GEOENVIRONMENTAL GROUND INVESTIGATION

M400 Heywood Distribution Park
Pilsworth Road
Heywood, Manchester

Reference	**5986-JPG-XX-XX-RP-G-0605-S2-P03**
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JPG. Site Constraints Plan. Plot M400, Heywood. Drawing no. 5986-JPG-ZZ-ZZ-DR-C-0001 S4 P03, dated 28.04.2022.

JPG. Bedrock Geology & Contours. Plot M400 Heywood Distribution Park. Drawing no. 5986-JPG-ZZ-ZZ-DR-C-0002 S4 P02, dated 28.04.2022.

AshtonSmith. Heywood Distribution Park – External Works. Proposed Site Plan, Drawing No. HDP1-ASA-30-EX.SI-D-A-3001_(S0. Dated 30 September 2021.

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CONFIDENTIALITY STATEMENT

This report is addressed to and may be relied upon by the following:

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DOCUMENT HISTORY

Rev	Date	Revision Details	Status	Author(s)	Approved
P01	12.01.2021	First Issue	Information	AJS	JBW
P02	16.03.2022	Second Issue – includes further foundation assessment	Information	JBW	JBS
P03	29.04.2022	Third issue - planning	Information	JBW	JBS

EXECUTIVE SUMMARY

Site Address	**Plot M400 Heywood Distribution Park, Heywood, Manchester**
Site Location	383819, 409515
Current Site Use & Proposed Development	The site has an area of approximately 11 hectares (ha) and comprises a roughly rectangular shaped parcel of land, measuring approximately 460m along its north – south axis and 310m along its east – west axis. The site currently comprises undeveloped land, predominantly used for the storage of container lorries, with an operational depot in the south-west. It is proposed to develop the site with a distribution centre, which will include two-storey offices, associated parking and ancillary infrastructure.
Fieldwork	Trial pits and window samples were excavated across the site to provide general coverage on the shallow ground conditions. Some trial pits and window samples were positioned on the raised scrubland in the north west. Other exploratory hole locations targeted former structures and tanks. Boreholes were advanced by dynamic sample and cable percussive techniques below the footprint of the proposed building to assess the strength of the underlying strata. In addition, the dynamic sample boreholes were extended into bedrock to obtain rock cores for logging and testing. Gas and groundwater monitoring wells were installed in two boreholes, seven window samples and four of the dynamic samples in order to assess the ground gas and groundwater regime.
Ground and Groundwater Conditions	Made ground was encountered at every location to depths of between 0.20m bgl to 2.88m bgl. The superficial deposits were found to consist of bands of cohesive and granular glacial till deposits. Where proven, the base of the glacial till was encountered at depths of between 2.40m bgl and 12.50m bgl. The glacial deposits were generally firm and becoming stiff and very stiff with depth. The underlying bedrock (Pennine Lower Coal Measures Formation) was found to comprise extremely weak to very weak mudstone and sandstone, proven to a maximum depth of 15.00m bgl. Generally perched groundwater was encountered locally in the made ground at shallow depth in some window sample boreholes and trial pits at depths of between 0.30m and 2.50m bgl. Occasional seepages were encountered in the cohesive glacial till. A groundwater strike was encountered in BH102 at 7.50m within the bedrock strata.
Geotechnical and Engineering Assessment	**Mining & Quarrying** – The Coal Authority Mining Report states that the site is not within a surface area that could be affected by past recorded underground coal workings. Based on the geological setting, the probability of shallow unrecorded coal workings is considered to be very low and not warranting further assessment. During the ground investigation a 0.55m to 0.90m thick coal seam was encountered at depths of 1.90m bgl and 2.00m bgl in the south-east. There was no evidence of coal workings to this coal seam. There are no recorded mine entries on the site or within 20m of the site boundary. The risk of unrecorded mine entries on the site is considered to be very low. **Earthworks** - It will be necessary to carry out cut and fill earthworks in order to create an appropriate development platform. An indicative cut and fill analysis has been carried out by JPG. This analysis suggests cutting up to approximately 3.00m generally in the western, north-western and eastern parts of the site and filling up to approximately 3.00m generally in the southern and northern areas. Topsoil should be stripped from the site surface and removed off site with the exception of the already landscaped areas in the north and north east that are to be retained. In addition, relict topsoil is to be removed from the west of the site as it poses a hazardous ground gas risk. Any earthworks should be carried out in accordance with the Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks. **Foundations and Ground Floor Construction** – Following removal of topsoil, concrete slabs and made ground from below the footprint of the building, engineered fill is to be placed in accordance with the Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks. Pad foundations are to extend through the engineered fill to bear onto the natural strata (glacial till) of appropriate allowable bearing pressure. An allowable bearing capacity 100kN/m² is considered appropriate for the firm, medium strength clay soils for total settlements of less than 25mm. Alternatively shallow foundations could bear onto the engineered fill of suitable bearing capacity. For higher loaded areas, e.g. column loads associated with two-story offices, consideration should be given to a piled foundation solution, bearing into/onto the underlying mudstone or sandstone bedrock. An allowable bearing pressure of 200kN/m² is considered appropriate for the extremely weak bedrock. In order to create the development platform, it is proposed to engineer site-won materials across the site. The proposed earthworks should be designed in order to accommodate a ground bearing floor slab. **Control of Groundwater** - Reference should be made to guidance given in the Manual of Contract Documents for Highway Works, Volume 1: Specification for Highway Works, Series 600 Earthworks. **Roads, Pavements and Hardstanding Surfaces** – Any earthworks/ground improvement works should be designed in order to provide a suitable CBR value for the proposed development. Variable CBR values have been achieved in the laboratory for the made ground and natural clay soils. It should

	be possible by appropriate selection of materials that a CBR of 3% can be achieved through the earthworks operation. Further testing of materials may be required to confirm suitability. **Excavations** - It is considered likely that if excavations were left unsupported then over time, some collapse would occur. Good working practice with respect to drainage of excavations and formations will be required to protect materials. **Obstructions** – Large parts of the site, in particular the east, have concrete handstanding at the surface. This will require breaking out and removal or incorporated into the earthworks following crushing and/or screening. Occasional boulders of sandstone were encountered in the site works. These could be broken down in order to be incorporated into the earthworks. Based on the previous usage of the site, some relict foundations and services should be anticipated. **Chemical Attack on Buried Concrete** - It is recommended that concrete should be designed to Aggressive Chemical Environment for Concrete (ACEC) Design Sulphate Class DS-1 and ACEC Class AC-2z, based on mobile groundwater conditions.
Environmental Risk Assessment & Gas Protection Measures	Based on the identified potential sources of contamination and available pathways and receptors, the following linkage assessments have been considered. This assessment is based on current site conditions and does not consider exposure pathways following any remediation of the site. Based on the above potential source, pathway and receptors, the following linkage assessments have been considered. • Risk to site development workers and end users if asbestos is present at concentrations greater than encountered during site investigation. • The underlying aquifers and inland river could become contaminated due to the leaching and migration of potential contaminants from the made ground. • Potential for development workers, future maintenance workers and future end users of the site to be exposed to hazardous ground gases. **Mitigation Measures** – In order to mitigate the risk posed by the potential contaminants which are present on the site, consideration should be given to the following mitigation measures. Based on the results of the above risk assessment, mitigation measures will be required with regard to hazardous ground gas. The ground gas risk assessment indicates CS2 conditions 'Low Hazard Potential', based on six visits. However, the CS should be confirmed on completion of the earthworks by a programme of continuous and spot monitoring to target the footprint of the proposed commercial development. The continuous monitoring should be carried out by a specialist contractor. During development of the site, all workers should remain vigilant to the possible risk of encountering areas of potentially contaminated material including gross asbestos contamination. Should potentially contaminated material be encountered, site management should be informed. Further testing may then be required to assess the risk to health and safety of the site workers and the environment. Although not exceeding GAC for a commercial end use, it is recommended that the hydrocarbon-impacted soils associated with a former fuel storage tank in the south of the site are removed. It is recommended that a sufficient thickness of topsoil and subsoil is placed in future landscaped areas. Any imported or site-sourced material will need to be tested to confirm its suitability for use. In addition, any topsoil and subsoil which is to be used on site should not contain any manmade debris, e.g. brick, concrete or metal. Based on the results of the chemical analysis, all of the samples can be classified as non-hazardous with the exception of WS107 at between 0.20m and 0.70m depth, which was classified as hazardous due to elevated (alkali) pH conditions.
This sheet is intended as a summary only of the assessment of the site in relation to ground condition. It does not provide a definitive engineering analysis.	

1.0 INTRODUCTION

1.1 Introduction

JPG (Leeds) Limited has been instructed by Black Cat Building Consultancy Limited to carry out a geoenvironmental ground investigation for a proposed commercial development at Plot M400, Heywood Distribution Park, Pilsworth Road, Heywood.

1.2 Objectives

The main objective of the geoenvironmental ground investigation was to identify potential geotechnical and environmental issues that may represent constraints to the proposed development of the site.

1.3 Scope of Works

The scope of works for the intrusive ground investigation comprised the following:

- Dynamic sample boreholes with rotary cored follow-on, complete with in-situ tests to provide geotechnical information in order to assess the nature of the made ground, superficial deposits and bedrock geology. These boreholes also facilitated the installation of gas and groundwater monitoring wells and allowed soil and rock samples to be obtained from depth.
- Cable percussive boreholes complete with in-situ tests to provide geotechnical information in order to assess the nature of the made ground, superficial deposits and bedrock geology. These boreholes also facilitated the installation of gas and groundwater monitoring wells and allowed soil samples to be obtained.
- Window sample boreholes to assess the shallow ground conditions at the site and confirm the composition, extent, depth and nature of the made ground. Samples were obtained and submitted for laboratory testing. These boreholes will also facilitate the installation of gas and groundwater monitoring wells where required.
- Trial pitting in order to assess the shallow ground conditions at the site and confirm the composition, extent, depth and nature of the underlying made ground. Samples will also be obtained to submit for laboratory testing.
- Chemical analysis of soil, leachate and water samples in order to determine the concentrations of potential contamination on the site.
- An assessment of the classification of materials for disposal off-site (not including WAC testing).
- Geotechnical testing to classify materials and inform foundation design and chemical testing to determine the Aggressive Chemical Environment for Concrete classification.
- An assessment of the suitability of the natural strata and made ground for re-use in earthworks.
- Monitoring of gas and groundwater wells for groundwater level and hazardous ground gases, including methane, carbon dioxide, oxygen and flow rate.

Comments on the likely requirements for any remedial measures which may be required, to address potential contamination or ground gas issues.

- Recommendations for further work (if required).

1.4 Location

The site is situated approximately 1.7km to the south-west of Heywood town centre and approximately 12km to the north of Manchester city centre. The approximate centre of the site is located at NGR 383819 409515.

A site location plan is provided as Figure 1 in Appendix A.

1.5 Site Description and Topography

The site has an area of approximately 11 hectares (ha) and comprises a roughly rectangular shaped parcel of land, measuring approximately 460m along its north to south axis and 310m along its east to west axis. The site can be accessed from the internal access road network associated with Heywood Distribution Park.

The site currently comprises undeveloped land, predominantly used for the storage of container lorries, with an office building/depot in the south-west. Steel palisade fencing bisects the site, separating the northern area from the southern area. Access roads extend approximately east to west along the southern boundary and east to west in the north.

The north of the site includes a concrete hardstanding area, which is used for car parking. The north-east of the site is primarily concrete surfaced with some areas of compacted gravel at the surface and utilised for storing refrigerator containers and lorries. There are peripheral areas of landscaping including some mature trees and shrubbery. The north-west of the site comprises an area of scrubland, which is raised above the surrounding landform and encompassed by concrete access roads. Headworks associated with recently installed monitoring wells are evident at ground level. The south-east comprises concrete hardstanding used for the storage of container lorries. The south-west also comprises concrete hardstanding used as a depot.

The landform is generally level and flat with the exception of the scrubland in the north-west, which is raised approximately 1m above the rest of the site.

The site's boundaries are formed by access roads along the two northern boundaries, steel post and mesh fencing along the western boundary, landscaping along the eastern boundary and an access road along the southern boundary. The south-east of the site is bordered by an industrial building.

Adjacent land use consists of commercial development associated with Heywood Distribution Park with small industrial buildings to the north and south of the site and large industrial units to the east and west.

An aerial photograph of the site is provided as Figure 2 in Appendix A.

1.6 Development Proposals

It is proposed to develop the site with a distribution centre, which will include two-storey offices, associated parking and ancillary infrastructure.

A proposed site layout plan has been provided. This is referenced below and included in Appendix A.

- Eireng. Ocado, Manchester. Site Gradient Information & Constraints. Drawing No. 202069-ECE-SW-XX-DR-C-0102 P4. Dated 25.08.21. Last revision dated 14.01.22.

1.7 Previous Reports

A desk study report for the site has been prepared by JPG, which is referenced below:

- JPG. Geoenvironmental Desk Study Report. M400 Heywood Distribution Park, Pilsworth Road, Heywood, Manchester. Report Ref. 5986-JPG-XX-XX-RP-G-0604-S2-P02. Dated January 2021. For Black Cat Building Consultancy Limited.

This report should be read in conjunction with the desk study report.

1.8 Limitations

The general limitations to the nature of the investigation are outlined in Appendix F.

2.0 FIELDWORK

2.1 Rationale

The intrusive investigation was designed to provide information on the general ground, groundwater and hazardous ground gas conditions across the site.

Trial pits and window samples were excavated across the site to provide general coverage on the shallow ground conditions. Some trial pits and window samples were positioned on the raised scrubland in the north west. Other exploratory hole locations targeted former structures and tanks.

Boreholes were advanced by dynamic sample and cable percussive techniques below the footprint of the proposed building to assess the strength of the underlying strata. In addition, the dynamic sample boreholes were extended into bedrock to obtain rock cores for logging and testing.

Gas and groundwater monitoring wells were installed in selected boreholes in order to assess the ground gas and groundwater regime beneath the site.

2.2 Fieldwork

The fieldwork was carried out between the 11 October 2021 and 16 November 2021. The works undertaken are summarised in Table 2.2 below.

Table 2.2 – Summary of Ground Investigation Works

Investigation Method	No. of Positions	Maximum Depth (m bgl)	Monitoring Wells	Monitoring
Trial Pits	14 (TP101, TP103 to TP112, TP115, TP118 to TP119)	3.20	-	-
Cable Percussive Boreholes	4 (BH101 to BH104)	9.95	2 x 50mm	GG, WL
Window Sample Boreholes	26 (WS101-WS119 and WS121-WS128)	6.00	7 x 50mm	GG, WL
Dynamic sample with Rotary Cored Follow-on Boreholes	7 (DS/RC101 to DS/RC106 and DS/RC108)	17.50	4 x 50mm	GG, WL

bgl – below ground level
GG – ground gas monitoring (methane, carbon dioxide, oxygen, hydrogen sulphide, gas flow and atmospheric pressure using a portable gas meter)
WL – standing groundwater level using an electric contact dip meter

The ground investigation was undertaken in general accordance with the techniques outlined in BS5930: 2015 Code of Practice for Site Investigations.

Exploratory hole positions are shown on the exploratory hole location plan contained in Appendix A. The exploratory hole records are contained in Appendix B. It should be noted that TP102, TP113, TP114, TP116, TP117, WS120 and DS/RC107 were not carried out due to access constraints and are therefore not shown on the as-built exploratory hole location plan.

The investigation was carried out under the supervision of an engineer from JPG.

2.3 Surveying

Exploratory locations were surveyed using Leica GPS equipment (accuracy +/- 10mm). The surveyed positions were then transferred onto the survey drawing.

3.0 LABORATORY TESTING

3.1 Chemical Analysis

The chemical analysis suite was designed to:

- Characterise near surface contamination levels to provide an assessment of the risks associated with direct contact with soils on site in its current state.
- Investigate the contamination status of the raised area in the north west of the site.
- Provide information on the solubility of contaminants and therefore the potential for impact on controlled waters; and,
- Assess the quality of groundwater beneath the site.

Chemical testing was carried out for the following determinands by Derwentside Environmental Testing Services Limited (DETS) in County Durham. Chemical analysis certificates are presented in Appendix D.

Soils – General
Selected samples of soil were analysed for the following potential contaminants on a total concentration basis:

Arsenic	Mercury	Copper
Cadmium	Lead	Nickel
Chromium	Zinc	Selenium
Cyanide (free)	Phenol	

Speciated Poly Aromatic Hydrocarbons (PAH)
Sulphate (water soluble) and pH
Asbestos Screen
Soil Organic Matter

In addition, selected samples were submitted for the following analysis:

- Calorific value, total chloride, total sulphate, total sulphide, ammoniacal nitrogen, hexavalent chromium and TPHCWG.

Soil Leachate and Groundwater
Selected samples of soil leachate and groundwater were analysed for the following contaminants:

Arsenic	Mercury	Copper
Cadmium	Lead	Nickel
Chromium	Zinc	Selenium
Cyanide (free)	Phenol	

Speciated Poly Aromatic Hydrocarbons (PAH)
Sulphate and pH

3.2 Geotechnical Testing

In-situ standard penetration tests (SPTs) were performed in all boreholes. The results are presented on the exploratory hole logs provided in Appendix B.

Laboratory geotechnical testing was carried out in order to determine the physical characteristics of the substrata and comprised the following:

- Moisture content and Atterberg Limits tests to classify the materials.
- Particle size distribution (PSD)/sedimentations to confirm the field descriptions of the soils encountered.
- Compaction testing (2.5kg and 4.5kg) and particle density to determine the compaction properties of the soils.
- California Bearing Ratio (CBR) test (2.5kg, unsoaked) to determine the bearing characteristics of the soils.
- Total organic carbon, pH, 2:1 water soluble sulphate, total sulphate, total sulphur and water-soluble chloride.
- Undrained shear strength in triaxial compression (without measurement of pore pressure).
- One dimensional consolidation testing to confirm settlement characteristics of the natural clay soils.
- Point load testing – axial and diametral on rock core samples, and
- Unconfined Compressive Strength (UCS) testing on rock core samples.

The geotechnical testing was carried out in accordance with BS1377:1990, "Methods of Test for Soils for Civil Engineering Purposes". The results of the geotechnical testing are provided in Appendix C.

4.0 GROUND AND GROUNDWATER CONDITIONS

4.1 Introduction

The ground and groundwater conditions encountered during the investigation were generally consistent with the anticipated sequence of strata indicated by the desk study.

An exploratory hole location plan is included in Appendix A. Exploratory hole logs are provided in Appendix B.

4.2 Ground Conditions

Reinforced concrete, typically 150mm to 300mm thick but locally less, and up to a maximum thickness of 450mm, is present across most of the site in the north, south and east with other areas, where made ground (compacted gravel) is present at the surface. In the north-west, grass over made ground was encountered in the raised area of scrubland. In the south-west, soft landscaped areas with topsoil at the surface are present.

Made ground was encountered at every location to depths of between 0.20m bgl and greater than 2.88m bgl. The made ground generally varied in thickness across the site but was typically shallowest in the north (WS102 and WS104) and thickest in the south (WS121) where the full thickness of made ground was not proven in this window sample borehole.

The majority of the made ground typically comprised cohesive, brown, sandy gravelly clay with occasional cobbles; the gravel and cobble component consisting of mainly sandstone and brick. Locally concrete boulders/fence posts and pieces of metal were noted.

In the area of scrubland in the north-west, further made ground comprising cohesive, grey, locally slightly organic clay (relict topsoil) was encountered, either immediately below the surface vegetation or below the cohesive made ground on the western margin of the site. It is likely that the cohesive made ground was brought onto the site from the land immediately to the west and placed over the landform resulting in buried topsoil being present in this area. The buried topsoil was identified in TP101 in the north-western corner, TP104 adjacent to the western boundary and DSRC105, WS113 and TP112.

In the south-east of the site, generally beneath the concrete hardstanding, granular made ground, comprising either sand and gravel of dark grey ash, reddish brown mudstone, burnt shale or sand, gravel and cobbles of sandstone, was encountered locally. It appears that the granular made ground of sandstone has been used to raise levels in the south-east.

Beneath the made ground, natural strata comprising glacial till was encountered. The glacial till was described as orange/brown, mottled light grey, slightly sandy slightly gravelly clay; the gravel component consisting mainly of subrounded to rounded of sandstone, was encountered in most locations. Where proven, the base of the glacial till was encountered at depths of between 2.40m bgl and 12.50m bgl. The glacial deposits were generally firm and becoming stiff and very stiff with depth. However, some softer material was encountered within the upper 3m within the central site area.

The underlying bedrock (Pennine Lower Coal Measures Formation) was found to comprise extremely weak to very weak mudstone and sandstone, proven to a maximum depth of 15.00m bgl. The weathering of the mudstone was found to be highly variable, ranging between partially un-weathered to destructed residual soils.

In WS127 and WS128 only, in the south-east of the site, a 0.55m to 0.90m thick intact coal seam was encountered at depths of 1.90m bgl and 2.00m bgl respectively. It is possible that some coal was extracted from near the surface during previous development in this part of site and replaced with sandstone made ground.

4.3 Visual and Olfactory Evidence of Hydrocarbon Contamination

A hydrocarbon odour was noted in the granular made ground in WS126 from 0.35m to 0.90m bgl. A sample of this material was tested for hydrocarbons (TPHCWG) as part of the laboratory testing programme.

No visual or olfactory evidence of potential hydrocarbon contamination, i.e. sheens or odours, was encountered at any other exploratory location.

4.4 In-Situ Testing

The results of the in-situ penetration testing have been plotted against depth (m bgl). The results have been corrected in accordance with the energy ratio of the testing equipment.

The plot is presented as Figure 3 in Appendix A and the SPT data (uncorrected) is included on the exploratory hole logs contained in Appendix B.

The SPT data generally indicates increasing strength/density with depth with N values of greater than 10 recorded below 3.00m bgl with some lower N-values recorded in the upper 2.50m bgl. It should be noted that an anomalous N-value of 0 was recorded in WS109 at 3.00m bgl. This may be due to the presence of extremely soft soils or a void at this location.

4.5 Geotechnical Laboratory Testing

The testing suite was designed to classify the materials and assess the suitability of the materials for re-use in earthworks.

Moisture Content and Atterberg Limits

15 samples of natural cohesive glacial till, five samples of cohesive made ground and one sample of granular made ground were submitted for moisture content testing with 18 samples tested further for Atterberg Limit testing. All the results are summarised in Table 4.5.1 below.

Table 4.5.1 – Summary of Moisture Content and Atterberg Limit Testing

Material	Moisture Content (%)		Atterberg Limits Modified Plasticity Index (%)	
	No of samples	Range	No of samples	Range
Cohesive Made Ground	7	8.6 – 3	5	10.4 – 18.2
Cohesive Glacial Till	13	13 – 21	13	9.0 – 16.9

The Plasticity Indices reported have been modified based on the percentage of particles smaller than 425µm. The results indicate the cohesive made ground is of low and intermediate plasticity with low volume change potential and the natural glacial till is of low and intermediate plasticity with low volume change potential.

Particle Size Distribution

Particle size distribution/sedimentation testing was carried out on three soil samples of natural glacial till, three samples of cohesive made ground and 1 sample of granular made ground, obtained at depths of between 0.2m and 2.40bgl. The tests were carried out to confirm the field descriptions of the materials and inform the earthworks classification. The results are summarised in Table 4.5.2 below.

Table 4.5.2 – Summary of Particle Side Distribution/Sedimentation Testing

Trial Pit	Depth (m bgl)	Material	Cobbles & above (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
TP103	0.70 – 1.10	Stiff, sandy, slightly gravelly CLAY	0	1	44	31	24
TP106	0.80 – 1.30	Stiff, sandy, slightly gravelly CLAY	0	3	39	32	26
TP109	0.50 – 1.00	MADE GROUND: Stiff, slightly sandy, slightly gravelly CLAY	0	1	19	42	38
TP110	0.40 – 0.90	MADE GROUND: Sandy, slightly gravelly CLAY	0	3	42	30	25
TP112	0.20 – 0.70	MADE GROUND: Stiff, sandy, slightly gravelly CLAY	0	7	47	25	21
TP118	2.40 – 2.90	Stiff, sandy, slightly gravelly CLAY	0	8	42	28	22
TP119	2.00 – 2.50	MADE GROUND: Sandy GRAVEL; medium cobble content, low boulder content	15	41	37	7	

Compaction Testing

Three soil samples of cohesive made ground, one of granular made ground and three samples of natural cohesive glacial till were submitted for dry density/moisture content relationship testing. The compaction tests were carried out using both a 2.5kg and a 4.5kg rammer. The results are summarised in Table 4.5.3.

Table 4.5.3 - Summary of Compaction Test Results

Exp. Hole	Depth (m bgl)	Material	Particle Density (Mg/m3)	Weight of Rammer	Natural Moisture Content (NMC)	Max. Dry Density (Mg/m3)	Optimum Moisture Content (OMC)	Suitability for Compaction and Range of Acceptable Moisture Contents*
TP103	0.70 – 1.10	Stiff, sandy, slightly gravelly CLAY	2.67	2.5kg	17	1.85	14	**Suitable 14% - 19%**
				4.5kg		1.89	14	**Suitable 13% - 18%**
TP106	0.80 – 1.20	Stiff, sandy, slightly gravelly CLAY	2.68	2.5kg	17	1.85	14	**Suitable 14% - 18.5%**
				4.5kg		1.97	11	Unsuitable (too wet) 11% - 15.5%
TP109	0.50 – 1.00	MADE GROUND: Stiff, slightly sandy, slightly gravelly CLAY	2.58	2.5kg	23	1.63	20	**Suitable 19.5% - 24%**
				4.5kg		1.71	17	Unsuitable (too wet) 17% - 21%
TP110	0.40 – 0.90	MADE GROUND: Sandy, slightly gravelly CLAY	2.55	2.5kg	13	1.85	13	**Suitable 12.5% - 17.5%**
				4.5kg		1.94	10	**Suitable 9.5% - 14.5%**
TP112	0.20 – 0.70	MADE GROUND: Stiff, sandy, slightly gravelly CLAY	2.59	2.5kg	19	1.77	16	**Suitable 15% - 19.5%**
				4.5kg		1.87	13	Unsuitable (too wet) 12% - 17%
TP118	2.40 – 2.90	Stiff, sandy, slightly gravelly CLAY	2.68	2.5kg	17	1.87	14	**Suitable 13.5% - 18%**
				4.5kg		1.99	11	Unsuitable (too wet) 10.5% - 15.5%
TP119	2.00 – 2.50	MADE GROUND: Sandy GRAVEL; medium cobble content, low boulder content	2.60	2.5kg	8.6	1.90	13	Unsuitable (too dry) 10.5% - 15.5%
				4.5kg		1.96	11	Unsuitable (too dry) 10% - 14.5%

* To achieve >95% of Maximum Dry Density and <5% Air Voids

Suitability for compaction is defined as achieving >95% of the maximum dry density and less than 5% air voids.

The results indicate the natural clay and cohesive made ground may be appropriately compacted using conventional plant (light compaction as indicated by the results for the 2.5kg rammer). However, approximately 50% of the samples tested were too wet to achieve the compaction criteria using the 4.5kg rammer, representing heavier compaction effort.

Under both light and heavy compaction, the granular made ground is generally too dry to be compacted based on the one sample tested.

California Bearing Ratio Testing

Three soil samples of cohesive made ground, one of granular made ground and three samples of natural cohesive glacial till were submitted for California Bearing Ratio testing, the samples were compacted with a 2.5kg rammer. The results are summarised in Table 4.5.4 below.

Table 4.5.4 – Summary of California Bearing Ratio Testing

Sample Ref.	Depth (m bgl)	Material	Final Moisture Content (%) (Top/Base)	CBR Value Top (%)	CBR Value Base (%)	Report CBR Average (%) *
TP103	0.70 – 1.10	Stiff, sandy, slightly gravelly CLAY	17	5.4	5.9	5.65
TP106	0.80 – 1.20	Stiff, sandy, slightly gravelly CLAY	17	3.4	3.3	3.35
TP109	0.50 – 1.00	MADE GROUND: Stiff, slightly sandy, slightly gravelly CLAY	23	2.9	3.8	NA
TP110	0.40 – 0.90	MADE GROUND: Sandy, slightly gravelly CLAY	13	12.2	10.4	NA
TP112	0.20 – 0.70	MADE GROUND: Stiff, sandy, slightly gravelly CLAY	19	4.7	5.1	4.9
TP118	2.40 – 2.90	Stiff, sandy, slightly gravelly CLAY	17	2.1	2.6	NA
TP119	2.00 – 2.50	MADE GROUND: Sandy GRAVEL; medium cobble content, low boulder content	8.4 / 7.9	47.4	40.5	NA

* To report a CBR average, the results for the top and base must be within 10%.

The results indicate CBR values of between 2.1% and 5.9% can be achieved in the natural clay.

The results indicate CBR values of between 2.9% and 12.2% can be achieved in the cohesive made ground.

The results indicate CBR values of 47.4% and 40.5% can be achieved in the granular made ground (sandstone).

Undrained Triaxial Testing

Five samples of the natural ground, obtained at depths of between 1.20m and 8.45m bgl were submitted to determine the undrained shear strength in triaxial compression. The results returned undrained shear strength values ranging from 24kPa and 148kPa. The results are indicative of variable strength soils. The results are summarised in Table 4.5.5 below.

Table 4.5.5 – Summary of Quick Undrained Triaxial Tests

Exp. Hole	Depth (m bgl)	Material (Laboratory Description)	Cell Pressure (kPa)	Shear Strength	Mean Shear Strength
BH101	3.00 – 3.45	Stiff brown gravelly very sandy CLAY	40 80 160	108 123 148	126
BH102	3.00 – 3.45	Firm brown slightly gravelly very sandy CLAY	40 80 160	33 44 52	43
BH102	8.00 – 8.45	Soft brown slightly gravelly very sandy CLAY	90 180 360	26 34 46	35
BH103	5.00 – 5.45	Firm brown mottled grey slightly gravelly very sandy CLAY	60 120 240	51 60 72	61
BH104	1.20 – 1.65	Soft brown slightly gravelly very sandy CLAY	20 40 80	24 31 37	31

One-Dimensional Consolidation Testing

Seven one-dimensional consolidation tests were carried out thin-walled samples obtained from BH101 between 1.20m and 1.65m bgl, BH101 between 3.00m and 3.45m bgl, BH102 between 3.00m and 3.45m, BH102 between 8.00m and 8.45m, BH103 between 1.20m and 1.65m, BH103 between 5.00m and 5.45m, and BH104 between 1.20m and 1.65m bgl. The results are summarised in Table 4.5.6 below.

Table 4.5.6 – Summary of One-Dimensional Consolidation Tests

Exp. Hole	Depth (m bgl)	Material	Pressure Range (kPa)	Mv (m2/MN)	Cv (m2/yr)
BH101	1.20 – 1.65	Firm medium strength orange brown mottled grey sandy slightly gravelly CLAY.	0 – 20 20 – 40 40 – 80 80 – 160 160 - 80	0.664 0.393 0.253 0.144 0.019	0.752 1.069 1.680 1.791 13.039
BH101	3.00 – 3.45	Firm medium strength orange brown mottled grey sandy slightly gravelly CLAY.	0 – 40 40 – 80 80 – 160 160 – 320 320 - 160	0.490 0.213 0.136 0.084 0.010	0.830 1.092 1.707 1.833 17.560
BH102	3.00 – 3.45	Firm, medium strength orange brown mottled grey sandy slightly gravelly CLAY.	0 – 40 40 – 80 80 – 160 160 – 320 320 - 160	0.495 0.215 0.138 0.085 0.010	0.816 1.072 1.677 1.799 17.239
BH102	8.00 – 8.45	Extremely weak dark grey laminated MUDSTONE.	0 – 90 90 – 180 180 – 360 360 – 720 720 - 360	0.306 0.141 0.096 0.057 0.006	5.367 3.705 3.289 3.475 24.265
BH103	1.20 – 1.65	Firm, medium strength orange brown mottled grey sandy slightly gravelly CLAY.	0 – 20 20 – 40 40 – 80 80 – 160 160 - 80	0.465 0.492 0.326 0.213 0.028	2.976 2.700 1.640 1.401 17.024
BH103	5.00 – 5.45	Firm, medium strength orange brown mottled grey sandy slightly gravelly CLAY.	0 – 60 60 – 120 120 – 240 240 – 480 480 – 240	0.436 0.189 0.124 0.076 0.003	0.697 0.660 0.951 0.945 8.609
BH104	1.20 – 1.65	Soft grey sandy slightly gravelly CLAY.	0 – 20 20 – 40 40 – 80 80 – 160 160 - 80	0.850 0.430 0.269 0.180 0.001	0.490 0.775 1.151 1.208 8.831

The results indicate that the cohesive deposits are typically of medium and high compressibility.

Rock Strength Testing

Rock core samples of the bedrock were selected and scheduled for strength testing. This included irregular, axial and diametral point load tests and laboratory unconfined compression strength (UCS) tests.

A summary of the laboratory unconfined compression strength (UCS) tests is presented in Table 4.5.6 below.

Table 4.5.6 – Summary of Laboratory Unconfined Compression Strength (UCS) Tests

Exp. Hole	Depth (m bgl)	Rock Type	Unconfined Compressive Strength (MPa)	Strength Term*
DS/RC102	4.50 – 4.80	Grey sandstone	0.1	(Less than) extremely weak
DS/RC104	10.60 – 10.80	Grey sandstone	0.1	(Less than) extremely weak
DS/RC105	14.70 – 14.90	Grey mudstone	0.4	(Less than) extremely weak

* In accordance with BS EN ISO 14689 (table 5)

The results of the point load index (PLI) tests have been corrected in accordance with Broch & Franklin (1972). The Is50 value has been multiplied by a factor of 24 in order to obtain an approximate UCS. A summary of the equivalent unconfined compression strength (UCS) tests is presented in Table 4.5.7 below.

Table 4.5.7 – Summary of Equivalent Unconfined Compression Strength (UCS) Tests

Exp. Hole	Depth (m bgl)	Rock Type	IS50 (PLI)	Equivalent Unconfined Compressive Strength (MPa)	Strength Term*
DS/RC104	5.70	Sandstone	0.13	3.12	Very weak
DS/RC104	5.70	Sandstone	0.12	2.88	Very weak
DS/RC104	8.95	Sandstone	0.05	1.20	Very weak
DS/RC104	8.95	Sandstone	0.06	1.44	Very weak
DS/RC105	12.50	Mudstone	0.28	6.72	Weak
DS/RC105	12.50	Mudstone	0.19	4.56	Very weak
DS/RC105	14.20	Mudstone	0.09	2.16	Very weak
DS/RC105	14.20	Mudstone	0.14	3.36	Very weak

* In accordance with BS EN ISO 14689 (table 5)

The results for all the UCS tests including equivalent UCS tests based on PLIs have been plotted against depth (m bgl) and are presented as Figure 4 in Appendix A. The plot illustrates the variability in rock strength below the site including the very low rock strengths obtained from the laboratory UCS tests. It is considered that the latter results are not reflective of the actual rock strength, possibly due to disturbance during drilling and/or transportation.

4.6 Groundwater

No groundwater was noted during the drilling of the dynamic sample/rotary-cored follow-on boreholes. However, this could be due to the drilling technique employed, i.e. use of air mist during drilling.

Generally perched groundwater was encountered locally in the made ground at shallow depth in some window sample boreholes and trial pits at depths of between 0.30m and 2.50m bgl. Occasional seepages were encountered in the cohesive glacial till.

A groundwater strike was encountered in BH102 at 7.50m within the bedrock strata.

A summary of all groundwater encountered is presented in Table 4.6.1.

Table 4.6.1 – Summary of Recorded Groundwater Events.

Location	Groundwater Event	Depth (m bgl)	Stratum
BH102	Groundwater strike	7.50	Mudstone
WS107	Perched groundwater	0.30	Granular made ground
WS108	Perched groundwater	0.40	Granular made ground
WS109	Perched groundwater	0.80	Cohesive made ground
WS115	Perched groundwater	0.50	Cohesive made ground
WS123	Groundwater seepage	1.80	Cohesive glacial till
WS126	Perched groundwater (with hydrocarbon odour and staining)	0.50	Granular made ground
TP103	Slight groundwater seepage	1.80	Cohesive glacial till
TP104	Rapid inflow (possible broken drain – hydrogen sulphide odour)	1.85	Cohesive glacial till
TP106	Groundwater seepage	2.10	Cohesive glacial till
TP115	Rapid inflow	1.50	Granular made ground
TP118	Slight groundwater seepage	1.30	Bottom of Granular made ground
TP119	Groundwater seepage	2.50	Granular made ground

Gas and groundwater monitoring wells were installed in seven of the window sample boreholes, two of the cable percussive boreholes and four dynamic sample with rotary core follow-on boreholes. Groundwater monitoring has been carried out on six occasions between 18 November 2021 and 6 January 2022. A summary of the monitored groundwater levels is provided in Table 4.6.2 below.

Table 4.6.2 – Summary of Monitored Groundwater Levels

Location	Water level during monitoring (m bgl)					
	18/11/2021	25/11/2021	01/12/2021	9/12/2021	20/12/2021	6/01/2022
WS101	0.52	1.37	1.08	1.05	0.29	1.20
WS103	0.79	0.87	0.38	NR	0.63	0.61
WS109	0.72	0.68	0.53	0.49	0.67	0.57
WS110	0.00	0.53	0.38	0.29	0.31	0.20
WS111	1.02	1.29	NR	0.91	1.10	1.90
WS122	NR	NR	NR	NR	NR	NR
WS125	1.25	1.72	1.62	1.39	1.33	4.79
BH101	0.00	NR	NR	NR	NR	6.14
BH103	NR	NR	NR	NR	NR	NR
DSRC101	2.57	3.24	3.12	2.99	3.22	10.80
DSRC103	0.56	1.35	NR	NR	NR	8.84
DSRC105	2.83	10.16	8.05	6.62	5.48	14.63
DSRC108	NR	NR	NR	NR	NR	NR

NR – Not recorded (generally due to monitoring installation being flooded at the time of monitoring)

It should be noted that the groundwater conditions recorded are based on observations made at the time that site work and monitoring was carried out. Groundwater levels are likely to vary owing to seasonal and weather-related effects.

4.7 Ground Gas

Ground gas monitoring has been undertaken on six occasions. The works were carried out using a portable gas meter in accordance with the standard JPG methodology and included measurements of methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide, gas flows and atmospheric pressure.

The results of the gas monitoring are presented in Appendix E and are discussed in Section 6 of this report.

5.0 GEOTECHNICAL AND ENGINEERING ASSESSMENT

5.1 Development Proposals

It is proposed to develop the site with a distribution centre, which will include two-storey offices, associated parking and ancillary infrastructure.

A proposed site layout plan has been provided. This is referenced below and included in Appendix A.

- Ashton Smith. Heywood Distribution Park – External Works. Proposed Site Plan, Drawing No. HDP1-ASA-30-EX.SI-D-A-3001_(S0. Dated 30 September 2021.

5.2 Mining & Quarrying

The Coal Authority Mining Report states that the site is not within a surface area that could be affected by past recorded underground coal workings. Based on the geological setting, the probability of shallow unrecorded coal workings is considered to be very low and not warranting further assessment.

During the ground investigation a 0.55m to 0.90m thick coal seam was encountered at depths of 1.90m bgl and 2.00m bgl in the south east. There was no evidence of coal workings to this coal seam.

There are no recorded mine entries on the site or within 20m of the site boundary. The risk of unrecorded mine entries on the site is considered to be very low. No further coal mining investigation is considered necessary.

Former sandstone and sand pits are present to the south of the site. However, there is no evidence of quarrying on the site.

5.3 Earthworks

There will be a requirement for earthworks in order to create a suitable development platform.

It will be necessary to carry out cut and fill earthworks in order to create an appropriate development platform. An indicative cut and fill analysis has been carried out by JPG. This analysis suggests cutting up to approximately 3.00m generally in the western, north-western and eastern parts of the site and filling up to approximately 3.00m generally in the southern and northern areas.

Topsoil should be stripped from the site surface and removed off site with the exception of the already landscaped areas in the north and north-east that are to be retained. In addition, relict topsoil is to be removed from the west of the site as it poses a hazardous ground gas risk.

Any earthworks should be carried out in accordance with the Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks.

Suitability for compaction is defined as achieving >95% of the maximum dry density and less than 5% air voids.

The results of the laboratory testing indicate that suitable compaction of the natural clay and cohesive made ground is likely to be achievable without modification or treatment.

Proper selection and control will be required as part of the earthworks to use these materials. The materials should not be allowed to deteriorate, i.e. become wet, during excavation and compaction and must be sufficiently protected from traffic after placement.

Ponds were present historically on the site. The ground investigation targeted these ponds but no deep made ground was encountered. It is therefore assumed that these infilled features are only shallow. During the earthworks the features should be fully excavated and any soft and/or organic soils removed and replaced with engineered fill.

5.4 Foundations

Following removal of topsoil, concrete slabs and made ground from below the footprint of the building, engineered fill is to be placed in accordance with the Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks.

Pad foundations (mass concrete) are to extend through the engineered fill to bear onto the natural strata (glacial till) of appropriate allowable bearing pressure. An allowable bearing capacity 100kN/m² is considered appropriate for the firm, medium strength clay soils for total settlements of no greater than 25mm. Alternatively shallow foundations could bear onto the engineered fill of suitable bearing capacity. Based on laboratory CBR testing, allowable bearing pressures of approximately 80kN/m² for the cohesive made ground and the natural cohesive strata if used as engineered fill are considered appropriate.

Preliminary consolidation assessment has been carried out for foundations bearing onto cohesive soils. The assessment has assumed a 1.5m square pad foundation with a design bearing pressure of 100kN/m² at a foundation depth of 117.00m AOD.

In the location of BH101 in the north-east, primary consolidation settlement of 26.8mm has been calculated. In the location of BH102, below the footprint of the proposed building in the north, primary consolidation settlement of 23.1mm has been calculated. In the location of BH103, below the footprint of the proposed building in the centre west, primary consolidation settlement of 25.7mm has been calculated. It can be seen from these results, that the predicted settlements in these locations are approximately 25mm.

In the location of WS(DPT)111 and DSRC106, softer soils are present below the assumed foundation depth of 117.00m AOD. Settlement in this area is calculated to be approximately 40mm. It will therefore be necessary to deepen and/or widen the foundation in order to limit settlements to tolerable limits or consider an alternative foundation solution.

For higher loaded areas, e.g. column loads associated with two-story offices, or where total potential settlement of less than 25mm is desired, consideration should be given to a piled foundation solution, bearing into/onto the underlying mudstone or sandstone bedrock. An allowable bearing pressure of 200kN/m² is considered appropriate for the extremely weak bedrock. Alternatively Constrained Modular Columns could be used.

Any earthworks or material improvement (where required) should be designed in order to provide the necessary acceptable allowable bearing capacity and tolerable settlements for the proposed foundation solution.

The allowable bearing capacity is a function of the foundation configuration, depth, and the ability of the structure to tolerate such movements and should therefore be validated during detailed design.

5.5 Ground Floor Construction

In order to create the development platform, it is proposed to engineer site-won materials across the site. The proposed cut and fill earthworks should be designed in order to accommodate a ground bearing floor slab.

It is understood that it is proposed to undertake ground improvement of the near surface materials in order to create a formation level of appropriate CBR value.

5.6 Roads, Pavements and Hardstanding Surfaces

Any earthworks/ground improvement works should be designed in order to provide a suitable CBR value for the proposed development. Variable CBR values have been achieved in the laboratory for the made ground and natural clay soils. It should be possible by appropriate selection of materials that a CBR of 3% is achievable through the earthworks operation. Further testing of materials may be required to confirm suitability.

Materials with high fines content will deteriorate rapidly due to water ingress and tracking by construction plant. Adequate protection of formation levels will be required to maintain the strength of the material.

5.7 Excavations

Based on the nature of the made ground and underlying natural strata, it is considered likely that if excavations were left unsupported, then over time collapse would occur, and this is likely to increase in the presence of perched groundwater.

Good working practice with respect to drainage of excavations and formations will be required to protect materials. Any excavation for structural foundations must be covered without delay with blinding concrete to prevent softening by water.

The requirement for temporary support of excavations should be assessed on an individual basis and in any case, excavations of greater than 1.20m depth requiring man entry will require temporary support in accordance with HSE guidance. Alternatively, the sides of the excavation will need to be battered back for the safety of operatives. Guidance on safe batter slopes can be obtained from CIRIA Report 97 Trenching Practice.

5.8 Control of Groundwater

During the recent JPG ground investigation, perched groundwater was generally encountered locally in the made ground at shallow depth in some window sample boreholes and trial pits at depths of between 0.30m and 2.50m bgl. Occasional seepages were encountered in the cohesive glacial till. A groundwater strike was encountered in BH102 at 7.50m within the bedrock strata.

Reference should be made to guidance given in the Manual of Contract Documents for Highway Works, Volume 1: Specification for Highway Works, Series 600 Earthworks. In particular the following recommendations are made with respect to the control of surface water and shallow groundwater.

The contractor shall keep earthworks free of water including:

- Arranging for the rapid removal of water which is shed on the earthworks or enter the earthworks from any source.
- Lowering and maintaining by appropriate measures, the water level in excavations sufficiently to enable the permanent works to be constructed.

In order to keep the site free of water the contractor shall do the following:

- Form and maintain cuttings, embankments and other areas of fill with appropriate falls, gradients and sealed surfaces.
- Provide where necessary temporary watercourses, drains, and pumping.
- Discharge accumulated water and groundwater into the permanent outfalls of the drainage system where practicable; and
- Provide adequate means for trapping silt on temporary systems discharging into permanent drainage systems.

5.9 Obstructions

Large parts of the site, in particular the east, have concrete handstanding at the surface. This will require breaking out and removal or incorporated into the earthworks following crushing and/or screening.

Occasional boulders of sandstone were encountered in the site works. These could be broken down in order to be incorporated into the earthworks.

Based on the previous usage of the site, some relict foundations and services should be anticipated.

5.10 Chemical Attack on Buried Concrete

Laboratory testing has been undertaken on samples of the made ground, natural strata, and water to determine the sulphate content and acidity and hence the concrete class required for buried concrete.

Laboratory testing of the made ground recorded water-soluble sulphate contents ranging between 11mg/l and 370mg/l and pH values of between 5.6 and 11.7.

Laboratory testing in the natural clay recorded water-soluble sulphate contents ranging between 16mg/l and 1934mg/l and pH values of between 5.7 and 8.6.

In the groundwater, a sulphate content of between 6.0mg/l and 21mg/l and pH values of between 6.5 and 7.6 were recorded.

The site has been assessed in accordance with BRE Special Digest 1:2005 'Concrete in Aggressive Ground'. Based on the history of the site, it has been assessed in accordance with the requirements for brownfield ground locations.

Foundations are likely to come into contact with made ground, natural strata and the underlying groundwater. On this basis it is recommended that concrete should be designed to Aggressive Chemical Environment for Concrete (ACEC) Design Sulphate Class DS-1 and ACEC Class AC-2z, based on mobile groundwater conditions.

6.0 ENVIRONMENTAL RISK ASSESSMENT

6.1 Introduction

The statutory definition of contaminated land is given in the Environmental Protection Act, Part IIA, Section 78, 1990, which was introduced by the Environment Act, Section 57, Department of Environment, 1995 and is defined as:

Land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that:

- Significant harm is being caused or there is a significant possibility of such harm being caused (where harm is defined as harm to health of living organisms or other interference with the ecological systems of which they form a part and, in the case of man, includes harm to his property); and/or
- Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused (by the land).

The presence of contaminated materials on a site is generally only of concern if an actual or potentially unacceptable risk exists. The potential for harm to occur requires three conditions to be satisfied:

- **Sources** – The presence of substances (potential contaminants/pollutants), in or under the ground, that may cause harm or pollution.
- **Receptors** - The presence of a receptor which may be harmed, e.g. the water environment or humans, buildings, fauna and flora; and
- **Pathway** - The existence of a linkage between the Source and the Receptor.

In summary, the presence of measurable concentrations of contaminants within the ground and subsurface environment does not automatically imply that a contamination problem exists, since contamination must be defined in terms of pollutant linkages and an unacceptable risk of harm to available receptors.

The nature and importance of both pathways and receptors, which are relevant to a particular site, will vary according to the sensitivity of the intended end use of the site and the sites characteristics and environmental setting.

Legislation and guidance on the assessment of contaminated sites acknowledges the need for a tiered risk-based approach. This is set out in the Environment Agency's manual *Land contamination: risk management* (published in October 2020 and last updated on 19 April 2021) and comprises the following stages of risk assessment:

Tier 1: Preliminary risk assessment (PRA)	As part of this assessment, the overall site objectives are defined. Current and historical information about the site and the potential contaminants expected to be present are assessed and an outline conceptual model (CM) is developed. The risks are assessed qualitatively, and the findings reported in the PRA (or desk study). The report recommends what further works would be required in order to assess whether the site is suitable for its proposed use.
Tier 2: Generic quantitative risk assessment (GQRA)	The GQRA uses Generic Assessment Criteria and a standard set of generic assumptions based on specific end uses in order to assess the risks to receptors. It includes the collection of more detailed information including laboratory analysis of soil and water samples in order to inform and assess the risks.
Tier 3: Detailed quantitative risk assessment (DQRA)	If pollutant linkages are confirmed as part of the GQRA, these are known as relevant pollutant linkages (RPLs) and further detailed assessment is required. At this tier, detailed site-specific information is collected to estimate the risk or to develop site-specific assessment criteria (SSAC). This may include collecting information about the receptor.

A Tier 1 Assessment has been prepared for the site by JPG and reported in the Geoenvironmental Desk Study Report, referenced 5986-JPG-XX-XX-RP-G-0601-S2-P01 and dated November 2021.

This environmental risk assessment undertaken by JPG constitutes a Tier 2 Generic Quantitative Risk Assessment (GQRA) and has been carried out in accordance with the Environment Agency's *Land contamination: risk management guidance*.

6.2 Assessment Approach

The results of the chemical analysis for each determinand will be assessed against their respective GAC.

Human Health
include the LQM/CIEH Suitable 4 Use Levels (S4UL) and Category 4 Screening Levels (C4SL) which were developed using the UK Contaminated Land Exposure Assessment (CLEA) Framework Documents and Software.

The CLEA model uses generic assumptions about the fate and transport of chemicals in the environment and a generic conceptual model (referred to as generic land use scenarios) for site conditions and human behaviour, to estimate child and adult exposures to soil contaminants for those living, working and/or playing on contaminated sites over long time periods.

The S4UL and C4SL screening levels have been derived for a variety of land uses including residential, allotments, commercial and public open space.

In the absence of S4UL and C4SL for potential contaminants, appropriate alternative GAC will be used.

Controlled Waters
Based on the environmental setting of the site, the leachate chemical test results have been compared against Generic Assessment Criteria (GAC) threshold values based on Drinking Water Standards and/or Environmental Quality Standards (EQS).

An exceedance of a threshold value does not directly imply there is an unacceptable risk, however, it indicates that the exceedance should be further assessed via the qualitative source-pathway-receptor (S-P-R) approach.

6.3 Evaluation of Soils Analysis

Initially, the results of the chemical analysis for each potential contaminant will be compared directly with their respective GAC. Based on the current development proposals for the site, i.e. commercial, the results of the chemical analysis for the soil samples have been assessed against GAC for a commercial end use.

If any significant exceedances of the GAC are noted, then the results will be subject to statistical analysis if appropriate. An outline of the methodology of the statistical analysis is presented in Appendix D.

In total, 21 samples of made ground were submitted for chemical analysis. A summary of the results is provided below.

Human Health - Soils
The results have been compared directly with their respective GAC and are summarised in Table 6.3.1.

Table 6.3.1 – Summary of Chemical Analysis for Soil Samples – Made Ground

Determinand	GAC for Commercial End Use (mg/kg)	Sample Mean (mg/kg)	Range of Results (mg/kg)	Do any samples exceed the GAC?
Arsenic	640(1)	9.25	1.4 - 24	No
Cadmium	190(1)	0.23	0.1 – 0.5	No
Chromium	8600(1)	18.27	5 – 35	No
Hexavalent Chromium	33(1)		<1.0	No
Copper	68,000(1)	30.96	8.2 – 71	No
Lead	2,330(2)	48.87	4.9 – 220	No
Mercury (Inorganic)	1,100(1)	0.13	0.05 – 0.37	No
Nickel	980(1)	16.38	4.4 – 27	No
Selenium	12,000(1)	0.65	0.6 – 0.7	No
Zinc	730,000(1)	53.29	15 – 110	No
Cyanide (free)	20(2)	0.25	0.1 – 0.4	No
Total Phenols	440*(1)	0.57	0.4 – 0.9	No
Naphthalene	190*(1)	0.61	0.22 – 1.5	No
Acenaphthylene	83,000*(1)	0.61	0.03 - 0.14	No
Acenaphthene	84,000*(1)	0.07	0.03 – 5.00	No
Fluorene	63,000*(1)	1.75	0.62 – 2.50	No
Phenanthrene	22,000*(1)	1.41	0.04 – 18.0	No
Anthracene	520,000*(1)	1.79	0.03 – 5.60	No
Fluoranthene	23,000*(1)	0.76	0.03 – 27.0	No
Pyrene	54,000*(1)	2.17	0.03 – 24.0	No
Benz(a)anthracene	170*(1)	1.96	0.03 – 7.70	No
Chrysene	350*(1)	0.90	0.04 – 5.80	No
Benzo(b)fluoranthene	44*(1)	0.83	0.03 – 4.20	No
Benzo(k)fluoranthene	1,200*(1)	0.61	0.03 – 2.00	No
Benzo(a)pyrene	35*(1)	0.38	<0.03 – 3.90	No
Indeno(123-cd) pyrene	500*(1)	0.60	<0.03 – 1.40	No
Dibenzo(ah)anthracene	3.5*(1)	0.36	<0.03 – 0.42	No
Benzo(ghi)perylene	3,900*(1)	0.14	0.06- 1.70	No

S4UL * BASED ON 1% SOM, (2) C4SL

None of the determinands were detected at concentrations in excess of their respective GAC.

Speciated TPH(CWG)(aliphatic : aromatic split) testing was carried out on the sample of granular made ground obtained from WS126 at 0.35m bgl that displayed a hydrocarbon odour. The results were compared to S4ULs for a commercial end use. No TPH fraction was found to exceed the GAC.

Asbestos, described as a 'bundle of chrysotile fibres' was recorded in TP109 in a sample obtained between ground level and 0.50m depth. Asbestos, described as a 'chrysotile present as fibre bundles' was recorded in WS107 in a sample obtained between 0.20m and 0.70m depth. Asbestos quantification was subsequently carried out on the samples. The total mass of asbestos was recorded as <0.001% w/w for both samples. At this concentration the material is not considered hazardous to human health. In addition, the made ground in these locations would not be classified as hazardous waste based on the concentration of asbestos recorded.

Evaluation of Controlled Waters Analysis

In total, 14 samples of made ground were submitted for leachability analysis. The results for each determinand were compared directly with their respective GAC, the results are summarised in Tables 6.3.2a and 6.3.2b.

Table 6.3.2a – Summary of Leachability Results (1)

Determinand	GAC (µg/l)	TP118 0.55m	TP115 0.50m	TP103 0.35-0.70m	TP111 0.50-0.10m	TP112 0.70-0.10m	TP104 0.10-0.60m
Arsenic	10 (1)	3.2	0.58	1.3	0.77	0.81	0.78
Cadmium	5 (1)	< 0.03	< 0.03	< 0.03	0.21	< 0.03	< 0.03
Chromium	50 (1)	< 0.25	< 0.25	< 0.25	1.9	< 0.25	< 0.25
Copper	2000 (1)	2.1	1.1	1.4	2.7	0.6	1.1
Lead	10 (1)	0.74	0.27	0.88	2.8	0.43	1.4
Mercury	1 (1)	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01
Nickel	20 (1)	< 0.5	< 0.5	< 0.5	1.7	< 0.5	< 0.5
Selenium	10 (1)	0.69	0.28	0.25	0.91	< 0.25	< 0.25
Zinc	5000 (1)*	2.4	7.5	3.3	7.6	4.9	5
pH	6.5-9.5	7.4	7.2	7.6	7.1	7.3	7.1
Cyanide Free	50 (1)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Sulphate	250	3.5	2	3	1.2	1.3	3.1
Naphthalene	4.24 (2)	0.12	0.06	0.07	< 0.05	0.06	0.06
Anthracene	0.193 (2)	0.02	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Fluoranthene	0.0122 (2)	0.03	0.05	0.07	< 0.01	< 0.01	< 0.01
Benzo (a) pyrene	0.1 (1)	< 0.01	0.01	0.02	< 0.01	< 0.01	< 0.01
Sum of: Benzo (b) fluoranthene, Benzo (k) fluoranthene, Indeno (1,2,3-c,d) pyrene, and; Benzo (g,h,i) perylene	0.1 (1)	<0.04	0.03	0.11	<0.04	<0.04	<0.04
Phenol	14.9 (2)	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50

(1) Water Supply (Water Quality) Regulations 2000.
*Historical 1989 Threshold Value.

(2) Water Framework Directive 2015, Surface Water, Maximum Threshold Value.

Table 6.3.2b – Summary of Leachability Results (2)

Determinand	GAC (µg/l)	WS101 0.25	WS103 0.20-0.50m	WS106 0.50m	WS113 0.80-1.15m	WS109 0.10-0.20m	WS121 0.10-0.20m	WS126 0.35m	WS107 0.20-0.70m
Arsenic	10 (1)	0.46	0.67	0.49	0.73	0.3	0.57	0.74	1.3
Cadmium	5 (1)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Chromium	50 (1)	< 0.25	0.29	< 0.25	0.28	< 0.25	0.28	< 0.25	0.48
Copper	2000 (1)	1.1	1.2	0.5	1.1	1.9	1.3	1.4	1.7
Lead	10 (1)	1.7	1.8	0.89	2.4	2.8	2.9	0.35	2.5
Mercury	1 (1)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	20 (1)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Selenium	10 (1)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Zinc	5000 (1)*	16	8.7	1.7	1.9	6.2	4.2	< 1.3	1.3
pH	6.5-9.5	7	6.9	6.8	6.8	6.8	6.2	11.1	9.4
Cyanide Free	50 (1)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2
Sulphate	250	0.88	1.1	2.5	0.63	1.1	0.85	3.7	13
Naphthalene	4.24 (2)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.65	0.52
Anthracene	0.193 (2)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.11	0.04
Fluoranthene	0.0122 (2)	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01	0.27	0.08
Benzo (a) pyrene	0.1 (1)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sum of: Benzo (b) fluoranthene, Benzo (k) fluoranthene, Indeno (1,2,3-c,d) pyrene, and; Benzo (g,h,i) perylene.	0.1 (1)	<0.04	<0.04	<0.04	<0.04	0.01	<0.04	0.01	0.05
Phenol	14.9 (2)	-	-	-	-	-	-	< 0.50	0.52

(1) Water Supply (Water Quality) Regulations 2000.
*Historical 1989 Threshold Value.
(2) Water Framework Directive 2015, Surface Water, Maximum Threshold Value.

Three elevated concentrations of leachable fluoranthene were recorded in TP103. TP115 and TP118 with concentrations of 0.03µg/l, 0.0503µg/l and 0.07µg/l respectively. The samples were of granular colliery spoil. In addition, the sum of benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-c,d)pyrene and benzo(g,h,i)perylene was found to be slightly above the threshold of 0.1µg/l in the sample obtained from TP103 at 0.30m – 0.70m with a recorded concentration of 0.1µg/l.

Four samples of groundwater, obtained from wells sealed within the natural ground, were submitted for chemical analysis. The results for each determinand were compared directly with their respective GAC. The results are summarised in Table 6.3.3.

Table 6.3.3 – Summary of Groundwater Results

Determinand	GAC (µg/l)	WS109 1.00m	WS125 1.50m	DS/RC101 3.00m	DS/RC105 5.00m
pH	6.5-9.5(1)	7.2	6.5	6.9	7.6
Arsenic	50(1)	0.97	0.29	0.73	1.6
Cadmium	5(1)	<0.02	0.16	0.04	<0.02
Chromium (total)	50(1)	0.62	<0.25	0.53	0.61
Copper	2000(1)	3.0	0.6	0.5	1.9
Lead	10(1)	0.18	<0.09	0.26	<0.09
Mercury	1(1)	<0.01	<0.01	0.12	0.72
Nickel	20(1)	3.0	14	1.7	4.2
Selenium	10(1)	0.37	1.2	0.57	0.29
Zinc	5000(1)	12	8.7	9.3	4.4
Cyanide (Free)	50(1)	<0.1	<0.1	<0.1	<0.1
Phenol	14.9(2)	<0.50	<0.50	<0.50	<0.50
Naphthalene	4.24(2)	0.1	0.06	<0.05	<0.05
Anthracene	0.193(2)	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.0122(2)	<0.01	<0.01	0.01	0.02
Benzo(a)pyrene	0.01(1)	<0.01	<0.01	<0.01	<0.01
Sum of: Benzo (b) fluoranthene, Benzo (k) fluoranthene, Indeno (1,2,3-c,d) pyrene, and; Benzo (g,h,i) perylene.	0.1 (1)	0.03	0.04	0.03	0.03
Sulphate as SO4	250(1)	6	21	19	14

(1) Water Supply (Water Quality) Regulations 2000.
*Historical 1989 Threshold Value.
(2) Water Framework Directive 2015, Surface Water, Maximum Threshold Value.

A slightly elevated concentration of fluoranthene was detected in the groundwater obtained from DS/RC105 with a recorded concentration of 0.02µg/l.

6.4 Evaluation of Hazardous Ground Gases

Based on the desk study information and ground conditions encountered, it is considered unlikely that there is the potential for the presence of significant concentrations of hazardous ground gases on the site.

In order to assess the potential risks posed to the proposed development from hazardous ground gases, groundwater and ground gas monitoring wells were installed in seven window sample boreholes, two cable percussive sample boreholes and four dynamic sample with rotary cored follow-on boreholes. Response zones were designed to target each natural strata as well as the varying types of made ground.

Ground Gas Monitoring
Ground gas monitoring has been undertaken on six occasions. The works were carried out using a portable infrared gas meter in accordance with the standard JPG methodology and included the measurement of methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide, gas flows and atmospheric pressure.

6.5 Summary of Results

The results following the six rounds of gas monitoring are presented on the site visit record sheets in Appendix E and are summarised below:

- Methane has been recorded at peak concentrations of 70.9% v/v with a maximum steady concentration of 70.9% v/v in WS110. In addition, a peak concentration of 49.2% v/v combined with a steady concentration of 18.2% v/v was recorded in WS103. It should be noted that groundwater levels in these wells were very shallow at the time of monitoring. Methane was also recorded in WS111 and DSRC105 at peak concentrations of 2.2% v/v and 1.5% v/v.
- Carbon dioxide was recorded at peak and steady concentrations of 23.3% v/v and 18.1% v/v respectively in WS103.
- Depleted oxygen concentrations as low as 0.4% was recorded in WS103 on the third visit. Reduced oxygen concentrations (i.e. <16% v/v) was not recorded in any other installation.
- A maximum peak positive flow rate of 11.5 l/hr was recorded in WS125 on the third visit and a maximum positive steady flow of 7.0 l/hr was recorded in WS125 also on the third visit.
- No significant concentrations of hydrogen sulphide or carbon monoxide were recorded.

One of the monitoring visits was carried out during a period of regionally falling atmospheric pressure and two during periods of rising atmospheric pressure. Barometric pressures during the monitoring period ranged between 982mB and 1015mB.

6.6 Requirements for Gas Protection Measures

The results of the gas monitoring have been assessed in accordance with the following:

- BS8485:2015+A1:2019, 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

It is understood that the made ground topsoil, both buried and at the surface, is to be removed from the north west as part of the earthworks. Based on the response zones, it is considered that the source of the highest concentrations of ground gas is the made ground topsoil located in the north-west of the site, where the elevated concentrations have been observed. On this basis the monitoring results for WS103 or WS110 have not been included in the ground gas assessment below as they are not reflective of the typical ground gas concentrations present on the site.

In addition, it is apparent that the flow rates observed in DSRC105 are the result of groundwater rebound following purging of the well on the first visit with the groundwater gradually recharging over the subsequent monitoring visits. Prior to purging there was no flow rate recorded in this monitoring well. On this basis the ground gas flow rates recorded in DSRC105 have been discounted from the ground gas risk assessment.

Based on a maximum peak methane concentration of 2.2% v/v (WS111) and maximum peak flow rate of 11.5 l/hr (WS125), a gas screening value (GSV) of 0.25 l/hr for methane can be calculated. Based on a maximum steady carbon dioxide concentration of 9.2% v/v (WS111) and maximum steady flow rate of 7 l/hr, a gas screening value (GSV) of 0.64 l/hr for carbon dioxide can be calculated.

Based on the calculated GSVs, the Characteristic Situation (CS) will be CS2 in accordance with BS8485:2015+A1:2019.

The CS should be confirmed following the earthworks operation by installing shallow wells below the building footprint and carrying out a programme of continuous and spot monitoring over a two-week period.

6.7 Radon Risk

The site is not in a radon affected area as defined by Public Health England with less than 1% of properties above the action level. In accordance with the Building Research Establishment (BRE) publication BR211, no radon protective measures are required for new properties constructed on the site.

6.8 Summary of Potential Sources, Pathways and Receptors

Potential Sources
Although asbestos quantification testing indicates the samples tested are not hazardous to human health based on the percentage asbestos in the sample, there is the potential that soils with greater amounts of asbestos may be present on the site. Therefore, asbestos is still considered a potential source of contamination.

Based on the results of the analysis carried out, the following potential source of contamination is considered to be present on the site:

- Asbestos fibres in made ground.
- Slightly elevated concentrations of potentially leachable PAH species within the made ground and groundwater.

- Elevated hazardous ground gases - carbon dioxide and methane.

Potential Pathways
Based on the available information and the proposed redevelopment of the site for a commercial end use, the following potential exposure pathways will require consideration, both during the redevelopment works and on completion of the construction:

- Inhalation of asbestos fibres.
- Leaching/migration of potential contaminants into groundwater and surface water via surface and groundwater flow.
- Migration of ground gas.

Potential Receptors
The potential receptors are considered to be:

- Development workers and future maintenance workers involved in excavations, e.g., foundations or where services are being installed or repaired following development.
- Future site end users, e.g. employees, visitors.
- Groundwater in the underlying Secondary Undifferentiated (glacial deposits) and Secondary A (superficial deposits in the north and bedrock geology).
- Surface water feature – Whittle Brook / Brightley Brook.
- Built environment.

6.9 Source – Pathway – Receptor Linkages

Based on the above potential source, pathway and receptors, the following linkage assessments have been considered.

- Risk to site development workers and end users if asbestos is present at concentrations greater than encountered during site investigation.
- The underlying aquifers and inland river could become contaminated due to the leaching and migration of potential contaminants from the made ground.
- Potential for development workers, future maintenance workers and future end users of the site to be exposed to hazardous ground gases.

This assessment is based on current site conditions (unless stated) and does not consider exposure pathways following any further works on the site.

The Underlying Aquifers and Surface Watercourses
Slightly elevated concentrations of potentially leachable PAH species were recorded within the made ground.

An assessment of risk to controlled waters should also consider the environmental setting of the site, which is summarised below:

- The adoption of the assessment criteria is considered to be conservative when applied to an assessment of risks to controlled waters.
- The proposed development will comprise new industrial unit, service area, parking area with limited soft landscaping. The buildings will be impermeable, thereby reducing infiltration and limiting the potential for the generation of leachate and mobilisation of potential contaminants. In addition, surface water run-off will be routed via an interceptor tank into the existing sewer network.
- The superficial deposits comprise glacial till, generally beds of both cohesive and locally granular material. This may provide a barrier to the downward migration of potential contaminants to the Secondary Aquifer.
- The inland river is likely to be partially or fully culverted.
- There are no active groundwater abstraction licences with 1km of the site.
- There are no active potable water abstraction licences within 2km of the site.
- The site does not lie within an Environment Agency Groundwater Source Protection Zone.

Based on the above factors, it is concluded that there are no plausible linkages to controlled water receptors. Therefore, the risk to controlled waters is considered to be negligible.

6.10 Conceptual Site Model & Risk Rating

The preliminary conceptual site model (CSM) has been revised following completion of this ground investigation, the chemical analysis results and the ground gas risk assessment presented above.

The revised CSM has been developed for a future commercial end-use. This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors, and attributes a risk rating for each pollutant linkage identified.

The updated conceptual model is summarised in Table 6.10.

Table 6.10 Conceptual Model

Source	Pathway	Receptor	Risk Rating	Comments
Asbestos fibres • Made ground (concentrations encountered to-date are at levels not deemed hazardous to human health.	**Inhalation** • If asbestos within made ground is disturbed.	**Site Development Workers** • Ground workers. • Construction workers. **Adjacent Site Users.** • Workers. • Visitors. **Future Site Users** • Future employees/ visitors. • Maintenance workers.	Low/Moderate	Trace asbestos fibres have been recorded at concentrations not hazardous to human health. If asbestos is noted during the enabling/earthworks, monitoring of asbestos fibres will be required. Appropriate health and safety procedures to be in place during the construction phase of the development.
Hazardous Ground Gases/Soil Vapours • Made ground below the site and adjacent to the site. • Two landfill sites located approximately 283m to the SW and 380m to the W. • Natural soils underlying and adjacent to the site.	**Ground Gas Migration** • Migration through permeable soils/ fractured rock. • Inhalation.	**Future Site Users** • Future employees/ visitors. • Maintenance workers.	Moderate	Based on the calculated GSVs, the Characteristic Situation (CS) will be CS2 in accordance with BS8485:2015+A1:2019. However, the CS should be confirmed on completion of the earthworks by continuous and spot monitoring. Ground gas protection will therefore be required in new buildings.
		Built Environment • Buildings. • Infrastructure.	Moderate	Based on the calculated GSVs, the Characteristic Situation (CS) will be CS2 in accordance with BS8485:2015+A1:2019 (based on three visits). However, the CS should be confirmed on completion of the earthworks by continuous and spot monitoring. Ground gas protection will therefore be required in new buildings.
		Users During Development • Development Workers.	Low/Moderate	Appropriate health and safety procedures to be in place during the construction phase of the development.

6.11 Risk Classification

Based on the updated conceptual site model, the site should be considered to be a **low to moderate risk** with respect to ground gas and soil and groundwater contamination.

6.12 Mitigation Measures

Based on the results of the above risk assessment, mitigation measures will be required with regard to hazardous ground gas. The ground gas risk assessment indicates CS2 conditions 'Low Hazard Potential', based on six visits. However, the CS should be confirmed on completion of the earthworks by a programme of continuous and spot monitoring to target the footprint of the proposed commercial development. The continuous monitoring should be carried out by a specialist contractor.

During development of the site, all workers should remain vigilant to the possible risk of encountering areas of potentially contaminated material including gross asbestos contamination. Should potentially contaminated material be encountered, site management should be informed. Further testing may then be required to assess the risk to health and safety of the site workers and the environment.

Although not exceeding GAC for a commercial end use, it is recommended that the hydrocarbon-impacted soils associated with a former fuel storage tank in the south of the site are removed.

It is recommended that a sufficient thickness of topsoil and subsoil is placed in future landscaped areas. Any imported or site-sourced material will need to be tested to confirm its suitability for use. In addition, any topsoil and subsoil which is to be used on site should not contain any manmade debris, e.g. brick, concrete or metal.

6.13 Classification of Materials for Disposal Offsite

In total, 21 samples of made ground were assessed using HazWasteOnline^{tm} in order to determine the classification of the materials for disposal off-site.

Based on the results of the chemical analysis, all of the samples can be classified as non-hazardous with the exception of WS107 at between 0.20m and 0.70m depth, which was classified as hazardous due to elevated (alkali) pH conditions. The made ground at this depth range was described as clayey, gravelly sand containing sandstone, limestone and brick.

Details of the classification generated by HazWasteOnline^{tm} are provided in Appendix D.

The results of the chemical analysis and the waste classification should be forwarded to the landfill operator to confirm this assessment and provide a price for disposal.