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PHASE 2

GEO-ENVIRONMENTAL REPORT

job number	C4182/24/E/6783
date	12.07.2024
site address	672 Bradford Road, Birkenshaw, Bradford, West Yorkshire, BD11 2EE
written by	S. Hale
checked by	I. Sakoor
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Report on a Phase 2 Geo-environmental Investigation

Location:	672 Bradford Road, Birkenshaw, Bradford, West Yorkshire, BD11 2EE		
For:	N Hall Construction Limited		
Report No.	C4182/24/E/6783	Report date:	July 2024

For and on behalf of **Rogers Geotechnical Services Ltd**

Steven Hale BSc FGS Geo-environmental Technician	**Imran Sakoor** BEng FGS Geo-environmental Engineer

Report Summary[1]

Item	Comments	Section
Development	Demolition of existing structures and the construction of two new residential properties with associated garden areas and drives.	1.
Geology	Solid geology – none over Pennine Lower Coal Measures Formation.	5.
Strata Conditions	Capping of topsoil overlying generally firm clay onto mudstone.	6.
Groundwater	None encountered during investigation.	6.2
Foundation Design	Shallow foundation solution.	10.1
Effect of Sulphates	DC-1 concrete.	10.5
Contamination	Lead and PAH contamination revealed at some locations.	11.

[1] This summary should not be relied upon to provide a comprehensive review. All of the information contained in this document should be considered.

1. Introduction

It is understood that the land at 672 Bradford Road is to be developed by the demolition of existing structures and the construction of two new residential properties with associated garden areas and drives. Consequently, a site investigation has been undertaken in accordance with the instruction from the client. This work was required in order to determine the nature of the underlying soils, to assess their engineering properties and to assist in the design of safe and economical foundations for the proposed development. This investigation also takes into consideration the risk of any contamination present. This report describes the work undertaken, presents the data obtained and discusses the ground conditions in relation to the proposed works.

2. Limitations

The recommendations made and opinions expressed in this report are based on the ground conditions revealed by the site works, together with an assessment of the site and of the laboratory test results. Whilst opinions may be expressed relating to sub-soil conditions in parts of the site not investigated, for example between borehole positions, these are for guidance only and no liability can be accepted for their accuracy.

This report has been prepared in accordance with our understanding of current best practice. However, new information or legislation, or changes to best practice may necessitate revision of the report after the date of issue.

3. Desk Study

A Phase 1 Desk Study and Coal Mining Risk Assessment has been undertaken by Rogers Geotechnical Services (RGS) and the results were presented as report number C4182/24/E/6397 in June 2024. This report has been used extensively during the current intrusive investigation.

4. Fieldworks

The fieldworks were undertaken on the 12th June 2024 and included the following:

- Four windowless sample boreholes with standard penetration tests.
- Installation of three gas monitoring standpipes.

The investigatory locations are shown on the site plan which is presented in Appendix 1 to this report.

4.1 Windowless Sample Boreholes

These boreholes were sunk using a drive-in windowless sampler. The cores were undertaken in 1m lengths and reduced in diameter from 87mm for the first 1m through to 77mm for subsequent 1m increments. The recovered cores were sealed and returned to the laboratory for logging and subsequent testing. The soils were described in general accordance with BS5930: 2015 +A1: 2020 and full descriptions are given on the windowless sample records which are presented in Appendix 2. Also included on these records are the core diameters and percentages of core recovered.

4.2 Standard Penetration Tests

Standard penetration tests (SPT) were undertaken at regular depth increments within all windowless sample boreholes. The SPT was conducted in accordance with the procedures given in BS EN ISO 22476: Part 3: 2005 +A1: 2011, and the results are summarised on the borehole record. During this work an automatic trip hammer of 63.5kg falling through 750mm was employed to drive either a cone or split barrel sampler assembly into the ground and the recovered barrel samples were retained in air tight plastic containers.

4.3 Gas Monitoring Standpipes

Gas monitoring standpipes were installed to 2.0m depth in boreholes 2, 3 and 4 and the installation details are shown on the appropriate borehole records. In all cases, the monitoring standpipe consisted of a perforated pipe from the base of the borehole to 1.0m below surface, with a non-perforated pipe to ground level. The response zone was filled with pea gravel, with a bentonite seal at the base and above, and the installation was capped with a stop box cover in a concrete surround.

5. Geology

The available published geological data for the site has been examined and the following table presents the anticipated geology.

Table 1: Geological Data for the Site

Strata Type	Strata Name[2]	Previous Name[3]	Description[3]
Superficial Geology	-	-	None indicated to underlie the site.
Solid Geology	Pennine Lower Coal Measure Formation	Grey Measures of Yorkshire and Nottingham	Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.

[2] Sources: British Geological Survey (NERC) Map Sheet 77; Huddersfield; Solid and Drift Edition, and Geology of Britain Viewer [*online resource from www.bgs.ac.uk*]
[3] Sources: British Geological Survey (NERC) Lexicon of Named Rock Units [*online resource from www.bgs.ac.uk*]

6. Strata Conditions

In accordance with the geology of the area, the succession has been shown to include the following:

Table 2: Generalised Strata Profile

Depth m below ground level to underside of layer	**Strata Type**	**Positions Encountered**	**Groundwater Strikes** m below ground level
0.30 – 0.50	TOPSOIL (Soft, dark brown, slightly gravelly, clayey SILT)	All	None
1.05 – 1.45	RESIDUAL PENNINE LOWER COAL MEASURES FORMATION (Firm, laminated, light grey mottled orange, silty CLAY)	All	None
1.80 – 2.00	RESIDUAL PENNINE LOWER COAL MEASURES FORMATION (Firm to stiff, thinly laminated, dark grey, slightly gravelly, clayey SILT)	All	None
+2.45	PENNINE LOWER COAL MEASURES FORMATION (Extremely weak, thinly laminated, grey MUDSTONE recovered as a silty gravel)	All	None

'+' denotes that the strata extended below the termination depth of the investigated positions, thus the extent of the deposit is only proven to the depths indicated

6.1 General Strata

In general, the borehole records indicate identical conditions across the site. Beneath a 0.30m to 0.50m capping of topsoil, firm becoming firm to stiff laminated, silty clay and clayey silt was revealed to between 1.8m and 2.0m depth. It is considered that this material is representative of the residually weathered fraction of the Pennine Lower Coal Measures Formation. Underlying this stratum, extremely weak mudstone recovered as a silty gravel was revealed to the termination of all boreholes. It is anticipated that this is representative of the highly weathered fraction of the Pennine Lower Coal Measures Formation.

6.2 Groundwater

No groundwater strikes were observed during the site investigation. However, it should be appreciated that the normal rate of boring does not permit the recording of an equilibrium water level for any one strike, moreover, groundwater levels are subject to seasonal variation or changes on local drainage conditions.

7. Insitu Testing

7.1 Standard Penetration Tests

The standard penetration tests carried out are summarised in the following table:

Table 3: Summary of Standard Penetration Tests

Strata	Depth Range (m)	SPT 'N' (Blows/300mm)		Comments
		Granular soils	Cohesive soils	
Silty CLAY	1.00m to 1.45m	-	11	SPTs indicate a firm in-situ condition.
Slightly gravelly, clayey SILT	1.00m to 1.45m	-	12 & 16	In-situ testing indicates a firm to stiff condition.
Weathered MUDSTONE	2.00m to 2.45m	+50	-	SPTs indicated refusal within the rock.

7.2 Gas and Water Level Monitoring

The standpipes were monitored between the 20th June and the 10th July 2024. The results of the gas monitoring undertaken to date are tabulated below and full results are presented in Appendix 3.

Table 4: Gas Monitoring

Location	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Flow (l/hr)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)
WS01	20.06.2024	0.1	1.7	17.9	0.1	↓ 1003	-	2.10
	26.06.2024	0.0	1.6	18.2	0.1	↓ 995	-	
	03.07.2024	0.1	1.8	19.7	0.1	↑ 989	1.99	
	10.07.2024	0.1	1.0	17.7	0.1	↔ 991	2.05	
WS02	20.06.2024	0.0	2.2	17.0	3.3	↓ 1004	0.63	1.77
	26.06.2024	0.0	2.3	15.6	1.3	↓ 996	0.73	
	03.07.2024	0.1	3.7	16.5	2.8	↑ 990	1.10	
	10.07.2024	0.0	2.5	18.4	0.5	↔ 992	1.09	
WS03	20.06.2024	0.0	5.1	14.0	0.1	↓ 1004	1.14	1.82
	26.06.2024	0.0	7.1	10.1	0.1	↓ 996	1.19	
	03.07.2024	0.1	6.3	10.7	0.1	↑ 990	1.29	
	10.07.2024	0.0	5.8	13.2	0.1	↔ 992	1.23	

↑ - rising pressure ↓ - falling pressure ↔ - steady pressure

This work was undertaken using a Geotechnical Instruments (UK) Ltd. GA5000 (serial No G503524) which was last calibrated on the 20th April 2024. The calibration certificate is presented in Appendix 4.

8. Laboratory Testing - Geotechnical

The following programme of laboratory testing has been undertaken on samples obtained during this investigation:

- Determination of water content — BS EN ISO 17892-1:2014
- Determination of liquid and plastic limits — BS EN ISO 17892-12:2018
- Soluble sulphate content — BS 1377-3:2018+A1:2021: Pt3: 7.3
- pH value — BS 1377-3:2018+A1:2021: Pt3: 12

The test results are presented in Appendix 5 and are summarised below:

Table 5: Summary of Geotechnical Test Results

Test type	Number of tests	Range of results		Comments
Water content determinations	8	21% to 41%		Generally reducing with depth.
Index properties (4 Point)	8	LL PL PI	55% to 84% 26% to 35% 32% to 57%	Clay of high to extremely high plasticity. Consistency index 0.8 to 1.3 NHBC Class - Medium
Soluble sulphate & pH	3	SO_4 pH	80mg/l & 90mg/l 5.65 to 6.24	

In cohesive soil the approximate cohesion, c_u, and coefficient of consolidation, m_v, may be obtained from the equivalent SPT 'N' value using the following expressions (Stroud 1975).

$c_u = f_1 N$

$m_v = \frac{1}{f_2 N}$

where:

c = cohesion (kN/m^2).
m_v = Coefficient of consolidation (m^2/MN).
f_1 & f_2 = factors based on plasticity index.
N = SPT 'N_{300}' value.

For the cohesive soils revealed at this site the highest (worst case) plasticity index[4] of 57% could be employed, which suggests an f_1 value of 4.2 and an f_2 value of 0.44.

8.1 Geotechnical Properties

The idealised geotechnical properties employed in design are summarised below.

Table 6: Summary of Geotechnical Properties

Property	Range of values		Comments
Volume change potential (NHBC)	Medium		Silty CLAY & Clayey SILT
Shear strength parameters (at proposed foundation level of 1.2m)	c_u	45kN/m^2	Stroud (1974) where $c_u = f_1 N$. Assuming an N of 11.
Consolidation characteristics	m_v	0.21m^2/MN	Stroud (1974) where $m_v = 1/f_2 N$
Concrete classification	DC-1		Natural ground locations (Static water).

[4] See paragraph 6.2 'Index Property Tests'

9. Laboratory Testing - Environmental

A suite of testing was conducted on samples from across the site and the following regime was undertaken.

- Metals – Cd, Cr^{VI}, Cu, Hg, Ni, Pb, V and Zn.
- Semi and Non-Metals - As, Se, Free CN^- and Phenols.
- Polycyclic aromatic hydrocarbons (PAHs).
- Petroleum hydrocarbons (TPHs).
- Others – pH, organic content and total/soluble SO_4^{2-}.
- Asbestos.

This testing was undertaken by i2 Analytical Ltd and the results of all of the chemical testing are presented in Appendix 5 of this report.

10. Discussion of Ground Conditions - Geotechnical

It is understood that the site is to be developed by the demolition of existing structures and the construction of two new residential properties with associated garden areas and drives. At the time of writing this report the precise layout and method of construction is not known, thus the discussion below is of a generalised nature.

It cannot be recommended that foundations be constructed directly within the weak near surface topsoils. These soils are present in a weak and variable condition such that excessive total and or differential settlement could occur under moderately light surface loading.

The results of this investigation indicate that firm to stiff clays will be revealed below the topsoil at shallow depth. It is considered that these soils will provide a suitable bearing stratum, provided that the foundations are placed within soil generally described as being present in a firm in-situ condition. It is considered that strip or spread foundations constructed within this material, at a minimum depth of say 1.0m, could be designed assuming an allowable increase in stress given in the following table:

Table 7: Allowable Increase in Stress

Foundation Type		**Strip Footings**			**Spread Footings**		
Foundation Breadth	B (m)	0.6	1.0	1.5	0.6	1.0	2.0
Foundation Depth	D (m)	1.0			1.0		
Allowable increase in stress	(kN/m^2)	100	95	90	115	110	105

The allowable increase in stress given above assumes a factor of safety of 3 against general shear failure, with cohesion of $45kN/m^2$ at the foundation depths. Settlements at the above loading intensities should remain within tolerable limits for the type of structure proposed provided that the underlying soils are carefully inspected immediately final trimming has taken place. Should any soft or weak material be encountered they should be locally removed and replaced with lean-mix concrete or compacted granular soil.

10.1 General Comments for Excavations

The stability of excavation faces cannot be guaranteed thus temporary support to the excavation faces may become necessary unless the foundations are constructed using trench-fill techniques. In this method the foundation trenches should be excavated, inspected and backfilled with concrete as a continuous operation. Under no circumstances should operatives be allowed to enter unsupported excavations.

Should the excavations be required to stand open, it is considered that a blinding layer of lean-mixed concrete be placed over the sub-grade. This expedient will reduce loosening or softening of the underling soil due to both physical disturbance and the ingress of surface water.

Should seepage of groundwater be encountered it is considered that it could be dealt with using a simple form of de-watering. Such a system could include the excavation of sumps from which the water could be pumped.

10.2 Ground-floors

It should be appreciated that whilst the boreholes suggest competent ground conditions, due to the medium volume change potential of the soils, it will be necessary to employ suspended floors in this instance. Moreover, given the presence of existing trees and shrubs, it would be necessary to provide a suitable void or utilise proprietary materials beneath the slab. Further guidance is available in the NHBC standards.

10.3 Hard-standing Areas

It is considered that any hard-standing at the site could be constructed employing traditional pavement design. A design California Bearing Ratio (CBR) of 3% could be employed in the pavement design[5]. However, it is recommended that proof rolling of the sub-grade be undertaken to establish the suitability of the soils, to expose any soft or weak ground and to ensure the sub-grade is well compacted prior to construction. Any areas of soft or weak ground should be remediated by increasing the sub-base thickness. Alternatively, weak material could be locally removed and replaced with a compacted granular capping layer. If construction were to be undertaken during the winter or after periods of prolonged rainfall, it may be prudent to employ a geotextile and/or a geogrid between the sub-base and sub-grade.

10.4 Effect of Sulphates

In view of the nature of the underlying soils it is considered that the design sulphate class be assessed with reference to Table C2[6], which is provided in BRE Special Digest 1, *Concrete in aggressive ground*: Part C. On the basis of this table and considering the soluble sulphate contents recorded, it can be shown that well compacted buried concrete should be designed in accordance with Class DS-1 requirements. Assuming static groundwater, the table also indicates that the aggressive chemical environment for concrete (ACEC) classification is AC-1s.

[5] Table 11.1, *Reproduction of TRRL Report LR1132 (1984)*, Smith (2006), Smith's Elements of Soil Mechanics, 8th ed.
[6] Table C2, *Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations*

In order to evaluate the design chemical (DC) class for the buried concrete at this site reference should be made to Table D1[7], which can be found in Part D, *Specifying concrete for general cast-in-situ use,* of BRE Special Digest 1. From this table it may be shown that for an intended working life of at least 50 years the concrete design class DC-1 is required.

11. Discussion of Ground Conditions - Environmental

11.1 Discussion of Test Results

It is understood that the site is to be developed by the demolition of existing structures and the construction of two new residential properties with associated garden areas and drives. Consequently, the site may be classified as residential with plant uptake.

11.1.1 Soil Samples

The results of the chemical testing undertaken on soil samples obtained during this investigation have been compared to the ATRISK soil screening values (SSVs) as compiled by WS Atkins plc. With respect to the results it should be appreciated that the soil organic matter (SOM) content for the samples tested was found to range between 1.3% and 14.0%. On this basis, it is considered that the screening values associated with 1% SOM should be adopted. These values have been derived in such a way as to adhere to the principles within the revised CLEA model and include the most current release of the SGVs. A list of subscribers is provided within the website[8] and these include many local authorities.

A comparison of the results of the testing, together with the data given above, can be found within Appendix 6. These results indicate the following:

Table 8: Summary of Contaminated Areas

Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential with plant uptake)
BH02	0.50 – 0.70	PAHs: Chrysene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene.
BH03	0.20 – 0.50	Metals: Lead PAHs: Naphthalene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-c,d)Pyrene dibenz(a,h)anthracene & Benzo(g,h,i)perylene. TPHs: Aromatic C10 – C12.
BH04	0.00 – 0.50	Metals: Lead PAHs: Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-c,d)Pyrene dibenz(a,h)anthracene & Benzo(g,h,i)perylene. TPHs: Aromatic C10 – C12.

Concentrations of cadmium, chromium^{VI}, mercury, free cyanide, phenols (total) and petroleum hydrocarbons (aliphatic C5 – C6; C8 to C10; C16 to C21 and aromatic C5 to C10) were below the detection limits for the tests. Detectable levels of all other contaminants were recorded, but these fell below the associated Atrisk Soil Screening Values. In addition, no asbestos was detected within the soils samples tested.

[7] Table D1, *Selection of the DC Class and the number of APMs for concrete elements where the hydraulic gradient due to groundwater is 5 or less: for general in-situ use of concrete.*
[8] http://www.atrisksoil.co.uk/pages/general/subscribers.asp

It should be appreciated that the soil screening values for PAHs and TPHs (where appropriate) represents vapour saturation limits. The inhalation of vapour pathway contributes less than 10% of total exposure, which is unlikely to significantly affect the combined assessment criterion[9]. In view of this, the ATRISK soil SSVs notes that the users may wish to consider using a combined assessment criterion if free product is not observed, the values for which are also provided on the summary of contamination analysis. It is therefore considered that the criteria for no free product should be adopted for the PAHs and TPHs at this site. The results of the contaminants found to exceed these screening values are tabulated below:

Table 9: Summary of Areas Contaminated by PAHs & TPHs

Location	Depth (m)	Contaminants found to be exceeding SSVs (Residential with Plant Uptake)
BH02	0.50 – 0.70	None
BH03	0.20 – 0.50	PAHs: Naphthalene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene. TPHs: Aromatic C10 to C12.
BH04	0.00 – 0.50	PAHs: Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene. TPHs: Aromatic C10 to C12.

On the basis of the above information, the results of the investigation have concluded that the site is contaminated by lead, PAHs and some TPHs. Given the depths from which the testing has been undertaken, it is considered that the contamination is limited to the topsoil present at the site.

11.1.2 Gas Concentrations

With respect to ground gas, the results of the monitoring visits indicated a maximum concentration of 0.1% methane, with concentrations of carbon dioxide ranging between 1.0% and 7.1%, in association with oxygen levels of between 10.1% and 19.5%. It should be appreciated that on non-contaminated sites there is generally about 20% by volume of oxygen, associated with low levels of carbon dioxide. In addition, a maximum flow rate of 3.3 litres per hour was recorded and will be employed in the following calculations.

The principal driving force for initiating the movement of gas in the ground is a change in barometric pressure. The most onerous gas condition on a site is usually observed on days of low or falling barometric pressure, preferably below 1000mb. It has been noted that measurements undertaken solely during high pressure conditions may be of lesser value. At this site the readings undertaken to date were at atmospheric pressures of between 995mb and 1004mb.

In order to establish the gas screening value (GSV) for carbon dioxide or methane, the maximum gas concentration (expressed as a decimal) is multiplied by the borehole flow rate (l/hr). In this case 0.1% (0.001) methane was recorded along with 7.1% (0.071) carbon dioxide, in association with a maximum flow rate of 3.3 l/hr. This results in a GSV of 0.0033 l/hr for methane and a GSV of 0.2343 l/hr for carbon dioxide.

In accordance with Table 2 of BS8485: 2015*, Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings,* the site may be characterised as *Characteristic Situation Level 2*. It is therefore considered that there is a moderate risk of harm to end users and site operatives and some special precautionary measures are

[9] Ref: ATRISK soil, SSVs derived using CLEA v1.071 for 6% SOM, Residential with home grown produce land use, 23.06.17.

required in accordance to Table 8.6, *Typical scope of gas protection measures,* of CIRIA report C665.

With regard to the number of monitoring visits required reference is made to Tables 5.5a and 5.5b of CIRIA report C665 (2007)[10]. Accepting that the proposed development is of high sensitivity and that the generation potential is low, these tables suggest that 6 readings could be undertaken over a period of 2 months. However, C665 notes that *not all sites will require gas monitoring for the period and frequency indicated in Tables 5.5a and 5.5b.*

However, in this case a total of four monitoring visits were undertaken over a 1-month time period, at which point monitoring was terminated because it was decided to assume Characteristic Situation Level 2 for the site. Therefore, some remediation will be required.

In this context, it should be noted that the gas screening value threshold for Characteristic Situation level 2, is <0.7 l/hr. Assuming the flow rate remains constant at 3.3/hr the gas concentration would need to exceed 200% to move into the next risk band, which is not possible. Moreover, by keeping the concentration constant, the flow rate would need to increase to 9 l/hr. It is considered that these increases are not feasible given the flow rates and gas concentrations encountered. This is subject to review by the local authority.

11.2 Site Specific Risk Assessment

11.2.1 Approach

The presence of contamination hazards and the risks associated with them should be assessed in accordance with industry practice and the 'suitable for use' approach. This has been conducted with reference to The Department for Environment, Food and Rural Affairs (DEFRA) and The Environment Agency[11] advice on the assessment of risks arising from the presence of contamination in soils and using the source-pathway-receptor approach.[12] This method dictates that there must be a risk of contaminant produced at a 'source' in sufficient concentration to cause harm and there must be a 'pathway' for the contaminant to reach an identifiable 'receptor' for the linkage to be proved and a contamination hazard to be considered present. Not all substances are contaminants and not all contaminants are considered to be a risk. Indeed, DEFRA and The Environment Agency state that 'a contaminant is a substance which has the potential to cause harm, while a risk itself is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.'[13]

[10] Adapted from tables 5.5a and 5.5b of CIRIA C665, 2007, *Assessing risks posed by hazardous ground gas to buildings, p60.*
[11] R&D Publication CLR 8, 'Assessment of Risks to Human Health from Land Contamination: An overview of the Development of Soil Guideline Values and Related Research'.
[12] The pollution linkage approach was developed by 'Circular 2/2000 Contaminated Land: Implementation of Part II of The Environmental Protection Act 1990' which provides meanings for the terms contained in The Environmental Protection Act 1990 Part IIA, the primary legislation for addressing the issues of contaminated land.
[13] See 'Circular 2/2000 Contaminated Land: Implementation of Part II of The Environmental Protection Act 1990', appendix A.

11.2.2 Conceptual Ground Model and Risk Assessment

In view of the results of the chemical testing undertaken the conceptual site model is presented accordingly as Table 10. Sources of contamination include the following:

On-site – Made Ground (Lead, PAHs and TPHs).

The preliminary risk assessment has been evaluated with reference to the following ratings and definitions:

N/A -	A source-pathway-receptor linkage is not considered to exist and therefore a risk assessment is not required.
Low -	A pollution linkage is unlikely and/or the likelihood of harm occurring is low and of minor consequence.
Moderate -	The linkage exists but the likelihood of harm occurring is not considered to be significant although remedial action may be necessary
High -	The linkage exists and the available data indicates that significant harm may be caused and remedial action could be necessary.

The results of the risk assessment are presented in Table 10.

Table 10: Conceptual Site Model and Site-Specific Risk Assessment [Contamination: Lead, PAHs and TPHs]				
Conceptual Site Model			**Site Specific Risk Assessment**	
Pathways	**Receptor**	**Linkage Present?**	**Risk Rating**	**Notes**
Direct contact/dermal absorption/soil ingestion	Operative	Yes – contamination found to be present at the site and contact with soil likely during works.	High	Some contamination is present in the soils underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways. However, as the site is anticipated to be secured during the development phase, contamination is not anticipated to affect neighbours.
	End User	Yes – contamination found to be present at the site and site to be developed into residential properties with landscaped areas.	High	
	Neighbours	Yes – contamination found to be present at the site and populated residential areas surround the site.	Low	
Inhalation of Dust/Vapours	Operative	Yes – dust may be derived from contaminated soils. In addition, some TPH contamination found is likely to represent a significant vapour risk.	High	Some contamination is present underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways.
	End User	Yes – dust may be derived from contaminated soils. In addition, some TPH contamination found is likely to represent a significant vapour risk.	High	
	Neighbours	Yes – contamination found to be present at the site and residential properties located within 250m radius of the site and possible inhalation of dust during the works.	High	
Ingestion of fruit/vegetables and/or waters	Operative	No – no edible plants or contained water sources in the area of the proposed new works.	N/A	Some contamination is present underlying the site. Precautionary measures will be required during the construction phase. Remediation will be required to either remove the contamination or break pathways. However, the contamination at the site is considered to be of limited mobility, therefore the likelihood of contamination affecting neighbouring gardens is considered low risk.
	End User	Yes – contamination found to be present at the site and site to be developed into residential properties with landscaped areas.	High	
	Neighbours	Yes – contamination found to be present at the site and residential area adjoins the site.	Low	
Migration of hazardous gases via permeable strata or shallow mining activity	Operative	Yes – elevated concentrations of carbon dioxide have been found to be present at the site (assuming *Characteristic Situation Level 2*).	Low	Elevated concentrations of harmful gases (carbon dioxide) were detected at the site. If ground gas conditions remain the same, precautionary measures are deemed to be required. Remediation will be required to remove or break pathways.
	End User		Low	

	Neighbours	No – whilst concentrations of ground gas have been found to be present at the site (assuming *Characteristic Situation Level 2*), no structures directly adjoin the site, therefore gases migrating from the site would vent to atmosphere before reaching neighbouring structures.	N/A	The development shall not change the existing source-pathway-receptor model.
Spillage/loss/run off direct to receiving water	Controlled Waters	No – no controlled waters within 250m.	N/A	Some contamination is present underlying the site. Remediation will be required to either remove the contamination or break pathways. Old services to be removed or capped.
Migration via permeable unsaturated strata	Controlled Waters	Yes – a Secondary A aquifer is present beneath the site. However, the site is underlain by cohesive soils of low permeability. The contamination found is not anticipated to be significantly mobile.	Low	
Run off via drainage/sewers etc	Controlled Waters	Yes – old services may be present on site.	Moderate ‘	
Direct contact with contaminated soils	Plants	Yes – contamination present at the site which may affect plants.	High	Some contamination is present underlying the site. Remediation will be required to either remove the contamination or break pathways.
Uptake via root system			High	
Direct contact with contaminated soils	Building Materials	Yes – minor PAH contamination revealed at the site may represent a risk to building materials or plastic water pipes. Moreover, testing indicates that the aggressive chemical environment for concrete classification is AC-1s.	Moderate (plastic services) Low (buried concrete)	Please see section 11.3.3 for information on good building practice.
Direct contact with contaminated groundwater				
Exposure to Radon	Operative	Yes – site currently indicated to be present in a low risk radon affected area	Low	Between 1% and 3% of properties are affected. The publication BR211 states that no protection measures are necessary.
	End User			
UXO Risk	Operative	No – it is considered that the activities of the end users are unlikely to affect any UXO devices that may be present below the site.	N/A	No further action required.
	End User			

11.3 Indicative Remediation Strategy

In view of the site-specific risk assessment it is considered that remediation will be required at this site. Such a strategy should include the following main elements.

11.3.1 Remediation Objectives

Based on the site-specific risk assessment the object of the remediation is likely to be as follows.

- To protect the site operatives during the construction process from the ingestion of soil or dust, dermal contact with the soil and inhalation of dust and vapours.
- To protect the end user from the ingestion of soil or dust, dermal contact with the soil and inhalation of dust and vapours.
- To protect the end user from the elevated levels of carbon dioxide.
- To protect neighbours from the inhalation and ingestion of dust during the construction process.
- To protect operatives and end users from the ingestion of contaminated fruit and vegetables.
- To protect plants from direct contact with contamination and prevent uptake via root system.
- To ensure that contamination cannot reach controlled waters via surface run-off or permeable strata.
- To ensure that contamination cannot enter the former services occupying the site which may return to controlled waters.
- To protect plastic services from being penetrated by, or degrading due to the presence of, contamination in the soil or groundwaters.

11.3.2 Development Requirements

Whilst the precise nature of this development has not been finalised it is understood that it is to be developed by the demolition of existing structures and the construction of two new residential properties with associated garden areas and drives. In view of the above a site-specific remediation strategy should be undertaken after the proposed development has been finalised. However, for preliminary design and costing the following remediation proposals are offered.

11.3.3 Outline Strategy

In order to fulfil the objectives defined above it is likely that the following remedial strategy could be utilised. It is recommended that a pragmatic approach be undertaken, with observational techniques being employed at each stage of the work.

Ground-works

During the ground-works phase of the development, protection to the site operatives is required. The risk to site operatives is considered under the Health and Safety at Work Act 1974, together with regulations made under the act, which includes the Control of Substances Hazardous to Health (COSHH) regulations. Therefore, the risks to site personnel must be considered under the Construction Design and Management (CDM) regulations at the planning stage and be included in the contractor's Health and Safety Plan and site-specific Method Statements. These documents should include the following main elements.

- Site operatives at all levels should be made aware of the hazards of working with contaminated soils and the potential hazards associated with materials containing volatile hydrocarbons.
- Personal hygiene facilities, including washing and messing, must be provided and site operatives be encouraged to use them.
- Where work is undertaken in dry weather the site should be dampened down to avoid dust. In addition, dust masks must be provided to all site operatives for use in dry weather.
- In order for contaminated soils to be disposed of to an appropriate landfill, it may be necessary to carry out Waste Acceptance Criteria (WAC) testing in accordance with BS EN 12457.
- Any stockpiles of contaminated soil on site should be sheeted over to prevent excessive amounts of airborne dust and cross contamination of imported fill.
- Where vehicles are transferring soil to the landfill site they should be covered to prevent contamination of the surrounding area by dust.
- Where work is undertaken in wet weather, vehicle and wheel washing facilities are required to ensure that the vehicles leaving the site do not transfer contamination to surrounding areas.

On completion of the ground-works a careful site inspection of the sub-grade would be required. Should visual or olfactory evidence of contamination be revealed then further testing may become necessary.

Construction

During the construction phase of the contract the following items are required to protect the end user from the potential contaminants revealed at this site.

- Beneath buildings, pavements and hard-standings clean inert granular sub-base should be employed.
- Any redundant services revealed at this site should be de-commissioned and piped services sealed. Any existing services that are to be employed in the new development should be carefully inspected to ensure that they are serviceable.
- New plastic services should be constructed in a surround of clean inert material and selected in accordance with the recommendation given in the United Kingdom Water Industry Research (UKWIR) website under Report Ref. No. 10/WM/03/21 - 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'. The statutory water authority for the area in which site is located may have a risk assessment form to complete which allows these recommendations to be met. However, further determinand specification contamination testing may be necessary.
- For buried concrete the results of the sulphate and pH testing indicate that the design sulphate class for the site should be DS-1.

Gardens and Landscaped Areas

It is understood that the proposed development includes gardens and soft landscaped areas. In view of this and the potential contamination on site, it is considered that landscaped areas will require some remediation. This could include the provision of a clean cover system including a capping layer of say 500mm of inert material, which will put the contaminated ground out of the end users' dig range. At the base of this layer, a granular capillary break of say 100mm of free draining granular soil should be placed in order to prevent mobile contamination rising upward. This expedient should also provide a suitable root barrier to isolate the plants from the underlying contaminated ground.

Gas Protection Measures

In order to assess the protection measures required BS8485: 2015+A1:2019: *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings* has been employed. In accordance with Table 3, *Building types,* of the code, the development may be considered to conform to Type A. Therefore, on the basis of Table 4 *Gas protection score by CS and type of building,* the minimum gas protection score (points) is 3.5. The gas protection system should consist of at least two different elements. The elements work independently and collaboratively, and a single element should not be used because there would be no redundancy to allow for defects in the component.

In order to achieve this score the following shall be undertaken.

Table 11: Combination of Protection Elements (BS8485: 2015) for CS2

Reference	Protection Element	Score
Table 5	Precast suspended segmental floor (i.e. beam and block)	0
Table 6	Passive sub-floor dispersal layer: - Good performance *(**Note 1**)*	*1.5*
Table 7	*Gas resistant membrane complying with the requirements given in Table 7 (**Note 2**)*	2
	Total Score	**3.5**

Note 1:
Good performance as defined by Figure B6 and B7 in BS 8485: 2015.

Note 2:
The gas resistant membrane shall meet the following criteria:

- Sufficiently impervious (methane gas transmission rate <40.0ml/day/m^2/atm (average) BS ISO 15105-1 manometric method).
- Sufficiently durable and strong to remain serviceable for the anticipated life of the building, to withstand in-service stresses and installation process.
- Capable, after installation, of providing a complete barrier to the entry of the relevant gas.
- Verified in accordance with CIRIA C735: 2014: *Good practice on the testing and verification of protection systems of buildings against hazardous ground gasses.*

In addition to the above, the following points shall be considered.

- Technical drawings of the incorporation of the gas protection measures into the sub-structure will be provided by a suitably qualified engineer/architect and produced in accordance with the guidance given in BRE 414.
- The sequence of construction indicating when the gas protection system will be installed will be included with the remediation statement. Where possible the installation of membranes will take place as a unique activity on site and shall not take place until sub-structure construction is complete.
- During and following the installation of the membrane, all parties in attendance at the site shall be made aware that a gas protection system is to be employed within the construction. Such communications should include, but not be limited to, the CDM documentation for the site and site inductions.
- The installation of the membrane shall be carried out only by suitable personnel and the qualifications or experience/training will be included as part of the remediation statement. The suitability of personnel will be assessed in accordance with Annex 1 of CIRIA C735.
- The installation shall be in strict accordance with manufacturer specifications and recommendations, which shall also be included as part of the remediation statement.
- The membrane system employed will not be an ensemble (i.e. a system comprising a mixture of products from different manufacturers will not be employed).
- Membranes shall be supplied to site on a single wound roll, creased product will not be accepted or employed.
- Whilst membranes are exposed, signage will be provided to indicate the access to the installation area is prohibited unless authorised. Footwear will be checked prior to accessing the membrane surface to ensure no sharp objects are apparent, such as stones caught in treads. The use of sharp objects or hot-works around the exposed membrane will be strictly prohibited unless the risk of damaging the membrane has been full assessed and mitigated.
- Non-conformance of manufacturer recommendations shall be discussed and agreed as acceptable, in writing, with a suitably qualified person from the manufacturer.

Verification of the installation of the gas protection system will be carried out on each plot, unless agreed with any statutory authorities prior to construction.

11.4 Fill Materials

It should also be appreciated that any fill material, either site-won or imported, to be employed at the site should be subjected to the following assessment to determine its suitability.

Fill materials should be initially screened, by a suitably qualified engineer to establish that:

- It is a suitable growing media if it is to be employed as such, including compliance with BS3882 (2015)
- It is free from obvious contamination i.e. visual or olfactory evidence
- It has not come from areas where Japanese Knotweed or other invasive or injurious plants are suspected to be growing
- It is not a statutory nuisance, such as being odorous
- It is free from unsuitable material i.e. whole bricks, brick ties, timber or glass.

It should also be appreciated that any fill should be subjected to validation testing to assess its suitability. The following table has been taken from YALPAG[14] documentation and may be used as a guide. Depending on the origin and nature of the material, not all fill will require the sampling frequency and testing indicated, although this should be in agreement with any regulatory bodies (such as the Local Authority).

Table 12: Validation Sampling and Testing

Fill Type	Frequency	Minimum Determinands
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)
Crushed Hardcore, Stone, Brick	Minimum 1 per 500m³	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, total TPH. Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).
Greenfield/ Manufactured Soils	Minimum 3 Dependent on source and receptor, between 1 per 50m³ and 1 per 250m³	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, pH and soil organic matter (SOM) (or calculated from total organic carbon (TOC)).
Brownfield/ Screened Soils	Minimum 6 Dependent on source and receptor, between 1 per 50m³ and 1 per 100m³	Standard metals/ metalloids (as above), PAH (16 USEPA speciation), TPH (CWG banded), asbestos, pH and SOM (or calculated from TOC). Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE)..

The screening values for the above regime should also be agreed with any regulatory bodies; however, the following is recommended in the first instance.

Table 13: Fill Screening Values

Contaminant	Screening Value (Residential with Plant Uptake) (mg/kg)		Reference
	1% SOM	6% SOM	
As	37	37	Atrisk^{SOIL} SSVs
Cd	22.1	22.1	Atrisk^{SOIL} SSVs
Cr(VI)	3.62	3.63	Atrisk^{SOIL} SSVs
Cu	4730	4790	Atrisk^{SOIL} SSVs
Hg	8.81	15.8	Atrisk^{SOIL} SSVs
Ni	136	136	Atrisk^{SOIL} SSVs
Pb	200	200	Atrisk^{SOIL} SSVs
V	136	138	Atrisk^{SOIL} SSVs
Zn	20000	20300	Atrisk^{SOIL} SSVs

Please see summary sheet within Appendix 7 for full screening values including PAHs & TPHs.

The above screening values should be considered with respect to the Soil Organic Matter (SOM) of the subject material i.e. 1% SOM would be typical for granular fill and 6% SOM for topsoil. Testing

[14] *YALPAG Technical Guidance for Developers, Landowners and Consultants – Verification Requirements for Cover Systems V4 .1* Appendix 1a, June 2021

should comply with UKAS and MCERTS, where applicable, and undertaken by an accredited laboratory.

Where the material has been derived from a commercial company, certificates or other industry quality protocol compliance i.e. WRAP should be obtained. However, it will be necessary to ensure that this documentation specifically related to the material being imported, it is no more than two months old and complies with the screening and frequency requirements given above.

Suitable fill materials should be either placed immediately or sufficiently quarantined to prevent cross-contamination. If it is necessary, the quarantined material should be placed on appropriate sheeting and covered to prevent it becoming mixed with contaminated soils or dust, or penetrated by mobile contaminants.

11.5 Verification Report

In order to demonstrate that the remedial works and provision of clean cover has been sufficiently carried out where applicable, it will be necessary to produce a verification report for submission to any statutory authorities.

It will be necessary for this report to include the following:

- The assessment of the extents of any contamination identified including the details of sampling points, such as location and descriptive logs, and the results of any chemical testing.
- Characterisation of the suitability of the clean material including the derivation of the material, comments from a visual screen, the tests results of chemical screening, delivery tickets where appropriate and the conditions by which the clean material has been stored and handled on site.
- Photographic and logged evidence the clean material has been handled on site and placed in a sufficient thickness over areas where made ground remains. This may be either at the time of placement or after placement by means of hand excavated trialpits. Photographs should include visual site references or reference boards to prove the location and date taken. A measurement reference should be visible in the photographs to substantiate the thickness of material placed. Please note that it may also be necessary to undertake a topographical survey and the requirement for which should be checked with any statutory authorities.

The report detailed above should be produced by a suitably qualified engineer. The number of verification areas for the development should be confirmed with any statutory authorities for the site.

12. Recommendations for Further Work

- This report should be forwarded to the relevant authorities as soon as practicable to ensure they have sufficient time to review and discuss any issues.
- Completion and reporting of gas monitoring.
- Discussions with ground work contractors in relation to the requirement for testing of materials to be disposed off-site (Waste Acceptance Criteria) and the suitability of imported materials.
- Discussions with service providers regarding suitable materials for pipe work given the nature of chemical determinands found within the soils on site.
- Discussions with contractors in relation to the suitability of materials and installation methods for gas membranes, if required.
- Produce a validation report to demonstrate that the geo-environmental risks discussed in this report have been mitigated.
- Detailed design of the sub-structure.

Clearly Rogers Geotechnical Services Ltd would be happy to offer advice with respect to the above and assist where necessary.

13. References

- British Geological Survey (NERC) (2024), BGS, Keyworth.
  - Geology of Britain Viewer: (*http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html)*
  - Lexicon of Named Rock Units:
  - (*http://www.bgs.ac.uk/lexicon/)*

- British Standards Institution (1990) BS1377: *British standard methods of test for soils for civil engineering purposes,* B.S.I., London.

- British Standard Institution (2005 +A1: 2011) BS EN ISO 22476-2: *Geotechnical investigation and testing – Field testing, Part 2: Dynamic Probing,* B.S.I., London.

- British Standard Institution (2005 +A1: 2011) BS EN ISO 22476-3: *Geotechnical investigation and testing – Field testing, Part 3: Standard penetration test,* B.S.I., London.

- British Standards Institution (2015 +A1: 2020) BS 5930: *Code of practice for ground investigations,* B.S.I., London.

- British Standards Institution (2011), BS 10175: *Investigation of potentially contaminated sites – Code of Practice,* British Standards Institute.

- British Standards Institution (2015 +A1:2019) BS8485: *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings,* B.S.I., London.

- British Standards Institution (2013), BS 8576 Guidance on Investigations for Ground Gas – Permanent Gases and Volatile Organic Compounds.

- British Standards Institution (2017) BS EN ISO 14688: *Geotechnical investigation and testing – Identification and classification of soil*, B.S.I., London.

- Building Research Establishment (BRE) Special Digest 1 (2005), Third Edition: Concrete in aggressive ground, BRE Press, Garston.
  - Part C: *Assessing the aggressive chemical environment.*
  - Part D: *Specifying concrete for general cast-in-situ use.*

- Department for Environment, Food and Rural Affairs and the Environment Agency (2009) DEFRA Science Report – Final SC050021/SR2, *Human Health toxicological assessment of contaminants in soil*. Environment Agency, Bristol.

- Department for Environment, Food and Rural Affairs and the Environment Agency (2009) DEFRA Science Report – SC050021/SR3, *Updated technical background to the CLEA model*. Environment Agency, Bristol.

- Department for Environment, Food and Rural Affairs (2014) SP1010: *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document*.

- Wilson S, Oliver S, Mallet H, Hutchings H, Card G, *Assessing risks posed by ground gasses to buildings,* CIRIA Report C665.

Appendix 1

Site Plan



Notes:

Investigation positions approximated from site operative's notes.

RGS Environmental Geotechnical Specialists

Rogers Geotechnical Services Ltd

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Shelley,
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HD8 8LU

Telephone: 0843 50 66 87
www.rogersgeotech.co.uk

Client:

N Hall Construction

Job Number:

C4182/24/E/6783

Project Details:

672 Bradford Rd

Scale:	Not to scale - reference only

ground investigation | drilling & excavation | insitu testing
laboratory testing & gas monitoring | engineering consultancy
surveying & flood risk assessments | training, CPD & expert witness
... delivered using our own drilling rigs / crews / soils lab / engineers

Appendix 2

Borehole Records

Borehole Log

Environmental Geotechnical Specialists

Borehole No. **BH01**

Sheet 1 of 1

Project Name: 672 Bradford Road	Project No. C4182/24/E/6783	Co-ords:	Hole Type WLS
Location: Birkenshaw, Bradford, West Yorkshire, BD11 2EE		Level:	Scale 1:25
Client: N Hall Construction Limited		Dates: 12/06/2024	Logged By JF

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
										TOPSOIL (Dark brown, slightly gravelly, clayey SILT. Gravel is sub-angular and fine to medium sandstone. Occasional wood fragments and small roots).
		0.55		87	100	HVP=50	0.50			
		0.56	D							Firm, thinly laminated, light grey mottled orange, silty CLAY. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		0.65				HVP=60				
		0.75				HVP=50				
		0.80	D							
		0.85				HVP=52				
		1.00				HVP=96	1.05			
		1.00	SPT			N=12 (2,2/3,3,3,3)				Firm to stiff, thinly laminated, dark grey, clayey SILT. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		1.25	D							
				77	100					
							1.80			Extremely weak, thinly laminated, grey. MUDSTONE recovered as a silty gravel. [PENNINE LOWER COAL MEASURES FORMATION]
		2.00	SPT			N=51 (5,7/11,13,13,13,14)				
							2.45			End of Borehole at 2.45m

Remarks

Cleared with CAT. No groundwater strike.

AGS

RGS Environmental Geotechnical Specialists

Borehole Log

Borehole No. **BH02**

Sheet 1 of 1

Project Name: 672 Bradford Road	Project No. C4182/24/E/6783	Co-ords:	Hole Type WLS
Location: Birkenshaw, Bradford, West Yorkshire, BD11 2EE		Level:	Scale 1:25
Client: N Hall Construction Limited		Dates: 12/06/2024	Logged By JF

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
										TOPSOIL (Dark brown, slightly gravelly, clayey SILT. Gravel is sub-angular and fine to medium sandstone. Occasional wood fragments and small roots).
		0.50	D	87	100		0.50			
		0.55				HVP=52				Firm, thinly laminated, light grey mottled orange, silty CLAY. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		0.65				HVP=48				
		0.75				HVP=48				
		0.76	D							
		0.85				HVP=50				
		1.00				HVP=80				
		1.00	SPT			N=11 (2,2/2,3,3,3)				
		1.30	D							
		1.50		77	100	HVP=86	1.45			Firm to stiff, thinly laminated, dark grey, clayey SILT. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		2.00	SPT			N=66 (7,7/11,16,17,22)	1.80			Extremely weak, thinly laminated, grey MUDSTONE recovered as a silty gravel. [PENNINE LOWER COAL MEASURES FORMATION]
							2.45			End of Borehole at 2.45m

Remarks

Cleared with CAT. No groundwater strike.

AGS

Borehole Log

Environmental Geotechnical Specialists

Borehole No. **BH03**

Sheet 1 of 1

Project Name: 672 Bradford Road	Project No. C4182/24/E/6783	Co-ords:	Hole Type WLS
Location: Birkenshaw, Bradford, West Yorkshire, BD11 2EE		Level:	Scale 1:25
Client: N Hall Construction Limited		Dates: 12/06/2024	Logged By JF

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
		0.30	D				0.50			TOPSOIL (Dark brown, slightly gravelly, clayey SILT. Gravel is sub-angular and fine to medium sandstone. Occasional wood fragments and small roots).
				87	70					Firm, thinly laminated, light grey mottled orange, silty CLAY. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION
		0.70				HVP=48				
		0.72	D							
		0.80				HVP=46				
		0.90				HVP=48				
		1.00	SPT			N=16 (2,2/2,4,5,5)	1.05			
		1.35	D							Firm to stiff, thinly laminated, dark grey, slightly gravelly, clayey SILT. Gravel is sub-angular to angular and fine to medium sandstone and iron nodules. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
				77	90					
		1.60	D							
		2.00	SPT			56 (7,9/56 for 225mm)	2.00			Extremely weak, thinly laminated, grey MUDSTONE recovered as a silty gravel. [PENNINE LOWER COAL MEASURES FORMATION]
							2.45			End of Borehole at 2.45m

Remarks

Cleared with CAT. No groundwater strike.

AGS

Borehole Log

Environmental Geotechnical Specialists

Borehole No. **BH04**

Sheet 1 of 1

Project Name: 672 Bradford Road	Project No. C4182/24/E/6783	Co-ords:	Hole Type WLS
Location: Birkenshaw, Bradford, West Yorkshire, BD11 2EE		Level:	Scale 1:25
Client: N Hall Construction Limited		Dates: 12/06/2024	Logged By JF

Well	Water Strikes	Samples and In Situ Testing: Depth (m)	Type	Dia. (mm)	TCR (%)	Results	Depth (m)	Level (m)	Legend	Stratum Description
		0.00 - 0.20	D							TOPSOIL (Dark brown, slightly gravelly, clayey SILT. Gravel is sub-angular and fine to medium sandstone. Occasional wood fragments and small roots).
							0.30			Firm, thinly laminated, light grey mottled orange, silty CLAY. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		0.40								
		0.50		87	95					
		0.58	D							
		0.60								
		0.70								
		0.80								
		0.90								
		1.00								
		1.00	SPT			N=14 (2,2/3,4,4,3)	1.10			Firm to stiff, thinly laminated, dark grey, slightly gravelly, clayey SILT. Gravel is sub-angular to angular and fine to medium mudstone. [RESIDUAL PENNINE LOWER COAL MEASURES FORMATION]
		1.20	D							
				77	95					
		1.65	D							
							1.80			Extremely weak, thinly laminated, grey MUDSTONE recovered as a silty gravel. [PENNINE LOWER COAL MEASURES FORMATION]
		2.00	SPT			77 (6,13/77 for 225mm)				
							2.45			End of Borehole at 2.45m

1 2 3 4 5

Remarks

Cleared with CAT. No groundwater strike.

AGS

Appendix 3

Gas Monitoring Sheets

Rogers Geotechnical Services Ltd

GAS/WATER MONITORING - SITE RECORD

Client:

Site:

Gas Monitor: Geotech GA5000
Serial No. G503524
Calibration Date: 20.04.2024
Dip Meter: 003

(If second monitor is used)
Gas Monitor:
Serial No.
Calibration Date:
Dip Meter

Input by : M. Tuck Checked by :

Date : 10.07.2024 Date :

Borehole No	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Flow (l/hr)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)	Depth During Visit	Atmospheric Conditions	COMMENTS
2	20.06.2024	0.1-0.1	1.7-1.7	17.9-18.7	0.1	1003	-		2.10	Sunny intervals	Falling pressure CO1
	26.06.2024	0.0-0.0	1.6-1.6	19.5-18.2	0.1	995	–		2.10	Sunny	Falling pressure CO1
	03.07.2024	0.1-0.1	1.8-1.8	19.7-19.7	0.1	**989**	1.99		2.10	Cloudy	Rising pressure
	10.07.2024	0.0-0.1	1.0-1.0	19.9-17.7	0.1	991	2.05		2.10	Cloudy	Steady pressure
3	20.06.2024	0.0-0.0	2.2-2.2	17.0-17.0	**3.3**	**1004**	0.63		1.77	Sunny intervals	Falling pressure CO13
	26.06.2024	0.0-0.0	2.3-2.3	15.6-15.6	1.3	996	0.73		1.77	Sunny	Falling pressure CO 3
	03.07.2024	0.1-0.1	3.7-3.8	17.1-16.5	2.8	990	1.10		1.77	Cloudy	Rising pressure CO 1
	10.07.2024	0.0-0.0	1.8-2.5	18.9-18.4	0.5	992	1.09		1.77	Cloudy	Steady pressure
4	20.06.2024	0.0-0.0	5.1-5.1	14.0-14.0	0.1	**1004**	1.14		1.82	Sunny intervals	Falling pressure CO1
	26.06.2024	0.0-0.0	7.1-7.1	10.1-10.1	0.1	996	1.19		1.82	Sunny	Falling pressure CO3
	03.07.2024	0.0-0.1	6.3-6.3	10.8-10.7	**0.1**	**990**	1.29		1.82	Cloudy	Rising pressure
	10.07.2024	0.0-0.0	4.8-5.8	13.2-13.2	0.1	992	1.23		1.82	Cloudy	Steady pressure CO 1

Appendix 4

Gas Monitor Calibration Certificate

CERTIFICATION OF CALIBRATION

PJLA Calibration
No. 66916

Date Of Calibration: 20-Apr-2024

Certificate Number: G503524_2/35282

Issued by: QED Environmental Systems Inc.

Customer: **QED ENVIRONMENTAL SYSTEMS LIMITED**
QED ENVIRONMENTAL SYSTEMS LTD CYAN PARK - UNIT 3 JIMMY HILL WAY COVENTRY, WEST MIDLA CV2 4QP GB

Description:

Model: GA5000

Serial Number: G503524

Accredited Results:

Methane (CH4)

Certified Gas (%)	Instrument Reading (%)	Uncertainty (%)
5.1	5.0	0.42
15.0	14.9	0.66
60.0	59.7	1.03

Carbon Dioxide (CO2)

Certified Gas (%)	Instrument Reading (%)	Uncertainty (%)
5.0	5.0	0.43
15.0	15.0	0.71
40.0	40.0	1.19

Oxygen (O2)

Certified Gas (%)	Instrument Reading (%)	Uncertainty (%)
20.9	21.0	0.25

Gas cylinders are traceable and details can be provided if requested.

CH4, CO2 readings recorded at: 31.2 °C/88.1 °F

O2 readings recorded at: 22.1 °C/71.7 °F

Barometric Pressure: 0987 mbar/29.15 "Hg

Method of Test : The analyzer is calibrated in a temperature controlled chamber using a series of reference gases, in compliance with procedure ISP17.

Instrument has passed calibration as the measurement result is within the specification limit. The specification limit takes into account the measurement uncertainty.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with NIST requirements.

The calibration results published in this certificate were obtained using equipment capable of producing results that are traceable through NIST to the International System of Units (SI). Certification only applies to results shown. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Calibration Instance: 118 IGC Instance: 118

CERTIFICATION OF CALIBRATION

PJLA Calibration

No. 66916

QED™

Date Of Calibration: 20-Apr-2024

Certificate Number: G503524_2/35282

Issued by: QED Environmental Systems Inc.

Non Accredited results:

Pressure Transducers (inches of water column)					
Transducer	**Certified (Low)**	**Reading (Low)**	**Certified (High)**	**Reading (High)**	**Accuracy**
Relative	0"	0"	40"	40.33"	2.0"

Barometer (mbar)	
Reference	**Instrument Reading**
0987 mbar / 29.15 "Hg	0987 mbar / 29.16 "Hg

As received gas check readings are only recorded if the instrument is received in a working condition. Where the instrument is received damaged no reading can be taken.

Date of Issue : 24 Apr 2024

Approved By Signatory

Linda Ostrowski

Laboratory Inspection

The calibration results published in this certificate were obtained using equipment capable of producing results that are traceable through NIST to the International System of Units (SI). Certification only applies to results shown. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

www.qedenv.com (800) 624-2026 info@qedenv.com

QED Environmental Systems Inc. 2355 Bishop Circle West, Dexter, MI 48130

Appendix 5

Laboratory Testing

Environmental
Geotechnical
Specialists

RGS

LABORATORY REPORT

job number	C4182/24/E/6783
date	12.07.2024
site address	672 Bradford Road, Birkenshaw, Bradford, West Yorkshire, BD11 2EE
date scheduled	S. Hale
date issued	I. Sakoor
issued by	S. Hale

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Schedule of UKAS Accredited Laboratory Tests

1. CLASSIFICATION OF SOIL	BS 1377-2:1990	BS EN ISO 17892	Accredited (A)	Unaccredited (U)
1.1 Moisture / Water content determination				
i. Oven drying	Pt 2 : 3.2	Pt 1 : 2014 Pt 12 : 2018 : 5.3 / 5.5	A	
ii. Saturation m/c of chalk	Pt 2 : 3.3			U
1.2 Index Properties				
i. Liquid limit – cone penetrometer	Pt 2 : 4.3		A	
ii. Plastic limit	Pt 2 : 5.3		A	
iii. Shrinkage limit	Pt 2 : 6.3			U
iv. Linear shrinkage	Pt 2 : 6.5		A	
1.3 Particle Density				
i. Gas jar	Pt 2 : 8.2		A	
ii. Large pyknometer	Pt 2 : 8.3			U
iii. Small pyknometer	Pt 2 : 8.4	Pt 3 : 2015 : 5.1		U
1.4 Density Tests				
i. Linear measurement	Pt 2 : 7.2	Pt 2 : 2014 : 5.1	A	
ii. Immersion in water	Pt 2 : 7.3	Pt 2 : 2014 : 5.2		U
iii. Fluid / Water displacement	Pt 2 : 7.4	Pt 2 : 2014 : 5.3		U
iv. Sand replacement	Pt 9 : 2.1, 2.2			U
v. Core cutter	Pt 9 : 2.4			U
1.5 Particle Size Distribution				
i. Dry Sieve	Pt 2 : 9.2	Pt 4 : 2016 : 5.2	A	
ii. Wet Sieve	Pt 2 : 9.3	Pt 4 : 2016 : 5.2	A	
iii. Sedimentation by pipette	Pt 2 : 9.4	Pt 4 : 2016 : 5.3 / 5.4	A	
iv. Sedimentation by hydrometer	Pt 2 : 9.5			U
2. CHEMICAL TESTS	**BS 1377-3:2018**			
ii. Mass loss on ignition	Pt 3 : 4			U
3. COMPACTION RELATED TESTS	**BS 1377-4:1990**			
3.1 Dry density/moisture relationship				
i. 2.5kg rammer – 1 litre mould	Pt 4 : 3		A	
- CBR mould	Pt 4 : 3		A	
ii. 4.5kg rammer – 1 litre mould	Pt 4 : 3		A	
- CBR mould	Pt 4 : 3		A	
3.2 Moisture Condition Value				
i. Single point test	Pt 4 : 5.4			U
ii. MCV/moisture content relationship	Pt 4 : 5.5			U
3.3 California Bearing Ratio				
i. Undisturbed sample	Pt 5 : 7		A	
ii. Recompacted sample	Pt 5 : 7		A	
iii. Soaked, inc measurement of swell	Pt 5 : 7		A	
4. COMPRESSIBILITY OF SOIL	**BS 1377-5:1990**			
i. One dimensional consolidation	Pt 5 : 3		A	
ii. Swelling pressure test	Pt 5 : 3			U
5. SHEAR STRENGTH OF SOIL	**BS 1377-7:1990**			
i. Hand shear vane	Makers instructions			U
ii. Shear box (100mm square sample)	BS 1377 : Pt 7 : 4			U
iii. Triaxial – quick undrained	BS 1377 : Pt 7 : 8, 9		A	
6. PERMEABILITY				
i. Falling head	K. H. Head Vol 2			U
ii. Constant head	BS 1377 : Pt 6 : 6			U
iii Triaxial cell	BS 1377 : Pt 6 : 6			U
7. ROCK TESTS				
7.1 Classification Tests				
i. Natural moisture content	-			U
ii. Saturated moisture content	-			U
iii. Natural density	-			U
iv. Porosity	-			U
7.2 Strength Tests				
i. Point load index	ISRM '85			U
ii. Uniaxial compression test	ISRM '81			U

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Rogers Geotechnical Services Ltd
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01484 604354 Company No. 5130864

Disclaimer

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Rogers Geotechnical Services Ltd
Offices 1 & 2 Barncliffe Business Park, Near Bank, Shelley, Huddersfield, HD8 8LU
01484 604354 Company No. 5130864

Summary of Classification Test Results

Project No.	Project Name
C4182/24/E/6783	672 Bradford Rd, Birkenshaw, Bradford

Hole No.	Sample				Soil Description	Density bulk Mg/m^3	Density dry Mg/m^3	*w* %	Passing 425µm %	LL %	PL %	PI %	Particle density Mg/m^3	1pt/4pt	Date	Increase/Decrease
	Ref	Top	Base	Type												
BH01	2	0.80			Firm laminated light grey mottled orange silty CLAY.			29	100	61	28	33		4pr	14-Jun	Increase
BH01	3	1.25			Very stiff laminated dark grey clayey SILT.			21	91	59	26	33		4pr	14-Jun	Increase
BH02	5	0.76			Firm laminated light grey mottled orange silty CLAY.			33	100	64	27	37		4pr	14-Jun	Increase
BH02	6	1.30			Very stiff laminated dark grey clayey SILT.			29	100	67	28	39		4pr	14-Jun	Increase
BH03	8	0.72			Very stiff laminated dark grey slightly gravelly clayey SILT. Gravel is subangular and angular fine to			35	100	84	32	52		4pr	14-Jun	Increase
BH03	9	1.35			Very stiff laminated dark grey slightly gravelly clayey SILT. Gravel is subangular and angular fine to			23	86	55	29	26		4pr	14-Jun	Increase
BH04	12	0.58			Firm laminated light grey mottled orange silty CLAY.			41	100	92	35	57		4pr	14-Jun	Increase
BH04	13	1.20			Very stiff laminated dark grey slightly gravelly clayey SILT. Gravel is subangular and angular fine to			25	96	66	34	32		4pr	14-Jun	Increase

All tests performed in accordance with BS1377-2:2022 and BS EN ISO 17892 Part 1 A1 2022 unless specified otherwise
All Liquid Limit Tests performed on a 80g/30 Degree Cone unless specified otherwise

Key			Date Printed	Approved By	Table
Density test	Liquid Limit	Particle density			1
Linear measurement unless :	4pt cone unless :	sp - small pyknometer	28/06/2024		
wd - water displacement	cas - Casagrande method	gj - gas jar			sheet
wi - immersion in water	1pt - single point test			Harry	1

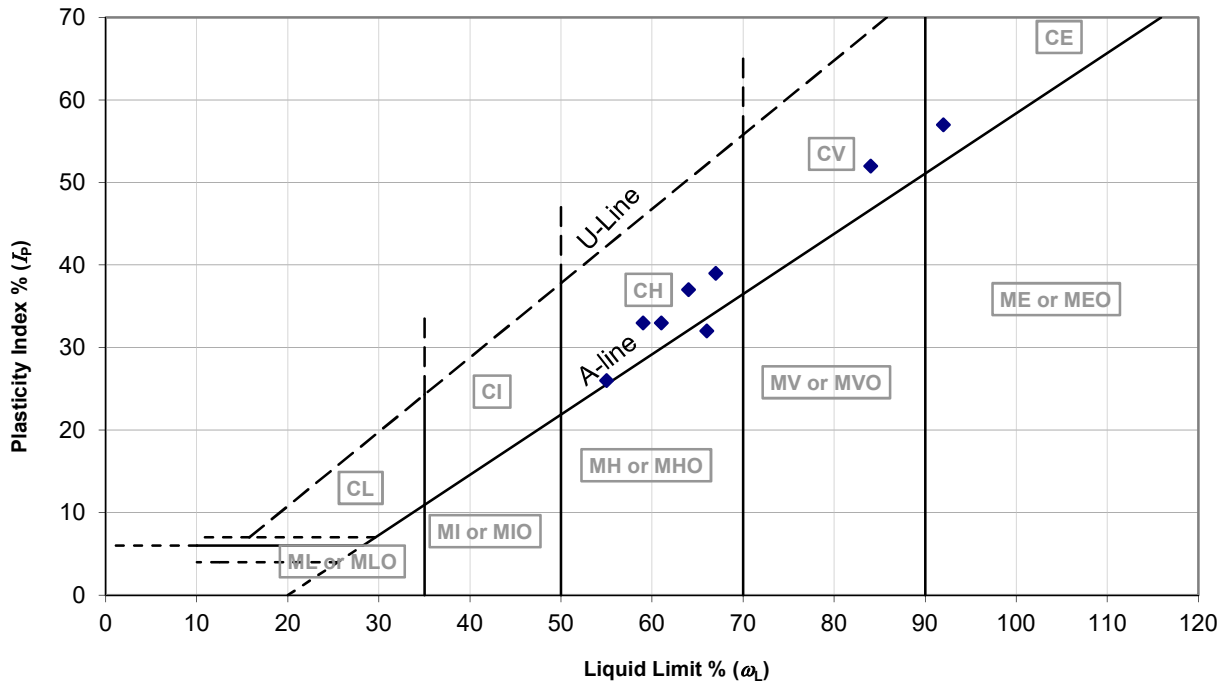
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Offices 1&2,
Barncliffe Business Park,
Near Bank, Shelley,
Huddersfield,
HD8 8LU

Classification of Index Properties

C4182/24/E/6783

Project Name:	672 Bradford Rd,	**BS EN ISO: 17892: Parts 1, 12**	Fig. 2 / Sheet. 1
Location:	Birkenshaw, Bradford		Input By: Harry
Client:	N Hall Construction Limited		Check By: Harry

Location	Depth (m)	Water Content (ω) (%)	Liquid Limit (ω_L) (%)	Plastic Limit (ω_P) (%)	Plasticity Index (I_P) (%)	Retained by 0.425mm (%)	Modified (ω) (ω') (%)	Modified (I_P) (I_P') (%)	Liquidity/ Consistency (I_L) (%)	Liquidity/ Consistency (I_C) (%)	Casagrande Class	N.H.B.C Class (%)
BH01	0.80	29	61	28	33	0	29	33	0.0	1.0	C H	MEDIUM
BH01	1.25	21	59	26	33	9	23	30	-0.2	1.2	C H	MEDIUM
BH02	0.76	33	64	27	37	0	33	37	0.2	0.8	C H	MEDIUM
BH02	1.30	29	67	28	39	0	29	39	0.0	1.0	C H	MEDIUM
BH03	0.72	35	84	32	52	0	35	52	0.1	0.9	C V	HIGH
BH03	1.35	23	55	29	26	14	27	22	-0.2	1.2	C H	MEDIUM
BH04	0.58	41	92	35	57	0	41	57	0.1	0.9	C E	HIGH
BH04	1.20	25	66	34	32	4	26	31	-0.3	1.3	M H	MEDIUM



Summary of Geotechnical Chemical Test Results

Project No.	Project Name
C4182/24/E/6783	672 Bradford Rd, Birkenshaw, Bradford

Hole No.	Sample				Soil Description	Org	LOI	pH	Sulphate as SO_4			Chloride, Cl		CO_2	TDS	<2mm	Remarks
	Ref	Top	Base	Type					Total acid sol.	2:1 water :soil	ground water	water sol.	acid sol.				
						%	%		%	g/l	g/l	%	%	%	mg/l	%	
BH01	1	0.56			Firm laminated light grey mottled orange silty CLAY.			6.32		0.09						99	
BH03	10	1.60			Firm laminated light grey mottled orange silty CLAY.			6.24		0.09						91	
BH04	14	1.65			Very stiff laminated dark grey slightly gravelly clayey SILT.			5.65		0.08						73	

Key	Date Printed	Approved By	Table
Tests performed in accordance with BS 1377 unless annotated otherwise			
Org Organic matter content; Cl Chloride content	28/06/2024		3
LOI Mass loss on ignition at 440°C; CO_2 Carbonate content (rapid titration)			sheet
TDS Total Dissolved Solids		HJL	1

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t: 01484 604354

e: harry.letch@rogersgeotech.co.uk

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Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 24-026154

Project / Site name:	Birkenshaw	**Samples received on:**	19/06/2024
Your job number:	C 4182 24 E 6783	**Samples instructed on/ Analysis started on:**	19/06/2024
Your order number:		**Analysis completed by:**	26/06/2024
Report Issue Number:	1	**Report issued on:**	26/06/2024
Samples Analysed:	3 soil samples		

Signed:

Joanna Wawrzeczko
Senior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

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Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

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The results included within the report are representative of the samples submitted for analysis.

Analytical Report Number: 24-026154
Project / Site name: Birkenshaw

Lab Sample Number				233448	233449	233450
Sample Reference				BH02	BH03	BH04
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				0.50-0.70	0.20-0.50	0.00-0.50
Date Sampled				14/06/2024	14/06/2024	14/06/2024
Time Taken				None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	25	39	42
Total mass of sample received	kg	0.1	NONE	0.8	0.8	0.8

Asbestos

Asbestos in Soil Detected/Not Detected	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected
Asbestos Analyst ID	N/A	N/A	N/A	PDO	PDO	PDO

General Inorganics

pH (L099)	pH Units	N/A	MCERTS	7.9	7	7.2
Free Cyanide	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0
Total Sulphate as SO_4	%	0.005	MCERTS	0.017	0.103	0.077
Water Soluble Sulphate as SO_4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	120	98	130
Water Soluble SO_4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	58.3	48.8	63.5
Organic Matter	%	0.1	MCERTS	-	-	14
Organic Matter (automated)	%	0.1	MCERTS	1.3	12	-

Total Phenols

Total Phenols (monohydric)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0

Speciated PAHs

Naphthalene	mg/kg	0.05	MCERTS	< 0.05	1.5	0.2
Acenaphthylene	mg/kg	0.05	MCERTS	< 0.05	0.29	0.24
Acenaphthene	mg/kg	0.05	MCERTS	0.1	2.1	0.49
Fluorene	mg/kg	0.05	MCERTS	0.1	1.7	0.44
Phenanthrene	mg/kg	0.05	MCERTS	1	19	6.3
Anthracene	mg/kg	0.05	MCERTS	0.27	4.9	1.4
Fluoranthene	mg/kg	0.05	MCERTS	1.8	32	15
Pyrene	mg/kg	0.05	MCERTS	1.6	27	14
Benzo(a)anthracene	mg/kg	0.05	MCERTS	0.7	13	6.4
Chrysene	mg/kg	0.05	MCERTS	0.79	15	7.4
Benzo(b)fluoranthene	mg/kg	0.05	ISO 17025	0.75	15	8.5
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	0.3	6.8	3.5
Benzo(a)pyrene	mg/kg	0.05	MCERTS	0.63	14	7.5
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	0.33	6.9	3.9
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	0.08	2	1
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	0.36	7.3	4.1

Total PAH

Speciated Total EPA-16 PAHs	mg/kg	0.8	ISO 17025	8.76	169	80.6

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Analytical Report Number: 24-026154
Project / Site name: Birkenshaw

Lab Sample Number				233448	233449	233450
Sample Reference				BH02	BH03	BH04
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				0.50-0.70	0.20-0.50	0.00-0.50
Date Sampled				14/06/2024	14/06/2024	14/06/2024
Time Taken				None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
Heavy Metals / Metalloids						
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	6.9	31	36
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	< 0.2
Chromium (hexavalent)	mg/kg	1.8	MCERTS	< 1.8	< 1.8	< 1.8
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	30	30	31
Copper (aqua regia extractable)	mg/kg	1	MCERTS	11	110	110
Lead (aqua regia extractable)	mg/kg	1	MCERTS	16	310	400
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	21	23	25
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	1.4	2.1	1.2
Vanadium (aqua regia extractable)	mg/kg	1	MCERTS	35	50	54
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	61	280	400
Petroleum Hydrocarbons						
TPHCWG - Aliphatic >EC5 - EC6 $_{HS_1D_AL}$	mg/kg	0.02	NONE	< 0.020	< 0.020	< 0.020
TPHCWG - Aliphatic >EC6 - EC8 $_{HS_1D_AL}$	mg/kg	0.02	NONE	0.14	< 0.020	< 0.020
TPHCWG - Aliphatic >EC8 - EC10 $_{HS_1D_AL}$	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050
TPHCWG - Aliphatic >EC10 - EC12 $_{EH_CU_1D_AL}$	mg/kg	1	MCERTS	< 1.0	1	< 1.0
TPHCWG - Aliphatic >EC12 - EC16 $_{EH_CU_1D_AL}$	mg/kg	2	MCERTS	< 2.0	6	3.6
TPHCWG - Aliphatic >EC16 - EC21 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0
TPHCWG - Aliphatic >EC21 - EC35 $_{EH_CU_1D_AL}$	mg/kg	8	MCERTS	< 8.0	29	29
TPHCWG - Aliphatic >EC35 - EC44 $_{EH_CU_1D_AL}$	mg/kg	8.4	NONE	< 8.4	< 8.4	< 8.4
TPHCWG - Aliphatic >EC5 - EC35 $_{EH_CU+HS_1D_AL}$	mg/kg	10	NONE	< 10	36	32
TPHCWG - Aliphatic >EC5 - EC44 $_{EH_CU+HS_1D_AL}$	mg/kg	10	NONE	< 10	36	32
TPHCWG - Aromatic >EC5 - EC7 $_{HS_1D_AR}$	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010
TPHCWG - Aromatic >EC7 - EC8 $_{HS_1D_AR}$	mg/kg	0.01	NONE	< 0.010	< 0.010	< 0.010
TPHCWG - Aromatic >EC8 - EC10 $_{HS_1D_AR}$	mg/kg	0.05	NONE	< 0.050	< 0.050	< 0.050
TPHCWG - Aromatic >EC10 - EC12 $_{EH_CU_1D_AR}$	mg/kg	1	MCERTS	< 1.0	2.7	2
TPHCWG - Aromatic >EC12 - EC16 $_{EH_CU_1D_AR}$	mg/kg	2	MCERTS	2.3	13	6.5
TPHCWG - Aromatic >EC16 - EC21 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	< 10	82	46
TPHCWG - Aromatic >EC21 - EC35 $_{EH_CU_1D_AR}$	mg/kg	10	MCERTS	< 10	120	100
TPHCWG - Aromatic >EC35 - EC44 $_{EH_CU_1D_AR}$	mg/kg	8.4	NONE	< 8.4	12	19
TPHCWG - Aromatic >EC5 - EC35 $_{EH_CU+HS_1D_AR}$	mg/kg	10	NONE	< 10	210	150
TPHCWG - Aromatic >EC5 - EC44 $_{EH_CU+HS_1D_AR}$	mg/kg	10	NONE	< 10	230	170
VOCs						
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	5	NONE	< 5.0	< 5.0	< 5.0
Benzene	µg/kg	5	MCERTS	< 5.0	< 5.0	< 5.0
Toluene	µg/kg	5	MCERTS	< 5.0	< 5.0	< 5.0
Ethylbenzene	µg/kg	5	MCERTS	< 5.0	< 5.0	< 5.0
p & m-Xylene	µg/kg	5	MCERTS	< 5.0	< 5.0	< 5.0
o-Xylene	µg/kg	5	MCERTS	< 5.0	< 5.0	< 5.0

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

This certificate should not be reproduced, except in full, without the express permission of the laboratory.
The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number : 24-026154
Project / Site name: Birkenshaw

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
233448	BH02	None Supplied	0.50-0.70	Brown clay
233449	BH03	None Supplied	0.20-0.50	Brown clay with vegetation
233450	BH04	None Supplied	0.00-0.50	Brown clay and loam with gravel and vegetation

Analytical Report Number : 24-026154
Project / Site name: Birkenshaw

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in Soil	Asbestos Identification with the use of polarised light microscopy in conjunction with dispersion staining techniques	In-house method based on HSG 248, 2021	A001B	D	ISO 17025
Organic matter (Automated) in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate (Walkley Black Method)	In-house method	L009B	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically (up to 30°C)	In-house method	L019B	W	NONE
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight	In-house method based on British Standard Methods and MCERTS requirements.	L019B	D	NONE
Organic matter in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate (Walkley Black Method)	In-house method	L023B	D	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil	L038B	D	MCERTS
Total sulphate (as SO4 in soil)	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES	In-house method	L038B	D	MCERTS
Sulphate, water soluble, in soil (16hr extraction)	Sulphate, water soluble, in soil (16hr extraction)	In-house method	L038B	D	MCERTS
Speciated PAHs and/or Semi-volatile organic compounds in soil	Determination of semi-volatile organic compounds (including PAH) in soil by extraction in dichloromethane and hexane followed by GC-MS	In-house method based on USEPA 8270	L064B	D	MCERTS
BTEX and/or Volatile organic compounds in soil	Determination of volatile organic compounds in soil by headspace GC-MS	In-house method based on USEPA 8260	L073B	W	MCERTS
Total petroleum hydrocarbons with carbon banding by GC-FID/GC-MS HS in soil	Determination of total petroleum hydrocarbons in soil by GC-FID/GC-MS HS with carbon banding aliphatic and aromatic	In-house method	L076B/L088	D/W	MCERTS
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in NaOH and addition of 1,5 diphenylcarbazide followed by colorimetry	In-house method	L080	W	MCERTS
Free cyanide in soil	Determination of free cyanide by distillation followed by colorimetry	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L080	W	MCERTS
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L080	W	MCERTS

Analytical Report Number : 24-026154
Project / Site name: Birkenshaw

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement	In-house method	L099	D	MCERTS

For method numbers ending in 'UK' or 'A' analysis have been carried out in our laboratory in the United Kingdom (Watford).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL' or 'B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

Information in Support of Analytical Results

List of HWOL Acronyms and Operators

Acronym	Descriptions
HS	Headspace Analysis
MS	Mass spectrometry
FID	Flame Ionisation Detector
GC	Gas Chromatography
EH	Extractable Hydrocarbons (i.e. everything extracted by the solvent(s))
CU	Clean-up - e.g. by Florisil®, silica gel
1D	GC - Single coil/column gas chromatography
2D	GC-GC - Double coil/column gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics
AR	Aromatics
#1	EH_2D_Total but with humics mathematically subtracted
#2	EH_2D_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total

Quality control parameter failure associated with individual result applies to calculated sum of individuals.
The result for sum should be interpreted with caution

End of Report

Constructionline
A UK GOVERNMENT CERTIFICATION SERVICE
QMS ISO 9001 : 2015 REGISTERED Cert No. 14123657
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CIVATION APPROVED Registered Member
UKAS United Kingdom Accreditation Service

RGS Environmental Geotechnical Specialists
Rogers Geotechnical Services Ltd
Offices 1 & 2 Barncliffe Business Park, Near Bank, Shelley, Huddersfield, HD8 8LU
01484 604354 Company No. 5130864

< ENVIRONMENTAL > < GEOTECHNICAL >

Appendix 6

Soil Screening Value Comparison Sheet

Rogers Geotechnical Services: Soil Screening Values Comparison Sheet

Rogers Geotechnical Services Ltd: Soil Screening Value (SSV) Comparison Sheet

Job Number	C4182/24/E/6783
Job Name	Birkenshaw
Date	12.07.2024
Client	N Hall Constrcution Limited

A = WS Atkins PLC, Atrisk Soil Screening Values.
A+ = Values updated June 2017.
A* = Atrisk's SSV is lower than i2's detectable limit for this compound.
B = health criterion values, which are available from toxicological reviews published in the C4SL project methodology report.
C = Category 4 Screening Levels (C4SLs) based on 6% soil organic matter.
D = Value provided is based on Methyl Mercury. Should elemental mercury be observed or a source be known then a limit of 102 should be used.

KEY
- Exceeds SSV
- Exceeds 2017, Below 2015
- Below limit of detection (LOD)

Determinand	Units	Ref	LOD	Residential With Plant Uptake 1%		Sample Location	BH02	BH03	BH04
				Atrisk 2015 (No Free Product	Atrisk 2017	Depth Top	0.50	0.20	0.00
						Depth Base	0.70	0.50	0.50
Cadmium	mg/kg	C	0.2		22.1		< 0.2	< 0.2	< 0.2
Chromium (Hexavalent)	mg/kg	B/C	1.8	20.5	3.62		< 1.8	< 1.8	< 1.8
Copper	mg/kg	A+	1.0		4730		11.00	110.00	110.00
Mercury	mg/kg	A/D	0.3		8.81		< 0.3	< 0.3	< 0.3
Nickel	mg/kg	A+	1.0		136		21.00	23.00	25.00
Lead	mg/kg	C	1.0		200		16.00	310.00	400.00
Zinc	mg/kg	A+	1.0		20000		61.00	280.00	400.00
Vanadium	mg/kg	A+	1.0		136		35.00	50.00	54.00
Arsenic	mg/kg	C	1.0		37		6.90	31.00	36.00
Selenium	mg/kg	A	1.0		375		1.40	2.10	1.20
Cyanide (Free)	mg/kg	A	1.0		34		< 1.0	< 1.0	< 1.0
Total Phenols	mg/kg	A	1.0		267		< 1.0	< 1.0	< 1.0
Naphthalene	mg/kg	A+	0.05		0.829		< 0.05	1.50	0.20
Acenaphthylene	mg/kg		0.05				< 0.05	0.29	0.24
Acenaphthene	mg/kg	A+	0.05	608	157		0.10	2.10	0.49
Fluorene	mg/kg	A+	0.05		735		0.10	1.70	0.44
Phenanthrene	mg/kg		0.05				1.00	19.00	6.30
Anthracene	mg/kg	A+	0.05		10200		0.27	4.90	1.40
Fluoranthene	mg/kg	A+	0.05		983		1.80	32.00	15.00
Pyrene	mg/kg	A+	0.05		668		1.60	27.00	14.00
Benzo[a]anthracene	mg/kg	A	0.05	4.52	1.71		0.70	13.00	6.40
Chrysene	mg/kg	A	0.05	585	0.44		0.79	15.00	7.40
Benzo[b]fluoranthene	mg/kg	A	0.05	7.72	1.22		0.75	15.00	8.50
Benzo[k]fluoranthene	mg/kg	A	0.05	84.4	0.686		0.30	6.80	3.50
Benzo[a]pyrene	mg/kg	B/C	0.05	4.95	1.51		0.63	14.00	7.50
Indeno(1,2,3-c,d)Pyrene	mg/kg	A*	0.05	7.31	0.0614		0.33	6.90	3.90
Dibenz(a,h)Anthracene	mg/kg	A	0.05	0.838	0.00393		0.08	2.00	1.00
Benzo[g,h,i]perylene	mg/kg	A	0.05	96.2	0.0187		0.36	7.30	4.10
Total Of 16 PAH's	mg/kg		0.8				8.76	169.00	80.60
Aliphatic TPH >C5-C6	mg/kg	A+	0.02		42.7		< 0.020	< 0.020	< 0.020
Aliphatic TPH >C6-C8	mg/kg	A+	0.02		99.3		0.14	< 0.020	< 0.020
Aliphatic TPH >C8-C10	mg/kg	A+	0.05		13.9		< 0.050	< 0.050	< 0.050
Aliphatic TPH >C10-C12	mg/kg	A+	1.0	81.7	49.9		< 1.0	1.00	< 1.0
Aliphatic TPH >C12-C16	mg/kg	A+	2.0	385	20.9		< 2.0	6.00	3.60
Aliphatic TPH >C16-C21	mg/kg	A+	8.0		210000		< 8.0	< 8.0	< 8.0
Aliphatic TPH >C21-C35	mg/kg	A+	8.0		210000		< 8.0	29.00	29.00
Aliphatic TPH >C35-C44	mg/kg		10.0				< 8.4	< 8.4	< 8.4
Total Aliphatic Hydrocarbons	mg/kg		10.0						
Aromatic TPH >C5-C7	mg/kg	A+	0.01		0.137		< 0.010	< 0.010	< 0.010
Aromatic TPH >C7-C8	mg/kg	A+	0.01		113		< 0.010	< 0.010	< 0.010
Aromatic TPH >C8-C10	mg/kg	A+	0.05		20.5		< 0.050	< 0.050	< 0.050

Rogers Geotechnical Services: Soil Screening Values Comparison Sheet

Rogers Geotechnical Services Ltd: Soil Screening Value (SSV) Comparison Sheet

Job Number	C4182/24/E/6783
Job Name	Birkenshaw
Date	12.07.2024
Client	N Hall Constrcution Limited

A = WS Atkins PLC, Atrisk Soil Screening Values.
A+ = Values updated June 2017.
A* = Atrisk's SSV is lower than i2's detectable limit for this compound.
B = health criterion values, which are available from toxicological reviews published in the C4SL project methodology report.
C = Category 4 Screening Levels (C4SLs) based on 6% soil organic matter.
D = Value provided is based on Methyl Mercury. Should elemental mercury be observed or a source be known then a limit of 102 should be used.

KEY

- Exceeds SSV
- Exceeds 2017, Below 2015
- Below limit of detection (LOD)

Determinand	Units	Ref	LOD	Residential With Plant Uptake 1%		Sample Location	BH02	BH03	BH04
						Depth Top	0.50	0.20	0.00
						Depth Base	0.70	0.50	0.50
Aromatic TPH >C10-C12	mg/kg	A+	1.0		70		< 1.0	2.70	2.00
Aromatic TPH >C12-C16	mg/kg	A+	2.0	165	155		2.30	13.00	6.50
Aromatic TPH >C16-C21	mg/kg	A+	10.0		319		< 10	82.00	46.00
Aromatic TPH >C21-C35	mg/kg	A+	10.0		1120		< 10	120.00	100.00
Aromatic TPH >C35-C44	mg/kg		10.0				< 8.4	12.00	19.00
Total Aromatic Hydrocarbons	mg/kg		10.0						
Total Petroleum Hydrocarbons	mg/kg		10.0						
pH			N/A				**7.90**	**7.00**	7.20
Sulphate (2:1 Water Soluble) as SO4	g/l		0.00125				0.06	**0.05**	**0.06**
ACM Type			N/A						
Asbestos Identification	%						Not detected	Not detected	Not detected
ACM Detection Stage			N/A						
Moisture	%		0.01				25.00	39.00	42.00
Soil Colour			N/A						
Other Material			N/A						
Soil Texture			N/A						
Sulphate (Total)	%		0.005						
Organic Matter	%		0.1				**1.30**	12.00	**14.00**

Appendix 7

Fill Screening Values

Rogers Geotechnical Services Ltd.

Atkins ATRISK Soil Screening Values (SSVs) - Residential With Plant Uptake Landuse

Tox Data Report No.	Compound	Residential with Homegrown Produce Landuse (mg/kg)				Reference
	Metals	**SOM: 1%**		**SOM: 6%**		
3	Cadmium	22.1		22.1		C
4	Chromium VI	3.62	20.5	3.63	20.5	B/C
	Copper	4730		4790		A+
7	Mercury	8.81		15.80		A/D
8	Nickel	136		136		A+
	Lead	200		200		C
	Zinc	20000		20300		A+
	Vanadium	136		138		A+
	Semi and Non Metals					
1	Arsenic	37		37		C
10	Selenium	375		375		A
	Free Cyanide	34		34		A
9	Phenols (total)	267		1200		A
	Poly Aromatic Hydrocarbons	Free product	No free product	Free product	No free product	
20	Napthalene	0.829		12.2		A+
	Acenaphthene	157	608	2760		A+
	Fluorene	735		2610		A+
	Anthracene	10200		26200		A+
	Fluoranthene	983		2980		A+
	Pyrene	668		2120		A+
	Benzo(a)anthracene	1.71	4.52			A
2	Chrysene	0.44	585			A
2	Benzo(b)fluoranthene	1.22	7.72			A
2	Benzo(k)fluoranthene	0.686	84.4			A
2	Benzo(a)pyrene	1.51	4.95	2.05	4.95	B/C
2	Dibenzo(a,h)anthracene	0.00393	0.838			A*
2	Indeno(1,2,3-cd)pyrene	0.0614	7.31			A
2	Benzo(g,h,i)perylene	0.0187	96.2			A
	Petroleum Hydrocarbons					
	Aliphatic C5-C6	42.7		369		A+
	Aliphatic C6-C8	99.3		768	1240	A+
	Aliphatic C8-C10	13.9		204		A+
	Aliphatic C10-C12	49.9	81.7	297	1180	A+
	Aliphatic C12-C16	20.9	385	125	4130	A+
	Aliphatic C16-C21	210000		210100		A+
	Aliphatic C21-C35	210000		210100		A+
	Aromatic C5-C7 (Benzene)	0.137		0.871		A+
	Aromatic C7-C8 (Toluene)	113		780		A+
	Aromatic C8-C10	20.5		232		A+
	Aromatic C10-C12	70		468		A+
	Aromatic C12-C16	155	165	830		A+
	Aromatic C16-C21	319		1040		A+
	Aromatic C21-C35	1120		1710		A+
Others						
Asbestos Not Detected						
A+ = Values update June 2017.						
A* Atrisk's SSV is lower than Chemtest's detectable limit for this compound.						
B = Health Criterion Values (available from toxicological reviews published in the C4SL project methodology report).						
C = Catergory 4 Screening Levels (C4SLs).						
D = SSV provided is for Methyl Mercury.						