

APPENDIX 7

MONITORING DATA

APPENDIX 8

REPORT LIMITATIONS

REPORT LIMITATIONS

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

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

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

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

The report was written in 2019 and should be read in light of any subsequent changes in legislation, statutory requirements and industry best practices. Ground conditions can also change over time and further investigations or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of Earth Environmental & Geotechnical Ltd. In the absence of such written advice of Earth Environmental & Geotechnical Ltd, reliance on the report in the future shall be at the client's own and sole risk. Should Earth Environmental & Geotechnical Ltd be requested to review the report in the future, Earth Environmental & Geotechnical Ltd shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between Earth Environmental & Geotechnical Ltd and the client.

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

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

The services are based upon Earth Environmental & Geotechnical Ltd observations of existing physical conditions at the site gained from a walkover survey of the site together with Earth Environmental & Geotechnical Ltd interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst Earth Environmental & Geotechnical Ltd have no reason to doubt the accuracy and that it has been provided in full from those it was requested from, the items relied on have not been verified.
No responsibility can be accepted for errors within third party items presented in this report. Further Earth Environmental & Geotechnical Ltd was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the services. Earth Environmental & Geotechnical Ltd is not liable for any inaccurate information, misrepresentation of data or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Earth Environmental & Geotechnical Ltd and including the doing of any independent investigation of the information provided to Earth Environmental & Geotechnical Ltd save as otherwise provided in the terms of the contract between the client and Earth Environmental & Geotechnical Ltd.

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

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

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