

**PONTEFRACT ROAD PRIMARY SCHOOL,
CUDWORTH**

**PHASE I/II
GEO-ENVIRONMENTAL INVESTIGATION
FOR
BARRATT SHEFFIELD**

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Executive Summary

This presents the salient points of the report and should not be referred to in isolation. All recommendations are subject to Regulatory Authority approval.

Site Location, Description & History	Location: The site is located at Pontefract Road Primary School, Cudworth, Barnsley, South Yorkshire at NGR 438980mE, 40920mN (approximate site centre). Description: The site occupies a roughly rectangular parcel of flat land, with an area of approximately 0.7ha (1.7 Acres). Access to the site is gained principally from Royston Road, whereby an area of hardstanding is given over to car parking/vehicular access. Adjacent to this, in the north-west corner, is a walled garden area with turf and planted borders. The main school building occupies the eastern half of the site and is built from brick. Tarmac hardstanding covers all remaining areas, with the exception of narrow planted borders which run along the eastern boundary. A number of trees are present in these areas. Adjacent to the western boundary is a smaller building, although at this stage its use is unknown. Children's play equipment is present in a couple of the yard areas. The boundaries of the site are marked by brick walling, beyond which lies Pontefract Road to the east, Royston Road to the west, School Street to the north and a residential properties (at a lower elevation) to the south. History: Historical Ordnance Survey plans dating back to 1893 indicate the site to be open agricultural land with field boundaries in the north. Some roads are shown to bound the east and west, with surrounding land being of similar land-use. From 1917 the school is shown to have been constructed (two buildings within the footprint of the existing main building). Residential development, which began around 1910, has continued to the north and south of site, with a working men's club being constructed to the east, beyond Pontefract Road. Additional school buildings were constructed around 1961, including one in an area in the north-west of site. Further development has occurred adjacent to the site. Additional buildings along the western boundary are shown between 1977 and 1982, although there are no significant off-site changes. Some of the buildings are shown to have been removed on the 1993 OS plan, including one in the north-west, being replaced possibly by a play area. No significant changes off-site are shown, but increasing 'urbanisation' in the area has occurred generally.
Geology, Mining & Ground Stability, Hydrogeology and Hydrology	Geology, Mining & Ground Stability: The site is shown on geological map sheet 87, Barnsley, Solid Edition (1:50,000 scale) to be underlain by sandstone (Mexborough Rock) of the Upper Carboniferous (Middle Coal Measures). The solid strata are indicated to dip towards the east/north-east. No drift deposits are shown to be present at the site.

	Information given in the Coal Authority mining report indicates that the site lies within the likely zone of influence from workings in seven seams of coal at 290m to 720m bgl, the last date of working being 1968. On the basis of available information, risk from shallow mine workings is not anticipated. On the basis of available information, there appears to be no evidence of quarries on, or within the vicinity of the site. There are no known faults, or other lines of weakness, shown to be on, or within the vicinity of the site. Hydrogeology: The site is shown on the groundwater vulnerability map for the area (Sheet 11, South Pennines, 1:100,000 scale) to be situated on a minor aquifer, with overlying soils of high leaching potential. Hydrology: The nearest surface watercourse is Shafton Beck, which is located approximately 620m to the east of the site. Information presented in the Envirocheck report indicates that water at this location has been given a general quality assessment (GQA) river water grade of E (poor).
Environmental Data Summary	Waste Management: On the basis of available information, there appears to be one historic landfill/BGS recorded landfill at a quarry located on Weetshaw Lane, Cudworth (approximately 390m north of the site). The license for the site, which accepts inert and commercial wastes, is held by Scolah-Stothard & Co. Ltd. The current status of the site is not known. The site and its proximity are however unlikely to have affected the site, or present a risk to future development. Pollution Incidents: There are two reported pollution incidents associated with controlled waters within 500m of the site. Both incidents were classed as being Category 3 (minor), involving the release of oils and sewage/storm overflow. These incidents are unlikely to have affected the site, or present a risk to future development. Discharge Consents: Information given in the Envirocheck report indicates that there is one discharge consent within 500m of the site for the discharge of treated effluent to land/soakaway. This discharge is unlikely to have affected the site, or present a risk to future development. Radon: Information given in the Envirocheck report indicates that the site lies within an area where basic radon precautions are required in the construction of new dwellings and extensions. Water Abstractions: There are no water abstractions within 500m of the site. Ecology: At the time of the works no evidence of Japanese Knotweed or other invasive plants was observed. However, it may be prudent to have an ecological survey of the site carried out.
Geotechnical Assessment	Made Ground: is present across the whole site and comprises tarmac / hardcore overlying a reworked mixed natural clayey / granular soil (weathered sandstone). There are possibly some anthropogenic soils (i.e. containing ash) within the made ground horizon. The depth of made ground is to between about 0.3m to 0.8m (possibly up to 2.7m in WS3), but limitations of the window

	sampling method should be noted. It is possible there are basements associated with existing buildings. Natural strata: comprises residual Coal Measures soils derived from the underlying sandstone. These have been found to be clayey in part. Geotechnical testing indicates however that the natural soils are unshrinkable. Sandstone bedrock was encountered at depths between about 0.6m and 2.7m bgl.
Environmental Assessment	No evidence of significant potential contamination was observed during the ground investigation. However, on the basis of the chemical test results and risk assessment, the principal potential risk to future end-users at the site appears to be from arsenic. An Upper Bound Value (95% confidence) of 21.58mg/kg has been calculated, which marginally exceeds the SGV of 20.00mg/kg. PAH concentrations were typically less than laboratory detection limits. No concentrations in excess of Abatech's Tier 2 non-validated Soil Screening Values were identified following completion of the risk assessment. There may be localised fuel impact in areas associated with former/existing boilers. No access was possible in these areas to assess potential impact. Asbestos containing materials may be present inside buildings/fittings as well as in exterior superstructures. Ecology: At the time of the works no evidence of Japanese Knotweed or other invasive plants was observed. However, it may be prudent to have a full ecological survey of the site carried out.
Development & Construction Proposals	Enabling Works/Ground Treatment: The site is mostly covered with concrete or tarmac hardstanding. It may be possible to crush and re-use some on-site materials below car parking areas/hardstanding (subject to planning layout), but it may be that much of the demolition material will require removal from site. Some of the stone in the school buildings could also be recycled. Services have been located, although it is possible that additional old foundations / substructures / underground fuel storage tanks may also be present. Further localised excavations will be required during enabling/demolition to check for additional old foundations and substructures associated with former development at the site. Site clearance works will need to be integrated with the removal / infilling of any basements, foundations and other obstructions associated with previous development at the site and any areas requiring remediation. Foundations: On the basis of the site investigation, it is considered that strip/trench fill foundations will be suitable. These will need to be taken through the overlying made ground soils into the underlying weathered sandstone strata. The minimum founding depth on competent sandstone should be 600mm. Should clay soils be encountered, the minimum founding depth should be assumed to be 900mm (see <i>Precautions Near Trees</i> below). Deepening of the footings may be needed where loose or soft ground is encountered. At this

stage, deepened foundations may be required on approximately 50% of the site. Confirmation would be given following completion of a plot specific foundation schedule.

There may be deeper areas of made ground, possibly to in excess of 2m bgl, being associated with existing and/or former development. Further assessment of foundation options may be required should deep(er) areas of made ground be encountered.

Where foundations straddle clay/sand or sandstone they will need to be thickened and reinforced. A plot specific foundation schedule will need to be completed.

Slope Stability: No significant issues are anticipated.

Precautions Near Trees: On the basis of current geotechnical test results and the depth of sandstone bedrock, it is considered that no precautions will be needed where houses are constructed near trees. However, should clayey soils be encountered at founding depth during construction works, further testing would be needed to assess the requirement for heave precautions. Specific foundation details would be given following receipt of the test results.

Floor Slabs: Suspended floor slabs should be assumed.

Sulphate Precautions: In accordance with BRE Special Digest 1 (2005), it is considered that Class DS1/ACEC-AC1s conditions may be assumed.

Road Construction: At this stage a CBR of between 4% and 5% at road formation may generally be assumed for pavement design on the underlying natural soils. A CBR of 1% should be assumed on all made ground materials. This would be subject to *in situ* testing (where required) and Local Authority approval prior to finalising design.

Potable Water Supply: Given the elevated concentrations of arsenic, it is anticipated that precautions may be required where made ground is present. Confirmation should be sought from the local water authority regarding the need for any protective measures they may require.

Ground Gas Precautions: No methane has been identified, although, carbon dioxide levels up to 3.6% have been measured in boreholes drilled at the site. Ground gas precautions comprising a Visqueen type 'CO₂ Barrier' (being taped and sealed across all service entries and cavity walls) will therefore be required in conjunction with passive ventilation. The design will need to be confirmed with the NHBC/Local Building Control.

Radon: Basic radon precautions are required in the construction of new dwellings or extensions. The design will need to be confirmed with the NHBC/Local Building Control where appropriate. The need for radon precautions will however be mitigated by the need for a CO₂ type barrier.

Soakaways and Site Drainage: It may be possible to use soakaways, if taken into fractured sandstone at depth. However, infiltration would be likely to rely on flow through fractures in the rock, which may vary in extent and frequency across the site. A combined chamber/trench network might be appropriate, subject to testing.

	All soakaway designs would be subject to Local Authority/Highways Authority approval prior to finalising the design. Groundwater: No groundwater or perched water was encountered during the ground investigation (water noted in gas monitoring installations is assumed to be due to rainfall percolation). Excavations: Localised instability of near surface soils may be encountered during excavation. Difficulties with deeper excavations, e.g. for services/soakaways, may also be encountered given the presence of relatively shallow rock. Where man entry is required, support must always be provided. Flooding: Information provided by the Environment Agency and Envirocheck indicates that the site lies in an area which is not at risk from flooding. Remediation & Environmental Management: On the basis of laboratory test results and risk assessment, it is considered that remediation will be required, given that elevated concentrations of arsenic have been identified. On this basis, capping to block the pathway for these contaminants is considered to be the most appropriate remedial option. Risk assessment has identified that a 100mm inert soil capping layer will need to be placed in areas of proposed soft landscaping and garden areas, with validation works being carried out to confirm the thickness of soils placed as part of the remediation. Proposed capping thicknesses given are subject to confirmation/discussion with the EHO. Any capping materials imported to site will need to be tested at source and confirmed as suitable in agreement with the NHBC/EHO prior to importation. Should contaminated soils be identified during redevelopment, further localised excavation/remediation may need to be carried out following risk assessment. Further sampling and testing will be needed. Where excavations to remediate contaminated soils are made, validation sampling will be carried out in agreement with the local authority. A validation report will need to be submitted to the EHO/NHBC following completion of the works. On the basis of the site investigation and laboratory test results, it is considered that risk to the wider environment (e.g. controlled water) is negligible. There is a limited source of topsoil at the site and importation will therefore be required. Any soils imported to site will need to be tested at source and confirmed as suitable in agreement with the EHO/NHBC.
Further Work	1. Noise and vibration assessments given the proximity of the site to Pontefract Road; 2. Plot specific foundation schedule; 3. Further geotechnical testing should clay soils be encountered at founding depth; 4. Ecological survey; 5. Remediation Method Statement to reflect the need for capping in garden areas/soft landscaping; 6. Type III (pre-demolition) asbestos survey of existing

	buildings; 7. Permeability testing to assess the suitability of soakaways.
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1.0 INTRODUCTION

1.1 Preamble

Abatech International Ltd. were appointed by Barratt Sheffield to undertake a Phase I/II Geo-Environmental investigation of land located at Pontefract Road Primary School, Cudworth, Barnsley.

1.2 Report Status

This report provides factual and interpretative geotechnical and environmental information, together with provisional construction proposals and recommendations, in relation to the proposed redevelopment of the site. The report has been prepared for the sole use and reliance of Barratt Sheffield.

1.3 Sources and Conditions

The findings and recommendations given in this investigation report are based on published information, a 'walkover', site investigation works carried on 12th May 2007 and subsequent laboratory testing. Return visits to carry out gas monitoring were carried out on 14th May and 21st May 2007.

Abatech International Ltd. accepts no responsibility for the reliability and authenticity of published information, or for reports prepared by third parties.

Whilst every effort has been made to carry out an intrusive investigation that enables a realistic and reliable characterisation of the geotechnical and environmental parameters, the possibility of significant variation in ground conditions existing between sampling locations cannot be discounted, given the history of the site.

Groundwater conditions reported herein are also based on observations made at the time of the investigation, but may be subject to variation because of seasonal fluctuation or other effects.

2.0 SITE LOCATION AND DESCRIPTION

2.1 Location

The site is located at Pontefract Road Primary School, Cudworth, Barnsley, South Yorkshire at NGR 438980mE, 40920mN (approximate site centre). The location of the site is shown on the appended site location plan (S7/028/001, Appendix I).

2.2 Description

The site occupies a roughly rectangular parcel of flat land, with an area of approximately 0.7ha (1.7 Acres).

Access to the site is gained principally from Royston Road, whereby an area of hardstanding is given over to car parking/vehicular access. Adjacent to this, in the north-west corner, is a walled garden area with turf and planted borders.

The main school building occupies the eastern half of the site and is built from brick. Tarmac hardstanding covers all remaining areas, with the exception of narrow planted borders which run along the eastern boundary. A number of trees are present in these areas. Adjacent to the western boundary is a smaller building, although at this stage its use is unknown. Children's play equipment is present in a couple of the yard areas.

The boundaries of the site are marked by brick walling, beyond which lies Pontefract Road to the east, Royston Road to the west, School Street to the north and a residential properties (at a lower elevation) to the south.

3.0 GEO-ENVIRONMENTAL SETTING

3.1 Geology, Hydrogeology, Hydrology and Mining

Table 3.1 – Geological Information

Superficial Deposits	No drift deposits are shown to be present at the site.
Solid Geology	The site is shown to be underlain by sandstone (Mexborough Rock) of the Upper Carboniferous (Middle Coal Measures). The solid strata are indicated to dip towards the east/north-east.
Discontinuities	There are no known faults, or other lines of weakness, shown to be on, or within the vicinity of the site.
Hydrogeology	The site is shown on the groundwater vulnerability map for the area (Sheet 11, South Pennines, 1:100,000 scale) to be situated on a minor aquifer, with overlying soils of high leaching potential.
Hydrology	The nearest surface watercourse is Shafton Beck, which is located approximately 620m to the east of the site. Information presented in the Envirocheck report indicates that water at this location has been given a general quality assessment (GQA) river water grade of E (poor).
Mining	Information given in the Coal Authority mining report indicates that the site lies within the likely zone of influence from workings in seven seams of coal at 290m to 720m bgl, the last date of working being 1968. On the basis of available information, risk from shallow mine workings is not anticipated. On the basis of available information, there appears to be no evidence of quarries on, or within the vicinity of the site.
Radon	Information given in the Envirocheck report indicates that the site lies within an area where basic radon precautions are required in the construction of new dwellings and extensions.

3.2 Environmental Data Search

The principal considerations of immediate relevance are given in the following table.

For a comprehensive list of environmental data, refer to Appendix II:

Table 3.2 - Environmental Data

Discharge Consents	Information given in the Envirocheck report indicates that there is one discharge consent within 500m of the site for the discharge of treated effluent to land/soakaway. This discharge is unlikely to have affected the site, or present a risk to future development.
Pollution Incidents to Controlled Waters	There are two reported pollution incidents associated with controlled waters within 500m of the site. Both incidents were classed as being Category 3 (minor), involving the release of oils and sewage/storm overflow. These incidents are unlikely to have affected the site, or present a risk to future development.
Water Abstractions	There are no water abstractions within 500m of the site.
Flooding	Information provided by the Environment Agency and Envirocheck indicates that the site lies in an area which is not at risk from flooding.
Landfill Sites, Waste Management / Transfer / Treatment and Disposal sites	On the basis of available information, there appears to be one historic landfill/BGS recorded landfill at a quarry located on Weetshaw Lane, Cudworth (approximately 390m north of the site). The license for the site, which accepts inert and commercial wastes, is held by Scoria-Stothard & Co. Ltd. The current status of the site is not known. The site and its proximity are however unlikely to have affected the site, or present a risk to future development.
Ecology	At the time of the works no evidence of Japanese Knotweed or other invasive plants was observed. However, it may be prudent to have an ecological survey of the site carried out.

4.0 HISTORY OF LAND USE

The following section provides an assessment of the site's historical land use, dating back to the first available OS plans. An assessment of the existing land use and that of the surrounding area is also given, along with information pertinent to the site's proposed redevelopment.

4.1 Historical Land Use

Historical Ordnance Survey plans dating back to 1893 indicate the site to be open agricultural land with field boundaries in the north. Some roads are shown to bound the east and west, with surrounding land being of similar land-use.

From 1917 the school is shown to have been constructed (two buildings within the footprint of the existing main building). Residential development, which began around 1910, has continued to the north and south of site, with a working men's club being constructed to the east, beyond Pontefract Road.

Additional school buildings were constructed around 1961, including one in an area in the north-west of site. Further development has occurred adjacent to the site. Additional buildings along the western boundary are shown between 1977 and 1982, although there are no significant off-site changes.

Some of the buildings are shown to have been removed on the 1993 OS plan, including one in the north-west, being replaced possibly by a play area. No significant changes off-site are shown, but increasing 'urbanisation' in the area has occurred generally.

4.2 Current Land Use

The site is currently occupied by Pontefract Road Primary School.

4.3 Proposed Land Use (Redevelopment)

On the basis of available information, it is proposed that residential houses of typical construction with private garden areas are to be constructed at the site. Surrounding land is to comprise soft landscaping with associated car parking.

5.0 PHASE I GEOTECHNICAL ASSESSMENT

5.1 Ground Conditions

5.1.1 Soils

Made ground materials of variable thickness and quality may be present at the site, having been used to level or raise the ground surface. On the basis of available information, the following potential sources of made ground have been identified:

- Materials derived from the demolition of former buildings/infrastructure;
- Locally sourced materials (including demolition and combustion residue) having been imported to level the site prior to construction of the existing school complex.

The underlying natural soils are anticipated to comprise a mixture of sand, sandy clay/clayey sand overlying shallow sandstone.

5.1.2 Groundwater

Shallow groundwater is not expected. The dewatering of excavations is not anticipated.

5.1.3 Stability Issues

Stability issues associated with historic coal mining activities are not expected. A copy of the coal mining report is presented in Appendix III.

Instability of near surface made ground soils are anticipated, particularly where these are deep.

6.0 PHASE I ENVIRONMENTAL ASSESSMENT

6.1 Phase I Conceptual Model

The following is based on desk study information and that gathered during the site 'walkover'.

6.1.1 Site Summary

The site has principally been used for educational purposes. Although no significant levels of contaminants harmful to human health are anticipated, elevated metals/metalloids and organics (e.g. arsenic and PAH) as well as anthropogenic materials (demolition soils) may be present. These contaminants have been found on sites of a similar nature.

On the basis of available information, no significant off-site sources of contamination are expected.

6.1.2 Tier 1 Risk Screening

The policy of the Environment Agency is to follow a tiered approach when assessing risk posed to human health from contaminated soils. Initially, this framework allows decisions to be informed by Tier 1 risk screening, which comprises the identification of potential contaminant sources, pathways and receptors (e.g. establishing pollutant linkages). A potential source is defined as, 'a contaminant, which is in, or under the land and has the potential to cause harm or to cause pollution of controlled waters'.

Although no significant levels of contaminants harmful to human health are anticipated, elevated metals/metalloids and organics (e.g. arsenic and PAH) as well as anthropogenic materials, may be present. Review of available desk study information has revealed the following preliminary potential on- and off-site contaminant sources (listed in Tables 6.1 and 6.2 below). Where possible, associated potential contaminants have been identified, with reference to the Environment Agency (EA) and the Department for Environment, Food and Rural Affairs (DEFRA) R & D Publication CLR8: Potential Contaminants for the Assessment of Land and the relevant Department of the Environment Industry Profiles. A list of potential pathways and receptors is given in Table 6.3.

On the basis of available information, no significant off-site sources of contamination are expected.

Table 6.1 - Potential On-site Sources of Contamination

Potential On-site Sources	Associated Potential Contaminants*	
	<i>Metals and inorganics (not limited to)</i>	<i>Organics (not limited to)</i>
Made ground materials of unknown origin having been used to infill and raise levels	Heavy metals and phytotoxic contaminants	Aromatic/Aliphatic Hydrocarbons, PAH
Historic Buildings (including construction / demolition materials in made ground)	Asbestos containing materials (including pipe lagging, roof and panel sheeting)	Hydrocarbons, PAH

* Tables 2.3 and 2.4 Defra and EA R&D Publication CLR 8: Potential Contaminants for the Assessment of Land.

Table 6.2 - Potential Off-site Sources of Contamination

Potential Off-site Sources	Associated Potential Contaminants*	
	<i>Metals and inorganics (not limited to)</i>	<i>Organics (not limited to)</i>
None anticipated	None anticipated	None anticipated

* Tables 2.3 and 2.4 Defra and EA R&D Publication CLR 8: Potential Contaminants for the Assessment of Land;

Table 6.3 - Potential Pathways and Receptors

Potential Pathways	Potential Receptors
Direct ingestion of soil and dust	Ground workers employed in the redevelopment of the site
Dermal contact with soil and dust	Future end users of the site
Inhalation of airborne contaminants	Neighbouring land users (part commercial, part residential)
Vertical and lateral migration of contaminants into controlled waters	Minor aquifer

A potential pollutant linkage is defined as 'the relationship between a contaminant, a pathway and a receptor' where the pollutant is the contaminant in the pollutant linkage. For land to be identified as contaminated under the current UK guidance all three elements of the pollutant linkage must be present. In many cases there may be more than one pollutant linkage on any given site.

A review of the desk study information, the features noted in the site walkover and the potential sources, pathways and receptors listed above has led to the following potential significant pollutant linkages (SPL) being considered (Table 6.4 below):

Table 6.4 - Potential Pollutant Linkages

Potential Source	Pathway	Receptors					SPL
		Controlled Waters	Ground workers	End-users	Flora	Building materials	
Metal/metalloids and inorganics in SOIL	Direct Ingestion		✓	✓			✓
	Dermal Contact		✓	✓			✓
	Inhalation		✓	✓			✓
	Leaching/direct movement	✓			✓	✓	✓
Asbestos containing materials in SOIL	Inhalation		✓	✓			✓
Organics in SOIL (hydrocarbons) including ground gases	Direct Ingestion		✓	✓			✓
	Dermal Contact		✓	✓			✓
	Inhalation		✓	✓			✓
	Leaching/direct movement	✓			✓	✓	✓
Metal/metalloids and inorganics in GROUNDWATER	Direct Ingestion		✓				✓
	Dermal Contact	✓	✓				✓
	Inhalation						
	Leaching/direct movement	✓			✓	✓	✓
Organics in GROUNDWATER (hydrocarbons including PAH)	Direct Ingestion		✓				✓
	Dermal Contact	✓	✓				✓
	Inhalation						
	Leaching/direct movement	✓			✓	✓	✓

6.1.3 Model Status and Uncertainty

The potential significant linkages listed above are based on available data and the features noted during the 'walkover'. Therefore, the linkages identified are tentative in nature and are subject to the following uncertainties:

- Nature of any made ground and the underlying strata;
- Actual distribution of contaminants in soils;
- Actual distribution of contaminants in groundwater;
- Water levels below the site.

6.1.4 Radon

Basic radon protective measures are required in the construction of new dwellings and extensions at the site.

7.0 RATIONALE FOR PHASE II INVESTIGATION

7.1 Rationale for Phase II Works

On the basis of available Phase I desk study information, the following recommendations for intrusive site investigation works were proposed. These works were carried out to identify environmental and geotechnical liabilities in relation to the proposed redevelopment of the site:

- facilitate the collection of soil samples from across the site from within made ground and the underlying natural strata;
- assess the thickness and nature of any made ground materials at the site;
- assess the geotechnical properties of the made ground and underlying natural strata and the depth to competent strata;
- carry out gas monitoring to determine the presence and flow rate of methane and carbon dioxide.

7.2 Investigation Design

Site investigation works were designed in general accordance with the guidelines prescribed in BS 10175:2001 ('Investigation of Potentially Contaminated Sites: Code of Practice') and BS 5930:1999 ('Code of Practice for Site Investigations').

Window sampler boreholes (as shown on the appended drawing S7/028/002) were positioned on the basis of the desk study and walkover, being located wherever possible to obtain samples representative of the ground conditions and contamination status of the underlying soils. However, constraints were placed on the positions of the boreholes given the nature of the site (i.e. school playground) and the presence of active service conduits.

Given the layout of the site, the spacing between the investigation locations was approximately 20-30m. This spacing was considered adequate and consistent with the objectives of the investigation, given that the site is to be redeveloped for residential end-use.

7.3 Environmental

Typically, samples of soil were taken from the site on the basis of non-targeted sampling, although where potential contaminant sources were identified during

the desk study and/or where soils displayed obvious signs of olfactory and visual evidence of contamination, these were also sampled.

Samples were selected for analysis on the basis of visual and olfactory evidence. All samples were collected in snap-top plastic containers, unless samples were suspected of containing hydrocarbon or volatile compounds. In these instances samples were collected in 250ml amber glass jars or vials. All samples were placed in cooled containers prior to transfer to a UKAS / MCERTS accredited laboratory.

Samples taken from the made ground and the underlying natural strata were analysed for a range of metal/metalloid and organic contaminants in accordance with NHBC Standards Chapter 4.1 'Land Quality – Managing Ground Conditions' and CLR 8 'Potential Contaminants for the Assessment of Land'. As a minimum, soil samples were analysed for the following parameters: arsenic, cadmium, chromium(VI), lead, mercury, copper, nickel, zinc, boron, selenium, speciated polynuclear aromatic hydrocarbons (PAH), sulphide, sulphur, phenols, total and free cyanide, pH, water soluble sulphate and total organic carbon.

7.4 Geotechnical

The geotechnical investigation comprised the boring of cable tool boreholes to obtain further information on the depth and condition of the made ground at the site. A visual description of the soils was recorded as part of the investigation. *In-situ* SPTs were taken to determine the strength profile of the underlying soils.

Where the underlying natural strata comprised cohesive soils, samples were taken so that the shrinkability of the clay could be determined. The geotechnical testing was carried out in accordance with BS1377:1990 'Standard Methods of Test for Soils for Civil Engineering purposes'.

8.0 SITE WORKS

Limited site works were carried out on 12th May 2007 and comprised the following:

- Five window sample boreholes (WS1 – WS5).

The positions of the investigation locations are shown on the appended site investigation Plan (S7/028/002).

A copy of the investigation logs are presented in Appendices IV.

Ground gas monitoring was carried out between 14th and 21st May 2007. A copy of the monitoring data is given in Appendix V.

9.0 LABORATORY ANALYSIS AND TEST RESULTS

9.1 Laboratory Analyses

Environmental analyses were scheduled by Abatech and carried out by Chemtest, Newmarket. Samples of made ground and natural strata were collected and tested for metals, non-metal inorganics and organics in order to assess the degree and nature of contamination within the soil.

9.2 Summary of Laboratory Chemical Test Results

A summary of the test results is given in the following tables, whilst a copy of the individual test results (and supporting MCERTS certification from the laboratory) are presented in Appendix V. Risk assessment is discussed in Section 12.0 below, whilst data sheets are presented in Appendix VI.

Table 9.1 - Summary Table of Chemical Test Results (CLEA SGVs)

Contaminant	Measured Concentration		Tier 2 Soil Screening Value (mg/kg)*	No. of results exceeding criteria
	Min	Max		
Arsenic	5.2	28	20	2 (6)
Cadmium	<0.1	-	2 (pH of 7)	0 (6)
Chromium (VI)	<5	-	130	0 (6)
Lead (log)""	0.8	2.1	2.65	0 (6)
Mercury	<0.1	0.32	8	0 (6)
Nickel	8.3	20	50	0 (6)
Selenium	0.20	0.68	35	0 (6)
Phenol	<0.3	-	150	0 (6)

*Threshold criteria determined as the Soil Guideline Value (SGV) with reference to CLEA residential with plant uptake;

"" The geometric mean, rather than the arithmetic mean, is used as the basis for the comparison of soil concentration data with the Soil Guideline Value (450mg/kg). All calculations are therefore transposed to log (after SEGHS (1993) Lead in Soil: Recommended Guidelines, Wixson, BG and Davies, BE (eds.) Society for Environmental Geochemistry and Health, Science Reviews;

-Number of samples tested given in (brackets);

-All results given in mg/kg;

-Where < is given, this indicates that the result is less than the laboratory detection limit;

ND Not determined.

Table 9.2 - Summary Table of Chemical Test Results (PAH)

Contaminant	Measured Concentration		Tier 2 Soil Screening Value (mg/kg)*	No. of results exceeding Soil Screening Value
	Min	Max		
Naphthalene	<0.1	0.2	37	0 (6)
Acenaphthene	<0.1	-	317	0 (6)
Fluorene	<0.1	0.2	74	0 (6)
Anthracene	<0.1	0.7	17	0 (6)
Fluoranthene	<0.1	4.9	58	0 (6)
Pyrene	<0.1	3.9	280	0 (6)
Benz(a)anthracene	<0.1	1.6	5.8	0 (6)
Chrysene	<0.1	1.4	3.3	0 (6)
Benzo(b)fluoranthene	<0.1	0.7	6.4	0 (6)
Benzo(k)fluoranthene	<0.1	1.0	9.2	0 (6)
Benzo(a)pyrene	<0.1	1.0	1.1**	0 (6)
Dibenzo(a,h)anthracene	<0.1	-	1.3	0 (6)
Indeno(1,2,3-cd)pyrene	<0.1	0.3	10.4	0 (6)
Benzo(g,h,i)perylene	<0.1	0.3	36	0 (6)

*Tentative non-validated Tier 2 Soil Screening Values (SSV) assuming the presence of the most sensitive CLR receptor (female aged 0-6 years);

**Based on an assessment of TOX Report 2, Benzo(a)pyrene, April 2002 for residential with plant uptake;

-All results given in mg/kg;

-Number of samples tested given in (brackets);

-Where < is given, this indicates that the result is less than the laboratory detection limit.

10.0 PHASE II GEOTECHNICAL ASSESSMENT

10.1 Ground Conditions

10.1.1 Soils – Made Ground

Made ground is present across the whole site and comprises tarmac / hardcore overlying a reworked mixed natural clayey / granular soil (weathered sandstone). There are possibly some anthropogenic soils (i.e. containing ash) within the made ground horizon.

The depth of made ground is to between about 0.3m to 0.8m (possibly up to 2.7m in WS3), but limitations of the window sampling method should be noted. It is possible there are basements associated with existing buildings.

10.1.2 Soils – Natural Ground

Natural strata was found to comprise residual Coal Measures soils derived from the underlying sandstone. These have been found to be clayey in part. Geotechnical testing indicates however that the natural soils are unshrinkable. Sandstone bedrock was encountered at depths between about 0.6m and 2.7m bgl.

10.1.3 Stability

On the basis of existing geological and site investigation data, no stability issues or ground treatment is anticipated.

Localised instability of near surface soils is anticipated during excavation however. Where man entry is required, support must always be provided.

10.1.5 Groundwater

No groundwater or perched water was encountered during the ground investigation (water noted in gas monitoring installations is assumed to be due to rainfall percolation).

10.2 Contamination and Performance of Building Materials

10.2.1 Sulphate

In accordance with BRE Special Digest 1 (2005) therefore, it is considered that Class DS1/ACEC-AC1s conditions may be assumed.

10.2.2 Other Contaminants

On the basis of laboratory testing, the present chemical status of the on-site soils does not include significant quantities of any other substances that are likely to

be detrimental to the performance of building materials during their expected lifespan.

Given the elevated concentrations of arsenic, it is anticipated however that precautions may be required where made ground is present. Confirmation should be sought from the local water authority regarding the need for any protective measures they may require.

11.0 PHASE II ENVIRONMENTAL ASSESSMENT

11.1 Phase II Conceptual Model

11.1.1 History

Historical Ordnance Survey plans indicate the site to have been predominantly used for educational purposes.

11.1.2 Ground Conditions

A thin covering of ashy made ground soils have been identified at the site, being underlain by a zone of weathered sandstone. Competent bedrock was proven at shallow depth.

11.1.3 Anthropogenic Constituents of Made Ground

The origin of the made ground materials identified at the site is not known. However, on the basis of historical information, it is considered that they are most probably derived from local industry and/or demolition works. In summary, made ground materials at the site and the risk they pose, comprise:

Demolition materials: consisting of relatively inert materials such as brick. Due to the physical form, this is not considered to represent a significant risk to human health via exposure pathways;

Hydrocarbon containing materials: consisting of combustion residues and particulates (e.g. ash and cinder). These materials have been found to contain elevated concentrations of high molecular weight organics (C₁₆-C₃₅ aliphatic and aromatic hydrocarbons) at localised positions. Polynuclear aromatic hydrocarbon concentrations within the soils have been found to be below laboratory detection limits. Risk to human health is not considered to be significant.

11.1.4 Hydrogeology

The site is also situated above a minor aquifer.

On the basis of the ground investigation and current soil test results, risk to controlled waters from near surface and/or areas of deeper made ground soils is considered to be low.

12.0 RISK ASSESSMENT

12.1 Preamble

Current UK legislation on contaminated land is principally contained in Sections 78(A) to (YC) in Part IIA of the Environmental Protection Act 1990, which was retrospectively inserted by Section 57 of the Environment Act 1995. This legislation came into effect in April 2000 and is enacted by the Contaminated Land (England) Regulations 2000.

The legislation adopts the principle of a 'suitable for use' approach for the assessment of contaminated land, the rationale reflected in the site-specific risk assessment and determination of remedial strategy. Action is only required if unacceptable risks are posed to human health or to the environment, taking into account the current land-use and geo-environmental setting.

The legislation places a responsibility on the Local Authority to determine whether the land under its jurisdiction is contaminated by consideration of whether:

- ***Significant harm is being caused;***
- ***There is a significant possibility of significant harm being caused;***
- ***Significant pollution of controlled waters is being caused or is likely to be caused.***

The statutory guidance describes a risk assessment methodology in terms of 'significant pollutants' and 'pollutant linkages', using SOURCE-PATHWAY-RECEPTOR' scenarios for the site.

On the basis of the available data and associated guidance (e.g. DEFRA, EA and USEPA), the site's geo-environmental setting and proposed end-use, qualitative and quantitative risk assessments have been carried out.

12.2 Tier 2 Risk Screening (Soil)

In accordance with CLEA guidance (DEFRA and EA, R&D Publication CLR 7, 2002) soil analysis results were subject to quantitative statistical analysis to assess soil contamination issues at the site. Where possible, the Contaminated Land Exposure Assessment (CLEA) guidelines have been used to assess risk posed to human health where Soil Guideline Values (SGVs) have been derived. Where no suitable generic assessment criteria (e.g. DEFRA and Environment Agency published Soil Guideline Values) are currently available, in-house Tier 2 assessment values for individual PAH species and TPH (carbon bands C₅-C₃₅) have been calculated.

Abatech's in-house Tier 2 values were derived using the Defra/EA CLEA UK (Beta) model released in November 2005, which was developed to allow, where necessary, generic assessment criteria to be calculated. The generic simulation mode of the model was used to derive Tier 2 values given in Tables 12.2 and 12.3 below.

12.2.1 Input Parameters & Methodology

In-house generic assessment values have been calculated for contaminants not covered by existing CLEA Soil Guideline Values. A summary of the physico-chemical input parameters is presented in Appendix VI.

12.3 Statistical Analysis

Statistical analysis provides more accurate results the greater the data set available. The statistics have been designed to review an entire data set, as opposed to comparing individual results to a given SGV. The CLEA statistical methodology produces two key outputs:

- The Mean Value Test compares the Soil Guideline Value (SGV) with the Upper Bound Value (US_{95}) of the mean measured concentration. Where the mean value test is applied and the Upper Bound Value is less than the SGV, then it may be considered that the mean value test has been passed and that the site requires no further action. Conversely, if the test is failed, further sampling, analysis, assessment and possibly remediation may be required, subject to the local authority considering the benefits of undertaking such work in relation to the risk posed to human health;
- The Maximum Value Test (7) is applied to a set of data to calculate an Outlier Critical Value (OCV). This enables an assessment to be made as to whether the highest value(s) in a dataset belong(s) to the general 'population', or whether they represent a statistical outlier, e.g. a 'hotspot', or an area of elevated contamination that has not been identified. Caution should however be applied to the output of the maximum value test, since if the test is passed it merely indicates that the maximum value is reasonably consistent with the distribution of other contaminants in the data set. The following tables summarise the statistical analysis for the samples taken.

Table 12.1 – Summary Table of CLEA Statistical Analysis

Determinand	No. of samples analysed	Upper Bound Value (UBV) (mg/kg)	Soil Guideline Value (SGV) (mg/kg)*	Is UBV greater than SGV?	Outlier Critical Value (T)	10% Value^
Metals						
Arsenic	6	21.58	20	yes	1.20	1.73
Cadmium	6	0.10	2	no	-	1.73
Mercury	6	0.23	8	no	1.64	1.73
Nickel	6	19.22	50	no	0.88	1.73
Lead	6	1.92	2.65	no	1.00	1.73
Chromium (VI)	6	5.00	130	no	-	1.73
Selenium	6	0.54	35	no	1.40	1.73
Phenol	6	0.30	150	no	0.00	1.73

*Threshold criteria determined as the Soil Guideline Value (SGV), with reference to CLEA residential with plant uptake;

^10% value (Tcrit) adopted from CLEA report CLR7 (EA, 2002), since this value is regarded to be the most stringent (i.e. health protective), in the context of contaminated land and the inclusion of potential outlier values in the data-set.

Table 12.2 - Summary Table of Statistical Analysis (PAH)

Determinand	No. of samples analysed	Upper Bound Value (UBV) (mg/kg)	Tier 2 Soil Screening Value (SSV) (mg/kg)*	Is UBV greater than Tier 2 SSV?	Outlier Critical Value (T)	10% Value^
Naphthalene	6	0.15	37	no	2.04	1.73
Acenaphthene	6	0.10	317	no	-	1.73
Fluorene	6	0.15	74	no	2.04	1.73
Anthracene	6	0.43	17	no	1.73	1.73
Fluoranthene	6	3.02	58	no	1.31	1.73
Pyrene	6	2.45	280	no	1.28	1.73
Benz(a)anthracene	6	1.00	5.8	no	1.48	1.73
Chrysene	6	0.87	3.3	no	1.53	1.73
Benzo(b)fluoranthene	6	0.49	6.4	no	1.40	1.73
Benzo(k)fluoranthene	6	0.67	9.2	no	1.40	1.73
Benzo(a)pyrene	6	0.60	1.1*	no	1.70	1.73
Dibenzo(a,h)anthracene	6	0.10	1.3	no	-	1.73
Indeno(1,2,3-cd)pyrene	6	0.22	10.4	no	1.67	1.73
Benzo(g,h,i)perylene	6	0.22	36	no	1.67	1.73

*Tentative non-validated Tier 2 Soil Screening Values (SSV) assuming the presence of the most sensitive CLR receptor (female aged 0-6 years);

^10% value (Tcrit) adopted from CLEA report CLR7 (EA, 2002), since this value is regarded to be the most stringent (i.e. health protective), in the context of contaminated land and the inclusion of potential outlier values in the data-set;

**Based on an assessment of TOX Report 2, Benzo(a)pyrene, April 2002.

12.4 Contamination Sources

Soil

On the basis of laboratory test results and risk assessment it appears that, with the exception of arsenic, there are no elevated concentrations of 'general' contaminants of concern at the site. Although no significant evidence of potential contamination was observed during the ground investigation, there may be a potential limited risk to future end-users. In summary, the following can be concluded:

Arsenic: An Upper Bound Value (95% confidence) of 21.58mg/kg has been calculated. Soil concentrations, on a site-wide basis, ranged between 3.3mg/kg and 28.0mg/kg.

Following completion of the laboratory testing and data analysis the following Source-Pathway-Receptor risk assessment table has been derived.

Table 12.4 - Risk Assessment Summary Table

SOURCE*	PATHWAY	TARGET (RECEPTOR)	COMMENTS	RISK LEVEL	ACTION
Metals/ Metalloids In soils	Direct Ingestion (active) Inhalation (passive)	Site users	End use is residential with private gardens and soft landscaping	LOW to MODERATE	No elevated 'general' contaminant concentrations identified other than arsenic. Inert soil capping in gardens and soft landscaping. (see 'Options Appraisal' below)
Metals/ Metalloids In Soils	Topsoil in landscaped borders	Vegetation	As above	LOW to MODERATE	No elevated 'general' contaminant concentrations identified other than arsenic. Inert soil capping in gardens and soft landscaping. (see 'Options Appraisal' below)
Organic Compounds In Soils	As above (plus skin contact)	Site users	Mainly a short- term exposure risk to ground workers, but may present longer-term risk to end-users at the site	LOW	No elevated PAH concentrations identified.
Leachate Burden (overall)	Sub-strata (beneath and adjacent site)	Groundwater/ Surface water	Potential for contaminants to migrate	LOW	Near surface soils overlie a minor aquifer. No groundwater present

Table Contd'

Radon and other ground gases	Subsurface soils/strata via services and buildings	Site users	Potential for migration into properties	LOW to MODERATE	Basic radon precautions required (mitigated by need for CO2 precautions however)
Japanese Knotweed	Spread in contaminated soils	Environment/ Structures/ Roads	Potential for on/off-site migration if not treated properly	LOW	None identified at the time of site investigation works – ecological survey required

Notes:

LOW / MODERATE / HIGH - Risk level is assigned a low/moderate/high qualitative value, based on assessment requirement for action in context of Part II EPA 1990;

* Including anthropogenic materials where identified.

12.5 Options Appraisal

12.5.1 Preamble

On the basis of laboratory soils testing and risk assessment above, it is considered that arsenic in the made ground soils may present an unacceptable risk to human health at the site given the pollutant linkages that exist. Those linkages given above comprise all risks identified at the site, being established either at the time of the Phase I study (e.g. the requirement for radon protective measures), or following completion of site works/laboratory testing (e.g. measures protective of human health for contaminated soils).

12.5.2 Options Appraisal (Overview)

In accordance with guidelines presented in the Contaminated Land Report (CLR) 11, Model Procedures for Management of Land Contamination (Environment Agency, September 2004), the following options appraisal has been carried out to determine the most effective method of managing the site and the identified pollutant linkages given above. As defined in Chapter 3 of CLR11:

"... there may be a number of ways to reduce or control unacceptable risks, all of which have advantages and limitations in any particular case. The role of options appraisal is to establish, taking all the circumstances of the site into account, which options (either singularly or in combination) offer the best overall approach to remediation for the site as a whole." (Environment Agency, 2004)

12.5.3 Remediation Objectives

As defined in CLR 11, there are a number of objectives that the remediation strategy needs to achieve. In this instance, the following pertinent objectives that relate to the reduction/control of the risks associated with one or more of the linkages, have been identified:

Table 12.5 - Remediation Objectives

Objectives:	Reasons:
1. The degree to which risks need to be reduced/controlled	To ensure protection of human health.
2. Practicability of implementing and, where needed, maintaining the strategy	To ensure remediation can be carried out effectively.
3. Technical effectiveness of the strategy in reducing identified risks	To ensure remediation methods employed are suitable for identified risks.
4. Cost effectiveness	To ensure financial viability in terms of risk posed by identified contaminant(s).
5. Compliance	To ensure remediation complies with current legislation.

12.5.4 Remediation Options

The following section identifies remediation options that could be utilised to effectively manage the identified pollutant linkages, given that the site is to be redeveloped for residential end-use with gardens and areas of soft-landscaping.

In determining the most effective remediation option(s) for a site, consideration needs to be given to a number of techniques, stating (where appropriate) the suitability and limitations of each chosen method. On the basis of the identified pollutant linkages and remediation objectives, the following options have been considered.

Table 12.6 - Remediation Options (Assessment)

Contaminant Source	Metals/ Organics in Soil (including PAH)	Metals/ Metalloids in Soil (i.e. Arsenic)	Organic Compounds in Soil (i.e. PAH)	Organic Compounds in Soil (i.e. TPH)	Ground Gases (i.e. CH ₄ and/or CO ₂)	Radon
Pollutant Linkage	Plant uptake by vegetation	Direct ingestion/ inhalation by end users	Direct ingestion/ inhalation by end users inc skin contact	Direct ingestion/ Inhalation by end users inc skin contact	Migration into properties	Migration into properties
Remediation Options						
Excavation with Disposal	Inherent arsenic contamination in made ground soils. Removal of all soils would be required. Not practicable or cost effective	Inherent arsenic contamination in made ground soils. Removal of all soils would be required. Not practicable or cost effective	No elevated contaminant concentrations identified	Subject to sampling and risk assessment should contamination be identified during redevelopment. Localised excavation with validation where needed	NA	NA
In-situ or Ex-situ Treatment	Not practicable or cost effective	Not practicable or cost effective	Not practicable or cost effective	Not practicable or cost effective	NA	NA

Table Cont'd...

On-site burial	Made ground materials to be covered with hardstanding/placed beneath buildings where possible	Made ground materials to be covered with hardstanding/ placed beneath buildings where possible	Made ground materials to be covered with hardstanding/ placed beneath buildings where possible	Made ground materials to be covered with hardstanding/placed beneath buildings where possible	NA	NA
Capping	Capping comprising 100mm clean inert soil (including topsoil) in areas of garden and soft landscaping	Capping comprising 100mm clean inert soil (including topsoil) in areas of garden and soft landscaping	NA	NA at this stage	NA	NA
Membrane	NA	NA	NA	NA	Visqueen 'CO ₂ Barrier' membrane or similar with passive ventilation. Design to be agreed with NHBC and/or Building Control prior to development	Basic precautions required
Justification	Arsenic contamination is present in made ground soils. Removal of soils from site is not practicable. Therefore a capping system will be required in gardens and soft landscaping	Arsenic contamination is present in made ground soils. Removal of soils from site is not practicable. Therefore a capping system will be required in gardens and soft landscaping	None identified, although capping would assist further in the long-term protection of human health	Carry out further risk assessment prior to remediation (if/where required). Validation to assess residual contaminant concentrations. Capping for metals/metalloids and PAH contamination would assist further in the long-term protection of human health	Only physical means of preventing gas migration into properties	Only physical means of preventing radon gas migration into properties

NA – Not applicable

Following completion of the options assessment, it is considered that the most effective remedial technique to address the contamination risks posed by arsenic impacted soils is to utilise a capping system. Risk assessment using the RSK/ENSR/NHBC (2004) software (Cover Systems for Land Regeneration), coupled with the mean value testing carried out in accordance with Appendix A, CLR 7, indicates that a capping thickness up to 100mm would be required on the basis of the identified contamination. Validation to check the thickness of capping soils placed in gardens and soft landscaped areas will be required.

Where currently unforeseen areas of generally contaminated soils or hydrocarbon contaminated soils are encountered during development, it is considered that the need for the excavation of soils would however be subject to results of further risk assessment. Further sampling and testing would be required. Where excavated soils impacted with hydrocarbons will need to be removed from site, validation testing to assess residual contaminant concentrations will be required.

In the short-term, risk to construction workers is considered to be the only risk where additional protective measures will be required. In this instance, site hygiene precautions, such as washing hands before eating, should be followed, together with appropriate PPE.

A summary of the most appropriate remediation option(s), for each relevant pollution linkage, is given in the following table.

Table 12.7 – Summary of Remediation Options (Most Appropriate)

Contaminant Source	Metals/ Organics in Soil (including PAH/TPH)	Metals/ Metalloids in Soil (e.g. Arsenic)	Organic Compounds in Soil (i.e. PAH)	Organic Compounds in Soil (i.e. TPH)	Ground Gases	Radon
Pollutant Linkage	Plant uptake by vegetation	Direct ingestion/inhalation by end users	Direct ingestion/ inhalation by end users inc skin contact	Direct ingestion/ inhalation by end users inc skin contact	Migration into properties	Migration into properties
Remediation Options	Inert soil capping 100mm thick with validation following placement	Inert soil capping 100mm thick with validation following placement	NA	Further risk assessment, or localised remediation with validation should contamination be identified Capping may be needed to provide additional protective measures in the long-term	E.g. Visqueen type 'CO ₂ Barrier' or similar with passive ventilation (design to be confirmed)	As ground gas precautions are needed, radon risk will be mitigated
Remediation Objectives met?	Yes	Yes	NA	Yes	Yes	Yes

NA – Not applicable.

13.0 RECOMMENDATIONS

13.1 Enabling Works

The site is mostly covered with concrete or tarmac hardstanding. It may be possible to crush and re-use some on-site materials below car parking areas/hardstanding (subject to planning layout), but it may be that much of the demolition material will require removal from site. Some of the stone in the school buildings could also be recycled.

Services have been located, although it is possible that additional old foundations / substructures / underground fuel storage tanks may also be present. Further localised excavations will be required during enabling/demolition to check for additional old foundations and substructures associated with former development at the site.

Site clearance works will need to be integrated with the removal / infilling of any basements, foundations and other obstructions associated with previous development at the site and any areas requiring remediation.

13.2 Foundations

On the basis of the site investigation, it is considered that strip/trench fill foundations will be suitable. These will need to be taken through the overlying made ground soils into the underlying weathered sandstone strata. The minimum founding depth on competent sandstone should be 600mm. Should clay soils be encountered, the minimum founding depth should be assumed to be 900mm (see *Precautions Near Trees* below). Deepening of the footings may be needed where loose or soft ground is encountered. At this stage, deepened foundations may be required on approximately 50% of the site. Confirmation would be given following completion of a plot specific foundation schedule.

There may be deeper areas of made ground, possibly to in excess of 2m bgl, being associated with existing and/or former development. Further assessment of foundation options may be required should deep(er) areas of made ground be encountered. Where foundations straddle clay/sand or sandstone they will need to be thickened and reinforced. A plot specific foundation schedule will need to be completed.

13.3 Precautions Near Trees

On the basis of current geotechnical test results and the depth of sandstone bedrock, it is considered that no precautions will be needed where houses are

constructed near trees. However, should clayey soils be encountered at founding depth during construction works, further testing would be needed to assess the requirement for heave precautions. Specific foundation details would be given following receipt of the test results.

13.4 Floor Slabs

Suspended floor slabs should be assumed.

13.5 Slope Stability

No significant issues are anticipated.

13.6 Sulphate Precautions

In accordance with BRE Special Digest 1 (2005), it is considered that Class DS1/ACEC-AC1s conditions may be assumed.

13.7 Road Construction

At this stage a CBR of between 4% and 5% at road formation may generally be assumed for pavement design on the underlying natural soils. A CBR of 1% should be assumed on all made ground materials. This would be subject to *in situ* testing (where required) and Local Authority approval prior to finalising design.

13.8 Excavations

Localised instability of near surface soils may be encountered during excavation. Difficulties with deeper excavations, e.g. for services/soakaways, may also be encountered given the presence of relatively shallow rock. Where man entry is required, support must always be provided.

13.9 Groundwater

No groundwater or perched water was encountered during the ground investigation (water noted in gas monitoring installations is assumed to be due to rainfall percolation).

13.10 Soakaways and Site Drainage

It may be possible to use soakaways, if taken into fractured sandstone at depth. However, infiltration would be likely to rely on flow through fractures in the rock, which may vary in extent and frequency across the site. A combined chamber/trench network might be appropriate, subject to testing.

All soakaway designs would be subject to Local Authority/Highways Authority approval prior to finalising the design.

13.11 Ground Gas

No methane has been identified, although, carbon dioxide levels up to 3.6% have been measured in boreholes drilled at the site. Ground gas precautions comprising a Visqueen type 'CO₂ Barrier' (being taped and sealed across all service entries and cavity walls) will therefore be required in conjunction with passive ventilation. The design will need to be confirmed with the NHBC/Local Building Control.

13.12 Radon

Basic radon precautions are required in the construction of new dwellings or extensions. The design will need to be confirmed with the NHBC/Local Building Control where appropriate. The need for radon precautions will however be mitigated by the need for a CO₂ type barrier.

13.13 Potable Water Supplies

Given the elevated concentrations of arsenic, it is anticipated that precautions may be required where made ground is present. Confirmation should be sought from the local water authority regarding the need for any protective measures they may require.

13.14 Flooding

Information provided by the Environment Agency and Envirocheck indicates that the site lies in an area which is not at risk from flooding.

13.15 Remediation & Environmental Management

On the basis of laboratory test results and risk assessment, it is considered that remediation will be required, given that elevated concentrations of arsenic have been identified.

On this basis, capping to block the pathway for these contaminants is considered to be the most appropriate remedial option. Risk assessment has identified that a 100mm inert soil capping layer will need to be placed in areas of proposed soft landscaping and garden areas, with validation works being carried out to confirm the thickness of soils placed as part of the remediation. Proposed capping thicknesses given are subject to confirmation/discussion with the EHO.

Any capping materials imported to site will need to be tested at source and confirmed as suitable in agreement with the NHBC/EHO prior to importation.

Should contaminated soils be identified during redevelopment, further localised excavation/remediation may need to be carried out following risk assessment. Further sampling and testing will be needed. Where excavations to remediate contaminated soils are made, validation sampling will be carried out in agreement with the local authority. A validation report will need to be submitted to the EHO/NHBC following completion of the works.

On the basis of the site investigation and laboratory test results, it is considered that risk to the wider environment (e.g. controlled water) is negligible.

There is a limited source of topsoil at the site and importation will therefore be required. Any soils imported to site will need to be tested at source and confirmed as suitable in agreement with the EHO/NHBC.

14.0 FURTHER WORK

- Noise and vibration assessments given the proximity of the site to Pontefract Road;
- Plot specific foundation schedule;
- Further geotechnical testing should clay soils be encountered at founding depth;
- Ecological survey;
- Remediation Method Statement to reflect the need for capping in garden areas/soft landscaping;
- Type III (pre-demolition) asbestos survey of existing buildings;
- Permeability testing to assess the suitability of soakaways.

INFORMATION SOURCES

Geological, Mining and Hydrogeological data	-British Geological Survey, 1:50,000 Series, Sheet 87, Barnsley, Solid & Drift Edition; -Environment Agency Groundwater Vulnerability Map 1:100,000 scale Series, Sheet 11, South Pennines; - Coal Authority Mining Report.
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Historical	As presented in Appendix II.