



**BROWNFIELD
SOLUTIONS LTD**

GEO-ENVIRONMENTAL ENGINEERING EXCELLENCE

Joe Battye

Bradford Road, Batley

Geo-Environmental Assessment Report

MS/C4575/9676 Rev B

March 2021

EXECUTIVE SUMMARY	
Location and Brief Site Description	The site is predominantly flat and is currently utilised as a carpark comprising mainly tarmac/concrete surfacing, a small bridge that is 6.5m wide crosses the Batley Beck. This is the only access to the site as the waterway is 2m below site level and runs the entirety of the western side of the site. The northern boundary comprises a 1.2m high concrete wall and a large stockpile of material approximately 3-4m in height is present against the northern boundary. The eastern boundary comprises a 2m high retaining wall running north south. The southern boundary is a 1.2m high concrete wall.
Ground Conditions	Generalised ground conditions from the ground investigation comprise (top down): • Made ground encountered from ground level to between 0.0m and 2.6m bgl within boreholes, however up to 3.6m within trial pits excavated into the stockpile. • Superficial Natural strata encountered from 2.2mbgl to between 3.9m and 4.8 m bgl. • Solid geology encountered from 4.4m bgl to 4.8m bgl. • Groundwater recorded between 3.2m and 3.5m bgl and may be partially confined as rest water levels were recorded within the clay overlying the granular deposits on site.
Human Health - Soils Contamination	The BSL investigation did not record any concentrations of contaminants above commercial screening values. Only concentration of Benzo(a)Pyrene were recorded above the commercial screening values for human health within the investigation previously undertaken. The site is proposed to consist of hardstanding which will limit exposure to soil contamination.
Controlled Waters – Surface and Groundwater Contamination	Groundwater was not encountered within the made ground and the levels of contamination recorded within the made ground is not considered to represent a risk to groundwater.
Ground Gas	BSL have referred to the methodology in Claire's RB17 which would place the site within CS1, and no gas precaution measures would be deemed necessary. As a precaution the site is classified as CS2 where gas protection measures would be required.
Outline Remedial Strategy	No specific remedial measures are considered necessary at the site to protect human health or controlled waters; however, gas protection measures in line with CS2 are recommended and confirmation on the design, and verification that it has been installed as per the specification would be required..
Waste	The soils encountered during the investigation undertaken by BSL indicate soils are Non-hazardous
Foundations and Floor Slabs	A suspended floor slab should be adopted at the site supported by piles. The presence of cohesive (shrinkable) strata needs to be considered in the design of the floor slab.
Concrete Classification	Within the made ground soils, sulphate class DS-2 and ACEC Class AC-1s conditions prevail in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005. DS-1 and ACEC Class AC-1s conditions prevail within the natural deposits and mudstone bedrock.
Highways Design	Equilibrium CBR values are likely to be 2% within the made ground due to the variability of soils encountered at shallow depths across the site. Where the CBR is found to be less than 2%, the sub-grade is unlikely to be suitable for both the trafficking of site plant and as a permanent highway foundation without improvement of the soils.
Sustainable Drainage Systems (SUDS)	Drainage to soakaways is considered unsuitable for this site.
Slope Stability & Retaining Walls	A 2m retaining wall exists on site's eastern boundary. The slope leads up to a railway line and is populated with mature trees. No drainage was visible within the wall. The age of the wall, founding depths, founding materials and the retained materials are unknown. It was outside the scope of this investigation to undertake a detailed inspection of the construction or a structural inspection of the walls and BSL recommends inspection of the walls by a structural engineer
Further Work	The following further works will be required to progress to the construction phase: • Tree survey by qualified arboriculturist. • Detailed foundation design by a structural engineer • Production of Materials Management Plan (MMP) under the CL:AIRE DoWCoP, if required.

This executive summary should be read in conjunction with the full report, reference MS/C4575/9676 Rev B and not as a standalone document.

PROJECT QUALITY CONTROL DATA SHEET

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DRAWINGS

Drawing Number	Rev	Title
2002_103C	-	Proposed Development Layout Plan
C4575/01	-	Site Location Plan
C4575/02	-	Site Features Plan
C4575/03	-	Exploratory Hole Location Plan

APPENDICES

Appendix	Title
Appendix A	BSL Methodology and Guidance
Appendix B	Exploratory Hole Logs
Appendix C	Chemical Testing Results
Appendix D	Geotechnical Testing Results
Appendix E	Gas Monitoring Results
Appendix F	Waste Assessment Report

1.0 INTRODUCTION

1.1 Context

This report describes a Geo-Environmental Assessment carried out by Brownfield Solutions Limited (BSL) for Joe Battye on a site off Bradford Road, Batley and has been completed in general accordance with the following guidance:

- Environment Agency guidance - Land Contamination: Risk Management (LCRM).
- BS 10175:2011+A2:2017 Investigation of Potentially Contaminated Sites.
- BS5930: 2015+A1:2020 Code of Practice for Ground Investigations.
- BS EN 1997-1:2004+A1:2013 Eurocode 7. Geotechnical design. General rules plus UK National Annex.
- BS EN 1997-2:2007 Eurocode 7 Geotechnical design. Ground investigation and testing plus UK National Annex.

Definitions of terms and acronyms used within this report is presented in Section 11.0. Proposed Development

The proposed development is for a commercial end use comprising the original steel framed commercial building along with two additional units and associated car park areas as shown on the proposed development plan, drawing No. 2002_103C provided to BSL by the client.

1.2 Previous Reports

This report should be read in conjunction with BSL Desk Study Assessment Report (AH/C4575/9450) issued in August 2020 and JPG Civil and Structural Engineering Geo-Environmental Ground Investigation Report (RM/GI/4575.v1) issued in November 2014.

1.3 Objectives and Scope

The objectives of this report are to determine the geo-environmental setting and ground conditions of the site, highlighting potential risks and areas of concern that may govern the development under the current planning regime. This assessment is also intended to fulfil the requirements of a Ground Investigation Report (GIR) as detailed in BS EN 1997-2:2007.

Following the Phase I Desk Study referenced above, an exploratory intrusive investigation was undertaken to confirm the findings of the preliminary CSM and risk assessment and meet any objectives that had not been satisfied. The exploratory investigation was undertaken using trial pitting, cable percussive drilling, gas and groundwater monitoring, laboratory chemical and geotechnical testing, with reporting on the findings.

1.4 Limitations

This assessment has been prepared in accordance with the relevant current legislative framework, guidance and risk assessment methodology as outlined in Appendix A. BSL is not liable for any subsequent changes in the guidance and legislation.

The findings and opinions conveyed via this report are based on information obtained from several sources as detailed within this report, BSL have assumed this information is correct and reliable. Nevertheless, BSL cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

BSL have used reasonable skill, care, and diligence for the investigation of the site and the production of this report. There may be other conditions prevailing on the site which are outside the scope of work and

have not been highlighted by this assessment and therefore have not been considered by this report. Responsibility cannot be accepted for such site conditions not revealed by the assessment.

This report has been prepared for the sole use and reliance of the Client, Joe Battye. No other third parties may rely upon or reproduce the contents of this report without the written permission of Brownfield Solutions Ltd (BSL). If any unauthorised third party comes into possession of this report, they rely on it at their own risk and BSL do not owe them any Duty of Care.

The investigation carried out on the site has been conducted to provide the best information on the ground conditions within site access and budgetary constraints. The inherent variation of ground conditions allows only for definition of the actual conditions at the locations and depths of exploratory locations at the time of the investigation. Different ground conditions may exist that have not been identified within this investigation.

The recommendations in this report assume that ground levels will remain as existing, unless stated otherwise within the report. If there is to be any re-profiling (e.g., to create development platforms or flood defences) then the recommendations may not apply.

The groundwater results described are only representative of the dates on which they were recorded, and levels may vary seasonally (e.g., due to changes in weather).

This assessment has been based on the proposed planning layouts provided. Any subsequent change to the planning layout may have an impact on the validity of recommendations made within this report. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Although every effort has been made to position exploratory holes in the least sensitive areas of the site, exploratory hole positions were located approximately as part of this investigation and no guarantee can be given as to their accuracy. Consideration should be given to the possibility that exploratory holes excavated as part of this investigation and indeed any previous ground investigation work by others may be encountered beneath or within the influence of individual foundations. BSL cannot be held responsible for structural failures caused by the location of foundations of any form of structure within the influence of exploratory holes.

Where it has not been possible to reasonably use an EC7 compliant investigation technique, a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

The chemical testing carried out for this report was not scoped to comply with the requirements of the water supply company and further work may be required, unless otherwise stated.

Notwithstanding site observations concerning the presence or otherwise of archaeological issues, asbestos-containing materials (ACM) or invasive weeds (e.g., Japanese knotweed), this report does not constitute a formal survey of these potential issues.

The site plans enclosed in this report should not be scaled off. Any site boundary line depicted on plans does not imply legal ownership of land.

Any recommendations made in this report should be confirmed with the Regulatory Authorities prior to implementation to ensure compliance.

2.0 THE SITE

2.1 Location

The site is located off Bradford Rd, Batley, WF17 6AR. It is situated approximately 1.50km north of Dewsbury Town Centre, centred on National Grid Reference 424747, 423391 as shown on the Site Location Plan, Drawing No. C4575/01.

2.2 Site Description

A walkover survey was carried out on the site on 23rd July 2020. The main site features and potential issues identified during this survey are detailed below and are shown on the Site Features Plan, Drawing No. C4575/02. A selection of photographs from the site walkover are presented to the rear of this report.

Feature	Description
Site Area	The site covers approximately 0.754 hectares.
Site Access	Access to the site is gained off Bradford Road to the west of the site.
Current Land Use and Site Features	The site is currently utilised as a carpark, A small bridge that is 6.5m wide crosses the Batley Beck. This is the only access to the site as the waterway is 2m below site level and runs the entirety of the western side of the site. Numerous manhole covers were noted on the south-western side of the site denoting possible drainage/sewers. A large pipe approximately 300mm in diameter was observed to the south of the site. There is some evidence of water pooling at the south of the site.
Potential Sources of Gross Contamination	Sub-surface pipework might be a source of potential contamination. Isolated asbestos was located on site.
Vegetation	There is sporadic vegetation across the site including some potential invasive species including Himalayan Balsam which is found along the eastern bank of the Batley Beck.
Topography	The site is generally flat however there are retaining walls approximately 2m high of masonry construction running along the eastern boundary of the site as well as both banks of the Batley Beck. An embankment is present in the north-eastern corner of the site sloping down to the south and west of the site approximately a 1:3 gradient. To the east of the site past the easternmost retaining wall is a 45° slope covered in birch and other deciduous trees. There is evidence of an access road running parallel to the site.
Site Boundaries	To the west of the site lies Bradford Road running in a general north-south direction and is separated with an approximately 1.2m high part masonry wall with decorative metal railings. To the north of the western parcel, the side wall of 'Auto Cure Motor Factors' form part of the northern boundary with a brick wall approximately 5m high followed (easterly) by a number of coniferous trees approximately 10-15m high. Within the eastern parcel, the northern boundary to the west exists as a 1.2m high concrete wall and a large stockpile of sandy gravel approximately 3-4m. The eastern boundary comprises a 2m high retaining wall running north south. The southern boundary appears to be a 1.2m high concrete wall. Within the western parcel, the southern boundary consists of a dense line of deciduous trees ranging from 15 to 20m in height.
Surrounding Area	The surrounding area comprises residential and commercial properties. To the north is an auto repairs shop and takeaway restaurants. To the east is a slope with mature trees leading up to a railway line. There is a motorcycle shop located to the south and residential properties located further west of the site.

3.0 SUMMARY OF PREVIOUS REPORTS

3.1 BSL Desk Study

A summary of the relevant points from the Desk Study completed by BSL (AH/C4575/9450) is presented below:

- The site has largely been a sewage works that has expanded, and converted various processes to include stormwater & bacteria beds, septic, settling, humus & unspecified tanks, and sludge lagoons. Expansion of the sewage works reached its peak around 1966 with adjacent offsite works before gradual downsizing and subsequent demolition and construction of Batley Variety Club (and then J.D Batley Gym) with associated car parks.
- Offsite works have primarily been industrial with the nearby railway and mills which have gradually downsized whilst offsite garages, warehouses, electrical substations & transformer stations have been developed, renovated, and downsized over the years with current offsite use comprising of a mix of residential/commercial and industrial.
- The western parcel of the site is indicated to be underlain by alluvial clay, silt, sand, and gravel. These deposits formed up to 2 million years ago in the Quaternary Period. No superficial deposits are recorded to be present within the eastern parcel.
- The deeper solid geology (western and eastern parcels) is indicated to be part of the Pennine Lower Coal Measures Formation, which typically comprises mudstone, siltstone, and sandstone.
- A rock fault is shown 144m north of the site and runs in an east-west orientation. A further three rock faults are identifiable within 500m of the site.
- The Geo-Environmental Data Report identifies a coal seam onsite that is shown to traverse the eastern boundary of the site in a south-westerly to north-easterly direction. Another coal seam is shown 84m north-west of the site and runs in a general south-westerly to north-easterly direction. An additional six coal seams are identified within 500m of the site.
- The Coal Mining Assessment and The Coal Authority Interactive Map identifies several coal outcrops in parallel to the south-east of the site from 150m from the site running in a general north-easterly direction. The Coal Mining Assessment indicates that Probable shallow coal mine workings are present in this area. The interactive map however does not provide further details of the locations of the seams.
- The nearest watercourse to the site is the Batley Beck River, which is onsite and flow direction is indicated to be from north to south.
- The western parcel of the site is indicated to lie within an EA designated Zone 2 flood zone compared to the eastern parcel which is indicated to lie within a Zone 3 flood zone.
- The risk to human health is low to moderate/low.
- The risk from ground gas is moderate and the site is not located in an area requiring radon protection measures.
- The risk to controlled waters is low to moderate.
- The site is in the UXO low risk zone.
- Recommendations were for an appropriate Phase II ground investigation to be carried out to confirm the identified risks and obtain information for preliminary design.

3.2 JPG Geo-Environmental Ground Investigation

A summary of the relevant points from the Geo-Environmental Ground Investigation Report completed by JPG (RM/GI/4575.v1) is presented below:

- Fieldwork comprised the drilling of 15 window sample boreholes and nine cable percussion boreholes. In-situ testing was carried out. Samples of soil and groundwater were obtained and submitted for chemical and geotechnical analysis.
- The exploratory boreholes located in the eastern parcel of land (the current development area) included WS07, WS08, WS09, WS10, WS11 and WS12. No cable percussion boreholes were drilled within the eastern parcel of the site.
- Of the six window sample boreholes mentioned above that were located in the eastern parcel of the site, WS09 and WS12 had monitoring wells installed. These were subsequently monitored for groundwater and ground gas on six occasions.
- Groundwater was encountered between 1.22m and 2.06m bgl across the two installations.
- No methane was detected in either of the installations in any of the six gas monitoring visits. Carbon dioxide was recorded at 5.1%v/v in WS09 on one occasion. The other 5 visits detected carbon dioxide below 5.0%v/v. The lowest oxygen concentration recorded was 15.8%v/v within WS09.
- Based on the gas monitoring results JPG recommended that gas protective measures, in accordance with Characteristic Situation 2 should be installed in the proposed development.
- Within the window sample boreholes in the eastern parcel, made ground was encountered to depths between 1.20m and 2.30mbgl. The made ground generally comprised gravel or clay with varying amounts of silt, sand, gravel, ash, and cobbles as minor constituents.
- All chemical test results were screened against the GAC for commercial end-use. There were no elevations in heavy metal determinants from samples tested from WS07 to WS12.
- After statistical analysis, WS09 (0.40m to 1.00m), WS10 (1.00m to 1.50m) and WS11 (0.20m to 1.00m) are potentially contaminated with respect to benzo(a)pyrene.
- No hydrocarbon fractions were detected at concentrations above the LQM threshold concentrations which pose a potential risk to human health.
- A sample of very soft dark grey silty clay (WS10, 1.00m to 1.50m), possibly associated with the former sewage works, was submitted for pathogen analysis. No significant concentrations of coliforms were detected, and salmonella was absent.
- 19 samples were screened for asbestos. Chrysotile fibres were detected in a sample from WS03 (0.15m to 0.70m) and chrysotile in a cement sheet was identified in a sample from WS04 (1.40m to 1.65m). No asbestos was detected in any of the samples tested from WS07 to WS12 in the eastern parcel of the site.
- No groundwater samples from WS09 or WS12 were obtained. Any elevations detected were in samples collected from installations located in the western parcel of the site.
- BH01, sealed within the made ground, had elevations of PAHs detected in the groundwater sample. Minor sulphate elevations were also detected in groundwater samples from BH01 and BH02. BH02 was sealed within natural strata.
- Based on the thickness of the made ground and the calculated shear strengths of shallower clays JPG recommended that foundation loads are transferred to deeper natural strata of suitable bearing capacity, e.g., piles. Ground improvement techniques were another option that could be utilised.
- If a ground bearing floor slab is required for the proposed units, then the made ground and shallow very soft and soft alluvial deposits will need to be subjected to some form of ground improvement/earthworks so that consistency can be achieved across the formation. This may include further vibro stone columns and earthworks.
- Due to the variability in material properties of the made ground, it is recommended that a CBR value of 2% should be adopted for the design of road pavements and parking areas.
- It is recommended that concrete should be designed to Aggressive Chemical Environment for Concrete (ACEC) Design Sulphate Class DS-2 and ACEC Class AC-2. This considers results from both the western and eastern parcels of the site.

4.0 METHOD OF INVESTIGATION

4.1 Objectives

To confirm the risks to the identified receptors and confirm the ground conditions in respect to the identified geotechnical and geo-environmental risks, an appropriate intrusive investigation was undertaken as per the recommendations of the Phase I Desk Study Assessment.

The aim of the fieldwork was to:

- Investigate ground conditions on the site and the potential need for detailed investigation.
- Further investigate the ground conditions on site. Focussing on the eastern parcel of the site.
- Install standpipes to allow future monitoring.
- Assess the potential contamination on the site and obtain samples for contamination screening.
- Assess the potential impact of any contamination on controlled waters.
- Obtain geotechnical information on the ground conditions at the site for preliminary foundation design and preliminary pavement design purposes.
- Give an assessment of the geo-environmental risks associated with redevelopment of the site.

4.2 Site Works

The following site works have been undertaken by BSL as part of the intrusive investigation between the dates of 1st and 3rd December.

Method	No.	Range Depths (m bgl)	Purpose
Trial pits – JCB 3CX	4	2.20 – 3.50	Obtain samples of the stockpile in the northwest corner of the site for waste classification purposes.
Cable percussive boreholes	3	6.50 – 7.20	Assess deeper ground conditions, carry out SPTs and obtain samples for contamination and geotechnical and testing. Installation of ground gas and water monitoring wells.

The approximate locations of the exploratory holes are indicated on the Exploratory Hole Location Plan, Drawing No C4575/03. The exploratory hole logs are presented in Appendix B.

The exploratory holes were logged by an experienced geo-environmental engineer in general accordance with the following guidance:

- BS 5930:2015+A1:2020 Code of Practice for Site Investigations.
- BS EN 14688-1:2018 Geotechnical Investigation and Testing – Identification and classification of soil.
- BS EN ISO 14689:2018 Geotechnical investigation and testing – Identification and classification of rock.

4.3 Sampling

During the drilling and excavation of the exploratory holes, representative samples were taken at regular intervals to assist in the identification of the soils and to allow subsequent laboratory testing. They were stored and transported in general accordance with BS 10175:2011+A2:2017.

The type of sample was dependent upon the stratum and the purpose of analysis in accordance with current environmental and geotechnical guidance.

The distribution of samples taken across the site is recorded on the exploratory logs and a summary of the samples taken is presented in the table below:

Type	Number
Environmental (ES)	31
Disturbed (D)	20
Bulk (B)	2
U100 (U)	3

4.4 Laboratory Testing

As part of the further assessment for potential contamination of the site, selected samples were taken for the purpose of chemical contamination testing.

A range of potentially contaminative processes have been recorded on site; therefore the following suite of determinants were chosen to screen for potential site impacts at a UKAS approved laboratory:

Determinant	No of Samples
BSL Default Soil Suite: Arsenic, Cadmium, Chromium (III), Chromium (VI), Copper, Nickel, Mercury, Lead, Zinc, Selenium, speciated polycyclic hydrocarbons (PAH 16), water soluble sulphate (2:1 Extract), soil organic matter (SOM) and pH.	6
Soil Suite A: Arsenic, cadmium, chromium (total and hexavalent), copper, lead, mercury, nickel, selenium, zinc, and pH.	4
Petroleum Hydrocarbons (TPH CWG) inc BTEX and MTBE.	5
Asbestos Screen.	6
Total Organic Carbon (TOC).	6
Thiocyanate	3
Total phenol	3
Free cyanide	3

The Chemical Laboratory Testing Results are presented in Appendix C.

Representative disturbed samples were obtained for all soil types encountered. Selected samples were scheduled for testing at an approved laboratory in accordance with BS 1377 'Method of Test for Soils for Civil Engineering Purposes' and BS EN ISO 17892- Parts 1-12:2018 'Geotechnical investigation and testing. Laboratory testing of soil'.

The following tests were scheduled for geotechnical purposes:

Description	No of Samples
Natural Water Content.	4
Plasticity Index Analysis.	4
pH Value.	5
Water Soluble Sulphate Contents.	5
SD1 BRE Full Suite.	5
Determination of Undrained Shear Strength in Triaxial Compression.	1

The Geotechnical Laboratory Testing Results are presented in Appendix D.

4.5 Monitoring Installations

Ground gas and ground water monitoring standpipes were installed in 3 boreholes.

Standpipes were constructed in general accordance with the relevant guidance. A summary of the installation construction is presented in the table below:

Location	Internal Diameter Pipe	Response Zone (m bgl)	Targeted Strata	Purpose
CP01	50mm HDPE	1.00 – 7.00	Made Ground & Natural Strata	Ground Gas & Groundwater
CP02	50mm HDPE	1.00 – 6.50	Made Ground & Natural Strata	Ground Gas & Groundwater
CP03	50mm HDPE	1.00 – 6.30	Made Ground & Natural Strata	Ground Gas & Groundwater

5.0 GROUND CONDITIONS

5.1 Summary

A summary of the ground conditions encountered by BSL is presented in the table below:

Stratum	Range Depths - Top (m bgl)	Range Depths - Base (m bgl)	Range Thickness' (m)	Brief Description
Made Ground (CP)	0.00	2.20 – 2.60	2.20 – 2.60	Tarmacadam / Concrete over sand and gravel / sandy gravelly clay. Cobbles throughout. Ash and clinker as minor constituents.
Made Ground (TP)	0.00	2.20 – 3.50	2.20 – 3.50	Sand / Gravel / Clay with cobbles throughout
Natural Superficial Strata	2.20 – 2.60	3.90 – 4.40	1.70 – 1.80	Sandy silty CLAY.
Natural Superficial Strata	3.90 – 4.40	4.40 – 4.80	0.20 – 0.55	Clayey sandy GRAVEL.
Solid Geology	4.40 – 4.80	6.50 – 7.20	1.70 – 2.75	Very weak to weak residual MUDSTONE.

A summary of the ground conditions encountered by JPG in WS07-WS12 is presented in the table below:

Stratum	Range Depths - Top (m bgl)	Range Depths - Base (m bgl)	Range Thickness' (m)	Brief Description
Made Ground	0.00	1.20 – 2.30	1.20 – 2.30	Tarmacadam / Concrete over sand and gravel / sandy gravelly clay. Cobbles throughout. Ash and clinker as minor constituents.
Natural Superficial Strata	1.20 – 2.30	3.15 – 5.45	1.55 – 3.65	Sandy silty CLAY.

Details are provided in the logs in Appendix B and the individual strata are described in the sections below.

5.2 Made Ground

Made Ground – General

During the BSL investigation made ground was encountered within all the exploratory holes across the site and was observed from ground level to depths between 2.20m and 2.60m bgl in the three cable percussive boreholes. It was observed from ground level to depths between 2.20m and 3.50m bgl in the four trial pits excavated in the stockpile in the northeast corner of the site.

Hardstanding surfacing of concrete or tarmacadam was present across the site recorded between 0.10m and 0.20m thick. Tarmacadam in CP01 and concrete in CP02 and CP03.

The composition of the made ground beneath the concrete was fairly consistent across the three boreholes site and represented demolition material comprising sands and gravels with varying amounts of ash as a minor constituent. A low cobble of brick was encountered in CP01 from 0.20m to 0.45mbgl.

A layer of black slightly clayey sand and gravel with ash and clinker was observed in CP01 and CP02 between 1.20m - 2.20mbgl and 1.10m - 1.90m bgl respectively.

5.3 Natural Superficial Strata

The natural strata underlying the site was generally very soft to soft clay with varying amounts of silt and sand as minor constituents. This is interpreted to represent Alluvium.

A slightly clayey sandy gravel was encountered in the three boreholes at depths between 3.90m and 4.40mbgl. This is interpreted to represent the historic riverbed.

5.4 Solid Geology

Very weak to weak residual mudstone bedrock was encountered from depths of between 4.40m and 4.80mbgl. This was proven to a maximum depth of 7.20m across the site and is interpreted to represent the Pennine Lower Coal Measures.

5.5 Groundwater

The depths to groundwater and locations present are shown in the table below:

Location	Depth During Site Works (m)
CP01	3.20
CP02	3.80
CP03	3.50

No groundwater was encountered within the made ground stratum above the more cohesive layer present on site, indicating that groundwater maybe partially confined, however the thickness of the more permeable deposits beneath the clay underlying the made ground is limited.

5.6 Observations

Contamination

During the works undertaken by BSL, observations for both visual and olfactory evidence of contamination were undertaken.

With the exception of ash and clinker observed as a minor constituent in the made ground soils, no other evidence of contamination was observed at the site.

Stability of Excavations/Boreholes

The sides of the trial pits were generally unstable due to the presence of deep granular made ground across the stockpile in the northeast corner of the site.

Casing was required within the three boreholes to prevent collapse with the granular materials during drilling of the window sample boreholes and cable percussive boreholes.

6.0 TEST RESULTS

6.1 Geotechnical Laboratory Testing

Plasticity Index Analysis

Plasticity index results ranged between 17% and 20% indicating the cohesive soils to be of low to medium plasticity. Associated water contents ranged between 14% and 36%.

After modification of particle size in accordance with BRE 240 the modified plasticity indices are in the range 17% to 19% indicating the cohesive soils to be of low volume change potential.

Undrained Shear Strength

A U100 sample of the residual mudstone (CP02 4.50 – 4.95mbgl) was scheduled for Determination of Undrained Shear Strength in Triaxial Compression. However, the sample was deemed unsuitable due to its low moisture content and stiffness meaning it easily crumbled under pressure.

6.2 Aggressive Ground Conditions – Geotechnical Chemical Testing

The test results for the assessment of aggressive ground conditions are presented in Appendix D. The results are summarised and assessed within Section 8.0 of this report.

6.3 In Situ Geotechnical Testing

In Situ Standard Penetration Tests

Standard Penetration Tests (SPTs) were carried out within the window sample and cable percussive boreholes at regular 1.00m intervals. The results of the individual blows and the N-values are recorded on the Exploratory Hole Logs in Appendix B.

All SPT N values are uncorrected. Density and strength descriptors are reported in accordance with the guidelines stated in BS 5930:2015+A1:2020, incorporating requirements of BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003.

6.4 Geo-Environmental Testing

Chemical Laboratory Testing

The chemical test results for soils are presented in Appendix C. The results are summarised and assessed within Section 8.0 of this report.

Ground Gas Monitoring

Ground gas monitoring installations were monitored by JPG on 6 occasions between 27th March and 29th April 2014.

BSL installed 3 standpipes in the cable percussive boreholes across the proposed development area. They were monitored for ground gas and groundwater on 3 occasions between 25th January and 2nd March 2021. The results are summarised and assessed within Section 8.0 of this report.

7.0 GEOTECHNICAL ASSESSMENT

7.1 Ground Model Summary

A small section towards the north of the eastern parcel of the site is used as a carpark. The majority of the area is disused and unoccupied with any previous buildings now demolished. It is surfaced in hardstanding tarmac or concrete.

The ground conditions can be summarised as below (top down):

-
- Made ground generally comprising sand and gravels and sandy gravelly clay from ground level to between 2.20m and 2.60mbgl.
 - Natural superficial deposits comprising very soft to soft clay with varying amounts of silt and sand followed by a clayey sandy gravel proven to depths between 3.90m and 4.40m bgl.
 - Solid geology comprising very weak to weak residual mudstone proven to depths ranging between 6.50m and 7.20m bgl.
 - Groundwater levels ranging between 3.20m and 3.80m bgl during site works.
-

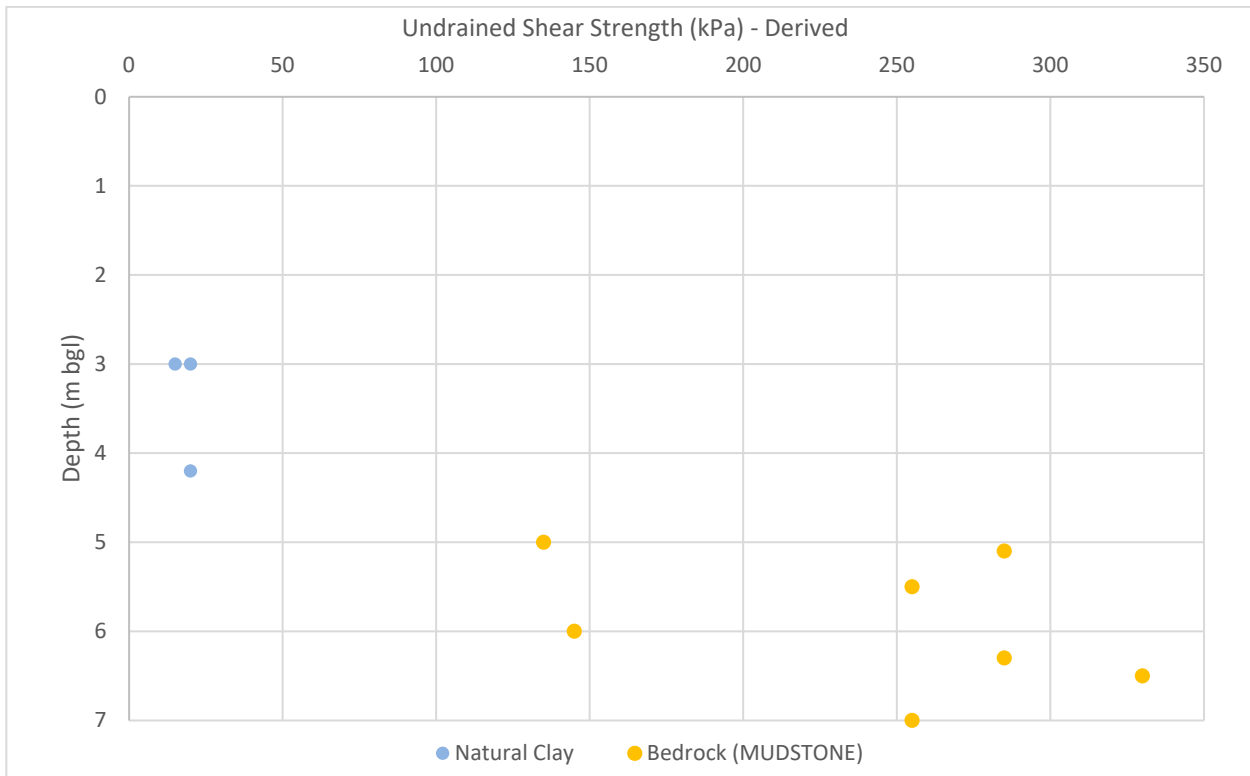
The eastern parcel of the site lies within a Zone 3 floodplain. Specialist flood risk advice should be sought, and this will require consideration when setting the finished levels for the site.

7.2 Design Soil Parameters

The relevant test results from the prior section have been evaluated to derive geotechnical soil parameters for the site in the following section. The parameters of the shallow soils have been provided to highlight the insufficient strength required for the envisaged loads of the proposed buildings.

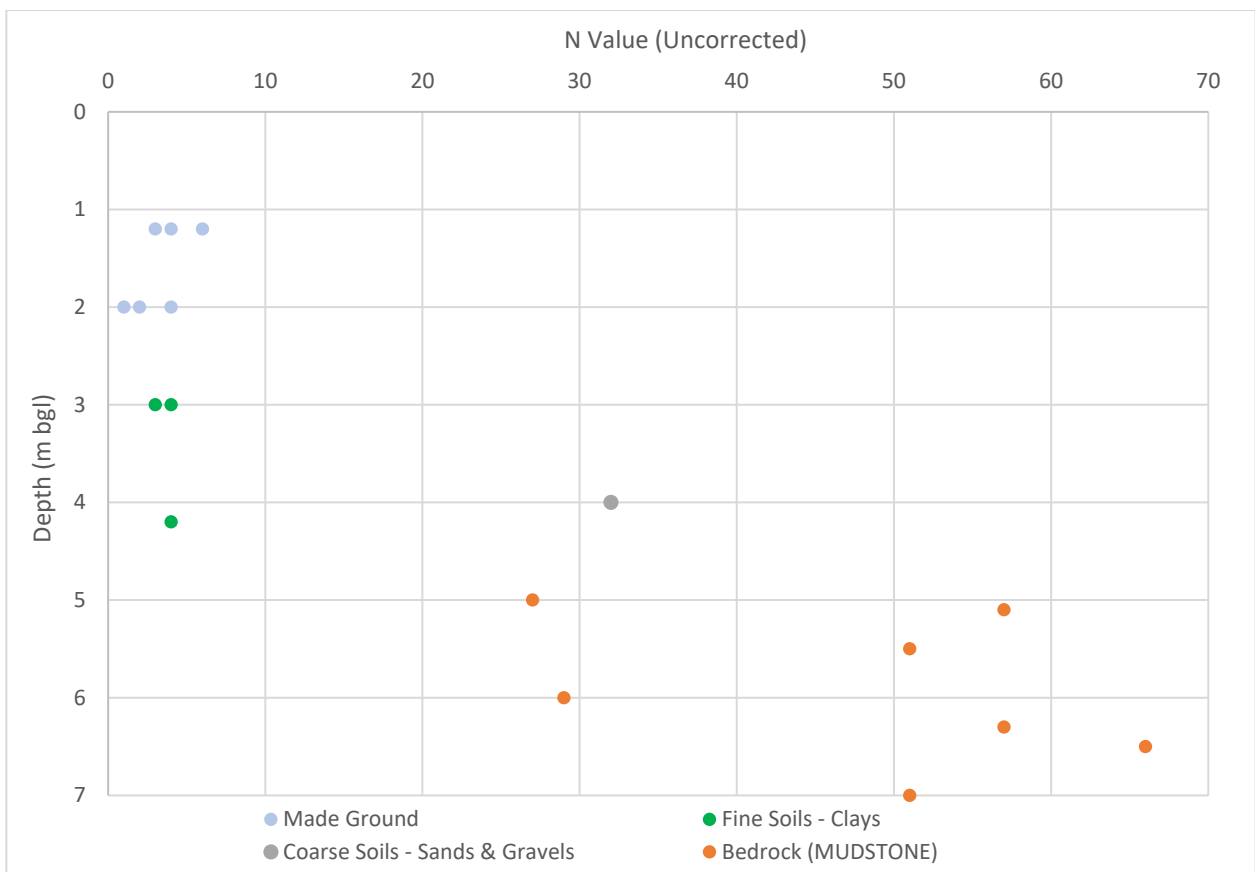
For cohesive (fine) soils, the equivalent approximate undrained shear strengths (C_u) and equivalent approximate coefficients of volume compressibility (m_v) have been calculated from the recorded SPT N values, adopting f_1 and f_2 values respectively, based on the correlation of Stroud (1975) and the 'average' plasticity.

A depth (m bgl) vs derived shear strength (C_u) graph is provided below to provide a profile of the cohesive soils underlying the site. It should be noted that the residual bedrock values have been incorporated into this graph.



The above graph shows a general increase in soils strengths as depth increases. The natural clays show a low derived shear strength whereas the values derived from the bedrock N values are considerably higher.

A depth (m bgl) vs SPT N value graph is also provided below to provide a profile different soils underlying the site.



The above graph shows a general increase in N value as depth increases.

Characteristic Values

Characterisation of the geotechnical parameters above has been undertaken to obtain characteristic values, which are a cautious estimate of the values affecting the occurrence of the limit state.

During the investigation, the SPT tool frequently sank into the soft clays or returned low SPT values. The characteristic value for undrained shear strength (C_u) for the soft clays has been interpreted to be at 18 kN/m between depths of 3 and 4.2m bgl. The characteristic value for undrained shear strength (C_u) in the weathered mudstone deposits between 5 and 7.0mbgl is interpreted to be 241kN/m². The calculated C_u value generally increases with depth increasing from 135kN/m² at 5.00mbgl and 275kN/m² at 6.00mbgl. However a calculated C_u of 250kN/m² at 7m bgl was recorded in CP01.

Approximate coefficients of volume compressibility (m_v) derived from the in situ SPT testing within the cohesive materials (shallow Clay) range from 0.500 m²/MN to 0.700 m²/MN adopting an f_2 value of 0.5 (based on the 'average' plasticity). The average derived coefficient of volume compressibility at 3.4m bgl has been calculated to be 0.6 m²/MN.

Approximate coefficients of volume compressibility (m_v) derived from the in situ SPT testing within the weathered bedrock range from 0.030 m²/MN to 0.1 m²/MN adopting an f_2 value of 0.5 (based on the 'average' plasticity). The average derived coefficient of volume compressibility at 6m bgl has been calculated to be 0.046 m²/MN.

Based on the parameters highlighted above, shallow foundation design is not considered feasible to support the envisaged loads of the proposed buildings.

7.3 Foundations

The development will comprise the original steel framed commercial building along with two additional units and associated car park areas as shown on the proposed development plan, drawing No. 2002_103C and is classed as Geotechnical Category 2 in accordance with Eurocode 7.

Preliminary design by calculation has been undertaken to determine the design resistance of the bearing strata in the following section. Preliminary foundation point loads have been provided to BSL by the client's structural engineer. The figure provided is 500kN. All BSL recommendations are provisional and should be reviewed at the detailed design stage.

Piles

Due to the depth of made ground and poor natural ground conditions on site, the use of shallow foundations is not considered feasible for the proposed development. Therefore, the most suitable foundations are piles extending through the made ground and superficial deposits end bearing on residual mudstone bedrock which was observed to depths of between 6.50m and 7.20m bgl.

Discussions should be made with the piling contractor regarding the suitability of driven piles due to the possible levels of disturbance to the medium pressure gas main located adjacent to the east boundary of the site. Driven piles may be deemed unsuitable for the site.

At this stage, bored piles with the use of casing or continuous flight auger (CFA) piles are considered potentially suitable piling solutions for this site.

Piles should be extended through the made ground and the superficial deposits. Depending on the structural loadings and design requirements, piles will likely utilise a combination of skin friction and end-

bearing resistance, transferring the majority of the load to the underlying competent residual mudstone bedrock.

The choice of piling system and the detailed design of piles are beyond the scope of this report and should be undertaken by a piling specialist. However, as a guide, preliminary calculations were undertaken for a circular concrete pile 0.3m in diameter, taking into account shaft resistance, end bearing resistance and the effects of negative skin friction.

Preliminary pile calculations indicate that the piles would need to extend beyond the depth of the boreholes that have been drilled in this investigation method due to refusal and limitation of the drilling method. The allowable loads for 7m deep piles are in the order of 400 – 450 kN. In order to achieve an allowable load of 500kN, the piles would need to extend to at least 8m using a CFA as driven piles will likely refuse and not achieve the desired depth. Alternatively pile groups could be considered.

We recommend that if piles are proposed that are longer than the depth of investigation that the ground conditions and strength values are confirmed by deeper boreholes and testing, this will require rotary techniques to obtain the penetration.

The following should be taken into consideration during the detailed design stage by a suitably competent contractor/engineer:

- Piles should extend a minimum of five pile diameters into the bearing stratum to fully mobilise end-bearing resistance and shaft resistance.
- Higher allowable loads than those indicated above could be achieved by increasing the diameter of the piles or by using pile groups.
- Obstructions in the ground (e.g. relict foundations) could cause piles to stop shallower than their anticipated design depth, or deviate from the vertical, therefore reducing their capacity.
- As groundwater was observed during the boring of the intrusive holes and monitoring, temporary casing may be required for bored piles.
- Bored piles through coarse soils will likely result in loosening, with resultant reduced shaft friction.
- Discussions should be made with the piling contractor regarding the suitability of driven piles due to the possible levels of disturbance to the medium pressure gas main located adjacent to the east boundary of the site.
- CFA piles are likely to be a suitable alternative to driven piles to reduce vibrations and potential disturbance of the gas main, although there will be additional costs associated with disposal of excess soils.
- The piling work should be undertaken in accordance with BS EN 12699:2015 'Execution of Special Geotechnical Work - Displacement piles', and also relevant standards associated with manufacturing the piles.
- In accordance with Eurocode 7 it would be prudent to verify the compressive resistance of the strata and the pile design should be by static load testing on working piles 1.5 times the characteristic load on more than 1% of working piles. This will provide an accurate strength of the end bearing stratum.

Piling Risk Assessment

A risk assessment is likely to be necessary for piling, as there is a possibility that this could lead to creation of new pathways for migration of contamination.

7.4 Building Near Trees

The clay soils on site are of low volume change potential. Where foundation excavations (or piles if adopted) encounter cohesive strata in the vicinity of existing, proposed or recently removed trees, foundations should be adjusted in full accordance with BRE 298. All foundations should be deepened below roots of greater than 5mm diameter during excavations for footings.

A survey of all trees and hedges on the site and within influencing distance of the site boundary should be undertaken to identify tree species and heights by a qualified arboriculturist in accordance with BS 5837:2012. This information will be required in order to assess the effects of trees on the cohesive strata.

Where foundation depths due to trees already present or recently removed exceeds 1.50m, there is a possibility for heave to occur on removal of the tree and guidance states that compressible material or void former is required against the inside face of the foundation / ground beam, unless it can be satisfied that the soil is not desiccated.

Where foundations are constructed on clay soils within the influencing distance of trees including proposed planting, the upper section of the pile (to the recommended minimum founding depth) should be sleeved or overbored to allow for clay volume change. Bored, cast-in-place piles are well suited to counteracting heave. Driven piles are less well suited to counteracting heave and are difficult to install in stiff desiccated clay without excessive noise and vibration.

The clay soils on site are of low volume change potential. Designs should take suitable precautions to protect against ground heave and the influence of trees if the inclusion of trees is proposed as part of the design of the new development or if evidence of current or former trees is uncovered during construction.

7.5 Floor Slabs

A suspended floor slab should be adopted at the site supported by piles. The presence of cohesive (shrinkable) strata needs to be considered in the design of the floor slab.

7.6 Site Preparation and Construction

There are several services crossing the site. A medium pressure gas main runs adjacent to the east boundary. The appropriate bodies should be informed before high disturbance works commence on site. To allow remediation and construction, all on-site services will need to be disconnected and any suspected dead services are confirmed as dead by testing.

Instability of excavations through natural soils is not anticipated provided they are not exposed to adverse weather conditions for any substantial period of time. Instability of the made ground should be allowed for. All excavations should be carried out in accordance with CIRIA Report 97 'Trenching Practice'.

Excavation depths should generally be readily achieved using conventional plant (JCB or similar) although high specification plant (tracked 360° or similar) is recommended to maintain the build programme. Breaking equipment may also be required locally to penetrate the hardstanding surface that covers the site.

To protect against the effects of heave, new drainage should be designed to take account of potential ground movement, including where pipes and services which pass through substructure walls or foundations. The volume change potential on this site is low and the potential ground movements that need to be considered for design are 50mm.

Recorded post site works groundwater levels (JPG & BSL) ranged between 0.61m and 3.87m bgl therefore will be encountered within likely excavation depths. Based on the exploratory hole logs and monitoring, it is considered that methods such as sump pumping will not be sufficient to deal with anticipated flows and alternative methods of dewatering may be required such as dewatering wells. A specialist dewatering contractor should be consulted for advice in this instance. Further guidance is provided in CIRIA C750 "Groundwater Control: Design and Practice". It should be noted that groundwater levels will vary seasonally, and the timing of construction may influence requirements.

7.7 Concrete Classification

The soluble sulphate and Ph test results (BSL) have been assessed in accordance with BRE Special Digest 1 “Concrete in aggressive ground” 2005. The Design Sulphate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in the table below.

For the purposes of this assessment, the groundwater has been classified as static given the site is underlain by low permeability deposits.

Stratum	No. Samples	Characteristic SO ₄ (g/l)	Characteristic pH	DS Class	ACEC Class
Made Ground	5	0.55	7.8	DS2	AC-1s
Natural Superficial Strata	1	0.15	7.1	DS1	AC-1s
Solid Geology - Mudstone	3	0.04	7.1	DS1	AC-1s

Based on the above, the results of laboratory pH and sulphate content, alongside the BRE full suite tests, indicate that the made ground sulphate class DS-2 and ACEC Class AC-1s conditions prevail in accordance with BRE Special Digest 1 “Concrete in aggressive ground” 2005. DS-1 and ACEC Class AC-1s conditions prevail within the natural deposits and mudstone bedrock.

The specific concrete mixes (the Design Concrete Class) to be used on site will be determined by the site-specific concrete requirements in terms of the durability and structural performance. These are assessed in terms of the Structural Performance Level (SPL) and any need for Additional Protective Measures (APM) detailed in Part D of BRE Special Digest 1 with further guidance in Pt E and F.

7.8 Highways

Equilibrium CBR values are likely to be 2% within the made ground due to the variability of soils encountered at shallow depths across the site.

Where the CBR is found to be less than 2%, the sub-grade is unlikely to be suitable for both the trafficking of site plant and as a permanent highway foundation without improvement of the soils.

To achieve the required design CBR value, improvement works should be carried out in accordance with DMRB IAN 73/06 Rev 1 Chapter 5 and may include proof rolling, excavation and re-engineering / replacement of weaker soils, the inclusion of a geogrid or use of stabilisation techniques such as the addition of hydraulic binders (e.g., cement/lime).

Based on the fines content of the soils, they are considered to be frost susceptible, therefore highway construction should be a minimum thickness of 450mm to mitigate against the risk.

Care should be taken to ensure the stratum at formation level is protected against inclement weather, as this is likely to lead to surface deterioration and a decrease in soils strengths.

7.9 Sustainable Drainage Systems (SUDS)

The use of soakaways is not recommended due to the presence of variable and potentially contaminated made ground near the surface and the presence of low permeability cohesive strata underlying the made ground strata.

7.10 Slope Stability and Retaining Walls

A retaining wall exists on site’s eastern boundary, above which is slope which leads up to a railway line and is populated with mature trees.

No drainage was visible within the wall. The age of the walls, founding depths, founding materials and the retained materials are unknown.

It was outside the scope of this investigation to undertake a detailed inspection of the construction or a structural inspection of the walls and slope.

8.0 GEO-ENVIRONMENTAL RISK ASSESSMENT

8.1 Introduction

The samples were tested for an assessment of the chemical contamination that may pose a risk to human health. The results were examined with reference to a selection of guidance documents as detailed in Appendix A. In this case the LQM/CIEH S4ULs and DEFRA C4SLs for a commercial end use have been adopted as Tier 1 generic screening values.

The apparent exceedance of the relevant screening value is taken as indicating further detailed assessment or remedial action is required.

A summary assessment sheet is presented in Appendix B alongside the chemical test results. Results are discussed in detail in the sections below.

8.2 Soils Test Results and Risk Assessment – Human Health

Metals

No metals have been detected above the adopted screening criteria.

Asbestos

No asbestos fibres have been detected in any of the 6 samples screened by BSL. No asbestos was identified in samples tested from WS07 to WS12 (located within the development area) during the JPG investigation.

Poly Aromatic Hydrocarbons (PAHs)

BSL testing found that no PAHs have been detected above the adopted screening criteria.

JPG highlighted exceedances in benzo(a)pyrene in samples of made ground from WS09 (0.40m-1.00m bgl), WS10 (1.00m-1.50m bgl) and WS11 (0.20m-1.00m bgl). These were still in exceedance after statistical analysis had been completed on the results.

Total Petroleum Hydrocarbon's (TPH CWG)

No petroleum hydrocarbons have been identified above the adopted screening criteria.

Volatile Organic Compounds (VOCs)

No VOCs have been identified above the adopted screening criteria.

8.3 Summary – Human Health Risk Assessment

Based on the testing and assessment undertaken by BSL, there are no determinants above the relevant assessment criteria and mitigation measures will not be required in respect to soils.

However, JPG identified exceedances in benzo(a)pyrene in three samples of made ground soils in the eastern parcel of the site. Although, as the proposed development is for the site to be surfaced in hardstanding, a viable pathway is not envisaged and the risk to human health is considered to be low.

8.4 Controlled Waters Risk Assessment

Several species of PAH have been detected above their respective method detection limits within soils samples recovered from the made ground, however with the exception of Naphthalene, Acenaphthylene, and Acenaphthene recorded up to concentrations of 4.6, 0.25 and 2.6 mg/kg respectively PAH are generally of low to very low mobility. Concentrations of petroleum hydrocarbons has also been detected; however, these are generally in the heavier fractions and likely relate to the PAH's.

The metal concentrations have been compared to the Normal Background Concentrations survey undertaken by the British Geological Survey. Concentrations of Arsenic, Cadmium, Copper, Mercury, Nickel and Lead, have been compared against concentrations for the principal domain, which relates to non-urban areas and should therefore be considered indicative of background concentrations of these contaminants.

A total of 2 No results are above the Principal domain for arsenic of 32 mg/kg with concentrations of 73 mg/kg and 48 mg/kg with the remaining 4 samples below the NBC. For copper 4 No results are above the principal domain of 62 mg/kg with concentrations ranging from 82 and 590 mg/kg, however only 2 No results are above the Urban NBC concentration of 190 mg/kg with concentrations ranging between 290 and 590 mg/kg. A total of 2 No results are above the nickel NBC concentration of 42 mg/kg with concentrations of 44 mg/kg. No other determinants were above the natural background concentrations.

The concentrations above the NBC are however not considered to be significant as arsenic and nickel only slightly exceed the NBC, and copper due to its low mobility within soils and groundwater.

Therefore, the severity of any impact to groundwater, considering the limited shallow groundwater encountered within the made ground during the ground investigation, the presence of lower permeability deposits between the more permeable groundwater bearing strata, and limited permeable deposits any impact should it occur is considered likely to be mild.

The band of clay strata encountered below the made ground will most likely limit vertical migration of potentially contaminated shallow groundwater. It is considered unlikely that that contamination contained within the groundwater within the made ground will reach the underlying superficial Secondary A Aquifer.

The nearest active groundwater abstraction licence is 1988m south of the site. There are no potable water abstractions within 2000m of the site and no Source Protection Zones (SPZs) within 500m of the site.

The hardstanding of the proposed development and the development of a new drainage system should help reduce surface run-off and water infiltrating through the made ground strata.

No groundwater was encountered on top of the natural clay strata within any of the three boreholes completed by BSL. This suggests that there are no large volumes of potentially contaminated groundwater migrating horizontally along the top of the cohesive strata and entering the Batley Beck.

If shallow groundwater reaches the Batley Beck, dilution of any contaminants is likely to occur, reducing the potential impact to the river. The likelihood of any impact is therefore considered to be unlikely and any impact mild.

Whilst there are elevated concentrations of contaminants, based on the investigation works undertaken to date and subject to agreement with the Environment Agency, the site is not considered to pose a significant risk to controlled water for the following reasons:

-
- No visual or olfactory evidence of contamination was identified during the ground investigation
 - Concentrations of PAH and TPH fractions are predominantly of low to very low mobility and are unlikely to represent a significant risk to controlled waters.
 - Metals and Sulphates are not considered to be a significant risk to controlled waters and are likely to be representative of naturally occurring background concentrations. Following development of the site potential ingress of contaminated water will not be any worse, indeed infiltration will likely be reduced with increased hard cover and a new drainage system.
 - No significant contamination has been identified on site in soils based on the results obtained as a potential indicator of groundwater contamination.
-

- The made ground is underlain by low permeability clays which will inhibit lateral and vertical contaminant migration.
- The site does not lie within 500m of an SPZ.
- There are no groundwater abstractions within 2000m.
- There are no potable (sensitive) water abstractions within 2000m.
- Evidence indicates the nearby wells are historical and related to low sensitivity commercial use.

8.5 Ground Gas Risk Assessment

In order to assess the ground gas situation and the requirement for ground gas precautionary measures at the site, guidance was taken from CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings' and BS8485:2015+A1:2019 'Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

As the proposed end-use is a commercial development, guidance dictates that the gas monitoring results should be assessed in accordance with the Wilson and Card methodology.

The JPG gas monitoring of WS09 and WS12 located in the eastern parcel of the site recorded no methane and a maximum concentration of carbon dioxide of 5.1%v/v on just one occasion in WS09. A maximum flow of 2.5l/hr was recorded on one occasion in WS12 with all other flows recorded as 0.0l/hr or negative flows. WS12 is not located within the footprint of the proposed building.

The BSL gas monitoring of CP01, CP02 and CP03 located in the area of the proposed development recorded a maximum methane concentration of 0.3%v/v in CP02 during the first and third visit. A maximum concentration of carbon dioxide of 2.3%v/v was recorded in CP02 on the first visit. A maximum flow of 0.1l/hr was recorded in all three boreholes during the third visit.

The Wilson and Card methodology uses the concept of a Gas Screening Value (GSV) which is derived using the following equation: $(\text{max gas concentration} / 100) \times \text{maximum flow}$.

A maximum positive flow of 0.1l/hr has been used to derive the GSVs from the JPG report is detailed below. The GSV's for the site are presented below from the .

Gas	GSV (l/h)	Typical Threshold Concentration Exceeded	Classification
Methane	0.0025	No	CS-1
Carbon Dioxide	0.1275	Yes	CS-2

The GSV for carbon dioxide places the site the site into Characteristic Situation 2 (CS2). However monitoring undertaken by BSL is provided below which indicates that the site falls within CS1 Gas monitoring data is Appendix E.

Gas	GSV (l/h)	Typical Threshold Concentration Exceeded	Classification
Methane	0.0003	No	CS-1
Carbon Dioxide	0.00230	No	CS-1

The Claire Research Bulletin 17 (RB17) states that where natural soils are present with made ground less than 5m maximum depth and less than 3m in average thickness, an assessment could be made based on the Total Organic Carbon (TOC) content and forensic description of the soils as described on the Exploratory Hole Logs.

Where TOC of the soil was considered unrepresentative of degradability (e.g., where it is predominantly ash or clinker) the TOC value used in the assessment was reduced based on the fraction of degradable organic carbon.

The trial pits to the north of the site were undertaken primary to target a suspected mound on site, the thickness of made ground within this area is not considered representative of the ground conditions. Made ground thickness are generally less than 3m across the site. A sample was tested for TOC from the trial pits which targeted the mound, however this sample was not considered representative of the made ground on site and was therefore excluded from the average TOC. The remaining 5 samples are assessed below.

Based on the above methodology, an average TOC of 1.22% is considered representative of the made ground in the eastern parcel of the site when reviewing the BSL test results. In addition, the made ground is judged to have been in place for more than 20 years. However, 4 out of the 5 TOC results were below 1.0% with one result (CP02 at 1.25m bgl) being 2.8%.

The exploratory hole log for the strata in CP02 at 1.25m bgl identifies ash and clinker as major constituents which is not consistent with the other boreholes. Therefore, BSL consider the average TOC for the made ground in the eastern parcel of the site to be $\leq 1.0\%$.

Table 1: Limiting values of organic content

Characteristic situation (BS 8485 and CIRIA C665)	Thickness of Made Ground (m)	Maximum total organic carbon content of Made Ground - TOC (%) ^{see note 1, 2 and 3}		Comments
		Made Ground	Made Ground in place for > 20 years	
CS1	Maximum 5m Average < 3m	≤ 1.0	≤ 1.0	Limiting values based on reported soil organic matter (SOM) content of natural soils up to about 1%
CS2	Maximum 5m Average < 3m	≤ 1.5	≤ 3	Limiting values based on gas generation modelling assuming slow degradation Equilibrium methane concentration in building above <0.01%
CS3	Maximum 5m Average < 3m	≤ 4	≤ 6	Limiting values based on gas generation modelling assuming slow degradation Equilibrium methane concentration in building above <0.01%
This method can only be used to define characteristic situations up to 3.	Gas monitoring required where TOC is greater than 4% (or 6% in old Made Ground). Gas monitoring results will show whether the high TOC is available and conditions are suitable to generate ground gas.			

Note 1: TOC = DOC x 1.33 (Hesse, 1971).

Note 2: TOC of soil tested in accordance with the method described in "Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures," Environment Agency (2005) and combined with estimate of discrete organic material from forensic description (Appendix C).

Note 3: Where TOC of soil is not representative of degradability (e.g. where it is predominantly ash or clinker) the TOC value used in the assessment should be reduced based on the fraction of degradable organic carbon.

The initial CSM assessed a high risk from the potential presence of a high organic content within the underlying made ground.

The initial assignment of CS2 from JPG was based on single results with carbon dioxide concentrations not exceeding 5.0%v/v on any of the other 5 visits. Zero, or negative flows, were recorded during the other 5 gas monitoring visits completed by JPG.

Although BSL monitoring of CP01, CP02 and CP03 would place the site in CS1 which is supported by the TOC results however if the results of the previous investigation by JPG were included in the data set based on the elevated methane and calculated GSV from the previous JPG report, the site could be assigned as CS2 meaning gas precaution measures will be required.

Placing the site within CS2, rather than CS1 is considered to be conservative at this time, as the lines of evidence would indicate that the risks from ground gas are likely to be low. Further monitoring could improve confidence in the data and allow reduce the Characteristic Situation if required. However proceeding based of a CS2 situation is likely to be protective of the occupants and buildings.

8.6 Potable Water Supply

As the site is brownfield, there is the assumption that barrier pipe would be utilised, although requirements should be confirmed by risk assessment and with the water supply company.

8.7 Qualitative Risk Assessment

The CSM has been revised based on the findings of the site investigation and laboratory testing results and these are presented overleaf. Unless stated otherwise, in respect to off-site sources, only risks that are assessed as moderate and above within the preliminary CSM, compiled in the phase 1 desk study (AH/C4575/9450), have been carried forward to this section, or where a previously unidentified potential source, pathway and / or receptor has been identified from the recent site works.

Human Health						
Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Level of Risk	Justification
On site Made ground former sewage work Metals Inorganic compounds Acids/ alkalis Asbestos Organic compounds Micro-organisms Methane Carbon dioxide Hydrogen sulphide	Ingestion of contaminated soils Dermal contact with contamination	End-users	Unlikely	Medium	Low	Chemical testing completed by BSL showed no exceedances in contaminant concentrations when screened against commercial end-use values. JPG identified elevations in benzo(a)pyrene in two samples of made ground in the eastern parcel of the site. However, the presence of hardstanding across the proposed commercial development will reduce the pathway to site end users, contact with contaminants post development is considered unlikely. The severity of any impact is considered to be Medium as BaP is a known carcinogen. The risk is considered to be low.
	Migration into confined spaces, inhalation, and asphyxiation/explosion	End-users / property / structures	Low likelihood	Medium	Moderate/Low	A maximum methane concentration of 0.3%v/v was detected by BSL. A maximum carbon dioxide concentration of 5.1%v/v was detected by JPG during their gas monitoring programmes. The GSV for carbon dioxide from JPG places the site in CS2. This was calculated using a flow of 2.5l/hr which was only recorded on one occasion within WS12 by JPG. Carbon dioxide was recorded above 5.0% (5.1%v/v) on just one occasion in WS09. However the BSL monitoring indicates the site is likely to be CS1 which is supported by the TOC results. As there has been low concentrations of methane detected on site, there is not considered to be an acute risk to human health. However, carbon dioxide at low levels can cause chronic damage to human health. For this reason, the severity has been assigned as medium. The likelihood is considered low due to the low recorded levels of organic material within the made ground. The risk is considered to be moderate/low.
On site Made ground Railway Metals Inorganic compounds Acids/ alkalis Asbestos Organic compounds Fuel & lubricating oils	Ingestion of contaminated soils Dermal contact with contamination	End-users	Unlikely	Medium	Low	Chemical testing completed by BSL showed no exceedances in contaminant concentrations when screened against commercial end-use values. JPG identified an exceedance in benzo(a)pyrene in two made ground samples, the severity of site users ingesting or touching the made ground soils is considered medium. The proposed development will see the site covered in hardstanding which will limit the pathway to site end-users. It is considered unlikely that site end-users will come into contact with any potentially contaminated soils. The risk is considered to be low.

Human Health						
Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Level of Risk	Justification
PAH						
Offsite Backfilled ponds/pits Methane Carbon dioxide	Migration into confined spaces, inhalation, and asphyxiation/explosion	Commercial End-users / property / structures	Unlikely	Medium	Low	Although the BSL gas monitoring results place the site in CS1. The site has been assigned as CS2 based on JPG gas monitoring results. Zero or negative flows were recorded on all, but one gas monitoring visits completed by JPG. Carbon dioxide was only recorded above 5.0%v/v on one visit also. Furthermore, given that the pond was infilled over 65 years ago, it is likely that any significant degassing of the infill material will have ceased, the severity of the risk is medium. It is considered unlikely that any gas from the backfilled pond will migrate to site. This is due to the fact gas will travel via the path of least resistance and is unlikely to migrate laterally below ground to then escape through the surface of the site due to the low permeability deposits underlying the made ground. Furthermore, the installation of gas precaution measures will prevent carbon dioxide migrating into the proposed buildings. The risk is therefore considered to be low.

Controlled Waters						
Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Level of Risk	Justification
Made Ground Metals, Inorganic compounds, Acids/ alkalis, Organic compounds, PAH	Surface run-off/ Overland flow, migration through saturated zone	Batley Beck (Surface waters)	Low Likelihood	Mild	Low	It is considered there is a low likelihood that contaminants associated with the made ground will impact the Batley Beck. The site is currently surfaced in hardstanding and will remain so along with the installation of a new drainage system. This will reduce the volume of water passing through the made ground potentially mobilising contaminants. Furthermore, the low permeability of the clays underlying the made ground will inhibit lateral and vertical migration to the wider aquifer and limit the basal recharge into the Batley Beck. Should any potentially contaminated groundwater enter the Beck dilution of contaminants will take place therefore the severity is considered to be Mild. The risk is therefore a Low.
	Leaching through unsaturated zone / Migration through saturated zone	Secondary A Aquifer – Superficial (Ground-water)	Unlikely	Mild	Very Low	Results indicate that contamination is generally of low mobility. No groundwater was encountered within the made ground strata. The site is currently surfaced in hardstanding and will remain so along with the installation of a new drainage system which will reduce infiltration and leaching into the superficial deposits. By virtue of the development taking place, therefore the severity is considered mild. The cohesive deposits encountered below the made ground strata will limit migration into the superficial aquifer to a minimum and it is considered unlikely that groundwater passing through the made ground will enter groundwater within the superficial Secondary A Aquifer. The risk is considered to be Very low.
	Migration through saturated zone	Secondary A Aquifer – Bedrock (Ground-water)	Unlikely	Mild	Very Low	The bedrock encountered beneath the site comprised weathered mudstone and was encountered as a clay. Therefore, any migration of contaminated groundwater to water bearing strata within the secondary A bedrock aquifer is considered unlikely. Any impact to water bearing strata within the underlying bedrock aquifer is likely to be limited due to the presence of low permeability deposits which are likely to attenuate and retard any metal or organic contaminant migration into the deeper aquifer, the severity is considered to be Mild. The risk is therefore considered to be very low.

8.8 Outline Remedial Measures

The level of protection for the clean potable water supply pipes should be determined using the local water company risk assessment criteria in accordance with UKWIR.

Chemical testing completed by BSL did not show any elevated concentrations of determinants. JPG's results identified slightly elevated benzo(a)pyrene in two samples of made ground in the eastern parcel of the site. However, the proposed development comprises the site being covered in hardstanding which will limit any potential pathway to site end-users. **Therefore, no specific remedial measures are required for soils in respect to human health for the proposed end use and no Remedial Strategy is required.**

Ground Gas Protection Systems

The JPG gas results indicate the site falls into the CS2 classification and protection measures are required this is considered to be conservative based on the BSL monitoring and TOC results.

For CS2 in accordance with BS 8485 for a Type C building placed within CS2, a minimum of 2.5 points is required to be obtained from gas protection measures. The gas protection system should consist of at least two separate elements including a structural barrier, ventilation measures and/or a gas resistant membrane.

The required level of protection should be obtained from a combination at least two or more different elements from the following options in line with BS8485:

-
- a) Structural barrier of the floor slab, or of the basement slab and walls if the basement is present– i.e. *A cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations* [1- or 1.5-point score dependant on construction quality].
 - b) Ventilation measures–i. e. A pressure relief pathway [0.5-point score] (Required as a minimum in all systems) or passive sub-floor dispersal layer [1.5 point score - good performance or 2.5 point score - very good performance]. Note for type A buildings active ventilation measures are inappropriate.
 - c) Gas resistant Membrane- i.e. a gas resistant membrane which is suitably impervious to carbon dioxide [2 point score].
-

Note that If the installation of the membrane is not verified by a suitably qualified independent engineer in accordance with CIRIA C735, then this will score 0 points and the criteria will not be met. This may have serious implications in terms of achieving regulatory sign off, potentially causing costly delays, and potentially placing end users of the site and the structure at risk.

All installations should be subject to verification. The verifier should be independent, competent, and suitably trained; BSL can provide this service. We recommend validation requirements should be discussed with the Local Authority prior to installation. **Verification of the gas protection measures would require attendance on site and a letter report confirming installation.**

General

It is recommended that the approval of the Regulators (Local Authority /NHBC / Environment Agency) is obtained in regard to the above prior to any irrevocable action is taken at the site.

8.9 Health and Safety Issues

During the reclamation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. The risk to construction and ground workers is assessed in the table below:

Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Level of Risk
Made Ground (heavy metals, PAHs, petroleum hydrocarbons)	Ingestion, direct contact, inhalation of dusts.	Construction Workers	Likely	Mild	Moderate/Low
Ground gas	Inhalation in confined spaces/trenches	Construction Workers	Unlikely	Severe	Moderate/Low

The risk from made ground will be mitigated by standard PPE including gloves. Welfare facilities should be made available to wash before hand to mouth activities.

It is noted that concentrations of carbon dioxide (an asphyxiant) in the soil exceed HSE Workplace Exposure Limits for personnel in the working environment of 1.5% for short term (15 minutes) exposure and/or 0.5% for long term exposure. Furthermore, soil concentrations of oxygen are below the HSE recommendations of 18%.

Soil gas concentrations are not necessarily reflected by those in the breathing zone, all contractors and maintenance workers should be made aware of the possible presence of carbon dioxide and should take all necessary health and safety precautions when working in trenches or confined spaces.

General guidance on these matters is given in the Health and Safety Executive (HSE) document “Protection of Workers and the General Public during the Redevelopment of Contaminated Land”. In summary, the following measures are suggested to provide a minimum level of protection:

- All ground workers should be issued with the relevant protective clothing, footwear, and gloves. These protective items should not be removed from the site and personnel should be instructed as to why and how they are to be used.
- Handwashing and boot-washing facilities should be provided.
- Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.
- Good practices relating to personal hygiene should be adopted on the site.
- The contractor shall satisfy the Health and Safety Executive with regard to any other matters concerning the health, safety, and welfare of persons on the site.

8.10 Asbestos

The investigation of asbestos issues within structures was beyond the scope of this report. However, guidance from UK Government indicates that asbestos should be assumed to be present in buildings unless proven otherwise.

Any asbestos within structures will require removal prior to re-development. This will need to be done by a suitably qualified experienced and licensed contractor, who ensures that adequate PPE is provided to operatives, and that all the relevant legislation is adhered to.

Excavations in soils containing asbestos should comply with the CL:AIRE publication ‘Interpretation for Managing and working with Asbestos in Soil and Construction and Demolition Materials’ (CARSOIL) and CAR 2012. All such works will need to be agreed with the regulatory bodies (HSE and/or LA).

Additional guidance is provided within the BSL methodology Guidance Note in Appendix A.

9.0 WASTE SOIL CLASSIFICATION & ASSESSMENT

9.1 Summary

BSL have undertaken a preliminary assessment of potential excavation waste to arise from the site during redevelopment to:

- Classify the excavation waste to arise as either hazardous or non-hazardous.
- Identify the most sustainable options for the wastes to arise in accordance with the waste hierarchy.
- Provide a written description of the waste required as part of the Duty of Care.
- Provide details of “hazardous properties” to complete hazardous waste consignment note (where applicable).
- Be able to provide a basic classification report to a landfill operator (where waste is destined for landfill disposal).

9.2 Waste Classification Procedure

As described in the ‘Waste Duty of Care Code of Practice (2016)’ any substance or object that the holder discards, intends to discard or is required to discard is a waste. It is the responsibility of the waste producer to classify this waste. The classification process is described in the ‘Guidance on the classification and assessment of waste’ WM3 and aims to determine whether the waste is Hazardous or Non-Hazardous to human health and the environment.

Hazardous wastes are signified by entries where the code is followed by an asterisk, where some wastes are deemed hazardous without further assessment, which are termed “Absolute Entries” e.g., most waste oils. Alternatively, waste entries are termed “Mirror” entries that require further assessment of hazardous properties, in order to determine whether they are hazardous waste or not (e.g., soil and stones). The EWC codes relevant to excavation wastes are:

- 17 05 03* - soil and stones containing dangerous substances.
- 17 05 04 - soil and stones other than those mentioned in 17 05 03.

The Landfill Directive (Directive 1999/31/EC on the landfilling of waste, Decision 2003/33/EC and Landfill Regulations 2005) led to the establishment of a methodology for classifying wastes.

Wastes first need to be classified based on their total concentrations and classified as either hazardous or non-hazardous waste. WAC testing is only required if the end disposal route is a landfill and WAC analysis must not be used for waste classification.

Wastes can only be accepted at a landfill if they meet the relevant Waste Acceptance Criteria (WAC) for that type of landfill. A waste must comply with the WAC limits for the relevant landfill, otherwise the soil will need to be pre-treated. There are three different WAC criteria, these are:

- Inert waste.
- Stable Non-Reactive Hazardous Waste (SNRHW).
- Hazardous waste.

There is no standard set of WAC limits for non-hazardous landfill sites and each non-hazardous landfill will have its own set of criteria under which it is licenced to accept non-hazardous waste. These will need to be determined through the selected waste receiver prior to disposal.

A non-hazardous waste should not be compared with WAC limits for hazardous or SNRHW waste sites and the WAC test should only be used to determine if the waste is suitable for disposal at an inert waste landfill site. Likewise, wastes classified as hazardous based on their total concentrations should not be compared with WAC limits for inert waste landfill sites, as these will not be accepted.

Details of how material should be classified for waste disposal are presented in the BSL Methodology and Guidance in Appendix A and are summarised in the table below:

Classification based on Total Concentrations ¹	PRIOR TO LEAVING SITE			
	Non-Hazardous Waste		Hazardous Waste	
	IF SOILS CANNOT BE RE-USED ELSEWHERE AND MUST GO TO LANDFILL			
WAC testing	Below inert WAC limit values	Above inert WAC limit values	Below hazardous WAC limit values ⁴	> WAC limit values
Landfill requirements	INERT landfill	NON-HAZARDOUS landfill ²	HAZARDOUS landfill	PRE-TREATMENT ³

1 Total concentrations are defined as tests results on solids as opposed to leachate (i.e., a liquid).

2 Individual sites may have certain limit values pre-determined in their licence.

3 After pre-treatment the material characteristics may have changed to an extent that allow the soil to be re-classified.

4 Possibility that wastes could be classified as stable Nonreactive HAZARDOUS waste in non-hazardous Landfill (e.g., soils containing low concentrations of asbestos, gypsum or sulphate bearing soils).

Waste classified as non-hazardous can be accepted into a non-hazardous landfill without having to pass any numerical WAC.

Soils above hazardous WAC limit values require pre-treatment prior to disposal. The effective pre-treatment, typically involving separation, sorting and screening, can offer cost savings through reducing the hazardous nature and volumes of soil. Costs for disposal of non-hazardous/hazardous soils are significant compared to the disposal of inert material.

Inert Waste

The possibility of automatic inert classification of the naturally occurring “clean” soils should be explored in accordance with Section 4.3 of the EA guidance document. The Council Decision includes a list of wastes in Section 2.1.1 of the document that are assumed to be inert and therefore acceptable at a landfill for inert waste without testing. This is the case if:

- They are single stream waste of a single waste type (although different waste types from the list may be accepted together if they are from a single source); and
- There is no suspicion of material or substances such as metals, asbestos, plastics, chemicals, etc to an extent which increases the risk associated with the waste sufficiently to justify contamination and they do not contain other classes of landfill.

9.3 Waste Classification

We have reviewed the testing results and assessed them through a waste classification database which allows users to code and classify waste as defined in the EWC (European Waste Catalogue) based on EC Regulation 1272/2008 on the Classification, Labelling and Packaging of Substances and Mixtures (CLP) and latest Environment Agency guidance (WM3 “Guidance on the classification and assessment of waste - Technical Guidance”).

8 samples were tested to assess whether they contained any contaminants in the hazardous range when screened against assessment criteria within WM3 using the HazWasteOnline tool.

The Waste Classification Report is presented in Appendix F. The results of the waste assessment based on total concentrations are presented in the table below.

Location	Depth (m)	Stratum	Waste Classification	Comments
CP01	0.20	MADE GROUND	Non-hazardous	-
CP02	0.25	MADE GROUND	Non-hazardous	-
CP02	0.60	MADE GROUND	Non-hazardous	-
CP02	0.70	MADE GROUND	Non-hazardous	-
CP03	0.25	MADE GROUND	Non-hazardous	-
CP03	0.40	MADE GROUND	Non-hazardous	-
CP03	1.20	MADE GROUND	Non-hazardous	-
TP01	0.10	MADE GROUND (Stockpile NE Corner)	Non-hazardous	-
TP03	2.00	MADE GROUND (Stockpile NE Corner)	Non-hazardous	-
TP04	2.10	MADE GROUND (Stockpile NE Corner)	Non-hazardous	-

Based on the waste classification database assessment, the of the made ground soils both in the cable percussive boreholes and the trail pits in the stockpile located in the northeast corner of the site have been classified as **non-hazardous**.

Note that further testing of the soils (WAC testing) may be required on the actual arisings in order to satisfactorily categorise the soil for its suitability for disposal to landfill.

9.4 Options Assessment

Following the classification of waste materials, the options available for the waste can be considered in the context of the waste hierarchy as below:

- Onsite re-use (with or without prior treatment) under suitable exceptions/permits.
- Offsite processing for recycling or recovery e.g., screening.
- Offsite disposal (with or without prior treatment) i.e., landfill.

Where feasible, efforts should be made to retain soils for onsite re-use to minimise costs and maximise the sustainability of projects.

Based on the above, the possible options for the generation of waste soils at the site are described in the table below:

Waste Generation Source	Comments
Made Ground from site levelling/foundations excavations/services excavations	Samples of made ground from across the site have been classified as non-hazardous and hazardous for off-site disposal purposes, although should be suitable for re-use on site if required under suitable exemptions/permits.
Natural ground from site levelling/foundations excavations/services excavations	The Till may be considered suitable for re-use onsite as fill where the criteria of the WFD exception for re-use of naturally occurring soils can be met. Naturally occurring clean materials could also be exported to another site under the direct transfer scenario of the DoWCoP. Classified as non-hazardous and below inert WAC testing criteria for off-site disposal purposes.

General

If any gross hydrocarbon contaminated material is encountered during the construction phase, it is possible that this may be classified as hazardous and testing should be undertaken at that time.

Where it is necessary to dispose material off site it is recommended that materials are segregated and sufficient time is allowed to further classify the actual soil arisings that constitute the waste, including discussion with landfill sites and waste transfer stations to find the best disposal route. It is illegal to dilute and mix soils without a suitable permit.

9.5 Re-use of Soils

By definition in law, any material excavated from the ground becomes waste at the moment of excavation. If that soil (now a “waste”) is then placed on another part of the development site (or used on another development site) without an appropriate materials management plan, permit or exemption being in place, by law this material is defined as “illegally deposited waste”.

Landfill tax rules allow HM Revenue & Customs (HMRC) to recover landfill tax on illegally deposited waste on construction sites. This could lead to excessive costs without the correct documentation in place. In addition, a person who makes, knowingly causes, or knowingly facilitates a disposal to be made at an unauthorised site is also liable to pay Landfill Tax.

In order to comply with UK legislation and avoid excessive costs, if the re-use of soils is proposed on site, this should be done in accordance with the relevant exemptions or permits in place.

Soils Re-use Under DoWCoP

One of the main industry mechanisms for allowing the re-use of soils in construction is the CL:AIRE “Development Industry Code of Practice for the Definition of Waste” (CL:AIRE DoWCoP) also known as a Materials Management Plan (MMP). Further guidance is provided in the BSL Methodology and Guidance in Appendix A.

To implement the DoWCoP (for Route A), there is a requirement to notify the Environment Agency and Local Authority of the intention to use the code of practice in principle, after which there is a 21-day notice period for their response.

In order to re-use soils under the DoWCoP, there are four key criteria that need to be met:

-
- The aims and objectives of the project meet the requirements of the Waste Framework Directive (does not harm human health or the environment).
 - The soils can be demonstrated to be suitable for use (backed up by chemical/geotechnical testing and assessment).
 - There is certainty of use (planning consents are in place alongside materials tracking, which should be in place as part of good site practice in any case).
 - Quantity (the quantity of materials used should be known).
-

Information on existing site levels, proposed levels, volumes generated (e.g., foundation / drainage excavation arisings) would need to be known in order to complete the MMP.

If the DoWCoP is the chosen route, the MMP should be in place and declared by a Qualified Persons (QP) before works commence, otherwise excavated soils could constitute an illegal deposit of waste and enforcement action could be taken by the EA and HMRC.

The declared MMP should be amended as new import sources are added.

Once the project is complete, a verification report detailing soils re-use/import will need to be produced and submitted to CL:AIRE, which may be subject to a random audit process. Sites found to be non-compliant with the CoP can be referred to the EA for further investigation.

Regardless of implementing re-use under the code of practice or not, all sites should have some form of materials tracking in place in compliance with current legislation. Any re-use scheme should also be designed to minimise disposal costs.

Re-use of soils containing asbestos should comply with the CL:AIRE publication 'Interpretation for Managing and working with Asbestos in Soil and Construction and Demolition Materials' (CAR-SOIL™) and CAR 2012.

In terms of the re-use of brick/concrete crush materials, the DoWCoP does cover aggregates, but only on the site of origin, and the EA WRAP aggregate Quality Protocol might best apply to ensure quality standards, which are discussed further below.

Soils Re-use under Exemptions and Permits

Other potentially suitable options to allow the re-use and/or import of soils and aggregates on site are provided in the table below:

Re-use Mechanism	Description
U1 Exemption	Can be applied to re-use/import of soils and stones, but only up to 1000 tonnes or for brick and concrete up to 5000 tonnes. This is usually an efficient way to re-use small volumes of waste materials. However, only one U1 can be filled in per site in any 3-year period. Quick and free via online registration.
Waste Framework Directive (WFD) exclusion	In regard to "clean" naturally occurring soils only that are to be re-used on their site of origin, these are covered by a Waste Framework Directive (WFD) exclusion which is an EA regulatory position statement. So long as the project can prove the four criteria listed above for the DoWCoP, then permits or the DoWCoP are not required. However, many projects still use the CoP to ensure compliance.
T7 Exemption	The T7 allows treatment of waste bricks, tiles and concrete by crushing, grinding or reducing in size. This needs to be registered with the Local Authority.
Other Permitting Routes	Other options include use under an Environmental Permit (Standard or Bespoke Rules), however these may be a time consuming and costly route, where use of the other above options (if applicable) is likely to be more feasible in construction.

10.0 CONCLUSIONS

10.1 Geo-Environmental

Geo-Environmental – Human Health

BSL testing of the made ground at the site did not reveal any exceedances of heavy metals, PAHs, petroleum hydrocarbons, VOCs, BTEX or MTBE compounds.

It should be noted that the JPG report highlighted exceedances in benzo(a)pyrene in samples of made ground from WS09 (0.40m-1.00m bgl), WS10 (1.00m-1.50m bgl) and WS11 (0.20m-1.00m bgl). These were still in exceedance after statistical analysis had been completed on the results.

However, the proposed development will see the site surfaced with hardstanding concrete/tarmac. This will limit the pathway to site end-users. Therefore, the risk to human health from soil contamination is considered to be low.

Although BSL gas monitoring results indicates the site falls into CS1, the JPG gas results indicate the site falls into the CS2 classification and protection measures are required.

BSL have referred to the methodology in Claire's RB17 which states that where natural soils are present with made ground less than 5m maximum depth and less than 3m in average thickness, an assessment could be made based on the Total Organic Carbon (TOC) content and forensic description of the soils as described on the Exploratory Hole Logs.

BSL consider the representative TOC for the made ground in the eastern parcel of the site to be $\leq 1.0\%$. Considering this along with the average thickness of the made ground encountered by both JPG and BSL, the eastern parcel would place the site within CS1 and no gas precaution measures would be deemed necessary.

However, based on ground gas concentrations detected during the JPG ground gas monitoring of WS09 and WS12 located in the eastern parcel of the site has revealed a maximum peak carbon dioxide concentration of 5.1%v/v which was recorded on one occasion.

No methane was detected in any of the 6 JPG gas monitoring visits and a maximum concentration of 0.3%v/v was recorded during the first BSL monitoring visit. JPG detected a flow of 2.5l/hr on one occasion with the remaining five visits detecting zero or negative flows. BSL detected a maximum flow of 0.1l/hr in all 3 installations. The GSV (max gas concentration / 100) x maximum flow for carbon dioxide detected by JPG places the site into Characteristic Situation 2 (CS2). However BSL monitoring data places the site within CS1. Therefore, as a precaution BSL recommend the site is classified as CS2 where gas protection measures would be required to enable the development to proceed.

While there is no requirement for a remedial strategy to mitigate risks from soil contamination, and the lines of evidence indicate that the risks from ground gasses are low gas protection measures are recommended as a precaution. The installation of the gas protection measures would require verification however a formal detailed remedial strategy is not required for this site. The details and design of any gas protection measures could allow the discharge of planning conditions associated with the remedial strategy, the confirmation that the gas protection measures have been installed as agreed could allow the discharge of planning associated with the verification measures.

Geo-Environmental – Controlled Waters

The overall risk to controlled waters is considered to be low to very and no further action is required.

Waste

Waste classification for the made ground at the site has revealed the soils from the cable percussive boreholes and the stockpile in the northeast corner to be non-hazardous.

Note that further testing of the soils (WAC testing) may be required on the actual arisings in order to satisfactorily categorise the soil for its suitability for disposal to landfill.

10.2 Geotechnical

Foundations

Discussions should be made with the piling contractor regarding the suitability of driven piles due to the possible levels of disturbance to the medium pressure gas main located adjacent to the east boundary of the site. Driven piles may be deemed unsuitable for the site.

Without prior consultation, the foundations used for the proposed development should be CFA piles into the mudstone bedrock circa. 10.00m bgl. The piles should be a minimum of 300mm in diameter in order to support the proposed load of 500kN which was provided to BSL by the client's structural engineer. Higher loads can be achieved by increasing the diameter of the pile.

Floor slabs

A suspended floor slab should be adopted at the site supported by piles. The presence of cohesive (shrinkable) strata needs to be considered in the design of the floor slab.

Concrete classification

Within the made ground soils, sulphate class DS-2 and ACEC Class AC-1s conditions prevail in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005. DS-1 and ACEC Class AC-1s conditions prevail within the natural deposits and mudstone bedrock.

Highways

Equilibrium CBR values are likely to be 2% within the made ground due to the variability of soils encountered at shallow depths across the site.

Where the CBR is found to be less than 2%, the sub-grade is unlikely to be suitable for both the trafficking of site plant and as a permanent highway foundation without improvement of the soils.

Drainage (SUDS)

The use of soakaways is not recommended due to the presence of variable and potentially contaminated made ground near the surface and the presence of low permeability cohesive strata underlying the made ground strata.

Slopes & Retaining Structures

A 2m retaining wall exists on site's eastern boundary. The slope leads up to a railway line and is populated with mature trees.

No drainage was visible within the wall. The age of the wall, founding depths, founding materials and the retained materials are unknown.

It was outside the scope of this investigation to undertake a detailed inspection of the construction or a structural inspection of the walls and BSL recommends inspection of the walls by a structural engineer to assess their condition and determine what, if any, specialist requirements there are in respect to demolition and removal. Inadequate demolition may result in the instability of soils behind the wall, potentially resulting in dangerous collapse.

10.3 Further Work

The following further work is considered necessary to progress the site to construction phase:

- Tree survey by qualified arboriculturist.
- Detailed foundation design by a structural engineer
- Production of Materials Management Plan (MMP) under the CL:AIRE DoWCoP, if required.

11.0 ABBREVIATIONS AND DEFINITIONS

GLOSSARY	
Term / Abbreviation	Definition
AST	Above Ground Storage Tank.
B(a)P	Benzo (a) Pyrene.
BGS	British Geological Survey.
BRE	Building Research Establishment.
BS	British Standard.
BSL	Brownfield Solutions Ltd.
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes.
CBR	California Bearing Ratio (used in pavement/highways design).
CAR 2012	Control of Asbestos Regulations (2012).
CBCB	Cheshire Brine Compensation Board.
CBCD	Cheshire Brine Compensation District.
CBR	California Bearing Ratio.
CIEH	Chartered Institute of Environmental Health.
CIRIA	Construction Industry Research Association.
CL:AIRE	Contaminated Land: Applications in Real Environments.
CLEA	Contaminated Land Exposure Assessment.
CLO	Contaminated Land Officer.
COMAH	Control of Major Accident Hazards.
Contamination	Presence of a substance which is in, on or under land, and which has the potential to cause significant harm or to cause significant pollution of controlled water. There is no assumption in this definition that harm results from the presence of the contamination. Naturally enhanced concentrations of harmful substances can fall within this definition of contamination. Contamination may relate to soils, surface water, groundwater or ground gas.
Controlled Waters	Inland freshwater (any lake, pond or watercourse above the freshwater limit), water contained in underground strata and any coastal water between the limit of highest tide or the freshwater line to the three-mile limit of territorial waters.
CPT	Cone Penetration Test.
CSM	Conceptual Site Model. A schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the basis of the information from the preliminary investigation and refined during subsequent phases of investigation and which is an essential part of the risk assessment process. The conceptual site model is initially derived from the information obtained by the preliminary investigation (i.e., the Phase I Desk Study). This conceptual model is used to focus subsequent investigations, where these are considered to be necessary, in order to meet the objectives of the investigations and the risk assessment. The results of intrusive investigations can provide additional data that can be used to further refine the conceptual site model.
DCP	Dynamic Cone Penetrometer.
DNAPL	Dense Non-Aqueous Phase Liquid.
DoWCoP	Definition of Waste Code of Practice.
DWS	Drinking Water Standard.
EA	Environment Agency.
EHO	Environmental health Officer.
EQS	Environmental Quality Standard.
GAC	Generic Assessment Criteria.

GLOSSARY	
Term / Abbreviation	Definition
GDR	Geotechnical Design Report.
GFR	Geotechnical Feedback Report.
GIR	Ground Investigation Report.
GSV	Gas Screening Value.
Harm	Adverse effect on the health of living organisms, or other interference with ecological systems of which they form part, and, in the case of human health, including property/structures and water supply pipelines.
Hazard	Inherently dangerous quality of a substance, procedure or event.
HDPE	High Density Polyethylene.
HSV	Hand Shear Vane.
K	Modulus of Subgrade Reaction.
LCRM	Land Contamination: Risk Management (EA guidance).
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel, kerosene).
LOD	Limit of Detection (for particular method adopted).
MMP	Materials Management Plan.
Mv	Modulus of Volume of Compressibility.
ND	Not Detected.
NHBC	National House Building Council.
NR	Not Recorded.
OS	Ordnance Survey.
PAH	Polycyclic Aromatic Hydrocarbon.
Pathway	Mechanism or route by which a contaminant comes into contact with, or otherwise affects, a receptor.
PCB	Poly-Chlorinated Biphenyl.
PCSM	Preliminary Conceptual Site Model.
pH	Scale used to specify how acidic or basic a water-based solution is.
PHC	Petroleum Hydrocarbons.
PID	Photo Ionisation Detector.
PNEC	Predicted No-Effect Concentration.
Precision	Level of agreement within a series of measurements of a parameter.
PSD	Particle Size Distribution.
PVC	Polyvinyl Chloride.
Receptor	Human health, living organisms, ecological systems, controlled waters (surface waters and groundwater within aquifers), atmosphere, structures and utilities that could potentially be adversely affected by contaminant(s).
Risk	Probability of the occurrence, magnitude and consequences of an unwanted adverse effect on a receptor.
Risk Assessment	Process of establishing, to the extent possible, the existence, nature and significance of risk.
Sampling	Methods and techniques used to obtain a representative sample of the material under investigation.
SOM	Soil Organic Matter.
Source	Location from which contamination is, or was, derived. This could possibly be the location of the highest soil, groundwater or gas concentration of the contaminant(s).
SPT	Standard Penetration Test.
SVOCs	Semi Volatile Organic Compounds.
TOC	Total Organic Carbon.
TPH CWG	Total Petroleum Hydrocarbon (Criteria Working Group).

GLOSSARY	
Term / Abbreviation	Definition
TVOCs	Total volatile organic compounds.
UCS	Unconfined Compressive Strength.
Uncertainty	Parameter, associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measurement.
UST	Underground Storage Tank.
UXO	Unexploded Ordnance.
VCCs	Vibro Concrete Columns.
VSCs	Vibro Stone Columns
VOCs	Volatile Organic Compounds.
WAC	Waste Assessment Criteria.
WFD (in waste context)	Waste Framework Directive.
WFD (in water context)	Water Framework Directive.
Units	Definition
°	Degrees
Φ	Phi angle (in degrees)
g/l	Grams per Litre
Km	Kilometres
kPa	Kilo Pascal (Equivalent to kN/m ²)
KN/m ² /mm	Kilo Newton per metered squared per millimeter
kN/m ²	Kilo Newtons per metre squared
kPa	Kilo Pascal (Equivalent to kN/m ²)
l/hr	Litres per hour
MJ/kg	Mega joule per kilogram
MN	Mega Newton
M ² /MN	Mega Newton per metre squared
M	Metres
m bgl	Metres Below Ground Level
m OD	Metres Ordnance Datum (sea level)
µg/l	Micrograms per Litre (parts per billion)
µm	Micrometre
mb	Millibars (atmospheric pressure)
mg/kg	Milligrams per kilogram (parts per million)
mg/m ³	Milligram per metre cubed
mm	Millimetre
ppb	Parts Per Billion
Ppm	Parts Per Million

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DRAWINGS

APPENDIX A

BSL Methodology and Guidance

APPENDIX B

Exploratory Hole Logs

APPENDIX C

Chemical Testing Results

APPENDIX D

Geotechnical Testing Results

APPENDIX E

Gas Monitoring Reports

APPENDIX F

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