Phase 2 Ground Investigation

REDBROOK ROAD
BARNSLEY

for

Vernon Holdings Limited

Report Number 4159

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Contents

Figures

Appendices

1 INTRODUCTION

1.1 At the request of Cadam Construction Limited, a Phase I Geoenvironmental and Geotechnical Assessment (Desk Study) has previously been carried out of a derelict site at Redbroook Road in Barnsley. It is proposed to redevelop the site with residential accommodation.

1.2 The purpose of the desk study was to review and assess published information on the site including geological, mining and hydrogeological data. It was also to review the past history of the site and its environmental setting. The findings were presented in Michael D Joyce Associates LLP's Report No. 4124 dated May 2021. As such it should be read in conjunction with this latest report.

1.3 Michael D Joyce Associates LLP has subsequently been instructed by Cadam Construction Limited, on behalf of Vernon Holdings Limited, to carry out a preliminary intrusive investigation of the site. This investigation has comprised trial pitting, window sampling and rotary openhole drilling with associated in-situ and laboratory testing. Based in the initial findings, recommendations are made for the safe and economic development of the site. The study has not included checks on services on or adjacent to the site, and no structural or asbestos surveys have been carried out.

2 THE SITE

2.1 The site covers an area of approximately 0.18 hectares. It is located to the west side of Redbrook Road, approximately 2km northwest of the centre of Barnsley. The Ordnance National Survey Grid Reference is 432130, 407710 and it lies at approximately 86 mAOD. Figure 1 shows the general site location, whilst figure 2 shows the site in more detail.

2.2 The site is located to the west of Redbrook Road. Redbrook Mill Close lies to the south, with a few shops to the north. These three sides are enclosed by a brick and palisade fence, with an access point off Redbrook Mill Close. An electricity sub-station lies at the northeastern corner of the site.

2.3 The western boundary is marked by an intermittent brick retaining wall, retaining ground that rises up to the west. The retaining wall appears to be part of an older building that was 'cut' into the slope.

2.4 The site itself is flat-lying and mainly covered by a hardcore of larger single sized stone. An area of concrete hardstanding lies at the northern end of the site.

3 THE INVESTIGATION

3.1 The investigation was designed to provide preliminary information on ground and groundwater conditions on the site, together with identifying potential areas of contamination. The investigation was undertaken in accordance with the principles of BS5930: 2015 + A1: 2020 and BS10175: 2011 + A2: 2017 and under the full-time supervision of a Chartered Engineer from Michael D Joyce Associates LLP.

3.2 The ground investigation was carried out between 29th September and 1st October 2021, and comprised trial pitting, window sampling and rotary openhole drilling. The exploratory borehole positions are shown on figure 2.

3.3 The trial pitting consisted of excavating a number of trial holes using a mechanical excavator. On completion, the excavations were backfilled with the arisings.

3.4 The window sampling consisted of driving a series of 1m and 2m long tubes into the ground using a dropping weight. On completion of each run, the tube was withdrawn. The next tube was then inserted and the process repeated to provide a continuous profile of the ground. On each run the tube diameter was reduced in order to assist in its recovery.

3.5 It was also possible to carry out Standard Penetration Tests using the window sampling equipment, which has the same specification as a conventional cable percussive SPT. On completion the boreholes were backfilled with the arisings and any tarmacked areas reinstated accordingly.

3.6 The rotary drilling was carried out using a Beretta T25 rig and using a water flush technique. The openhole technique meant that logging was carried out by inspecting the arisings that were brought to the surface in the water flush.

3.7 On completion the boreholes were backfilled with arisings and bentonite.

4 STRATA PROFILE

4.1 The full exploratory records are presented in Appendices 1 to 3. These give full strata descriptions based on visual examination and are in accordance with the requirements of BS EN ISO 14688-1:2018 "Geotechnical Investigation and Testing - Identification and Classification of Soil - Part 1", BS EN ISO 14688-2:2018 "Geotechnical Investigation and Testing - Identification and Classification of Soil - Part 2", and BS EN ISO 14689-1:2018 "Geotechnical Investigation and Testing - Identification and Classification of Rock - Part 1".

Trial Pitting and Window Sampling

4.2 The majority of the site is covered by single size stone (limestone), except for the northern part of the site which comprises reinforced concrete hardstanding, which is approximately 150mm thick.

4.3 A total of five trial pits were excavated across the site, and these encountered Made Ground at the surface. The Made Ground typically comprised a brown silty sandy clay containing much brick and pieces of concrete up to boulder size. In the case of trial pit TP3, it also contained some plastics, metal fragments and pieces of timber.

4.4 The Made Ground was generally uncompacted and loose state, such that the sides of the trial pits were very unstable.

4.5 At between 1.1m and 1.3m depth, a concrete slab was encountered. This was broken out by a rock-breaker and found to be typically 200mm thick. However, in trial pit TP1, the concrete was 600mm thick. There was no evidence of reinforcing.

4.6 The slab appears to be present over most of the site, except the northern part of the site, where there is reinforced concrete hardstanding at the surface. Trial pit TP4 encountered the edge of the slab at 1.1m depth, where it was 200mm thick. The trial pit was extended down the side of the slab. The slab was underlain by a very soft grey and brown silty clay, containing a little organic matter and rotting vegetation. This appeared to be natural and likely to be alluvium laid down by the adjacent watercourse. The alluvium continued to a depth of at least 3.4m, when further became impossible due to the collapse of the trial pit sides. Water ingress also occurred below 1.3m depth.

4.7 In trial pit TP5, also encountered a soft, in places very soft, sandy silty clay (alluvium) below the concrete slab. This extended to a depth of 3.0m, and was underlain by a highly, becoming moderately, weathered mudstone.

4.8 It therefore appears the southern and eastern parts of the site are underlain by alluvium, which has a very soft or soft consistency. In trial pit TP5, bedrock occurs at 3.0m depth, but is in excess of 3.4m depth in trial pit TP4. Groundwater ingress was also encountered in the alluvium below the Made Ground.

4.9 In contrast, borehole WS1 encountered weathered mudstone bedrock directly below the concrete hardstanding. Borehole WS2 encountered the mudstone bedrock at 2.2m depth.

4.10 It should be noted that in borehole WS2 managed to penetrate the concrete slab at 1.1m depth. However, boreholes WS3 and WS4 were unable to do so. In borehole WS2 there was also a little Made Ground directly below the slab.

Rotary Boreholes

4.11 The rotary boreholes encountered Made Ground, underlain by a sequence of predominantly mudstone to a maximum proven depth of 30m.

4.12 Three bands of coal were also encountered across the site. All three were of poor quality and containing dirt bands. The shallowest coal seam occurred at around 6m to 7m depth and was typically 0.5m thick. A second seam occurred at around 12m to 14m depth, and was typically 0.6m thick. The deepest coal was encountered at between 21m and 23m depth and was typically 0.8m thick.

4.13 No evidence of workings were found in the coal seams. This is most likely due to the poor quality of the coal which resulted in the coal having no economic value.

General Observations

4.14 There was no unusual colouration or odours to any of the soils encountered during the investigation and no obvious visual evidence of contamination, such as asbestos, was found during the investigation. This does not mean that asbestos containing materials or asbestos fibres are not present.

4.15 It should be noted that lateral and vertical changes can occur between exploratory points and care is needed when extrapolation is used. This is particularly true of the Made Ground which, by its nature, can be very variable in its physical and chemical composition.

5 IN-SITU AND LABORATORY TESTING

5.1 In-Situ Gas Monitoring

5.1.1 Methane is the dominant constituent of landfill gas, and can form an explosive mixture in air at concentrations of between 5% and 15%. Thus 5% methane in air is known as the Lower Explosive Limit (LEL). Concentrations less than this do not normally ignite. Carbon dioxide can also be a potential problem, especially where it occurs in concentrations greater than 1.5%.

5.1.2 In-situ gas tests were carried out in the boreholes on completion and in probe holes made in the sides of the trial pits. Testing was with a portable meter, which measures the methane content as its percentage volume in air. The corresponding oxygen and carbon dioxide concentrations are also measured.

5.1.3 No methane, carbon monoxide or hydrogen sulphide gases were detected in any of the boreholes. Carbon dioxide ranged from 0.2% to 0.5% by volume.

5.1.4 In order to monitor over the longer term, gas monitoring standpipes were installed in three probe holes DP1, DP2 and DP3. These comprise slotted uPVC pipework surrounded by single sized gravel to between 1.6m and 2.5m depth. The top 0.5m of pipework is not slotted and is surrounded by bentonite pellets to seal the boreholes. Valves were also fitted.

5.1.5 The risks associated with the gases have been considered in accordance with British Standard BS 8485:2007 “Code of Practice for the Characterisation and Remediation from Ground Gas in Affected Developments”, CIRIA report C665, “Assessing Risks

Posed by Hazardous Ground Gases to Buildings" and NHBC Report No. 4 "Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present". Gas monitoring is currently on-going and the results will be reported separately.

5.2 Soakaway Testing

5.2.1 Soakaway tests were carried out in trial pits TP1, TP2 and TP3 in accordance with BRE Digest 365: Soakaway Design. This involved filing the trial pit with water from a water bowser and recording the fall in water level over a period of time. From this it is possible to calculate the Soil Infiltration Rate (SIR) based on the trial pit dimensions and the rate of dissipation. It should be noted that since it is not possible to use soakaways in Made Ground, the tests were carried out in the natural clay deposits below the concrete slab only.

5.2.2 All three trial pits were monitored for a period of 2 hours. However, no falls in groundwater level were recorded due to the impermeable nature of the clay and underlying mudstone bedrock. Since clay and mudstone occur across the whole site, soakaways will not be suitable for surface water drainage and the existing piped system will have to be used.

5.3 Geotechnical Laboratory Testing

The soil testing was carried out to BS1377:1990 Methods of Test for Soils for Civil Engineering Purposes. Testing was carried out by Chemtech Limited to UKAS accredited procedures. The full results are presented in Appendix 4.

5.3.1 Sulphate and Acidity Tests

Chemical tests were carried out on representative samples of the Made Ground and sub-soils in order to determine their water soluble content and acidity.

Contamination testing recorded water soluble sulphate contents between 0.16 g/l and 1.54 g/l, with pHs ranging from 8.7 to 10.1, indicating alkaline conditions.

5.4 Contamination Testing

Rationale

5.4.1 The investigation and sampling was under the full time direction of a Chartered Engineer. All the recovered soil samples were screened on site for any visual or olfactory evidence of contamination including the presence of VOCs. Samples were selected from the trial pits and window sample boreholes on the basis of those which were most likely to be contaminated and those which gave the most appropriate indication of the spread of any contaminants. The samples were stored in both glass and plastic containers and kept in cooled conditions. Testing was carried out by Chemtech Limited to UKAS accredited procedures in accordance with MCERTS performance standards.

5.4.2 The aim of this was to make a preliminarily assessment of the level of any contamination on the site in order to determine if there was any significant risk associated with contaminants in respect of both human health and the environment, including controlled waters.

5.4.3 Standard Appendix B attached to this report discusses the methodology for the assessment of contamination and should be read in conjunction with the comments overleaf.

5.4.4 The Land Contamination Risk Management (LCRM) series of documents have been produced by the Environment Agency. It is to provide guidance to identify and assess if there is an unacceptable risk, assess suitable remediation options, and carry out and verify the remediation.

5.4.5 DEFRA previously issued "Outcome of the Way Forward Exercise on Soil Guideline Values". This document was intended to provide guidance to determine if there is a Significant Possibility of Significant Harm (SPOSH) i.e. whether land meets the legal trigger of being contaminated land.

5.4.6 In the context of Part 2A, a risk assessor using an SGV would conclude the following (DEFRA, 2008).

- At a representative average soil concentration at or below an SGV, it is very unlikely that there will be a *significant possibility of significant harm (SPOSH)*.

- At a representative average soil concentration above an SGV, there *might* be a *significant possibility of significant harm* with the significance linked to the margin of exceedance, the duration and frequency of exposure, and other site-specific factors that the enforcing authority may wish to take into account. Further investigation and/or detailed evaluation will usually be required.

5.4.7 It should be stressed that where there is any uncertainty as to whether or not there is

a SPOSH, it was the policy of this practice to adopt a conservative approach, particularly in the adoption of clean cover systems.

5.4.8 In April 2012, Defra published new Statutory Guidance which forms a major part of their contaminated land regimes under Part 2A of the Environment Protection Act 1990. The regime provides a means of dealing with contaminated land which poses a significant risk to human health or the environment where there is no alternative solution. It also works alongside planning rules and building regulations to help ensure that affected land is made suitable for use when it is redeveloped.

5.4.9 Since the regime was first introduced in 2000 there has been considerable uncertainty over how to decide when land is, and is not, contaminated land on grounds of the legal test of *significant possibility of significant harm to human health or the environment*.

5.4.10 To help address this, one of the main changes set out in the new Statutory Guidance, is the introduction of a new four category test to help decide when land is, and is not, contaminated land on grounds of *significant possibility of significant harm to human health*. Under the new four category test:

- Category 1 describes land that is clearly contaminated land, for example because similar land is known to have caused significant harm in the past.

- Categories 2 and 3 cover less straightforward land where more detailed consideration is needed before the regulator can decide either: (a) that there is a strong case for regulatory action, in which case the land would be in Category 2 and be classified as contaminated land under Part 2A; or (b) that such a case does not exist, in which case the land would be in Category 3 and not be classified as contaminated land under Part 2A.

- Category 4 describes land that is clearly not contaminated land, as discussed below.

5.4.11 One of the main purposes of including the Categories in the Statutory Guidance is to provide a legal framework against which new technical tools can be developed by the land contamination sector to describe the Categories in more detail with regard to specific substances and/or situations.

5.4.12 The new Category 4 test is particularly important in terms of reducing uncertainty over when land is definitely not caught by the regime.

5.4.13 The new Statutory Guidance makes clear what land should be placed into Category 4, for example:

(a) Land where no relevant contaminant linkage has been established.

(b) Land where there are only normal levels of contaminants in soil (as explained in Section 3 of the guidance), unless there is a particular reason to consider otherwise. In other words land with normal background concentrations in the soil.

(c) Land that has been excluded from the need for further inspection and assessment under Part 2A because contaminant levels do not exceed relevant generic assessment criteria in accordance with Section 3 of the guidance, or relevant technical tools or advice that may be developed in accordance with paragraph 3.30 of the guidance, e.g. Category 4 Screening Levels.

(d) Land where estimated levels of exposure to contaminants in soil are likely to form only a small proportion of what a receptor might be exposed to anyway through other sources of environmental exposure (e.g. in relation to average estimated national levels of exposure to substances commonly found in the

environment, to which receptors are likely to be exposed to in the normal course of their lives).

5.4.14 The guidance clarifies how generic assessment criteria should and should not be used. It states that:

3.27 It is common practice in contaminated land risk assessment to use "generic assessment criteria" (GACs) as screening tools in generic quantitative human health risk assessment to help assessors decide when land can be excluded from the need for further inspection and assessment, or when further work may be warranted.

3.28 Local authorities may use GACs and other technical tools to inform certain decisions under the Part 2A regime, provided: (i) they understand how they were derived and how they can be used appropriately; (ii) they have been produced in an objective, scientifically robust and expert manner by reputable organisations; and (iii) they are only used in a manner that is in accordance with Part 2A and this Guidance.

3.29 GACs relating to human health risk assessment represent cautious estimates of levels of contaminants in soil at which there is considered to be no risk to health or, at most, a minimal risk to health. With regard to such GACs:

(a) They may be used to indicate when land is very unlikely to pose a significant possibility of significant harm to human health. This is on the basis that they are designed to estimate levels of contamination at which risks are likely to be negligible or minimal and far from posing a significant possibility of significant harm to human health.

(b) They should not be used as direct indicators of whether a significant possibility of significant harm to human health may exist. Also, the local authority should not view the degree by which GACs are exceeded (in itself) as being particularly

relevant to this consideration, given that the degree of risk posed by land would normally depend on many factors other than simply the amount of contaminants in soil.

(c) They should not be seen as screening levels which describe the boundary between Categories 3 and 4 in terms of Section 4 (i.e. the two Categories in which land would not be contaminated land on grounds of risks to human health). In the very large majority of cases, these SGVs/GACs describe levels of contamination from which risks should be considered to be comfortably within Category 4.

(d) They should not be viewed as indicators of levels of contamination above which detailed risk assessment would automatically be required under Part 2A.

(e) They should not be used as generic remediation targets under the Part 2A regime. Nor should they be used in this way under the planning system, for example in relation to ensuring that land affected by contamination does not meet the Part 2A definition of contaminated land after it has been developed.

5.4.15 The way in which the new four category system is intended to operate and the place of the C4SLs within that system, was explained in detail in the Impact Assessment which accompanied the Statutory Guidance. Please note that although the detail of the Impact Assessment is included here to provide clarity on the job expected of C4SLs, the Statutory Guidance, itself, sets out the regime that needs to be delivered under Part 2A.

5.4.16 The C4SLs are intended as "*relevant technical tools*" provides to help local authorities

and others when deciding to stop further assessment of a site, on the grounds that it falls within Category 4 (Human Health).

5.4.17 The Impact Assessment (IA), which accompanied the revised SG (Defra, 2012b) provides further information on the nature and potential role of the C4SLs. Paragraph 47(h) of the IA states that:

> *"The new statutory guidance with bring about a situation where the current SGVs/GACs are replaced with more pragmatic (but still strongly precautionary) Category 4 screening levels (C4SLs) which will provide a higher simple test for deciding that land is suitable for use and definitely not contaminated land".*

5.4.18 C4SLs, therefore, should not be viewed as "SPOSH levels" and they should not be used as a legal trigger for the determination of land under Part 2A.

5.4.19 In 2014 CL:AIRE (Contaminated Land: Application in Real Environments) published "*Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination*". In it a series of C4SLs were proposed as follows. Where C4SLs are not available, the LQM/CIEH "Generic Assessment Criteria for Human Health Risk" have been used.

Analyte	Residential (with home grown produce) (mg/kg)	Residential (without home grown produce) (mg/kg)	Allotments (mg/kg)	Commercial (mg/kg)	POS (mg/kg)
Arsenic	37	40	49	640	79
Benzene	0.87	3.3	0.18	98	140
Benzo(a)Pyrene	5.0	5.3	5.7	77	10
Cadmium	22	150	3.9	410	880
Chromium (vi)	21	21	170	49	21
Lead	200	310	80	2300	630

Results

5.4.20 The following range of results was obtained and the full results are presented in Appendix 4.

Soils

Analyte	Concentration Range (mg/kg)		Concentration for Residential Use (mg/kg)
Arsenic	7	14	37 (2)
Cadmium	0.2	2.0	22 (2)
Chromium (vi)	<1	<1	21 (2)
Copper	15	49	2400 (1)
Mercury (Inorganic)	<0.5	<0.5	40 (1)
Nickel	15	31	130 (2)
Selenium	0.5	1.6	350 (2)
Lead	68	518	200 (2)
Zinc	64	224	3700 (1)
Phenol	<0.5	<0.5	420 (2)
Benzo(a)pyrene	0.28	2.36	5.0 (2)
Dibenzo(a,h)anthracene	0.04	0.36	0.28 (1)
Naphthalene	0.02	0.08	5.6 (1)
Fluorene	<0.02	0.14	400(1)
Asbestos	None	None	None

(1) *Values derived by LQM/CIEH "Generic Assessment Criteria for Human Health Risk Assessment" 2009. For organics a SOM of 2.5% assumed.*

(2) *C4SL published 2014.*

5.4.21 A total of nine samples were tested. The vast majority of the results fell below their respective SGVs. However, the majority of samples tested contained elevated levels of lead. Concentrations ranged from 151 mg/kg to 518 mg/kg, compared to a limit of 200 mg/kg. Occasional samples also contained elevated levels of Dibenzo (a,h) anthracene. No asbestos containing materials or asbestos fibres were detected in any of the samples.

6 GEOENVIRONMENTAL RISK ASSESSMENT

Conceptual Site Model

6.1 A quantitative health and environmental risk assessment has been carried out as part of this assessment. The process of risk assessment is set out in Part IIA of the Environment Protection Act 1990 and amended in part by The Water Act 2003. This defines contaminated land as "*any 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 there is a significant possibility of significant harm being caused, or that significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused".*

6.2 The Act introduces the concept of a pollution linkage. This linkage consists of a pollution (contaminative) source or hazard and a receptor, together with an established pathway between the two. For land to be contaminated, a pollution linkage (hazard-pathway-receptor) must exist. This forms a so-called 'conceptual model' of the site.

6.3 Examples of pathways and effects from land contamination (after PPS 23) are given below, and these are illustrated on figure 3.

6.3.1 Human Health (Pathways 1-5, Receptors A – C)

Uptake of contaminants by food plants grown in contaminated soil - Uptake will depend on concentration in soil, its chemical form, soil pH, plant species and prominence in diet.

Ingestion and inhalation - Substances may be ingested directly by young children playing on contaminated soil, by eating plants which have absorbed metals or are contaminated with soil or dust. Ingestion may also occur via contaminated water supplies. Metals, some organic materials and radioactive substances may be inhaled from dusts and soils.

Skin contact - Soil containing tars, oils and corrosive substances may cause irritation to the skin through direct contact. Some substances (e.g. phenols) may be absorbed into the body through the skin or through cuts and abrasions.

Irradiation - As well as being inhaled and absorbed through the skin, radioactive materials emitting gamma rays can cause a radiation response.

Fire and explosion - Materials such as coal, coke particles, oil, tar, pitch, rubber, plastic and domestic waste are all combustible. Both underground fires and biodegradation of organic materials may produce toxic or flammable gases. Methane and other gases may explode if allowed to accumulate in confined spaces.

6.3.2 Buildings (Pathways 7 and 8)

Fire and explosion - Underground fires may cause ground subsidence and cause structural damage. Accumulations of flammable gases in confined space leads to a risk of explosion. Underground fires may damage services.

Chemical attack on building materials and services - Sulphates may attack concrete structures. Acids, oils and tarry substances may accelerate corrosion of metals or attack plastics, rubber and other polymeric materials used in pipework and service conduits or as jointing seals and protective coatings to concrete and metals.

Physical - Blast-furnace and steel-making slag (and some natural materials) may expand. Degradation of fills may cause settlement and voids in buried tanks and drums may collapse as corrosion occurs or under loading.

6.3.3 Natural Environment (Pathway 6, Receptors D - E)

Phytotoxicity (prevention/inhibition of plant growth) - Some metals essential for plant growth at low levels are phytotoxic at higher concentrations. Methane and other gases may give rise to phytotoxic effects.

Contamination of water resources - Soil has a limited capacity to absorb, degrade or attenuate the effects of pollutants. When this is exceeded, polluting substances may enter into surface and groundwaters.

Ecotoxological effects - Contaminants in soil may affect microbial, animal and plant populations. Ecosystems or individual species on the site, in surface waters or areas affected by migration from the site may be affected.

6.4 For any contaminant source identified, judgement is used regarding the probability of a pollution linkage occurring and the potential consequences of that linkage. Based on the probability and likely consequences, the overall risk (significance) can be established. The definitions that have been used for this purpose are given in Standard Appendix B. The probability of a hazard, combined with its consequences, can be used to assess risk. This forms the so-called Conceptual Site Model.

Sources

6.5 The site has previously been used as a bleach works, linen works, warehouse and depot.

6.6 Ground contamination may result from the accidental spillage of chemicals in storage areas or during the various stages of manufacturing yarn, making dyes and dyeing textiles.

6.7 Off-loading areas, storage tanks and drum storage areas, pipework and surface water soakaways should all be considered likely areas of contamination. Older or upgraded works may have redundant underground tanks or pipelines containing chemical residues or wastes.

6.8 Effluents from washing fibres, yarn or fabric are normally discharged to the foul sewer but may be lost to the surrounding ground if the sewer leaks. There is the possibility

that effluent may have contained pesticides such as lindane (g-hexachlorocyclohexane) and pentachlorophenol (PCP), particularly where imported fibres or fabrics have been used.

6.9 Finished or partly finished fabrics are a possible fire risk and, if there has been a fire, firefighting water may have spread contaminants over a wide area.

6.10 Many industries, including the textile industry, have in the past used solid waste to make up ground levels on site. Solid wastes may have been disposed of in on-site landfills.

6.11 Where asbestos has been used in buildings or pipework, decommissioning or demolition may result in local contamination. Asbestos pipework and boiler ash (containing heavy metals and sulphates) may have been disposed of in on-site landfills. Any organic infill has the potential to generate landfill gases, principally methane and carbon dioxide.

6.12 Contamination may also occur from PCBs where transformers or capacitors containing these have been refilled or decommissioned.

6.13 The fate of organic compounds, particularly solvents which have been lost to the ground, will depend on their solubility and volatility and on physical, chemical and biological factors. Volatile organic solvents will readily partition from the liquid phase to the vapour phase resulting in high concentrations in the soil pore space above the unsaturated zone. Close to the soil surface, some will be lost directly to the atmosphere by evaporation. Under favourable ground conditions, less volatile solvents of low aqueous solubility will tend to migrate to the water table, where those

of a lower density than water will form layers on the water table surface. Compounds which are denser than water, for example chlorinated solvents, generally accumulate at the base of the water body. Although small quantities of the solvents will be dissolved and thus migrate in a manner consistent with general groundwater flow, the bodies of the free phase solvents may not.

6.14 The higher the natural organic matter and clay content of the soil, the greater the degree of adsorption of the organic contaminants and the greater the reduction of contaminant migration. Thus, the greater degree of mobility will occur in coarse-grained sands and gravels with little organic matter. The less soluble and therefore less mobile compounds which become adsorbed on to clay or organic matter may cause water pollution long after the original source has been removed, by continuing to desorb into the soil-water.

6.15 The more soluble organic compounds including the alcohols, for example methanol, will dissolve in water and readily migrate through the soil system, eventually reaching the ground water.

6.16 Widespread contamination by solvents may enhance the mobility of some organic compounds which, though of low aqueous solubility, may dissolve readily in organic solvents, for example adhesives, halogenated oils, flame retardants and some resins. The potential for groundwater contamination by organic compounds of low aqueous solubility may therefore be increased.

6.17 Organic compounds such as resins and solvents may present flammability risks and are potentially biodegradable, producing methane and carbon dioxide gases.

6.18 Biodegradation processes in soils can be influenced by a number of factors, namely moisture content, oxygen concentration and pH, acting separately or in combination. For example, low moisture content reduces microbiological activity, while high moisture content can reduce oxygen penetration and possibly lead to anaerobic soil conditions. Such conditions enhance the biodegradation of some materials, for example chlorinated compounds, while aerobic conditions are needed to biodegrade many oils. Low pHs tend to reduce the bacterial population and encourage fungal activity; at pHs lower than 5 microbiological activity is much reduced. The presence of heavy metals also inhibits micro-organisms. As a result of these factors, at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

6.19 Partial degradation can produce intermediate breakdown products which are more mobile than the parent compound. Even potentially biodegradable compounds such as toluene, acetone and oil-related hydrocarbons may persist due to unfavourable conditions.

6.20 As with organic compounds, the transport of metals through the soil is significantly influenced by the presence of clay minerals and organic matter. The solubility of some metals (for example copper, zinc and lead) may increase under acidic conditions. In other cases, the relationship is more complex, for example trivalent chromium is soluble under both acidic and alkaline conditions. Certain heavy metals may be taken up by plants and animals, thereby entering the food chain.

6.21 A variety of inorganic compounds are used by the textile industry, particularly mineral acids, alkalis, bleaching agents and metal salts. The most significant effects resulting of the loss to ground of these compounds are acidic or alkaline ground conditions;

raised chloride concentrations can result from some bleaching agents and metal chlorides. As most, if not all, of the compounds used are in an aqueous form, it can be assumed that, following loss to ground, they will readily migrate in groundwater and, depending on the attenuation properties of the underlying ground may reach the underlying water table.

6.22 Reference has been made to DEFRA publication CLR8 'Potential Contaminants for the Assessment of Land' and the relevant DOE Industry Profiles to identify the typical contaminants associated with the past industrial use.

Risk Assessment based on Conceptual Site Model

Summary of Hazards, Pathways and Receptors

Source	Potential Pollutant	Pathways	Receptor	Risk
Potential contaminated Made Ground. **Possible past minor spillages and metals.** **Off-site Dyeworks and Woollen Mill.**	Oils, fuels, grease, hydraulic fluid, metals, asbestos. See 6.5 - 6.21	1 - 5	A. Present Occupants.	**Low Risk** (Limited visitors).
			B. Groundworkers.	**Low Risk** involved with excavation work, providing personnel adopt suitable precautions, together with washing facilities.
			C. Future Occupants.	**Low Risk** for residential use, providing clean cover applied to garden/landscaped areas.
		6	D. Controlled Waters.	**Low Risk.** Provided on-site monitoring undertaken throughout the ground work phases of development shows no adverse effects, the risk will be **low**.
			E. Ecosystems.	**Low Risk** as leaching is not considered likely.
		7	F. Building Materials and Services.	**Low Risk.** Install pipes in clean bedding materials. Adequate precautions to be taken in respect of buried concrete.
Organic Material.	Landfill Gases, Radon, VOCs, SVOCs.	8	A - F	**Low to Moderate Risk.** Gas monitoring is currently on-going and this will be reviewed once the results of the longer term monitoring are known.

Pathways and Receptors

6.23 The principal receptors are groundworkers, future residents and controlled water (Receptors B, C and D).

6.24 The overall risk at this stage is assessed to be *low to moderate,* and it is not considered that there is likely to be any immediate significant risk. Once the remedial works outlined in Section 7 are carried out, the overall risk will be considered low.

6.25 With any site, the possibility of contaminants being present, sufficient to cause significant harm cannot be entirely precluded without extensive intrusive investigation, sampling and testing since it is not always possible to determine if contaminants have been tipped on the site, or have seeped into the ground, or have migrated below the ground onto the site from adjacent pieces of land, such as the mill/dyeworks.

7 RECOMMENDATIONS

7.1 It is proposed to redevelop the site for residential purposes. At present there do not appear to be any major geotechnical constraints to developing this site. However, there are a number of aspects that need to be taken into consideration when assessing the feasibility and design of this scheme.

7.2 Foundation Criteria

7.2.1 The underlying ground conditions are variable. In the extreme northwestern part of the site, weathered mudstone bedrock exists close to the surface. However, the depth to bedrock increases in both an easterly and southerly direction. Trial pit TP4 was excavated at the southeastern part of the development and bedrock was not encountered in the trial pit which was excavated to a depth of 3.4m.

7.2.2 The foundation options are also influenced by the presence of the concrete slab encountered at between 1.1m and 1.3m depth. Given the findings of the investigation, it is likely to be below the footprint of most of the properties, but not all.

7.2.3 It is therefore recommended that a combination of foundation solutions shall be adopted. The following is based on the anticipated ground conditions at the individual plots, although it should be noted that much will depend upon the actual conditions encountered during construction. In this regard, a flexible approach will be necessary.

Strip Footings - Plots 5 to 8

7.2.4 Normal to deep strip footings should be suitable for Plots 5 to 8. They will have to be sited below any Made Ground or mudstone bedrock after site clearance, and founded upon the underlying firm clay. Clay can be expected to exhibit high swelling and shrinkage properties. In order to allow for seasonal variations in the moisture content of this clay, foundation levels should be at least 1.0m below groundlevel. However, where new planting is proposed, or existing trees are present, this may have to increase. At this depth, for foundations sited upon the firm clay, allowable bearing pressures of up to 80kN/m^2 can be adopted. It would also be prudent to lightly reinforce the footings.

7.2.5 All foundation excavations must be inspected to ensure that no footings are sited upon any weak Made Ground, softer clays or other such weak materials that would be incapable of safely sustaining the applied foundation loads. This will be particularly important wherever any appreciable amounts of Made Ground occur. Wherever any suspect ground is encountered at proposed foundation level, then that footing must be deepened until a satisfactory bearing medium is obtained.

7.2.6 It will also be necessary to locally break out the concrete slab such that the foundations are placed upon the underlying soils.

Piling - Plots 1 to 4

7.2.7 The Made Ground and very soft/soft alluvium deposits are not suitable for founding upon. It is recommended that piled foundations are used. In order to provide a satisfactory bearing medium, especially in view of the variable depth and density of fill

across this area, all piles will have to be sited within the underlying mudstone bedrock.

7.2.8 Piling may be inhibited by the presence of dense fill or large sandstone boulders in the Made Ground. Where these occur they would either have to be dug out if shallow or additional piles installed if any individual pile terminates above bedrock level. In addition, it will be necessary to locally remove the concrete slab so that the piles can be advanced beyond the level of the slab and founded on the underlying bedrock..

7.2.9 If piling is adopted, it is recommended that either driven pre-cast concrete or steel tubular piles are used. Steel tubular piles can then be infilled with concrete. Driven piles are preferable to bored piles, as they will be better able to overcome the presence of large boulders. A 275mm square pre-cast concrete pile, founded upon competent mudstone bedrock, can be expected to have a safe working load of 20 tonnes.

7.2.10 In order to achieve their full working load, each pile must be driven to a `set'. In view of the nature of the backfill, it would be advisable to site all the piles on the underlying bedrock, in order to take full advantage of their maximum carrying capacity. In this respect they should be designed as essentially end bearing.

7.2.11 For piles sited upon bedrock, it is normally recommended that they penetrate into rock at least 5 times their diameter in order to achieve the maximum working load. However this may not always be possible where hard resistant bedrock is encountered. It is recommended therefore that a sufficient number of pile load tests are carried out to ensure that the piles can carry the required working loads without

giving rise to any unacceptable settlements. This will be particularly important should piling terminate at shallower levels on suspected fill.

7.2.12 Negative skin friction is not expected to be a major problem especially if no appreciable loads are exerted on the ground at surface level. However, there may be some settlement of the fill around the piles, but as they will be essentially end bearing, this is not expected to affect their performance.

7.2.13 The houses can then be founded upon ring beams designed to span between the piles. In order to bond them to the piles, the tops of the piles must be broken out to expose the reinforcement, which can then be tied into that of the beams.

7.2.14 It is recommended that a specialist piling contractor is used for any detailed design. Any solution must also take into account vibration and the effect on adjacent properties.

7.3 Building Near Trees

7.3.1 Wherever any houses are located near existing or proposed planting of new trees, their foundations must be sited below the potential root growth zone. Reference should therefore be made to the NHBC Standards Chapter 4.2 "Building Near Trees", which gives guidance on foundation criteria, depths and construction. All services will also have to be similarly protected.

7.4 Landfill and Radon Gas

7.4.1 The site is not in an area where Basic Radon Protection Measures are required for new properties, and no elevated levels of ground or landfill gases have been found on the site. Nevertheless in accordance with good practice and the possibility of unrecorded ground gas, it would be prudent to incorporate basic gas protection measures in the new houses by way of an appropriate moisture-resistant membrane.

7.4.2 If suspended concrete beams and block ground floors are adopted for the houses, it is recommended that a membrane is laid over the concrete blocks and covered by a concrete screed. It is recommended that the selected membrane affords protection against methane and carbon dioxide, together with Volatile Organic Compounds.

7.4.3 Any void spaces beneath ground floors must be well ventilated both internally and externally with closely spaced air-bricks. Sleeper walls should either be of honeycomb structure or contain sufficient openings to ensure a through draught. Air-bricks must be placed at the top of the void space and not allowed to become blocked by soil or vegetation. They should be lined or cased through cavity walls.

7.4.4 Where possible, all services, drains and pipe work should enter the buildings from above groundlevel. Where this is not possible, they should be sealed at the points of entry, in order to prevent landfill gases entering the buildings via backfilled trenches. It will also be important to properly seal all services where they pass through the impermeable membrane(s).

7.4.5 British Standard BS8485: 2015 “Code of practice for the design of protective measures from methane and carbon dioxide ground gases for new buildings”, and Building

Research Establishment Report BR414 "Protective Measures for Housing on Gas Contaminated Land", together with the CIRIA Report 149 "Protecting Development from Methane" and BR211 (2015) "Radon: Guidance on Protective Measures for New Buildings" all give construction advice for preventing gases entering buildings, the principles of which are incorporated in the above recommendations. Advice is also given in respect of sealing services where they pass through impermeable membranes.

7.4.6 The supervision of the installation will need to be undertaken by a suitably qualified consultant. Detailed records and photographs of the installations should be made.

7.5 Existing Drains and Services

7.5.1 Drains and possible buried service channels or basements may also be present on the site. It will be necessary therefore to ensure that all ground bearing footings for the new houses are not sited directly over any of them, as they could eventually collapse and cause loss of strength to the foundation stratum.

7.5.2 Wherever any redundant drains and other services channels are likely to underlie building foundations, they must be dug out and replaced by lean mix concrete, or compacted hardcore. Alternatively, long drainage runs can be grouted up, particularly where their alignments are uncertain but care is needed to ensure that no grout enters any live services. In the case of roads, they should be dug out and the areas infilled by properly compacted fill.

7.6 Road Construction

7.6.1 No new road construction is envisaged, although a shared driveway and parking spaces are proposed.

7.6.2 It is envisaged that Made Ground will underlie the new parking areas. This Made Ground is unconsolidated and should be dug out to a depth of 0.75m and replaced by suitable, non-frost susceptible materials, laid in properly compacted layers to formation level.

7.6.3 Prior to the application of any sub-base, all subgrades must be checked by proof rolling to ensure that an adequate CBR exists. Where any loose granular or soft clayey areas remain, these must be either dug out and replaced by compacted material or an additional 150mm of sub-base added. This will be especially important wherever trench works for drains, sewers and other services have been carried out. Any old foundations should be removed to a depth of 1m below subgrade level to prevent hardspots occurring. It will also be necessary to prevent the deterioration of the subgrade due to the effects of wet weather and the site traffic.

7.7 Sustainable Surface Water Drainage

7.7.1 The soakaway tests carried out were all unsuccessful. Given the presence of impermeable clays and mudstone across the site, it will be unsuitable for soakaways and consideration will have to be given to discharging surface water to the existing piped system.

7.8 Excavations and Groundwater

7.8.1 Soft ground plant should prove suitable for most of the excavations. However, a rock-breaker will be required to remove the concrete slab where necessary.

7.8.2 For all deeper excavations where vertical sides are necessary, trench supports should be provided as the soils will not be self-supporting. It would also be prudent to monitor excavations for the presence of explosive or asphyxiating gases.

7.8.3 No groundwater seepages were noted in the near surface. However it should be noted that trapped groundwater can be released from areas of Made Ground when they are excavated. In addition seasonal variation in groundwater levels will occur and groundwater will be shallower during the winter months. Groundwater seepages can be expected in excavations below the level of the concrete slab.

7.9 Contamination

7.9.1 Laboratory testing to date has recorded elevated levels of lead in the near surface, which are above that which is acceptable for residential gardens.

7.9.2 As a precautionary measure and to provide a growing medium for plants, it is recommended that a clean cover system is applied to garden and landscaped areas only. The clean cover system should consist of a minimum of 600mm of clean topsoil and sub-soil. This is in accordance with the recommendations in the joint NHBC, Environment Agency and Chartered Institute of Environmental Health publication "Guidance for the Safe Development of Housing on Land Affected by Contamination" published in 2008.

7.9.3 According to the Environment Agency's Remediation Position Statements, the placement of a cover system using "clean" material is not treatment of waste. Consequently, no licensing/permitting position statements are applicable to this type of remediation. If the cover system uses 'waste materials' in its construction, waste management licensing exemption paragraph 9A may be applicable to its installation. If the installation of the proposed cover system does not meet the criteria for registration of this exemption, the activity may be regulated through a waste management site licence.

7.9.4 The clean cover system should be validated in accordance with the "Verification Requirements for Cover Systems – Technical Guidance for Developers, Landowners and Consultants". This document has recently been issued by the Yorkshire and Humberside Pollution Advisory Council and adopted by Local Authorities in Yorkshire, Humberside and Lincolnshire. Where applicable, it should also be in accordance with the requirements of the NHBC as set out in Standards Extra 47 (June 2010) "Contaminated Land – Cover System Validation".

Source of Material

7.9.5 Material can be sourced from clean site won. In the interest of sustainability, Local Authorities promote the use of such site-won materials providing that they are suitable for the intended end use of the site. Alternatively, materials can be sourced from other developments and commercial companies.

7.9.6 Should it be necessary to import any topsoil or subsoil, the topsoil should be sourced from a recognised provider. The soil concentrations should not exceed any of the following levels, and as such the material supplier should be made aware of these.

The topsoil should also comply with BS3882: 2015: Specification for Topsoil, and a test certificate to confirm this should be provided in advance. The subsoil should comply with BS8601: 2015: Specification for Subsoil and requirements for use. No certificate or test results should be more than 30 days old.

Characterisation of Material

7.9.7 It is essential that material is inert and suitable for its intended use. Sampling of materials should be undertaken as early as possible i.e. *prior to placement* (for site won material) and *prior to importation* (for imported material). This is to avoid the costly exercise of re-excavating *unsuitable* materials and the possibility of cross contamination.

Certificates from Commercial Suppliers

7.9.8 Where material is provided by a commercial company, certificates or other industry Quality Protocol compliance i.e. WRAP, will normally be accepted. Caution should be given to importing materials, specifically soils that have been recycled from demolition or skip waste as they could be contaminated. Imported topsoil should be as specified in BS 3882:2007 as 'suitable for its intended purpose'.

Initial Screening

7.9.9 A visual / olfactory inspection of the topsoil should be carried out by an Environmental Engineer to ensure that:

- It is a suitable growing medium.
- It is free from obvious contamination i.e staining / free product etc.

- It has not come from areas where Japanese Knotweed or other invasive or injurious plants, as specified by the Environment Agency are suspected to have been growing.
- It is not odorous (could be considered a statutory nuisance).
- It is free from unsuitable materials i.e. bricks, brick ties, timber and glass etc).
- There are no visible signs of asbestos containing materials (ACM's).

Testing Schedule and Number of Samples

7.9.10 Chemical testing will normally be required on any materials that are to be used as cover material, even where this includes first generation quarried material. This should be carried out by Michael D Joyce Associates LLP.

Suitability of Material

7.9.11 Based on the characterisation of materials, they should be either deemed suitable or unsuitable. The soil concentrations should not exceed any of the following levels, and as such the material supplier should be made aware of these.

Analyte	Maximum Permitted Concentration (mg/kg)
Arsenic	37 (2)
Cadmium	22 (2)
Chromium (vi)	21 (2)
Copper	2400 (1)
Mercury (Inorganic)	40 (1)
Nickel	130 (2)
Selenium	350 (2)
Lead	200 (2)
Zinc	3700 (1)
Phenol	420 (2)
Benzo(a)pyrene	5.0 (2)
Dibenzo(a,h)anthracene	0.28 (1)
Naphthalene	5.6 (1)
Fluorene	400(1)
Asbestos	None

Stockpiling and Quarantining of Material

7.9.12 It is essential that 'suitable' material is either placed in its intended area straight away i.e soft / landscaped areas or stockpiled in a suitable quarantine area to prevent on-site contamination, i.e. for example, fuel leakage from machinery.

Verification of Required Depth

7.9.13 It is important to establish that the required depth has been achieved and is consistent across the site. There are two main ways to achieve this:

- *Depth testing in-situ* – small trial pit excavated to allow measurement of its depth by tape measure or measuring staff.
- *Topographical surveys* – accurate survey of the base and final formation layer height to establish the depth of cover.

7.9.14 The verification of depth and confirmation of such layers should be carried out by Michael D Joyce Associates LLP. In addition, samples will be taken for analysis of both the topsoil and subsoil at a rate of 1 in every 3 plots. The results should comply with the Maximum Permitted Concentration given previously.

Reporting

7.9.15 The purpose of verification documentation is to provide transparent reasoning as to why the remediation, was required, a methodology about how it was to be undertaken and proof that the specified works have been undertaken so as to provide confirmation that the site is 'suitable for its intended use'.

7.9.16 The document is utilised not only to satisfy conditions of planning permissions but also is to be kept on record by the Local Authority should queries be raised during the lifetime of the development and to confirm to future purchasers that the site is suitable for use. The report should be carried out by Michael D Joyce Associates LLP.

7.9.17 The Local Authority ideally would recommend the following programme of photographs to be undertaken of the placement of inert cover:

- Photographs of any stockpiles and quarantine areas.
- Proof that the depth of inert cover has been installed.
- Proof that the quality of the material to be used as inert cover.
- Proof of the method of placement and different layers if appropriate.

- Proof of the completed project.
- Inclusion of geographic background features which will aid locating the photograph.
- Inclusion of site identification boards within the photos which show the date, position taken i.e. corner of plot 3 and the site name.
- Inclusion of photographs of site stockpiles and quarantine areas.

7.9.18 When hardstanding is proposed, the link between the potential contaminants in the soil and the end users will no longer exist. As such, no special precautions are necessary. If the Made Ground has been removed during site strip, a clean cover system is not required although some topsoil will be needed as a growing medium.

7.9.19 If off-site disposal is envisaged, this may necessitate taking the materials to a suitably licensed facility as required by the landfill directive. Landfilling is now actively discouraged and consequently material classified as contaminated can prove expensive to dispose of.

7.9.20 The main objective of the Landfill Directive is to prevent or reduce as far as possible the negative effects of landfilling waste on the environment and on human health. It is intended to reduce the disposal of waste materials to landfills and to encourage more sustainable approaches to dealing with wastes. It bans the landfill of liquids and certain solid wastes, introduces requirements for the treatment of wastes prior to landfill and provides for the classification of landfills as sites for inert, hazardous or non-hazardous waste and prohibits co-disposal.

7.9.21 It sets out procedures for waste acceptance at landfills and the types of waste for each class of landfill as specified by Waste Acceptance Criteria (WAC). The WAC are predominantly lists of “limit values” for certain parameters obtained from standard

leaching tests of wastes going into landfills. WAC are set out in the Landfill Directive itself. Full details can be found in the Environment Agency document "Guidance for waste destined for disposal in landfills" Version 2 June 2006.

7.10 Cement and Buried Concrete

7.10.1 The Made Ground has generally been found to contain low to moderate levels of soluble sulphates. As such consideration should be given to providing some sulphate resistance.

7.10.2 In accordance therefore with the Building Research Establishment Special Digest No. 1 "Concrete in Aggressive Ground", a sulphate resisting cement in accordance with Group DS-2 Specifications should be used for all buried concrete, mortar, concrete piles, and pre-cast concrete pipes.

7.11 Services

7.11.1 Flexible service connections will be necessary on this site, especially in the areas of deeper fill. In addition, adequate gradients should be provided for all drains and sewers so as not to create backfalls should any future ground movements take place in the deeper backfill. Compacting the bases of all such trenches will reduce settlement.

7.11.2 Wherever drains and mains services pass from natural to Made Ground strata, adequate flexibility should be provided so that breakages do not occur due to adverse settlements between materials of differing compressibility.

7.11.3 The results of the chemical testing should be provided to the utilities companies so that any specific requirements they may have can be provided for.

7.12 Retaining Wall

7.12.1 The existing retaining wall should be assessed by a Structural Engineer, so as to determine any improvements/replacement necessary.

7.13 Further Monitoring and Inspection

7.13.1 Should any geotechnical or geoenvironmental problems arise on site or if ground conditions are different from those that we predicted, they should be referred back to Michael D Joyce Associates LLP.

A D Joyce

BSc MSc ARSM CEng CGeol CEnv MICE FGS SiLC SQP

October 2021

Procedure Notes

The desk study and/or ground investigation have been carried out using reasonable skill and care in accordance with the principles of Ground Investigation and Testing", BS5930: 2015 + A1: 2020 and BS10175: 2011 + A2: 2017, and the terms of the client's brief. The report has been prepared for the specific purposes notified at the time of the initial enquiry. It is not fully compliant with Eurocode 7 (EC7) and the report does not constitute a Ground Investigation Report or Geotechnical Design Report as defined by Eurocode 7.

By its very nature any ground investigation only encounters and samples a small percentage of the ground. Consequently changes in ground conditions, soil properties and contamination can occur between any two exploratory points, for example local features such as soft ground, pockets of contamination and faults. This is also true of the exploration of mineworkings and such features can extend beneath parts of the site not investigated. Unrecorded bell pits and shafts can also exist between exploratory points. The ground investigation is designed to minimize such risks with budgetary constraints. Conclusions and recommendations are based on the information presented in this report, but unforeseen features may exist. No liability can be accepted for ground conditions not revealed by the exploratory holes or for contamination not sampled or tested for. Therefore, actual ground conditions should be noted during construction and further advice sought if they differ from those predicted. Michael D. Joyce Associates LLP reserves the right to amend the conclusions and recommendations in the light of further information. Actual methods of construction or alternative designs should be notified to Michael D. Joyce Associates LLP, such that the recommendations made can be reconsidered in the light of any changes.

Further investigation can be carried out to reduce uncertainty further and risk but ultimately these risks cannot be eliminated. Similarly a desk study normally only considers readily available information and further information could be held by other sources. In commissioning further research or investigation the cost/benefit of doing so must be considered.

It is assumed that groundlevels will not change significantly from those at present. The groundwater conditions are based on observations made at the time of the investigation, unless stated otherwise. It should be noted that the observations are subject to the method of the boring or excavation and that groundwater levels will vary due to seasonal or other effects.

Where buildings are present on a site, structural and asbestos surveys have not been carried out, unless specifically stated. An Unexploded Ordnance Survey has not been carried out unless specifically stated. In relevant situations it would be prudent to commission such surveys.

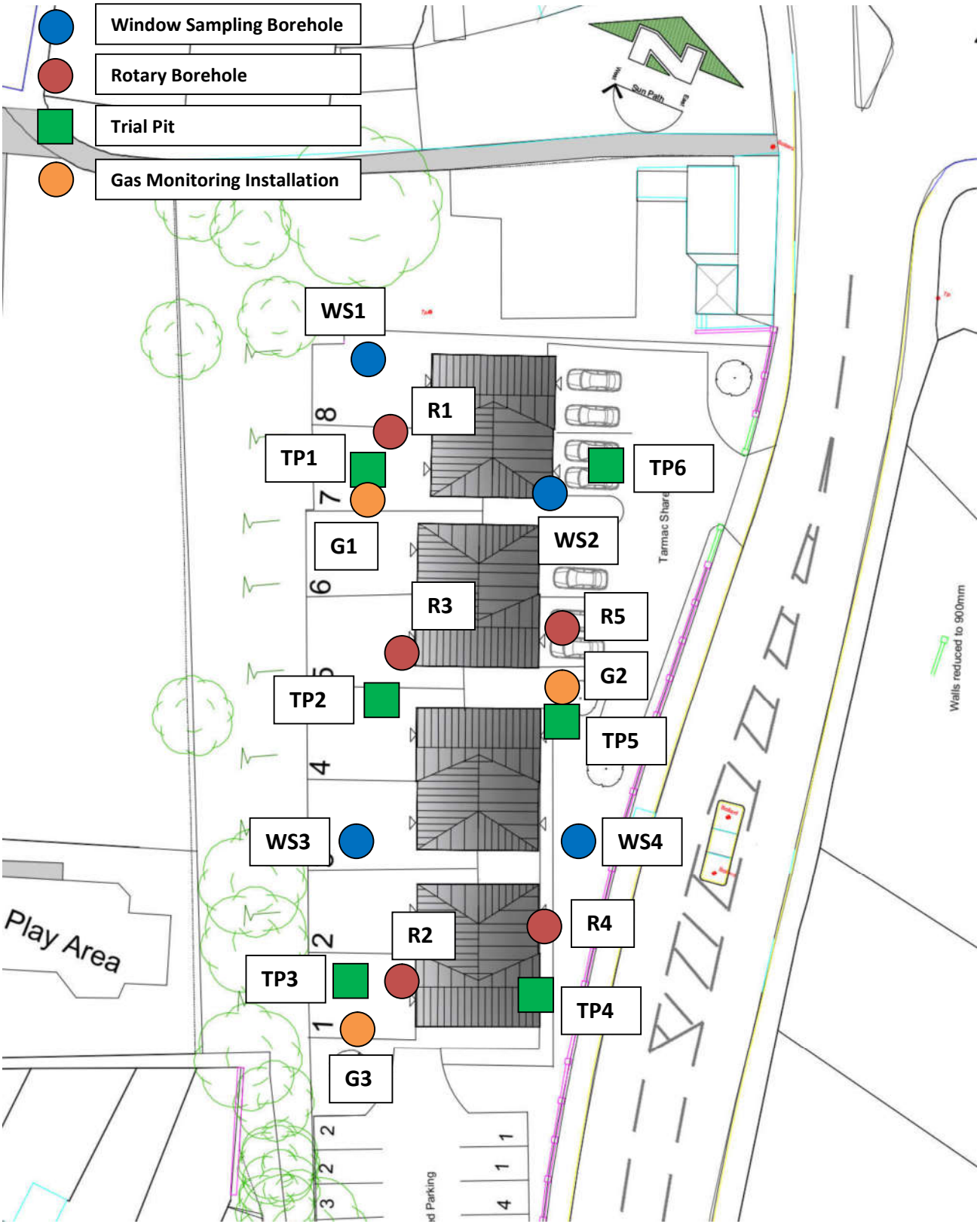
Where information has been obtained from Third Parties, no liability can be accepted for the accuracy or completeness of this information. Where anecdotal evidence or speculations are presented, they must be treated as such and cannot be relied upon.

Redbrook Road, Barnsley
Site Location

Michael D Joyce Associates LLP
Geotechnical and Geoenvironmental Consultants

Scale: NTS

Figure: 1



Redbrook Road, Barnsley

Development Proposals with Exploratory Borehole and Trial Pit Positions

Michael D Joyce Associates LLP

Geotechnical and Geoenvironmental Consultants

Scale: NTS

Figure: 2

APPENDIX 1

Window Sampling Records

Site: REDBROOK ROAD (4159)
Location: BARNSLEY
Method: Terrier Rig
Date: 29th September 2021
Client: Vernon Holdings Ltd

Window Sampling No: 1

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Reduced Level (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
				-0.15		MADE GROUND: Reinforced concrete with moisture membrane.	
						Brown moderately weathered silty MUDSTONE.	
1.00	SPT		N>50	-1	1	End of Borehole	
					2		
					3		
					4		
					5		

General:
Groundwater: Not encountered.
Remarks:

Site: REDBROOK ROAD (4159)
Location: BARNSLEY
Method: Terrier Rig
Date: 29th September 2021
Client: Vernon Holdings Ltd

Window Sampling No: 2

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Reduced Level (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.20	D					MADE GROUND: Limestone hardcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
1.00	SPT		N>50	-1.1	1		
				-1.3		MADE GROUND: Concrete slab.	
						MADE GROUND: Limestone hardcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
				-1.8			
2.00 - 2.45	SPT		N=31		2	Brown silty CLAY.	
				-2.2			
				-2.5		Brown moderately weathered silty MUDSTONE.	
						End of Borehole	
					3		
					4		
					5		

General:
Groundwater: Not encountered.
Remarks:

Site: REDBROOK ROAD (4159)
Location: BARNSLEY
Method: Terrier Rig
Date: 29th September 2021
Client: Vernon Holdings Ltd

Window Sampling No: 3

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Reduced Level (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.15	D					MADE GROUND: Limestone hardcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
					1	Refusal on concrete slab at 1.1m depth.	
				-1.1		End of Borehole	
					2		
					3		
					4		
					5		

General:
Groundwater: Not encountered.
Remarks:

Site: REDBROOK ROAD (4159)
Location: BARNSLEY
Method: Terrier Rig
Date: 29th September 2021
Client: Vernon Holdings Ltd

Window Sampling No: 4

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Reduced Level (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.50	D					MADE GROUND: Limestone hardcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
					1	Refusal on concrete slab at 1.1m depth.	
				-1.1		End of Borehole	
					2		
					3		
					4		
					5		

General:
Groundwater: Not encountered.
Remarks:

APPENDIX 2

Trial Pit Records

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 1

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.15	D					MADE GROUND: Limestone hardcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
				-1.2	1	MADE GROUND: Concrete slab (600mm thick).	
				-1.8		Brown moderately weathered silty MUDSTONE.	
				-2.5	2	End of Trial Pit	
					3		
					4		

Stability: Sides very unstable in Made Ground.

General:

Groundwater: Water ingress below 1.8m.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 2

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
				-0.1		MADE GROUND: Limestone and brick (single size stones).	
0.20	D					MADE GROUND: Brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
					1		
				-1.2			
						MADE GROUND: Concrete slab.	
				-1.4			
						Firm brown silty CLAY.	
				-1.9			
					2	End of Trial Pit	
					3		
					4		

Stability: Sides very unstable in Made Ground.

General:

Groundwater: Wet below 1.40m depth.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 3

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.20	D					MADE GROUND: Limestone harcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete together with some plastics, metal fragments and timber.	
				-1.3	1		
						Very soft brown silty CLAY.	
				-2	2		
						End of Trial Pit	
					3		
					4		

Stability: Sides very unstable in Made Ground.

General:

Groundwater: Wet below 1.50m depth.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 4

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
						MADE GROUND: Limestone harcore over brown silty sandy clay containing much brick and concrete upto boulder size concrete.	
0.40	D				1	Edge of concrete slab (200mm thick) encountered at 1.1m depth.	
				-1.3		Very soft grey and brown silty CLAY with a little organic material and rotting vegetation.	
					2		
					3		
				-3.4		End of Trial Pit	
					4		

Stability: TP sides collapsing in Made Ground.

General:

Groundwater: Water ingress below 1.3m.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 5

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.50	D			-1.1	1	MADE GROUND: Brown clayey sand and gravel with some brick and stone, plastic piping and a metal cable.	
				-1.3		MADE GROUND: Concrete slab.	
				-3	2	Soft in places very soft becoming firm light brown slightly sandy silty CLAY.	
				-3.4	3	Brown highly becoming moderately weathered silty MUDSTONE.	
						End of Trial Pit	
					4		

Stability: Unstable in Made Ground.

General:

Groundwater: Not encountered.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Excavated by: JCB 3CX

Date: 29th September 2021

Client: Vernon Holdings Ltd

Trial Pit No: 6

Michael D Joyce Associates LLP

Depth (m)	Samples	Water Depth (m)	Field Records	Depth (m)	Depth (m)	Description	Legend
				0	0	Ground Surface	
0.30	D					MADE GROUND: Brown clayey sand and gravel with some brick and stone, plastic piping and a metal cable.	
					1		
				-1.5		Terminated on concrete slab at 1.5m depth.	
						End of Trial Pit	
					2		
					3		
					4		

Stability: Unstable in Made Ground.

General:

Groundwater: Not encountered.

APPENDIX 3

Rotary Borehole Records

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R1

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						0	0	Ground level.	
						-0.3		MADE GROUND: Concrete hardstanding.	
								MADE GROUND.	
							1	Brown MUDSTONE.	
							2		
						-2.4		Grey silty MUDSTONE.	
							3		
							4		
							5		
							6		
						-7	7	Intact COAL with mudstone partings.	
						-7.5		Grey silty MUDSTONE.	
							8		
							9		
							10		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R1

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							11	Grey silty MUDSTONE.	
							12		
							13		
						-14.2	14		
								Intact COAL.	
						-14.8	15	Grey silty MUDSTONE.	
							16		
							17		
							18		
							19		
							20		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R1

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							21		
							22		
							23		
						-23.2		Intact COAL.	
						-24	24	Grey silty MUDSTONE.	
							25		
						-25.5		Grey SANDSTONE.	
							26		
							27		
							28		
							29		
						-30	30	End of Borehole	
							31		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R2

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						0	0	Ground level.	
								MADE GROUND.	
						-1.3	1		
						-1.5		MADE GROUND: Concrete.	
								Grey MUDSTONE.	
							2		
							3		
							4		
							5		
						-5.4		Intact COAL with mudstone partings.	
						-5.9			
							6	Grey silty MUDSTONE.	
							7		
							8		
							9		
							10		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R2

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							11	Grey silty MUDSTONE.	
						-12.1	12	Intact COAL with mudstone partings.	
						-12.7	13	Grey silty MUDSTONE.	
							14		
							15		
							16		
							17		
							18		
							19		
							20		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 29th September 2021

Client: Vernon Holdings Ltd

Borehole No: R2

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						-21.1	21		
								Intact COAL.	
						-21.8			
							22	Grey silty MUDSTONE.	
						-23	23	End of Borehole	
							24		
							25		
							26		
							27		
							28		
							29		
							30		
							31		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R3

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						0	0	Ground level. MADE GROUND.	
						-1.2	1	MADE GROUND: Concrete. Grey MUDSTONE.	
							2		
							3		
							4		
							5		
						-5.8	6	Intact COAL with mudstone partings.	
						-6.5		Grey silty MUDSTONE.	
							7		
							8		
							9		
							10		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R3

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							11	Grey silty MUDSTONE.	
							12		
							13		
						-13.7			
							14	Intact COAL.	
						-14.3			
								Grey silty MUDSTONE.	
							15		
							16		
							17		
							18		
							19		
							20		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R3

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							21		
						-22.1	22	Intact COAL.	
						-22.9	23	Grey silty MUDSTONE.	
						-24	24	End of Borehole	
							25		
							26		
							27		
							28		
							29		
							30		
							31		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R4

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						0	0	Ground level.	
								MADE GROUND.	
						-1.5			
						-1.8		MADE GROUND: Concrete.	
							2	Dark grey/brown silty MUDSTONE.	
						-3.5			
								Grey MUDSTONE.	
						-5.8			
							6	Intact COAL with mudstone partings.	
						-6.6			
								Grey silty MUDSTONE.	
							10		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R4

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							11	Grey silty MUDSTONE.	
							12		
						-13	13		
						-13.3		Intact COAL with mudstone partings.	
								Grey silty MUDSTONE.	
							14		
							15		
							16		
							17		
							18		
							19		
							20		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 30th September 2021

Client: Vernon Holdings Ltd

Borehole No: R4

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							21		
						-21.9	22	Intact COAL with mudstone partings.	
						-22.6		Grey silty MUDSTONE.	
							23		
							24		
							25		
						-25.2		Grey SANDSTONE.	
							26		
							27		
							28		
							29		
						-30	30	End of Borehole	
							31		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 1st October 2021

Client: Vernon Holdings Ltd

Borehole No: R5

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
						0	0	Ground level.	
								MADE GROUND.	
						-1.3	1		
						-1.5		MADE GROUND: Concrete.	
								Brown MUDSTONE.	
							2		
							3		
						-3.7		Grey silty MUDSTONE.	
							4		
							5		
						-6	6	Intact COAL with mudstone partings.	
						-6.8		Grey silty MUDSTONE.	
							7		
							8		
							9		
							10		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 1st October 2021

Client: Vernon Holdings Ltd

Borehole No: R5

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							11	Grey silty MUDSTONE.	
							12		
							13		
						-13.2		Intact COAL with mudstone partings.	
						-13.7		Grey silty MUDSTONE.	
							14		
							15		
							16		
							17		
							18		
							19		
							20		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

Site: REDBROOK ROAD (4159)

Location: BARNSLEY

Method: Rotary water flush

Date: 1st October 2021

Client: Vernon Holdings Ltd

Borehole No: R5

Michael D Joyce Associates LLP

Depth (m)	TCR (%)	SCR (%)	RQD (%)	FI (%)	Field Records	Reduced Level (mAOD)	Depth (m)	Description	Legend
							21		
						-22	22	Intact COAL with mudstone partings.	
						-22.7		Grey MUDSTONE.	
						-23	23	End of Borehole	
							24		
							25		
							26		
							27		
							28		
							29		
							30		
							31		

Equipment: Beretta T25 Rig.

Flush: Water

Groundwater:

Returns: Good.

Remarks: No gases recorded.

APPENDIX 4

Contamination and Geotechnical Laboratory Test Results

ANALYTICAL TEST REPORT

Contract no: 101069

Contract name: Redbrook Road, Barnsley

Client reference: -

Clients name: Michael D Joyce Associates

Clients address: Charnock Court
6 South Parade
Wakefield
WF1 1LR

Samples received: 04 October 2021

Analysis started: 04 October 2021

Analysis completed: 11 October 2021

Report issued: 11 October 2021

Notes:
Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

Key:
U UKAS accredited test
M MCERTS & UKAS accredited test
$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by:
K Campbell
Karan Campbell
Director

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.
Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
101069-1	TP1	0.15	Loamy Sandy Clay with Gravel & Roots	-	-	12.6
101069-2	TP2	0.20	Sandy Sand with Gravel	-	-	13.8
101069-3	TP3	0.20	Loamy Sandy Clay with Gravel & Roots	-	-	18.5
101069-4	TP4	0.40	Loamy Sandy Clay with Gravel & Roots	-	-	12.7
101069-5	TP5	0.30	Loamy Sandy Clay with Gravel & Roots	-	-	12.6
101069-6	TP6	0.50	Loamy Sandy Clay with Gravel & Roots	-	-	10.8
101069-7	WS2	0.20	Sandy Clay with Gravel & Roots	-	-	10.2
101069-8	WS3	0.15	Sandy Clay with Gravel & Roots	-	-	13.1
101069-9	WS4	0.50	Sandy Clay with Gravel & Roots	-	-	11.0

Chemtech Environmental Limited

SOILS

Lab number			101069-1	101069-2	101069-3	101069-4	101069-5	101069-6
Sample id			TP1	TP2	TP3	TP4	TP5	TP6
Depth (m)			0.15	0.20	0.20	0.40	0.30	0.50
Date sampled			29/09/2021	29/09/2021	29/09/2021	29/09/2021	-	29/09/2021
Test	**Method**	**Units**						
Arsenic (total)	CE127 M	mg/kg As	12	9.4	14	14	14	7.6
Cadmium (total)	CE127 M	mg/kg Cd	0.3	0.4	0.2	0.2	0.4	1.0
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	<1	<1	<1	<1
Copper (total)	CE127 M	mg/kg Cu	27	23	49	48	35	17
Lead (total)	CE127 M	mg/kg Pb	155	237	518	517	161	163
Mercury (total)	CE127 M	mg/kg Hg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel (total)	CE127 M	mg/kg Ni	31	16	28	28	23	15
Selenium (total)	CE127 M	mg/kg Se	1.6	0.6	1.2	1.4	0.9	1.1
Zinc (total)	CE127 M	mg/kg Zn	86	71	64	64	95	114
pH	CE004 M	units	8.8	9.0	10.1	8.8	8.9	8.7
Sulphate (2:1 water soluble)	CE061	mg/l SO_4	249	282	1536	159	238	149
Cyanide (total)	CE077	mg/kg CN	<1	<1	<1	<1	<1	<1
Phenols (total)	CE078	mg/kg PhOH	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PAH								
Naphthalene	CE087 M	mg/kg	0.06	0.05	0.08	0.04	0.07	0.02
Acenaphthylene	CE087 M	mg/kg	0.06	0.07	0.26	0.03	0.09	0.04
Acenaphthene	CE087 M	mg/kg	0.03	0.02	0.06	<0.02	0.14	<0.02
Fluorene	CE087 U	mg/kg	0.04	0.04	0.07	0.03	0.14	<0.02
Phenanthrene	CE087 M	mg/kg	0.71	0.93	1.11	0.41	1.55	0.13
Anthracene	CE087 U	mg/kg	0.24	0.26	0.34	0.16	0.39	0.08
Fluoranthene	CE087 M	mg/kg	2.55	2.32	3.77	1.21	3.42	0.47
Pyrene	CE087 M	mg/kg	2.43	2.02	3.47	1.14	3.02	0.43
Benzo(a)anthracene	CE087 U	mg/kg	1.88	1.24	2.06	0.75	1.82	0.30
Chrysene	CE087 M	mg/kg	1.89	1.25	2.29	0.75	1.87	0.31
Benzo(b)fluoranthene	CE087 M	mg/kg	2.65	1.28	2.79	0.94	2.12	0.36
Benzo(k)fluoranthene	CE087 M	mg/kg	1.00	0.47	1.20	0.33	0.89	0.15
Benzo(a)pyrene	CE087 U	mg/kg	2.05	1.05	2.36	0.72	1.71	0.28
Indeno(123cd)pyrene	CE087 M	mg/kg	1.69	0.70	1.83	0.53	1.18	0.21
Dibenz(ah)anthracene	CE087 M	mg/kg	0.36	0.15	0.32	0.10	0.27	0.05
Benzo(ghi)perylene	CE087 M	mg/kg	1.38	0.60	1.62	0.45	1.01	0.19
PAH (total of USEPA 16)	CE087	mg/kg	19.0	12.5	23.6	7.58	19.7	3.02
Subcontracted analysis								
Asbestos (qualitative)	$	-	NAD	NAD	NAD	NAD	NAD	NAD

Chemtech Environmental Limited

SOILS

Lab number			101069-7	101069-8	101069-9
Sample id			WS2	WS3	WS4
Depth (m)			0.20	0.15	0.50
Date sampled			29/09/2021	29/09/2021	29/09/2021
Test	**Method**	**Units**			
Arsenic (total)	CE127 M	mg/kg As	6.9	8.7	10
Cadmium (total)	CE127 M	mg/kg Cd	2.0	0.3	0.3
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	<1
Copper (total)	CE127 M	mg/kg Cu	15	29	24
Lead (total)	CE127 M	mg/kg Pb	193	68	117
Mercury (total)	CE127 M	mg/kg Hg	<0.5	<0.5	<0.5
Nickel (total)	CE127 M	mg/kg Ni	15	29	24
Selenium (total)	CE127 M	mg/kg Se	0.5	0.9	0.7
Zinc (total)	CE127 M	mg/kg Zn	186	224	81
pH	CE004 M	units	8.8	8.0	8.6
Sulphate (2:1 water soluble)	CE061	mg/l SO_4	222	1584	684
Cyanide (total)	CE077	mg/kg CN	<1	<1	<1
Phenols (total)	CE078	mg/kg PhOH	<0.5	<0.5	<0.5
PAH					
Naphthalene	CE087 M	mg/kg	0.02	0.04	0.05
Acenaphthylene	CE087 M	mg/kg	<0.02	0.06	0.12
Acenaphthene	CE087 M	mg/kg	<0.02	0.02	0.04
Fluorene	CE087 U	mg/kg	<0.02	0.03	0.07
Phenanthrene	CE087 M	mg/kg	0.10	0.36	0.97
Anthracene	CE087 U	mg/kg	0.03	0.12	0.31
Fluoranthene	CE087 M	mg/kg	0.31	1.30	3.93
Pyrene	CE087 M	mg/kg	0.29	1.28	3.23
Benzo(a)anthracene	CE087 U	mg/kg	0.18	0.79	2.16
Chrysene	CE087 M	mg/kg	0.17	0.79	1.93
Benzo(b)fluoranthene	CE087 M	mg/kg	0.28	0.95	2.36
Benzo(k)fluoranthene	CE087 M	mg/kg	0.11	0.38	0.97
Benzo(a)pyrene	CE087 U	mg/kg	0.21	0.78	1.92
Indeno(123cd)pyrene	CE087 M	mg/kg	0.18	0.58	1.36
Dibenz(ah)anthracene	CE087 M	mg/kg	0.04	0.12	0.27
Benzo(ghi)perylene	CE087 M	mg/kg	0.17	0.49	1.04
PAH (total of USEPA 16)	CE087	mg/kg	2.10	8.10	20.7
Subcontracted analysis					
Asbestos (qualitative)	$	-	NAD	NAD	NAD

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE146	Chromium (VI)	Acid extraction, Colorimetry	Dry		1	mg/kg CrVI
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Zinc (total)	Aqua regia digest, ICP-MS	Dry	M	5	mg/kg Zn
CE004	pH	Based on BS 1377, pH Meter	As received	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		10	mg/l SO_4
CE077	Cyanide (total)	Extraction, Continuous Flow Colorimetry	As received		1	mg/kg CN
CE078	Phenols (total)	Extraction, Continuous Flow Colorimetry	As received		0.5	mg/kg PhOH
CE087	Naphthalene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	PAH (total of USEPA 16)	Solvent extraction, GC-MS	As received		0.34	mg/kg
$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments
Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.
For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.
Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
101069-1	TP1	0.15	N	
101069-2	TP2	0.20	N	
101069-3	TP3	0.20	N	
101069-4	TP4	0.40	N	
101069-5	TP5	0.30	Y	All (NSD)
101069-6	TP6	0.50	N	
101069-7	WS2	0.20	N	
101069-8	WS3	0.15	N	
101069-9	WS4	0.50	N	

Standard Appendices

A and B

STANDARD APPENDIX A

NOTES ON SITE INVESTIGATION PROCEDURE (June 2021)

1. **GENERAL.** The ground investigation has been carried out in accordance with the requirements of BS5930: 2015 and BS10175: 2011+A1: 2020. By its very nature, any ground investigation only samples a small percentage of the ground. Consequently, changes in ground conditions and soil properties can occur between any two exploratory points, for example local features such as soft ground, pockets of contamination and faults. This is also true of the exploration of mineworkings and such features can extend beneath parts of the site not investigated. Unrecorded bell pits and shafts can also exist between exploratory points. The ground investigation is designed to minimise such risks but they cannot be eliminated.

2. **GROUND INVESTIGATION.**

2.1 **BOREHOLE AND TRIAL PIT RECORDS.** These illustrate the ground conditions only at the location of the particular borehole or trial pit. Correlation between boreholes is for guidance only and its accuracy cannot be guaranteed.

2.2 **SHELL AND AUGER BORING.** This technique uses a tripod winch and an essentially percussive action using a variety of tools. Disturbed and undisturbed samples can be taken. This is the most suitable method for soft ground investigation, enabling the maximum amount of information to be obtained. However, minor changes in lithology may be overlooked unless continuous undisturbed sampling is used.

2.3 **GROUNDWATER**. Groundwater levels vary seasonally and the details given on the borehole logs relate only to the dates and the conditions described in the borehole records. The rate of boring may not have allowed an equilibrium water level to be established and the use of casing may seal off certain seepages.

2.4 **SAMPLING.** Disturbed samples of soils are taken for identification and classification purposes. In cohesive soils 'undisturbed' samples 100mm in diameter are taken by open drive sampler for laboratory testing of strength, permeability and consolidation characteristics.

2.5 **STANDARD PENETRATION TESTS**. S.P.T tests are used in granular and cohesive materials and in soft or weathered rocks. Difficulties in obtaining true 'N' values mean they must only be used as a guide and not as an absolute value in foundation design.

2.6 **ROTARY DRILLING.** Two main types of rotary drilling are carried out in rock. Rock coring using diamond or tungsten carbide tipped core bits provides samples and information on rock types, fissuring and weathering. Openhole drilling only produces small particles for identification purposes and the information gained is therefore limited. The latter is, however, useful as a quick method for detecting major strata changes and for the location of coal seams and old workings. Water, air, foam or drilling muds may be used as the flushing medium in either case.

2.7 **PERMEABILITY TESTS.** These can be carried out in boreholes or trial pits and gives a good indication of in-situ permeability.

2.8 **TRIAL PITTING.** This enables soil conditions to be closely examined at any specific point and samples taken. It also gives useful information on the stability of excavations and ingress of water.

2.9 **WINDOW SAMPLING**. Window sampling consists of driving a series of 1m-long tubes into the ground using a dropping weight. On completion of each 1m run, the tube is withdrawn. The next tube is then inserted and the process repeated to provide a continuous profile of the ground. On each run the tube diameter is reduced in order to assist in its recovery.

2.10 **GAS MONITORING.** This is routinely carried out in trial pits or probe holes to check for elevated levels of methane and carbon dioxide or oxygen deficiency, particularly since risks can exist from natural gases, landfill sites and rising groundwater levels in mine workings below ground. Longer term monitoring is carried out with gas monitoring standpipes.

3. **SOIL DESCRIPTION.** Samples from borings or trial pits are described as specified in the standard procedure outlined in the British Standards. The description includes colour, consistency, structure, weathering, lithological type, inclusions and origin. All descriptions are based on visual and manual identification.

Fire Soils (Cohesive Soils)

The following field terms are used:

Soil Type	Description
Very soft	Exudes between fingers
Soft	Moulded by light finger pressure
Firm	Cannot be moulded by the fingers but can be rolled in hand to 3mm threads.
Stiff	Crumbles and breaks when rolled to 3mm threads but can be remoulded to a lump.
Very stiff	No longer moulded but crumbles under pressure. Can be indented with thumbs.

The following terms are used in accordance with the results of laboratory and field tests.

Description	Undrained Shear Strength Cu (kPa)
Extremely Low	<10
Very Low	10 - 20
Low	20 - 40
Medium	40 - 75
High	75 - 150
Very High	150 - 300
Extremely High	>300

Fine soils can also be classified according to their sensitivity, which is the ratio between undisturbed and remoulded undrained shear strength.

Sensitivity	Ratio
Low	8
Medium	8 - 30
High	>30
Quick	>50

Granular Soils (Non-Cohesive)

The following descriptions are used for granular soils.

Description	Normalised Blow Count (N_1) 60
Very Loose	0 - 3
Loose	3 - 8
Medium	8 - 25
Dense	25 - 42
Very Dense	42 - 58

4. **NATURAL OR IN-SITU MOISTURE CONTENT**. The natural or in-situ moisture content of a soil is defined as the weight of water contained in the pore space, expressed as a percentage of the dry weight of solid matter present in the soil. Soil properties are greatly affected by the moisture content and the test can help to give an indication of likely engineering behaviour.

5. **LIQUID AND PLASTIC LIMITS**. Two simple classification tests are known as the liquid and plastic limits. If a cohesive soil is remoulded with increasing amounts of water, a point will be reached at which it ceases to behave as a plastic material and becomes essentially a viscous fluid. The moisture content corresponding to this change is arbitrarily determined by the liquid limit test. 'Fat' clays, which have high contents of colloidal particles, have high liquid limits; 'lean' clays, having low colloidal particle contents have correspondingly low liquid limits. An increase in the organic content of a clay is reflected by an increase in the liquid and plastic limits.

   If a cohesive soil is allowed to dry progressively, a point is reached at which it ceases to behave as a plastic material, which can be moulded in the fingers, and it becomes friable. The moisture content of the soil at this point is known as the 'plastic limit' of the soil.

   The range of water content over which a cohesive soil behaves plastically, i.e. the range lying between the liquid and plastic limits, is defined as the plasticity index.

   A cohesive soil with a natural water content towards its liquid limit will, in general, be an extremely soft material whereas a cohesive soil with a natural water content below its plastic limit will tend to be a stiff material.

6. **PARTICLE-SIZE DISTRIBUTION.** A knowledge of particle-size distribution is used to classify soils and to indicate likely engineering behaviour. British Standards define soils in relation to their particle-size as shown below:-

Boulders	>200mm	Coarse Sand	2.0 to 0.63mm
Cobbles	200 to 63mm	Medium Sand	0.63 to 0.2mm
		Fine Sand	0.2 to 0.063mm
Coarse Gravel	63 to 20mm	Coarse Silt	0.063 to 0.02mm
Medium Gravel	20 to 6.3mm	Medium Silt	0.02 to 0.0063mm
Fine Gravel	6.3 to 2mm	Fine Silt	0.0063 to 0.002mm
		Clay	<0.002mm

7. **BULK DENSITY.** The bulk density of a material is the weight of that material per unit volume and includes the effects of voids whether filled with air or water. The 'dry density' of a soil is defined as the weight of solids contained in a unit volume of the soil.

8. **PERMEABILITY.** The permeability of a material is defined as the rate at which water flows through it per unit area of soil under unit hydraulic gradient.

9. **CONSOLIDATION CHARACTERISTICS.** When subjected to pressure, a soil tends to consolidate as the air or water in the pore space is forced out and the grains assume a denser state of packing. The decrease in volume per unit of pressure is defined as the 'compressibility' of the soil, and a measure of the rate at which consolidation proceeds is given by the 'coefficient of consolidation' of the soil. These two characteristics Mv and Cv are determined in the consolidation test and the results are used to determine settlement of structures or earthworks.

10. **STRENGTH CHARACTERISTICS.** The strength of geological materials is generally expressed as the maximum resistance that they offer to deformation or fracture by applied shear or compressive stress. The strength characteristics of geological materials depend to an important degree on their previous history and on the conditions under which they will be stressed in practice. Consequently, it is necessary to simulate in the laboratory tests the conditions under which the material will be stressed in the field.

In general, the only test carried out on hard rocks is the determination of their compressive strength but consideration must be given to fissuring, jointing and bedding planes.

The tests at present in use for soils and soft rocks fall into two main categories. Firstly, those in which the material is stressed under conditions of no moisture content change, and secondly those in which full opportunity is permitted for moisture content changes under the applied stresses. Tests in the first category are known as undrained (immediate or quick) tests, while those in the second category are known as drained (slow or equilibrium) tests. The tests are normally carried out in the triaxial compression apparatus but granular materials may be tested in the shear box apparatus.

The undrained triaxial test gives the apparent cohesion C_u and the angle of shearing resistance $\emptyset_u$. In dry sands, $C_u = 0$ and $\emptyset_u$ is equal to the angle of internal friction whereas with saturated non-fissured clays $\emptyset u$ tends to 0 and the apparent cohesion C_u is equal to one-half the unconfined compression strength qu. On site the vane test gives an approximate measure of shear strength.

For some stability problems use is made of a variant of the undrained triaxial test in which the specimen is allowed to consolidate fully under the hydrostatic pressure and is then tested to failure under conditions of no moisture content change. This is known as the consolidated undrained triaxial test. Pore water pressures may be measured during this test or a fully drained test may be carried out. In either case the effective shear strength parameters C' and $\emptyset$' can be obtained which can be used to calculate shear strength at any given pore water pressure.

11. **COMPACTION.** The density at which any soil can be placed in an earth dam, embankment or road depends on its moisture content and on the amount of work which is used in compaction. The influence of these two factors can be studied in compaction tests, which can determine the maximum dry density (MDD) achievable at a certain optimum moisture content (OMC).

12. **CALIFORNIA BEARING RATIO TEST.** In flexible pavement design a knowledge of the bearing capacity of the subgrade is necessary to enable the thickness of pavement for any particular combination of traffic and site conditions to be determined. The quality of the subgrade can be assessed by means of the California Bearing Ratio Test or approximately by the MEXE cone penetrometer.

13. **ROCK DESCRIPTION.** This is based on;

i. Colour (minor then principal colour).
ii. Grain Size.

Description	Predominate Grain Size (mm)
Very Coarse - grained	>63
Coarse - grained	63 - 2
Medium - grained	2 - 0.063
Fine - grained	0.063 - 0.002
Very Fine - grained	<0.002

iii. Matrix.
iv. Weathering.

Term	Description
Fresh	No visible sign of weathering/alteration of the rock material.
Discoloured	The colour of the original fresh rock material is changed and is evidence of weathering/alteration. The degree of change from the original colour should be indicated. If the colour change is confined to particular mineral constituents, this should be mentioned.
Disintegrated	The rock material is broken up by physical weathering, so that bonding between grains is lost and the rock is weathered/altered towards the condition of a soil in which the original material fabric is still intact. The rock material is friable but the grains are not decomposed.
Decomposed	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a sol in which the original material fabric is still intact; some or all of the grains are decomposed.

v. Carbonate Content.
vi. Stability of Rock Material.

Stable indicates no changes when sample left in water for 24 hours. Fairly stable indicates fissuring and crumbling of surfaces. Unstable indicates complete disintegration of the sample.

vii. Unconfined Compressive Strength.

Term	Field Identification	Unconfined Compressive Strength (MPa)
Extremely Weak[a]	Indented by thumbnail.	Less than 1
Very Weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1 to 5
Weak	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5 to 25
Medium Strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 to 50
Strong	Specimen required more than one blow of geological hammer to fracture it.	50 to 100
Very Strong	Specimen requires many blows of geological hammer to fracture it.	100 to 250
Extremely Strong	Specimen can only be chipped with geological hammer.	Greater than 250

[a] Some extremely weak rocks will behave as soils and should be described as soils.

viii. Structure.

Sedimentary	Metamorphic	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flowbanded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	
Graded	Gneissose	
	Folded	

ix. Discontinuities.
x. Discontinuity Spacing, persistence and roughness, infilling and seepage.
xi. Weathering of the Rock Mass.

Term	Description	Grades
Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.	0
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces.	1
Moderately weathered	Less than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones.	2
Highly weathered	More than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones.	3
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	4
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soils has not been significantly transported.	5

xii. Rock Mass Permeability

14. **CHEMICAL TESTS.** A knowledge of total soluble sulphate content and pH of soils and groundwater is important in determining the protection required for concrete or steel in contact with the ground. Other specialist tests may be carried out on sites suspected of being contaminated by toxic materials (see standard appendix B).

15. **REFERENCES**

BS5930: 2015+A1:2020 British Standard Code of Practice for Site Investigations
BS10175: 2011+A2:2017 British Standard Code of Practice for the Investigation of Potentially Contaminated Sites

STANDARD APPENDIX A

NOTES ON SITE INVESTIGATION PROCEDURE (October 2019)

1. **GENERAL.** The ground investigation has been carried out in accordance with the principles of British Standards BS EN ISO 14688-1 and 2 "Geotechnical Investigation and testing – Identification and Classification of Soil" Parts 1 and 2 and BS EN ISO 14689: 2018 "Geotechnical Investigation and Testing – Identification and Classification of Rock". BS 5930: 2015 the Code of Practice for Site Investigation is partly superseded. This appendix briefly describes the nature of the work carried out. It also gives a brief description of the more important tests, which are made for engineering purposes on rocks and soils (see also BS 1377: 2016). By its very nature, any ground investigation only samples a small percentage of the ground. Consequently, changes in ground conditions and soil properties can occur between any two exploratory points, for example local features such as soft ground, pockets of contamination and faults. This is also true of the exploration of mineworkings and such features can extend beneath parts of the site not investigated. Unrecorded bell pits and shafts can also exist between exploratory points. The ground investigation is designed to minimise such risks but they cannot be eliminated.

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Fine soils can also be classified according to their sensitivity, which is the ratio between undisturbed and remoulded undrained shear strength.

Sensitivity	Ratio
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Quick	>50

Granular Soils (Non-Cohesive)

The following descriptions are used for granular soils.

Description	Normalised Blow Count (N_1) 60
Very Loose	0 - 3
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4. **NATURAL OR IN-SITU MOISTURE CONTENT**. The natural or in-situ moisture content of a soil is defined as the weight of water contained in the pore space, expressed as a percentage of the dry weight of solid matter present in the soil. Soil properties are greatly affected by the moisture content and the test can help to give an indication of likely engineering behaviour.

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   If a cohesive soil is allowed to dry progressively, a point is reached at which it ceases to behave as a plastic material, which can be moulded in the fingers, and it becomes friable. The moisture content of the soil at this point is known as the 'plastic limit' of the soil.

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Coarse Gravel	63 to 20mm	Coarse Silt	0.063 to 0.02mm
Medium Gravel	20 to 6.3mm	Medium Silt	0.02 to 0.0063mm
Fine Gravel	6.3 to 2mm	Fine Silt	0.0063 to 0.002mm
		Clay	<0.002mm

7. **BULK DENSITY.** The bulk density of a material is the weight of that material per unit volume and includes the effects of voids whether filled with air or water. The 'dry density' of a soil is defined as the weight of solids contained in a unit volume of the soil.

8. **PERMEABILITY.** The permeability of a material is defined as the rate at which water flows through it per unit area of soil under unit hydraulic gradient.

9. **CONSOLIDATION CHARACTERISTICS.** When subjected to pressure, a soil tends to consolidate as the air or water in the pore space is forced out and the grains assume a denser state of packing. The decrease in volume per unit of pressure is defined as the 'compressibility' of the soil, and a measure of the rate at which consolidation proceeds is given by the 'coefficient of consolidation' of the soil. These two characteristics Mv and Cv are determined in the consolidation test and the results are used to determine settlement of structures or earthworks.

10. **STRENGTH CHARACTERISTICS.** The strength of geological materials is generally expressed as the maximum resistance that they offer to deformation or fracture by applied shear or compressive stress. The strength characteristics of geological materials depend to an important degree on their previous history and on the conditions under which they will be stressed in practice. Consequently, it is necessary to simulate in the laboratory tests the conditions under which the material will be stressed in the field.

In general, the only test carried out on hard rocks is the determination of their compressive strength but consideration must be given to fissuring, jointing and bedding planes.

The tests at present in use for soils and soft rocks fall into two main categories. Firstly, those in which the material is stressed under conditions of no moisture content change, and secondly those in which full opportunity is permitted for moisture content changes under the applied stresses. Tests in the first category are known as undrained (immediate or quick) tests, while those in the second category are known as drained (slow or equilibrium) tests. The tests are normally carried out in the triaxial compression apparatus but granular materials may be tested in the shear box apparatus.

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For some stability problems use is made of a variant of the undrained triaxial test in which the specimen is allowed to consolidate fully under the hydrostatic pressure and is then tested to failure under conditions of no moisture content change. This is known as the consolidated undrained triaxial test. Pore water pressures may be measured during this test or a fully drained test may be carried out. In either case the effective shear strength parameters C' and Ø' can be obtained which can be used to calculate shear strength at any given pore water pressure.

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13. **ROCK DESCRIPTION.** This is based on;

i. Colour (minor then principal colour).
ii. Grain Size.

Description	Predominate Grain Size (mm)
Very Coarse - grained	>63
Coarse - grained	63 - 2
Medium - grained	2 - 0.063
Fine - grained	0.063 - 0.002
Very Fine - grained	<0.002

iii. Matrix.
iv. Weathering.

Term	Description
Fresh	No visible sign of weathering/alteration of the rock material.
Discoloured	The colour of the original fresh rock material is changed and is evidence of weathering/alteration. The degree of change from the original colour should be indicated. If the colour change is confined to particular mineral constituents, this should be mentioned.
Disintegrated	The rock material is broken up by physical weathering, so that bonding between grains is lost and the rock is weathered/altered towards the condition of a soil in which the original material fabric is still intact. The rock material is friable but the grains are not decomposed.
Decomposed	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a sol in which the original material fabric is still intact; some or all of the grains are decomposed.

v. Carbonate Content.
vi. Stability of Rock Material.

Stable indicates no changes when sample left in water for 24 hours. Fairly stable indicates fissuring and crumbling of surfaces. Unstable indicates complete disintegration of the sample.

vii. Unconfined Compressive Strength.

Term	Field Identification	Unconfined Compressive Strength (MPa)
Extremely Weak[a]	Indented by thumbnail.	Less than 1
Very Weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1 to 5
Weak	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5 to 25
Medium Strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 to 50
Strong	Specimen required more than one blow of geological hammer to fracture it.	50 to 100
Very Strong	Specimen requires many blows of geological hammer to fracture it.	100 to 250
Extremely Strong	Specimen can only be chipped with geological hammer.	Greater than 250

[a] Some extremely weak rocks will behave as soils and should be described as soils.

viii. Structure.

Sedimentary	Metamorphic	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flowbanded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	
Graded	Gneissose	
	Folded	

ix. Discontinuities.

x. Discontinuity Spacing, persistence and roughness, infilling and seepage.

xi. Weathering of the Rock Mass.

Term	Description	Grades
Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.	0
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces.	1
Moderately weathered	Less than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones.	2
Highly weathered	More than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones.	3
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	4
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soils has not been significantly transported.	5

xii. Rock Mass Permeability

14. **CHEMICAL TESTS.** A knowledge of total soluble sulphate content and pH of soils and groundwater is important in determining the protection required for concrete or steel in contact with the ground. Other specialist tests may be carried out on sites suspected of being contaminated by toxic materials (see standard appendix B).

15. **REFERENCES** (where applicable)

ICE: Effective Site Investigation (2013)
The Coal Authority: Guidance on Managing the Risk of Hazardous Gases when Drilling or Piling Near Coal, 2013
Site Investigation Practice by Michael D Joyce; E & F N Spon 1982.

BRITISH STANDARDS

BS3882: 2015 British Standard Specification for Topsoil
BS5930: 2015 British Standard Code of Practice for Site Investigations
BS8485: 2015 British Standard Code of Practice for the design and protective measures from methane and carbon dioxide ground gases for new buildings
BS10175: 2011+A1:2013 British Standard Code of Practice for the Investigation of Potentially Contaminated Sites

STANDARD APPENDIX B

NOTES ON CONTAMINATION INVESTIGATION PROCEDURE (June 2021)

1. **GENERAL.** The desk study and/or intrusive ground investigation is typically carried out in accordance with the Environment Agency's "Land Contamination Risk Management (LCRM) documents and the requirements of BS5930: 2015 and BS10175: 2011+A1: 2020. In relation to contamination the desk study is referred to as the preliminary investigation in BS10175 and the intrusive ground investigation is referred to as the Exploratory Investigation. This appendix briefly describes the nature of the work carried out and explains the standards against which contamination data has been assessed. The nature of any contamination investigation is such that only a small percentage of the ground, and therefore potential contamination, is sampled. Consequently variations in both ground conditions and contaminant levels can occur between any two sampling positions. The contamination investigation is designed to minimise such risks, but they cannot be eliminated.

2. **REVIEW OF CONTAMINATION ISSUES –** The National Planning Policy Framework (NPPF) and Part 2A of the Environmental Protection Act 1990 create a new regime for the identification and remediation of contaminated land. It introduced a definition of contaminated land described in Section 78A(2) of the Act of:

"any 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

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused:

Both Part 2A and the planning regime embrace the "suitable for use" approach. In the context of Part IIA, action is necessary only where there are unacceptable risks to health or to the environment, taking into account the current use of the land and its environmental setting.

For humans, significant harm is defined as "death, disease, serious injury ". Specifically, disease is taken to mean an unhealthy condition of the body or part of it. "Significant possibility of significant harm" is described as health effects arising from the intake of a contaminant or other direct bodily contact with the contaminant where the intake or exposure is unacceptable. The assessment should also take into account the total intake from all sources, the relative contribution of the pollutant linkage in question, and the duration of intake or exposure. The various statutory definitions are given overleaf.

The presence of unnatural substances does not automatically constitute a risk unless there is a link or pathway between the contamination (the hazard) and the receptor (the target) be it humans, the environment or property. Therefore the assessment needs to determine whether a hazard is present and whether the necessary pathway exists the so-called "pollution linkage" or "conceptual site model".

The effect of any hazard on a site depends primarily on the site use and groundwater conditions since these determine who and what may be at risk and the routes by which they may be exposed to the hazard. Site uses can include allotments, domestic gardens on residential developments, amenity and recreational areas, public open space and industrial and commercial buildings. On any site, the potential contaminants have to be identified together with the potential receptors. The pathway for that contaminant to reach its target has then to be considered.

3. **PRELIMINARY INVESTIGATION.** The preliminary Phase I Geoenvironmental Assessment (desk study) report normally considers the following key sections:

Introduction	
The Site	Contaminated Land
Site History	Radon
Geology and Mining	Geoenvironmental Risk Assessment
Hydrogeology	Geotechnical Assessment
Groundsure Geo-Insight and Enviro-Insight	Ground Investigation (Recommendations)

The report will summarise the findings and also relate our opinions to the potential for a site to be geoenvironmentally impaired, at levels likely to warrant mitigation or further consideration appropriate to the current or future use. Findings are based on information obtained and described during the desk study and site inspection without intrusive ground investigation. It is possible that further information exists. The absence of indicators of impairment does not mean that such impairment does not exist. Additional investigation including intrusive methods can reduce the risks but cannot eliminate them and may not be cost effective. We can advise on the additional research opportunities, their cost and their possible impact on mitigating risk. Recommendations are normally given based on the redevelopment proposals for the site.

Type of Receptor	Description of harm that is to be regarded as significant harm	Conditions For There Being A Significant Possibility Of Significant Harm
1. Human beings	Death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. For these purposes, disease is to be taken to mean an unhealthy condition of the body or a part of it and can include, for example, cancer, liver dysfunction or extensive skin ailments. Mental dysfunction is included only insofar as it is attributable to the effects of a pollutant on the body of the person concerned.	If the amount of the pollutant in the pollutant linkage represents an unacceptable intake or direct bodily contact, assessed on the basis of relevant information on the toxicological properties of that pollutant. Such an assessment should take into account: • the likely total intake of, or exposure to, the substance or substances which form the pollutant, from all sources including that from the pollutant linkage in question; • the relative contribution of the pollutant linkage in question to the likely aggregate intake of, or exposure to, the relevant substance or substances; and • the duration of intake or exposure resulting from the pollutant linkage in question. The question of whether an intake or exposure is unacceptable is independent of the number of people who might experience or be affected by that intake or exposure. Toxicological properties should be taken to include carcinogenic, mutagenic, teratogenic, pathogenic, endocrine-disrupting and other similar properties.
2. All other human health effects (particularly by way of explosion or fire)		If the probability, or frequency, of significant harm of that description is unacceptable. The pollutant linkage might cause "significant harm which" • would be irreversible or incapable of being treated; • would affect a substantial number of people; • would result from a single incident such as a fire or an explosion; or • would be likely to result from a short-term (lees than 24-hour) exposure to the pollutant.
3. Any ecological system, or living organism forming part of such a system, within a location which is protected.	For any protected location: • harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or • harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.	If either: • significant harm of that description is more likely than not to result from the pollutant linkage; or • there is a reasonable possibility of significant harm of that description being caused, and if that harm were to occur, it would result in such a degree of damage to features of special interest at the location in question that they would be beyond any practicable possibility of restoration.
4. Property in the form of: • crops, including timber; • produce grown domestically, or on allotments, for consumption; • livestock; • other owned or domesticated animals; • wild animals which are the subject of shooting or fishing rights.	For crops, a substantial diminution in yield or other substantial loss in the value resulting from death, disease or other physical damage. For domestic pets, death, serious disease or serious physical damage. For other property in this category, a substantial loss in its value resulting from death, disease or other serious physical damage.	If significant harm of that description is more likely than not to result from the pollutant linkage in question.
5. Property in the form of buildings.	Structural failure, substantial damage or substantial interference with any right of occupation.	If significant harm of that description is more likely than not to result from the pollutant linkage in question during the expected economic life of the building.
6. Controlled waters.		

4. **INTRUSIVE INVESTIGATION.** BS10175 describes this as an exploratory investigation. Intrusive ground investigation is described in Standard Appendix A. During the investigation representative or indicative samples are obtained for testing by an accredited laboratory. The aim is to determine (with a degree of confidence appropriate to the objectives), the presence, concentration and distribution of contaminants in respect of those points investigated. The extent of any necessary intrusive investigation will depend on the size of the site and any hazards, either known or suspected.

5. **ASSESSMENT OF CONTAMINATION.** The assessment of contaminated land under the terms of Part II A of the Environmental Protection Act 1990 is based upon pollution linkage (source - pathway - receptor model) and the principles of the Environment Agency's "Contamination Land Risk Management" documentation.

DEFRA previously issued "Outcome of the Way Forward Exercise on Soil Guideline Values". This document was intended to provide guidance to determine if there is a Significant Possibility of Significant Harm (SPOSH) i.e. whether land meets the legal trigger of being contaminated land.

In the context of Part 2A, a risk assessor using an SGV would conclude the following (DEFRA, 2008).

- At a representative average soil concentration at or below an SGV, it is very unlikely that there will be a *significant possibility of significant harm (SPOSH)*.

- At a representative average soil concentration above an SGV, there *might* be a *significant possibility of significant harm* with the significance linked to the margin of exceedance, the duration and frequency of exposure, and other site-specific factors that the enforcing authority may wish to take into account. Further investigation and/or detailed evaluation will usually be required.

It should be stressed that where there is any uncertainty as to whether or not there is a SPOSH, it was the policy of this practice to adopt a conservative approach, particularly in the adoption of clean cover systems.

In April 2012, Defra both published new Statutory Guidance which forms a major part of their contaminated land regimes under Part 2A of the Environment Protection Act 1990. The regime provides a means of dealing with contaminated land which poses a significant risk to human health or the environment where there is no alternative solution. It also works alongside planning rules and building regulations to help ensure that affected land is made suitable for use when it is redeveloped.

Since the regime was introduced in 2000 there has been considerable uncertainty over how to decide when land is, and is not contaminated land on grounds of the legal test of *significant possibility of significant harm to human health or the environment*.

To help address this, one of the main changes set out in the new Statutory Guidance, is the introduction of a new four category test to help decide when land is, and is not, contaminated land on grounds of *significant possibility of significant harm to human health*. Under the new four category test:

- Category 1 describes land that is clearly contaminated land, for example because similar land is known to have caused significant harm in the past.

- Categories 2 and 3 cover less straightforward land where more detailed consideration is needed before the regulator can decide either: (a) that there is a strong case for regulatory action, in which case the land would be in Category 2 and be classified as contaminated land under Part 2A; or (b) that such a case does not exist, in which case the land would be in Category 3 and not be classified as contaminated land under Part 2A.

- Category 4 describes land that is clearly not contaminated land, as discussed below.

One of the main purposes of including the Categories in the Statutory Guidance is to provide a legal framework against which new technical tools can be developed by the land contamination sector to describe the Categories in more detail with regard to specific substances and/or situations.

The new Category 4 test is particularly important in terms of reducing uncertainty over when land is definitely not caught by the regime.

The new Statutory Guidance makes clear what land should be placed into Category 4, for example:

(a) Land where no relevant contaminant linkage has been established.

(b) Land where there are only normal levels of contaminants in soil (as explained in Section 3 of the guidance), unless there is a particular reason to consider otherwise. In other words land with normal background concentrations in the soil.

(c) Land that has been excluded from the need for further inspection and assessment under Part 2A because contaminant levels do not exceed relevant generic assessment criteria in accordance with Section 3 of the guidance, or relevant technical tools or advice that may be developed in accordance with paragraph 3.30 of the guidance, e.g. Category 4 Screening Levels.

(d) Land where estimated levels of exposure to contaminants in soil are likely to form only a small proportion of what a receptor might be exposed to anyway through other sources of environmental exposure (e.g. in relation to average estimated national levels of exposure to substances commonly found in the environment, to which receptors are likely to be exposed to in the normal course of their lives).

The guidance clarifies how generic assessment criteria (including the currently available SGVs/GACs) should and should not be used. It states that:

3.27 It is common practice in contaminated land risk assessment to use "generic assessment criteria" (GACs) as screening tools in generic quantitative human health risk assessment to help assessors decide when land can be excluded from the need for further inspection and assessment, or when further work may be warranted.

3.28 Local authorities may use GACs and other technical tools to inform certain decisions under the Part 2A regime, provided: (i) they understand how they were derived and how they can be used appropriately; (ii) they have been produced in an objective, scientifically robust and expert manner by reputable organizations; and (iii) they are only used in a manner that is in accordance with Part 2A and this Guidance.

3.29 GACs relating to human health risk assessment represent cautious estimates of levels of contaminants in soil at which there is considered to be no risk to health or, at most, a minimal risk to health. With regard to such GACs:

(a) They may be used to indicate when land is very unlikely to pose a significant possibility of significant harm to human health. This is on the basis that they are designed to estimate levels of contamination at which risks are likely to be negligible or minimal and far from posing a significant possibility of significant harm to human health.

(b) They should not be used as direct indicators of whether a significant possibility of significant harm to human health may exist. Also, the local authority should not view the degree by which GACs are exceeded (in itself) as being particularly relevant to this consideration, given that the degree of risk posed by land would normally depend on many factors other than simply the amount of contaminants in soil.

(c) They should not be seen as screening levels which describe the boundary between Categories 3 and 4 in terms of Section 4 (i.e. the two Categories in which land would not be contaminated land on grounds of risks to human health). In the very large majority of cases, these SGVs/GACs describe levels of contamination from which risks should be considered to be comfortably within Category 4.

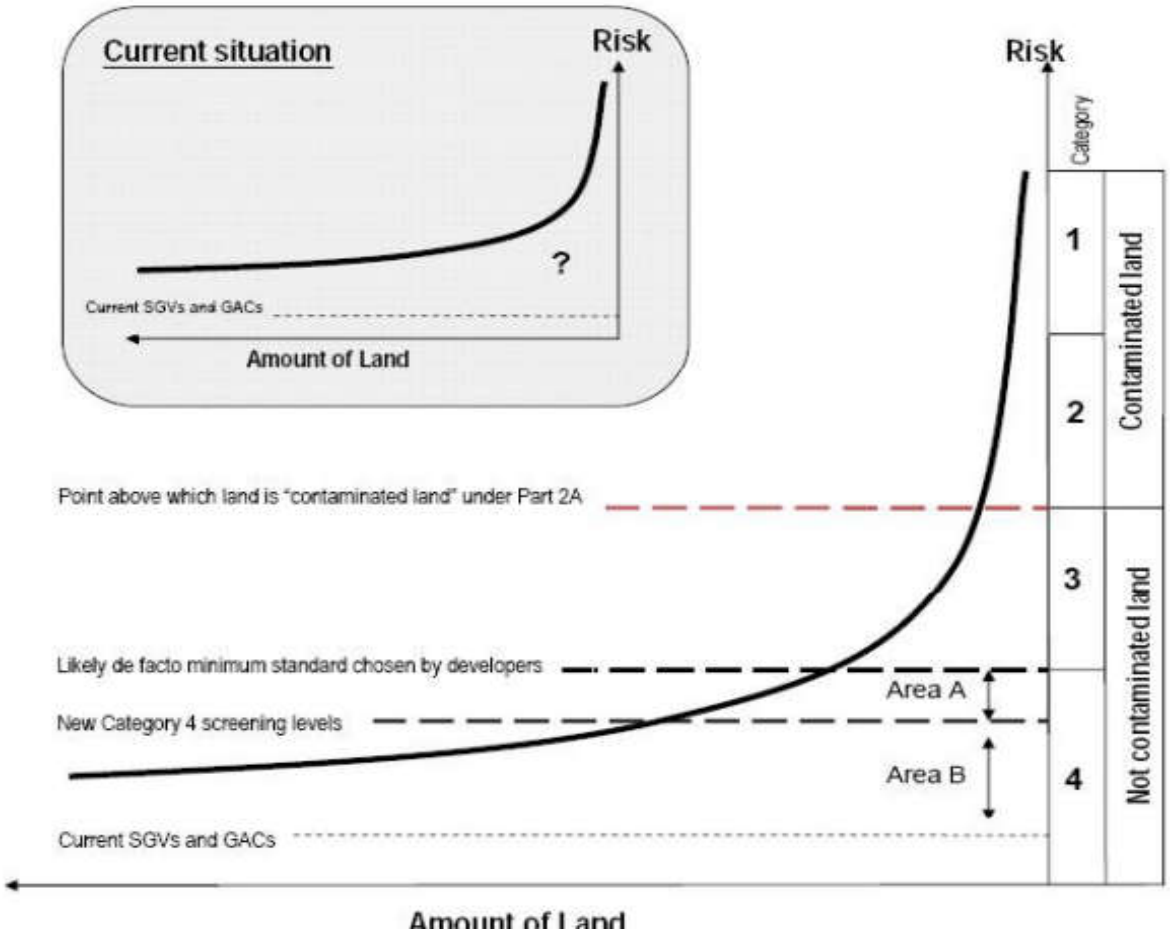
(d) They should not be viewed as indicators of levels of contamination above which detailed risk assessment would automatically be required under Part 2A.

(e) They should not be used as generic remediation targets under the Part 2A regime. Nor should they be used in this way under the planning system, for example in relation to ensuring that land affected by contamination does not meet the Part 2A definition of contaminated land after it has been developed.

The way in which the new four category system is intended to operate and the place of the C4SLs within that system, was explained in detail in the Impact Assessment which accompanied the Statutory Guidance. Please note that although the detail of the Impact Assessment is included here to provide clarity on the job expected of C4SLs, the Statutory Guidance, itself, sets out the regime that needs to be delivered under Part 2A.

Paragraph 47 of the Impact Assessment describes the diagram in detail. Of particular relevance to this project is the description of the overall diagram (sub-paragraph a), description of category 4 (sub-paragraphs c (part iv) and h) and the description of how the monetised benefits of the new system will be realised (sub-paragraph h). These sub-paragraphs are reproduced below.

Diagram showing the new Category 1-4 system (compared to current situation)



The diagram above seeks to illustrate, in a simplified manner, broadly what the changes to the statutory guidance on significant possibility of significant harm to human health are intended to achieve. To explain:

(a) The curved line and axes illustrate the spectrum of risk presented by land contamination. The idea is to show that a very large amount of land is low risk, and only a small amount of land would pose sufficient risk to be contaminated land in the legal sense. The axes and lines in the diagrams are not to scale, and they have been compressed for the purposes of illustration (in reality the risks on Category 1 land would probably be orders of magnitude above Category 4 risks, and vastly more land would be in Category 4 compared to the other Categories).

(b) The smaller diagram summarizes the current situation. In the area below the SGV/GACs there is near certainty that land is not contaminated land, however, above the line there is increasing uncertainty. As explained above, currently remediation usually occurs to just below the SGV/GAC level because they are perceived as offering the only cast-iron guarantee of when land is definitely not contaminated land. Sometimes consultants are employed to justify remediating to levels above the SGV/GACs, however the further they go away from the SGV/GACs the more legal risk they and their clients are exposed to.

(c) The new statutory guidance will end the current situation, and it would not be legally possible e.g. for individual regulators to ignore the changes being made. For example, as explained above, the new statutory guidance will specifically say:

(i) that Part 2A cannot be used to force remediation to below a point where it ceases to be contaminated land in the legal sense i.e. the Category 2/3 border in terms of the diagram), although responsible parties can choose to go further;

(ii) that SGV/GACs cannot be used as one size fits all remediation thresholds under either Part 2A of the planning system;

(iii) that normal background levels of contamination are not caught by Part 2A; and

(iv) that SGV/GACs are well into Category 4, sometimes by only a few times and sometimes by orders of magnitude. These changes and others also provide the legal backing for the development e.g. of Category 4 screening levels, as discussed below.

(d) The new Category 1-4 system divides the spectrum of risk posed by contaminated land into four different categories, and the statutory guidance will explain how to decide when land falls into each Category. This is more sophisticated than the current statutory guidance, which in effect has only two categories (contaminated land or not) and does not explain how to decide which category land falls into. The new Category 1-4 system

reflects what assessors find when they investigate real sites i.e. some are clearly contaminated land (Category 1) ; some clearly are not (Category 4) and some are less-straightforward and need some level of detailed assessment before a decision can be taken as to whether or not they are contaminated land (Categories 2 and 3).

(e) In the case of Category 2 and 3 sites, the regulator will have flexibility to take decisions within the parameters set by the new Guidance. There would be less flexibility for Category 2 and 3 sites that clearly pose either a high or low risk. However, the regulator will have considerable flexibility for sites closer to the Category 2/3 border to judge which side of the border a site would fall (e.g. taking account of their understanding of the risks, uncertainties and the interests of the local community). These are often complex decisions which need to be taken case-by-case given the many factors involved.

(f) In the case of Categories 1 and 4 the regulator will have far less flexibility. For example, if a regulator claimed that a site matching the Category 1 description was not contaminated land, or that a site matching the Category 4 description was contaminated land, they would be acting directly against the statutory guidance which the Act requires that they follow, and decisions could be challenged (e.g. in a law court) with a high chance that the challenge would be successful. Among other things, the intention of doing this is to create far more legal certainty around when land is definitely not contaminated land in the legal sense. With the specific wording of the new statutory guidance, and the supporting tools such as the new Category 4 screening levels, it would be very difficult for a regulator e.g. to threaten landowners with the Part 2A regime, and if they tried to determine land as contaminated land they would be operating in direct opposition to the statutory guidance.

(g) In the many consultation meetings held in developing the Category 1-4 system, all the developers, landowners and consultants we spoke to were strongly of the view that they would want the ensure their land is safely within Category 4 (even though in theory they could remediate to a level within Category 3 and still satisfy Part 2A and planning rules). They would do this for various reasons, including the fact that the flexibility granted to regulators in Categories 2 and 3 means that the further into Category 3 a site gets, the greater the risk that the regulator might decide it is in Category 2. Also they would want to be in Category 4 for reasons of marketability, future proofing etc. So developers and others would have a strong incentive to seek the regulatory certainty of being safely within Category 4. Thus, as far as development taking place under the planning system is concerned, Category 3 would, in effect, normally be a buffer which provides added reassurance that development falling within Category 4 will not be caught by the Part 2A regime.

(h) The new statutory guidance will bring about a situation where the current SGV/GACs are replaced with more pragmatic (but still strongly precautionary) Category 4 screening levels (C4SLs) which will provide a higher simple test for deciding that land is suitable for use and definitely not contaminated land. Above the C4SLs, in Area A on the diagram, there will be much stronger legal backing for experts to use their judgement to make sensible and precautionary decisions on when land should be considered to be towards the top end of Category 4, without fear that land may be caught as contaminated land. This recognizes that the generic C4SLs will not be able to describe the Category 3/4 border itself because they are generic and would therefore have to err on the side of caution whilst a detailed site specific assessment would be able to push further by looking at specific circumstances relating to a specific site.

(i) The very large majority of the monetized benefits of the changes to the regime discussed in this Impact Assessment manifest themselves in Category 4, and in particular in Areas A and B on the diagram. The main effects of moving to the new system would include Low risk land falling within Area B (pre-development) on the diagram would no longer have to be remediated because it would fall below the new C4SLs. Similarly land which is in Area A pre-development would no longer need to be remediated if justified by a detailed site-specific assessment. For these sites the cost of remediation would be removed altogether. The cost of remediating land which is initially in Categories 3, 2 or 1 would fall because it would be remediated to the new C4SL levels (or somewhere within Area A if there has been a detailed assessment) rather than the SGV/GAC level. This will have the overall effect of reducing the cost of remediation, with the effect varying according to specific site circumstances, the type of remediation etc. Generally the cost of remediation would fall for many affected brownfield land sites. This would have the general effect of making such land more economically viable for development. It would also mean that some land that is not currently economically viable to develop becomes reduce pressure to develop Greenfield land in some cases. The C4SLs will also speed up regulatory decisions on the reuse of brownfield land by providing a simple remediation standard.

The C4SLs are intended as "*relevant technical tools*" (in relation to Paragraph 4.2.1(c)) provides to help local authorities and others when deciding to stop further assessment of a site, on the grounds that it falls within Category 4 (Human Health).

The Impact Assessment (IA), which accompanied the revised SG (Defra, 2012b) provides further information on the nature and potential role of the C4SLs. Paragraph 47(h) of the IA states that:

> *"The new statutory guidance with bring about a situation where the current SGVs/GACs are replaced with more pragmatic (but still strongly precautionary) Category 4 screening levels (C4SLs) which will provide a higher simple test for deciding that land is suitable for use and definitely not contaminated land".*

A key distinction between the Soil Guideline Values (SGVs) and the C4SLs is the level of risk that they describe. As described by the Environment Agency (2009a):

> *"SGVs are guidelines on the level of long-term human exposure to individual chemicals in soils that, unless stated otherwise, are tolerable or pose a minimal risk to human health".*

C4SLs, therefore, should not be viewed as "SPOSH levels" and they should not be used as a legal trigger for the determination of land under Part 2A.

CL:AIRE (Contaminated Land: Application in Real Environments) has published "*Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination*". In it a series of C4SLs were proposed as follows;

Analyte	Residential (with home grown produce) (mg/kg)	Residential (without home grown produce) (mg/kg)	Allotments (mg/kg)	Commercial (mg/kg)	POS (mg/kg)
Arsenic	37	40	49	640	79
Benzene	0.87	3.3	0.18	98	140
Benzo(a)Pyrene	5	5.3	5.7	77	10
Cadmium	22	150	3.9	410	880
Chromium (vi)	21	21	170	49	21
Lead	200	310	80	2300	630

Where C4SL's are not available, Generic Assessment Criteria have been used as follows;

6. GEOENVIRONMENTAL RISK ASSESSMENT

6.1 **Potential Hazard Sources.** Ground contamination can occur through several causes, particularly from historical use of the site and is often linked to the processes of waste disposal, underground storage, open storage, process pipework, leaks, spillages, tanks, site filling and various other reasons. The contamination can either arise from site sources or be the result of migration from other sources off site.

6.2 **Potential Migratory Pathways.** The primary pathways are considered to be laterally or vertically downward through underlying strata or upward to the ground surface. Such pathways also provide the potential for contaminants to migrate towards local watercourses and groundwater.

6.3 **Potential Targets At Risk.** Potential environmental liabilities related to current legislation associated with contaminated land with regard to existing ownership and redevelopment are summarised.

The probability of a hazard, linked with its consequences, can be used to assess risk in accordance with the tables below for use in decision making.

Consequence of Pollution Linkage

Severe	Damage to human health. Substantial pollution of controlled waters. Significant change in ecosystem population. Irreparable damage to property.
Moderate	Non-permanent damage to human health. Minor pollution of controlled waters. Change in ecosystem. Damage to property.
Mild	Short term health effects. Slight pollution of controlled waters. Slight effect on ecosystem. Minor repairable damage to property.
Near Zero	No noticeable effect on human health. No significant pollution to controlled waters. No measurable effect on ecosystem densities. Non-structural cosmetic damage to property.

Decision Making

Probability of a hazard and an associated linkage	**Consequences of a pollution linkage (hazard-pathway-target)**			
	Severe	Moderate	Mild	Near Zero
High	High	High	Medium/low	Negligible
Medium	High	Medium	Low	Negligible
Low	High/medium	Medium/low	Low	Negligible
Unlikely	High/medium/low	Medium/low	Low	Negligible

Final overall risk is based on an assessment of probability of a hazard and its consequences. Risk categories are shown shaded in the table above and defined below.

Risk	**Description**
High	Site probably or certainly unsuitable for present use or environmental setting. Contamination probably or certainly present and likely to have an unacceptable impact on key targets. Urgent action needed.
Medium/ Moderate	Site may not be suitable for present use or environmental setting. Contamination may be present, and likely to have unacceptable impact on key targets. Action may be needed on the medium term.
Low	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impacts on key targets. Action unlikely to be needed in present use.
Negligible	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impacts on key targets. No action needed while site remains in present use.

The review of the information from the exploratory investigation may be such that a decision is made that there is no need for further investigation. Alternatively, it may be necessary to carry out a further main investigation.

The Environment Agency has set out guidance as to the classification of waste arising from construction sites in its document "The Definition of Waste" dated April 2006. This document outlines how waste is to be handled

The following activities are not regarded as a waste management activity requiring licencing.

1) Construction activities carried out for the purpose of producing a suitably engineered soil e.g. lime stabilisation, vibro-replacement and piling.

2) Uncontaminated materials produced on site (including excavated soils and materials from demolition) which can be reused without further treatment. Examples include site regrading and footing excavations.

   These must be done in accordance with the Planning Permission. Demolition material must be used in accordance with the quality protocols for the production of aggregates from inert waste, subject to appropriate testing and the lack of any harmful constituents. Uses include pipe bedding, backfill and sub-base.

3) Contaminated soils can be moved on-site providing they do not require treatment or containment. There should be no risk to the environment i.e. non-leachable and in accordance with Planning Permission. Relevant activities can include site regarding and use of materials below clean cover systems, capping, buildings and hardstanding.

Where contaminated materials have to be placed in an engineered cell to prevent pollution, then this would be classed as landfilling and require PPC permits. Any material taken off site is considered to be waste. However, this is under review. If material is waste, then there is a duty of care including ensuring material is transported by a registered carrier. The destination of material leaving the site should be regularly checked and Waste Transfer Notes kept.

Clean Cover Systems

According to the Environment Agency's Remediation Position Statements of May 2006, the placement of a cover system using "clean" material is not treatment of waste. Consequently, no licensing/permitting position statements are applicable to this type of remediation. If the cover system uses 'waste materials' in its construction, waste management licensing exemption paragraph 9A may be applicable to its installation. If the installation of the proposed cover system does not meet the criteria for registration of this exemption, the activity may be regulated through a waste management site license.

7. WASTE ACCEPTANCE CRITERIA (WAC)

The main objective of the Landfill Directive is to prevent or reduce as far as possible the negative effects of landfilling waste on the environment and on human health. It is intended to reduce the disposal of waste materials to landfills and to encourage more sustainable approaches to dealing with wastes. It bans the landfill of liquids and certain solid wastes, introduces requirements for the treatment of wastes prior to landfill and provides for the classification of landfills as sites for inert, hazardous or non-hazardous waste and prohibits co-disposal.

It sets out procedures for waste acceptance at landfills and the types of waste for each class of landfill as specified by Waste Acceptance Criteria (WAC). The WAC are predominantly lists of "limit values" for certain parameters obtained from standard leaching tests of wastes going to landfills. WAC are set out in the Landfill Directive itself. Full details can be found in the Environment Agency document "Waste Classification – Guidance on the classification and Assessment of Waste " Technical Guidance WM3 - 2015

8. MAIN REFERENCES

British Standards	BS3882: 2015 British Standard Specification for Topsoil BS5930: 2015+A1:2020 British Standard Code of Practice for Site Investigations BS8485: 2015 British Standard Code of Practice for the design and protective measures from methane and carbon dioxide ground gases for new buildings BS10175: 2011+A2:2017 British Standard Code of Practice for the Investigation of Potentially Contaminated Sites
BRE	Radon: Guidance on protective measures for new dwellings, BR211, 2015 Protective measures for housing on gas-contaminated land, BR414, 2015 Cover systems for land regeneration, 2004 Concrete in aggressive ground. Special Digest SD1, 3rd Edition, 2005 Soakaway Design (DG365)
CIEH	The LQM / CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)
CIRIA	Assessing risks posed by hazardous ground gases to buildings, CIRIA C665 Asbestos in Soil and Made Ground: a guide to understanding and managing risks, CIRIAC733, 2014 Good Practice on the testing and verification of protection systems for buildings against hazardous ground gases. C735:2014
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This list is not intended to be exhaustive.

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