GEOENVIRONMENTAL APPRAISAL

of

Land at

GREY TOWERS FARM

NUNTHORPE

MIDDLESBROUGH

prepared for

SHEPHERD HOMES LTD

CONTENTS

APPENDICES

1.0 INTRODUCTION

Sirius Geotechnical and Environmental Ltd (Sirius) was commissioned by Shepherd Homes Ltd (Shepherds), to undertake a Geoenvironmental Appraisal of land at Grey Towers Farm, Nunthorpe, Middlesbrough.

It is understood that Shepherds are considering development of the site with residential properties and domestic gardens.

The objectives of this investigation were:

- To determine the land use history of the site from an inspection of available historical plans;
- To ascertain the environmental setting of the site, including details of the geology, hydrogeology and hydrology;
- To determine the near surface ground and groundwater conditions;
- To assess the degree of near surface ground contamination;
- To evaluate the risk to the site from hazardous ground gas emissions;
- To provide preliminary foundation recommendations; and
- To provide advice on measures to deal with proven contamination.

As part of this investigation, information has been sourced from Landmark Information Group (LIG), Middlesbrough Borough Council (MBC), the British Geological Survey (BGS), and the Coal Authority (CA).

Fieldwork comprised the excavation of six trial pits and recovery of samples of materials encountered.

This report presents the factual information obtained during this investigation, an interpretation of results and recommendations relating to the proposed end use of the site.

It is assumed in the production of this report that the development is to comprise the most sensitive end use; residential properties with private gardens. In addition, it is assumed that the final levels will not alter significantly from those which were present at the time of investigation. If this is not the case significant amendments to the conclusions and recommendations presented in this report may be required.

The comments and opinions presented in this report are based on the findings of a review of available information; ground conditions encountered during the intrusive investigation work and on the results of tests carried out in the laboratory.

There may be other conditions prevailing on the site which have not been disclosed by this investigation and which have not been taken into account by this report. Responsibility cannot be accepted for conditions not revealed by the investigation. Any diagram or opinion of the possible configuration of ground conditions between exploratory holes is conjectural and given for guidance only and confirmation of intermediate ground conditions should be considered if deemed necessary.

This report has been prepared for the sole use of Shepherds. No other third parties may rely upon or reproduce the contents of this report without the written permission of Sirius. If any unauthorised third party comes into possession of this report they rely upon it entirely at their own risk and the authors do not owe them any Duty of Care or Skill.

2.0 SITE DESCRIPTION

Table 2.1: Summary of Site Description

Site Location:	The site is located immediately south-west of Grey Towers farmhouse, approximately 200m south-west of the junction of the A172 and A1043, some 8km southwest of Middlesbrough town centre. An approximate National Grid Reference for the centre of the site is NZ 536 138. A site location plan is presented as Drawing No. C1783/1, attached to this report.
Topography:	Undulating ground with 2-3 metre high stockpiles of crushed brick in the centre and southwest of the site. Along the north-western boundary the site appears to have been lowered by approximately 1m from original ground levels, resulting in a low but steep south facing slope along the north of the site.
Surface Cover	Stockpiled crushed brick in centre and south-west. Surrounding land is overgrown with vegetation.
Existing Buildings:	None present on site. Stockpiles of crushed bricks suggest buildings have been recently demolished.
Fuel Storage Tanks:	None noted during walkover.
Adjacent Land Uses:	North, west and south west: Agricultural fields. South: Narrow lane beyond which are residential gardens East: Low brick buildings, possibly stables, as part of Grey Towers Farm complex. Beyond Grey Towers Farm there are agricultural fields.
Services:	None noted on walk over. A small diameter ceramic drain was encountered at 0.8m bgl in TP1.

A plan showing the main site features is presented as Drawing No. C1783/2, within Appendix A of this report.

3.0 ENVIRONMENTAL SETTING

3.1 Site History

In order to investigate the history of the site, extracts of historical maps and Ordnance Survey (OS) plans dated from 1856, obtained as part of the Landmark Information Group Envirocheck Report, enclosed within Appendix B, have been examined.

Table 3.1 below provides a summary table of the salient points relating to the history of the site from 1856 to 2006 with respect to the proposed end use. It is not the intention of this report to describe, in detail, all the changes that have occurred on or adjacent to the site, only those pertinent to the development.

Table 3.1: Summary of historical uses

Map	On-site Features	Off-site Features
1856 1:10,560 scale Yorkshire County Series map.	• Site is located within open land.	• Surrounding land agricultural in use. • Mount Pleasant farm 300m to south. • Nunthorpe Grange 500m to north.
1894, 1:2,500 scale and 1895 1:10,560 scale Yorkshire County Series maps.	• Site developed with outbuildings associated with Grey Towers Farm. • Pump marked within site adjacent to south-eastern boundary.	• Grey Towers Farm constructed immediately adjacent to north-eastern boundary. • Track constructed along south-eastern boundary. • Small residential properties constructed 60m to south-east, beyond track. Pump marked 100m to south-east of site. • Building formerly labelled as Mount Pleasant, 300m to south relabelled as Grey Towers. Additional buildings including glass houses constructed in that area to within 200m of site.
1915, 1:2,500 scale and 1919 1:10,560 scale Yorkshire County Series maps.	• Pump adjacent to south-eastern boundary no longer labelled.	• Sheepwash labelled 20m to south. • Pump 100m to south no longer marked. • Pavilion 150m south-east. • School and playing fields 220m to south-east, with some possible levelling to form playing fields.
1928 1:2,500 scale Yorkshire County Series map.	• No significant changes.	• Allotment gardens 25m to south-west.
1938 1:2,500 scale Yorkshire County Series map.	• Additional buildings, possibly farm outbuildings, constructed spanning north-western site boundary.	• Allotment gardens not labelled. • Pavilion no longer shown. • Unlabelled rectangular feature 120m north. • Residential properties constructed 220m to north-east.
1952 1:10,560 scale Yorkshire County Series and 1953/58 1:10,560 OS maps.	• No significant changes.	• Grey Towers 200m to south relabelled as Poole Sanatorium. Three large unlabelled buildings constructed 450m to south. • Electricity substation labelled 200m east.
1967/8 1:10,000 scale OS plan.	• No significant changes.	• Additional residential properties constructed 60m to south-east. • Poole Sanatorium relabelled Poole Hospital to south, with associated chimney and electricity substation labelled 240m to south.

		• Pavilion, tennis courts and large unlabelled structure 170m to south-east. • A172 constructed 175m to north, with associated roundabout junction with A1043,
1971/3 composite 1:10,000 scale OS plan.	• No significant changes.	• No significant changes.
1982/3 1:10,000 scale composite OS plan.	• No significant changes.	• Continued urban development of Nunthorpe to north.
1992 1:2,500 scale OS plan.	• No significant changes.	• No significant changes.
1991/4 1:10,000 scale OS plan.	• No significant changes.	• Urban development of land to north of A172 175m to north.
2004/6 1:10,000 scale OS plan.	• Buildings formerly within site no longer shown. • Track trending north-north-east passing through middle of site.	• Former Hospital buildings to south no longer labelled.

3.2 Geology

Table 3.2: Summary of Geological Setting

Maps/ Publications Referenced	BGS 1:50,000 scale sheet 33 Stockton.
Drift Geology	Undifferentiated Glacial Till. Thickness unrecorded
Solid Geology	Redcar Mudstone Formation.
Likely Ground Conditions	Made ground associated with former farm outbuildings, including possible in situ foundations and demolition materials overlying firm and stiff gravelly glacial clay to in excess of 5m depth, underlain by mudstone.
Dip of Solid Strata	Not indicated
Faults	None shown in vicinity of site.
Coal Seams / Mine Workings	No coal bearing strata at shallow depth beneath site. No shallow coal workings anticipated beneath site.

3.3 Mining and Quarrying

With consideration to the geological setting of the site, and the absence of any seams of coal at shallow depth, the risk to the site from former shallow coal workings is considered negligible.

However, in order to determine the risk to the site from recorded coal mining, a mining report has been requested from the Coal Authority (CA). A copy of the Coal Authority report is enclosed within Appendix C. Salient points of the report are summarized below:

- *"the property is not within the zone of likely physical influence on the surface from past underground coal workings".*
- *"The property is not within the zone of likely physical influence on the surface from any present underground coal workings".*
- *The property is not within a geographical area for which a licence to extract coal by underground methods is awaiting determination / has been granted by the Coal Authority.*

- *"The property is not within the zone of likely physical influence on the surface from any future workings".*

- *The Coal Authority "have no knowledge of any mine entries within, or within 20m of, the boundary of the property. The records held by the Coal Authority may be incomplete. Consequently, there may exist in this locality mine entries of which we have no knowledge".*

In addition, the Coal Authority has no records of any opencast coal mining within 200m of the site.

On the basis of BGS and CA data, the risk to surface stability of the site from shallow coal workings is considered to be **negligible**.

There is no evidence of quarrying activities having taken place within the boundaries of the site on either geological survey or historical OS plans dating from 1856. When considering the probable thickness of drift deposits, and the underlying geology comprising mudstone, the possibility of unrecorded quarrying is considered unlikely.

3.4 Hydrology and Hydrogeology

Surface Waters

Inspection of the OS plans reviewed as part of this investigation indicate that the closest named surface water feature to the site is Nunthorpe Stell, approximately 1.1km to the southeast, flowing to the east.

There are no Environment Agency GQA scheme water monitoring points within 2km of the site.

The LIG Report for the site reveals that:

- There are no recorded surface water abstractions within 2km of the site.
- There are no licensed discharge consents within 250m of the property.
- There are no recorded pollution incidents to controlled waters within 250m of the site.
- The site does not lie within an area of flooding from Rivers or Sea without defences.

Groundwater

The site is recorded as being underlain by undifferentiated glacial till overlying the Redcar Mudstone Formation. Under the Environment Agency's Policy and Practice for the Protection of Groundwater, and the 1:100,000 scale Groundwater Vulnerability Map, Sheet 8 (Central and North Yorkshire), the underlying strata are classed as a Non Aquifer which is defined as:

> *"Formations which are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such rocks, although imperceptible, does take place…Some Non-Aquifers can yield water in sufficient quantities for domestic use."*

Soils beneath the site have not been assigned a leachability class owing to the presence of the Non-Aquifer beneath the site.

The LIG states that there are no groundwater abstractions within 2km of the site.

According to the EA website, there are no groundwater Source Protection Zones (SPZs) within at least 5km of the site.

Middlesbrough Borough Council state that there are no licences for private water abstractions within a 1km radius of the site.

3.5 Landfilling

Information on areas of known landfilling within 2km of the site was sourced from the Landmark Information Group (LIG). Copies of the information from the LIG are included within Appendix B of this report.

According to the LIG report, there are no recorded landfill sites, waste management facilities, waste transfer sites or waste treatment or disposal sites recorded within a 250m radius of the subject site.

Middlesbrough Borough Council was been contacted to obtain details of recorded landfill sites within the vicinity of the site. According to MBC, there is no history of landfill/tips within a 500m radius of the site.

3.6 Radon

To determine whether the site is at risk from radon gas, the BRE Document “Radon: Guidance on the protective measures for new dwellings” has been referenced. This document states that the site lies within an area in which **no radon protective measures are required.**

3.7 Miscellaneous

According to the LIG report, there are no contemporary trade directly entries or fuel station entries within 500m of the site.

There are no areas of sensitive land uses e.g. nature reserves, Sites of Special Scientific Interest (SSSIs) within 2km of the site.

MBC state that the area under investigation and surrounding has not been at the present time classified as ‘contaminated land’ under the provisions of Part IIA of the Environmental Protection Act 1990.

According to MBC, there are no Part A or Part B Authorised Processes carried out at the site or adjoining properties.

MBC have no record of any reported nuisances, or history of spillages or other incidences associated with the site or neighbouring properties.

4.0 PREVIOUS GROUND INVESTIGATION

Sirius is not aware at this time of any previous ground investigations pertaining to potential development of the site.

5.0 FIELDWORK

5.1 Introduction

Fieldwork was undertaken on 29 August 2006 and comprised:

- Mechanical excavation of six trial pits (TP1, TP1A and TP2 to TP5) with a JCB 3CX to a maximum depth of 3.7m below ground level;
- Recovery of samples of soils encountered during trial pitting, and of stockpiled mounds of demolition rubble across the site.

On completion of each excavation, the trial pits were backfilled with arisings and compacted, in approximate reverse order to the order of excavation.

The fieldwork was supervised by a Sirius Geoenvironmental Engineer.

A copy of the exploratory hole records are presented within Appendix D of this report.

5.2 Strata Description

Depths and descriptions of strata and groundwater together with details of the samples recovered are presented on the Sirius exploratory hole record sheets within Appendix D of this report.

Strata descriptions are based on an examination of the strata encountered together with consideration of the in situ and laboratory test data. Procedures and principles contained in BS5930 (1999), BS10175 (2001) and BS1377 (1990) have been followed.

The depths of strata on the record sheets are related to current ground levels at each location. The information contained in this report is limited to accessible areas within the site boundary, as indicated on the site plans shown in Appendix A.

5.3 Sampling and In Situ Testing

Samples were selected by a Sirius geoenvironmental engineer during the site investigation works. Samples of soil for chemical analysis and geotechnical testing were placed into one litre plastic containers. Samples for chemical analysis were stored at approximately 4°C until delivery to UKAS and MCERTS accredited laboratories.

5.4 Exploratory Hole Locations

Exploratory hole locations were selected by Sirius to produce a representative view of shallow ground conditions across the site.

Exploratory holes were positioned, as far as possible, in accordance with BS10175 and CLR4. However, the presence of mounded demolition rubble across the site, as indicated on Drawing No. C1783/2, within Appendix A, restricted the positioning of some exploratory holes.

The locations of the exploratory holes are shown on Drawing No. C1617/2 within Appendix A.

6.0 LABORATORY TESTING

6.1 Geotechnical

Geotechnical laboratory testing, as scheduled by Sirius, was carried out on selected samples in accordance with techniques outlined in BS 1377:1990 at Fugro Engineering Services (FES) a UKAS accredited laboratory.

Selected natural soil samples were delivered to the laboratory of FES for the following tests in accordance with BS1377: 1990:

- Seven natural moisture content and Atterberg Limit determinations;
- Four water soluble sulphate and pH analyses.

The results of the laboratory analysis, as received from the laboratory are presented in Appendix E of this report, and are discussed in Section 7, below.

6.2 Contamination

Selected samples of the made and natural ground were tested for a range of potential contaminants under subcontract with Derwentside Environmental Testing Services (DETS), an UKAS and MCERTS accredited laboratory. The analytes tested are listed in Section 8.1 of this report. The results of the tests as received from the laboratory, are included in Appendix E, and are discussed in Section 8 of this report.

7.0 GROUND CONDITIONS AND MATERIAL PROPERTIES

The following sections present a summarised description of the soils encountered across the site. For a detailed description of the actual ground conditions revealed at the individual exploratory hole positions, these generalised notes should be read in conjunction with the accompanying exploratory hole record sheets (Appendix D).

7.1 Made Ground

Made ground was proved to depths of between 0.3m and 0.9m, although where deeper than around 0.5m, made ground was generally associated with buried structures including services and shallow foundations.

Within the south of the site, TPs 1 and 1A encountered a thin (0.05m) horizon of tarmac.

From ground level elsewhere within the site other than immediately adjacent to the northern part of the eastern boundary, and below the tarmac surfacing in the south, made ground comprising gravel of brick, sandstone and some slag, which was encountered to depths of between 0.2m bgl and 0.5m below ground level (bgl).

The granular made ground was found to be underlain locally, within the south and south-east of the site, by reworked clay with inclusions of brick and slag, to depths of between 0.8m and 0.9m, possibly associated with buried services and former building foundations. This reworked clay with inclusions was also encountered to a depth of 0.3m within the north-east of the site.

Water soluble sulphate (SO_4) concentrations predominantly between 0.06g/l and 0.27g/l were recorded for samples of the made ground. Alkaline pH conditions (i.e. 8.7 to 9.2), were recorded across the site within the topsoil and made ground.

7.2 Superficial Deposits

Within the centre and south of the site, horizons of firm sandy clay, friable very sandy clay; laminated clay with interbedded thin horizons of silt were encountered. Within TP5, excavated toward the centre of the site, a 0.4m thick horizon of sand was encountered toward the base of this sequence. These soils, considered to be fluvio-glacial or fluvio-lacustrine in nature, were encountered to depths of between 2.5m to 3.0m bgl, being generally deepest toward the south-western corner of the site.

Underlying made ground within the north and north-east of the site, from a depth of 0.3m bgl, and below the fluvio-glacial/lacustrine soils described above at depths of between 2.5m to 3.1m bgl, natural strata comprised stiff sandy gravelly clay (glacial till). This stratum was proved to depths of 3.6m to 3.7m bgl, across the site, at which depths excavations were terminated, with the stiff sandy gravelly clay persisting at the base of the excavation.

Moisture content tests on five samples of the natural cohesive soils returned values of 13% to 24%. Liquid Limits of 29% to 36% and Plastic Limits of 14% to 18% were recorded, together with corrected Plasticity Indices of 12% to 20%, indicating the soils to be generally low to intermediate plasticity clay, and of low volume change potential.

However, moisture content tests on two samples of cohesive soils from relatively shallow depth within the south and central area of the site returned values of 30% and 31%. On these samples, Liquid Limits of 65% and 73% and Plastic Limits of 21% and 28% were recorded, with corrected Plasticity Indices of 37% and 52%, indicating those soils to be high to very high plasticity clay of medium to high volume change potential.

Water soluble sulphate (SO_4) concentrations of 0.05 to 0.16g/l were recorded for samples of the natural soils, together with alkaline pH conditions (i.e. 7.8 to 8.3).

7.3 Solid Geology

Rockhead was not encountered during the fieldwork.

7.4 Groundwater

A groundwater seepage was encountered at one location only, toward the centre of the site, at a depth of 2.7m, associated with granular strata.

It should be borne in mind that water levels are likely to fluctuate with season/rainfall and may therefore be substantially higher at wetter times of year than those found during this investigation.

7.5 Visual/olfactory Evidence of Contamination

No visual or olfactory evidence of gross hydrocarbon contamination was observed during the fieldwork.

8.0 CHEMICAL CONTAMINATION

8.1 Preliminary Conceptual Site Model

The desk study has revealed that the site has been developed with farm outbuildings since the mid to late 1800's. In recent times, the buildings have been demolished, with associated demolition rubble still remaining in a mound spread across the site.

The past use of the site is considered to give rise to a **moderate** potential for significant ground contamination, including asbestos in former construction materials, fuels and lubricating oils associated with maintenance of farm machinery and possible pesticides associated with farming practices. The presence of a sheep dip nearby on historical maps suggests associated chemicals may have been stored in buildings on site.

The site is considered to lie within a setting of **low** environmental sensitivity. Factors which are considered pertinent to this conclusion are:

- The site is located above a Non-Aquifer, likely to be mantled by a significant thickness of low permeability natural drift deposits;
- The closest major surface water feature to the site is located 1.1km to the south-east;
- There are no EA GQA scheme water monitoring points within 2km of the site;
- The area does not lie within an Indicative Floodplain;
- There are no recorded surface or groundwater water abstractions within 2km;
- The nearest recorded EA SPZ is located in excess of 5km from the site;
- There are no sensitive land uses recorded within 2km of the site.

It is understood that consideration is being given to development of the site with residential properties with private domestic gardens. This is considered a **highly** sensitive end use as occupiers could be exposed to any potential ground contamination for a significant period of their lifetime.

8.2 Current Guidance and the Interpretation of Analytical Data

Contaminated land is defined under law through Part IIA of the Environmental Protection Act 1990, implemented through Section 57 of the Environment Act 1995. This supports a 'suitable for use' based approach to the risk assessment of contaminated land. The site specific risk assessment is based upon an assessment of plausible pollutant linkages, referred to as the contaminant → pathway → receptor model, based upon the current or proposed use of the site.

The first stage usually comprises the development of an initial conceptual site model (CSM), usually based on desk top study data. This is undertaken in order to identify potential contaminants, pathways and targets. This initial model can then be used to scope an effective/ targeted intrusive ground investigation.

Following completion of the investigation, the findings are used to refine the initial CSM, in order that a suitable cost effective remediation strategy can be devised or further investigation and risk assessment undertaken.

The process of refining the CSM from the initial model, involves semi quantitative risk assessment, which is split into two parts:

a) The comparison of the soil analysis results against generic soil screening values, to establish sources of contamination (Generic Quantitative Risk Assessment); and,

b) A qualitative risk assessment to identify any plausible pathways from contaminant to receptor.

If the screening levels are exceeded and the qualitative risk assessment identifies a plausible pollutant linkage, then assessment could move onto another stage, which includes more sophisticated Detailed Quantitative Risk Assessment (DQRA), or remedial action taken to break the pollutant linkages. The benefits of undertaking a DQRA must be weighed against the likelihood that it will bring about cost savings in the proposed remediation.

The initial screening levels currently used by Sirius are as follows:

CLEA (2002)

The current best practice soil screening values for use in UK are derived using CLEA (2002) published by DEFRA. A number of standard land uses are defined within CLEA (2002) for which generic soil guideline values (SGVs) can be derived. Currently, published SGVs are only available for a limited number of parameters. SGVs for other determinands are currently awaited.

Dutch Ministry of Housing, Spatial Planning and Environment (2000)

In the absence of SGVs for various determinants reference is first made to the intervention and target values established by the Dutch Ministry of Housing, Spatial Planning and Environment 2000.

Sludge (Use in Agriculture) Regulations (1989)

In the case of assessing phytotoxic risk from contaminants such as copper and zinc, comparison of site soil results has been made to generic criteria set out in the Sludge (use in agriculture) Regulations (1989).

Soil Leachability Results

For the purposes of this report, a screening assessment is being carried out using leachability data obtained from tests performed on soils for this site and groundwater analysis results, to asses the potential risks to local controlled waters. The results of the analysis will be compared against a variety of generic criteria from various guidance sources as detailed below:

- Dutch Ministry of Housing, Spatial Planning and Environment (2000) Intervention Values and Target Values – soil quality standards and groundwater standards;
- BRE (2005) Special Digest No. 1; 3rd Edition, Concrete in Aggressive Ground;
- Water Supply (Water Quality) Regulations 1989 and 2001; and
- Environment Agency (2002) Technical advice to third parties on Pollution of controlled waters for Part IIA, EPA1990.

The decision to carry out a DQRA will be dependant on the extent and implications of the initial semi quantitative assessment.

The semi quantitative risk assessment carried out as part of this report assumes a **residential with plant uptake** end use as areas of private garden are believed to be proposed as part of the redevelopment.

8.3 Laboratory Analysis

Based on the findings of the intrusive investigation, and the potential for the presence of contaminants, 3 samples of made ground were tested for the following determinants:

arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, total and water soluble sulphate, total organic carbon, pH, speciated polyaromatic hydrocarbons (PAHs), and monohydric phenols.

Two samples of shallow clayey organic soil were also analysed for a suite of common organo-chlorine and organo-phosphate compounds present within pesticides and herbicides.

Two samples of demolition rubble were screened for the presence of asbestos fibres.

The leachable concentrations of the following analytes were determined in two samples of made ground:

arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, pH, speciated polyaromatic hydrocarbons (PAHs) and total phenol.

8.4 Results and Generic Quantitative Risk Assessment

Total Soil Concentrations

The results of the soils analysis are presented in Appendix E of this report, and are summarised in the table below.

Table 8.1 Summary of Total Soil Concentrations and Generic Quantitative Risk Assessment

Parameter	Screening value (mg/kg, unless otherwise stated)	No. of samples above screening value	No. of samples tested	Maximum concentration (mg/kg, unless otherwise stated)
Metals/Metalloids				
Arsenic	20 (a)	0	3	
Cadmium	8 (pH 8) (a)	0	3	
Chromium (Total)	130 (a)	1	3	170: TP1, 0.2
Lead	450 (a)	0	3	
Mercury	8 (a)	0	3	
Selenium	35 (a)	0	3	
Copper	200 (pH >7) (b)	0	3	
Nickel	50 (a)	0	3	
Zinc	300 (pH >7) (c)	0	3	
Inorganics				
pH	<5		3	
Total Sulphate	2,400 (d)	0	3	
Water Soluble Sulphate	0.5 g/l (d)	0	3	
Organics				
Monohydric Phenol	78 (1% SOM) (a) 150 (2.5% SOM) 280 (5% SOM)	0	3	
*Benzo(a)pyrene	0.62 (f)	1	3	2.7: TP1, 0.2
**Naphthalene	56 (g)	0	3	
TOC	3 w/w% (h)	0	3	
Other				
Asbestos	Fibres present	0	2	

(a) DEFRA soil guideline values for 'residential with plant uptake' end-use.
(b) The Sludge (Use in Agriculture) Regulations 1989 and Amendment 1990.
(c) Department of Environment, 1989 (revised 1996). Code of Practice for Agricultural Use of Sewage Sludge. Advisable limits for zinc.
(d) BRE (2005) Special Digest 1, 3rd Edition, Concrete in aggressive ground. Upper limits for DS-1 Design Sulphate Class concrete.
(e) Ministry of Housing, Spatial Planning and Environment (2000) Intervention values for soil and groundwater in the Netherlands. Intervention values for xylenes derived using recommended correction factors for soils with <10% SOM.
(f) Sirius' in-house soil screening values (risk assessment methodology can be provided on request)
(g) USEPA (1996) 2nd Edition, Soil screening guidance: user's guide. Levels for 'residential end use' (with dermal exposure).
(h) The Hazardous Waste (England and Wales) Regulations 2005. 'Inert' waste threshold.
(i) ICRCL (1986) Guidance Note 61/84, 2nd Edition, Notes on the fire hazards of contaminated land.
* Risk driver for 'toxic' PAHs (non threshold)
** Risk driver for 'volatile' PAHs (threshold)
SOM Soil Organic Matter

Organic-Chlorine and Organo-phosphates

None of the samples of shallow soils analysed for the presence of common pesticides and herbicides returned concentrations of individual parameters elevated above detection limits of 0.1mg/kg.

Metals

The concentration of chromium in one sample of made ground containing slag exceeded the relevant guidance value.

Inorganics

None of the samples analysed returned concentrations of determinands exceeding the selected Tier 1 screening values.

Organics

The concentration of benzo(a)pyrene in one sample of made ground containing slag (and identified to contain an elevated chromium concentration) exceeded Sirius' in house derived screening concentration of 0.62mg/kg.

Further statistical analysis of the results of all benzo(a)pyrene and chromium concentrations detected in the soils, in accordance with CLEA methodology, is not possible owing to the limited extent of testing on this small site. However, it is noted that the elevated concentration of both benzo(a)pyrene and chromium both arise in the same sample of made ground containing, amongst other inclusions, slag.

Soil Leachate Testing

The results of the leachability testing of the soils are summarised in the table below. Analytical test results are presented in Appendix E.

Where a range of freshwater EQS values are given for parameters, these are dependant upon the hardness of the receiving water, However the closest water course is in excess of 1km from the site. In light of the environmental setting of the site the upper WQS values have been chosen for this assessment. It is assumed that the most likely receiving surface water is cyprinid.

Table 8.2: Summary of Soil Leachate Concentrations and Generic Quantitative Risk Assessment:

Parameter	Screening value (units µg/l unless otherwise stated)	No. of samples above screening value	No. of samples tested	Maximum concentration (units µg/l unless otherwise stated)
Metals/Metalloids				
Arsenic	10 [b] (50) [a]	0	2	
Cadmium	5 [a, b]	0	2	
Chromium	250 [a] (50) [b]	0	2	
Lead	250 [a] (25) [b]	0	2	
Mercury	1 [a, b]	0	2	
Selenium	10 [b]	0	2	
Copper	28 [a] (2,000) [b]	0	2	
Nickel	200 [a] (20) [b]	0	2	
Zinc	500 [a] (3,000) [b]	0	2	
Organics				
Phenol	0.5 [b] (30 [300]) [a]	0	2	
Total PAH	0.1 [b]	1	2	3.1: TP1, 0.2m
Benzo(a)pyrene	0.01 [b]	0	2	
Benzo(b)fluoranthene	0.1 [b]	0	2	
Benzo(k)fluoranthene	0.1 [b]	0	2	
Benzo(ghi)perylene	0.1 [b]	0	2	
Indeno(1,2,3-cd)pyrene	0.1 [b]	1	2	0.24: TP1, 0.2m
Others				
pH	6-9 pH units [c]	0	2	

(a) Environment Agency (2002) Environment Agency technical advice to third parties on pollution of controlled waters for Part IIA of the EPA 1990. Freshwater EQS.
(b) The Water Supply (Water Quality) (Amendment) Regulations 2001.
(c) The Surface Waters (Fishlife) (Classification) Regulations 1997.
For some organic parameters (e.g. phenol 300 [30] µg/l) two values are given, which relate to an acceptable annual average followed by the maximum admissible peak concentration.

Metals

None of the samples tested returned concentrations of determinands above the chosen Tier 1 trigger values.

Organics

Concentrations of the sum of all leachable PAHs in one sample, comprising the made ground including slag, exceed the maximum permissible concentration for drinking waters. The Tier 1 value for leachable concentrations of the individual PAH Indeno(1,2,3-cd)pyrene was also exceeded in this sample.

Generic Quantitative Risk Assessment

As discussed in Section 8.2, risk assessment is based on contaminant → pathway → receptor principles. With respect to the proposed end use of the subject land as residential properties with domestic gardens, these can be defined as follows:

Contaminants

- Concentrations of benzo(a)pyrene and chromium in made ground. In particular those containing slag fragments.
- Concentrations of leachable PAHs in made ground containing slag fragments.

Pathways

- Direct contact
- Inhalation and ingestion of dusts and vapours
- Attack of building materials

Receptors

- End users
- Construction and maintenance workers
- Built environment
- Controlled waters

In assessing risk, the following categorisation has been developed:

Term	Description
Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action harm could arise to a designated receptor. It is relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely that such harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard. It is likely that, at worst if any harm was realised any effects would be mild.
Negligible Risk	The presence of an identified hazard does not give rise to the potential to cause harm to a designated receptor.

The above is intended to be an aid in assessing the degree of risk. It should be noted that in terms of the Environmental Protection Act 1990, there is no differing degree of risk, i.e. it is either significant or not.

The proposed end use of the site as residential properties including domestic gardens is regarded as a **high** sensitivity target.

The environmental setting of the site can be classified as **low** sensitivity, as detailed previously.

End Users

A sample of made ground in the south of the site was observed to contain inclusions of slag, have returned concentrations of the PAH benzo(a)pyrene, and of chromium, in excess of the relevant guidance value. The concentrations detected may present a significant risk to end users.

Considering the proposed residential end use of the site, with private gardens, it is considered that there are recognisable pollutant linkages between benzo(a)pyrene and chromium in some made ground in the south of the site, and end users via dermal contact, direct and/or indirect ingestion and inhalation of dusts. As such this material within the site is currently considered to present a **moderate risk** to end users, and is not considered suitable to remain at shallow depth within garden and landscaped areas of the site.

During development, this material should be excavated and either removed from site for disposal to an appropriate waste receiver, or, if practicable, placed beneath hardsurfaced areas of the site (i.e. carriageways / below buildings) in order to break the identified potential pollutant linkages. If none of the above solutions is practical, capping of this material could be considered.

Controlled Waters

The greatest perceived risk from the site to controlled waters is the presence of leachable concentrations of PAHs in made ground in the south of the site, which has also been identified to present some risk to potential end users of the site.

The site is underlain by low permeability clay and a non aquifer. In addition, the closest watercourse is shown to lie in excess of 1km from the site. CLR1 indicates that contamination on a site is unlikely to affect watercourses in excess of 500m from the site. In light of the above, leachable quantities of contaminants are considered unlikely to have an effect on controlled waters.

Construction and Maintenance Workers

It is considered that there is a **moderate** short term risk of exposure to contaminants during the redevelopment works to construction and maintenance workers. It is recommended that normal health and safety procedures should be adopted by groundworkers including no eating, drinking or smoking on-site, designated clean and wash areas and protective clothing. It is also recommended that procedures outlined in the HSE document “Protection of Workers and the General Public during Redevelopment of Contaminated Land” be followed.

Built Development

Chemical results should be forwarded to the appropriate utility companies in order to determine the necessity for services protection.

In accordance with BRE Special Digest 1 (2005) and the results of the water-soluble sulphate testing, a Design Sulphate Class of DS-1 and an ACEC Class of AC-1 may be assumed for concrete products across the site.

Adjacent Land Users

Concentrations of contaminants associated with soils and groundwater identified at the site are unlikely to present a significant risk to adjacent land users.

A diagrammatic representation of the Revised Conceptual Site Model is presented as Drawing No. C1783/3 in Appendix A.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Mining and Quarrying

According to BGS data, shallow strata are not coal bearing. Consequently, on the basis of BGS and CA data, the risk to surface stability of the site from shallow coal workings is considered to be **negligible**.

With consideration to the presence of rockhead at or near to the surface across the site, the site is unlikely to have been subject to past quarrying activities.

9.2 Foundations

Owing to the heterogeneous nature of the made ground deposits, it is expected that they will have highly variable compressibility and bearing capacity characteristics. Shallow foundations placed within these materials could incur unacceptable total and differential settlements. It is therefore considered that the made ground in its current condition is not suitable for the support of shallow spread foundations. Notwithstanding the above, it is likely that owing to the relatively thin layer of made ground encountered at this site foundation s would bear upon natural clays at normal founding depths.

An allowable net bearing capacity of 100kN/m^2 is considered appropriate for the stiff and very stiff sandy gravelly clays present at shallow depth within the north of the site. Structural loads could be supported upon traditional strip foundations bearing upon the stiff and very stiff soils in the north of the site.

Within the south, of the site a bearing capacity of 60kN/m^2 is considered appropriate for the firm and friable sandy clays, laminated clays and sand horizons. Traditional strip foundations could be used to support structural loads subject to application of the above recommended bearing pressures.

If anticipated building loads are such that they can not be adequately supported upon traditional shallow spread foundations, imposing the above recommended bearing pressures, consideration could be given to alternative foundation solutions, particularly when bearing upon firm fluvio-glacial/lacustrine clays. In this instance, both deep trench fill foundations, extending through the shallower soils to bear entirely within the underlying sandy gravelly clay which is at least stiff in consistency; or, raft foundations placed within natural soils at shallow depth could be considered. The decision should be subject to a cost engineering exercise.

The natural stiff and very stiff soils encountered in the north, and at depth within the centre and south of the site are classified as low to intermediate plasticity clay and, according to NHBC guidance, of low volume change potential. Soils at shallow depth in the central and southern areas of the site are of medium to high volume change potential. In light of this, the minimum foundation depth below finished ground levels should be 0.75m in the north of the site, and 1.0m in the central and southern areas of the site. This depth is required to alleviate any effects on the foundations, resulting from volumetric changes in the clay, owing to seasonal variations in moisture content.

Foundations should be taken below a line drawn up at 45º from the base of any existing or proposed services. Allowance should be made for the relocation where necessary of the existing culverted watercourse beneath the site.

Based on the samples tested, and in accordance with BRE Special Digest 1, a Design Sulphate Class of DS-1 and an ACEC Class of AC-1s may be used for concrete structures or services below ground level, assuming static groundwater.

The founding stratum is expected to deteriorate especially upon exposure to rain or groundwater. In light of this, the formation should be protected by a layer of blinding concrete, immediately following excavation of the foundation trench.

Generally, less than 600mm of made ground has been identified across the site, although deeper pockets have been identified locally, thought to be associated with former buried domestic services/ land drains and foundations. Following grubbing out of former services beneath proposed plots, it is expected that ground bearing floor slabs will be appropriate.

9.3 Excavations

Based on the nature of the made ground identified, it is considered that excavations should generally be within the capacity of normal earthworks plant.

Adequate shoring should be provided to all excavations. Reference to CIRIA Report 97 'Trenching Practice' should be made to establish suitable methods of ground support or battering back of any excavation face.

Based upon the results of the ground investigation, no significant ingress of groundwater is anticipated at shallow depths. Any which does occur should be adequately controlled by traditional site pumping practices.

It is recommended that an adequate drainage system for surface water be installed by a competent contractor in order to prevent surface water ponding or collecting during and post construction, which may in turn lead to deterioration of the founding stratum.

9.4 Road Pavement Design

Reference has been made to Highways Agency publication Interim Advice Note 73/06. With respect to the subgrade comprising natural cohesive soils a preliminary CBR design value of 2% is considered appropriate, assuming a low water table and good construction conditions.

In the north of the site, a CBR design value of the order of 6% is considered appropriate, assuming a low water table and good construction conditions. This should be reduced to between 2% and 3% for central and southern areas of the site.

9.5 Contamination Constraints to Development

It is understood that the site is to be developed with residential properties with domestic gardens, carriageways, car parking and areas of soft landscaping.

End users

Samples of localised made ground associated with tarmac hardsurfacing in the south of the site have returned concentrations of the PAH benzo(a)pyrene, and of chromium, in excess of the selected guidance value.

Based on the contaminant > pathway > receptor philosophy, and the chemical results obtained as part of this investigation, it is considered that there is currently a **moderate** risk to end users from the identified contaminants.

During development, this soil should be excavated and either removed from site for disposal to an appropriate waste receiver, or, if practicable, relocated into hardsurfaced areas of the site (i.e. carriageways / below buildings) in order to break the identified potential pollutant linkages.

As an alternative, if the above options are impractical, a capping layer of suitable thickness could be placed over the made ground to break any pollutant pathway linkages. The required thickness of such a capping layer should be negotiated with the local authority environmental health department.

Controlled Waters

With regard to the environmental setting of the site, and the results of laboratory testing of identified soils, controlled waters are not considered at risk from contaminants on this site.

Construction and maintenance workers

Normal health and safety procedures should be adopted by groundworkers including no eating, drinking or smoking on-site, designated clean and wash areas and protective clothing. It is also recommended that procedures outlined in the HSE document “Protection of Workers and the General Public during Redevelopment of Contaminated Land” be followed. This report should be forwarded to the construction company undertaking the groundwork’s in order for them to assess the risk to their personnel.

It is possible that other areas of more significant contamination may be encountered on site. If any areas of odorous, liquid, fibrous, noxious, drummed etc. ‘waste’ are encountered, works should cease and the advice sought of a suitably qualified consultant.

9.6 Hazardous Gas

Basic radon protection measures are not required for development on this site.

According to the LIG report, there are no recorded landfill sites within 250m of the site.

MBC have no record of historical landfilling within a 500m radius of the site.

No evidence of putrescible matter within made ground or natural soils was identified during the investigation, and the risk from 'landfill' gas is considered low. On this basis, it is considered that no protective measures are required in this respect.

9.7 Services

Results of contamination testing should be provided to service suppliers to determine the requirements for any protection of buried services within the made ground. Suppliers should be made aware of the undertaking, and validation of any remedial measures. Following remediation of the site, protection of buried services should be reassessed.

9.8 Regulatory Approval

The conclusions and recommendations presented above are considered practical based on the findings of the site investigation. The conclusions and recommendations cannot be guaranteed to gain regulatory approval, and therefore, should the report be required as a planning condition, it should be passed to the regulators (local authority, Environment Agency and NHBC as appropriate) for their comment/approval prior to undertaking remedial works or commencement of development.

A formal remediation statement / strategy should be drawn up for the site, detailing the methodology to be followed during execution of the remedial actions recommended. This should be submitted to, and approved by, the local authority and NHBC prior to commencement of any associated works at the site.

Any remediation undertaken should be carried out by appropriately experienced and competent contractors in accordance with current legislation, and should be supervised and validated by a suitably qualified and experienced third party. If remediation is considered necessary, a formal validation report detailing the extent of remedial works, and confirming risks to identified receptors have been addressed will be necessary to gain local authority and NHBC approval.

9.9 Disposal of soils and groundwaters

Where excess spoil is generated, or it is deemed materials are unsuitable for on-site retention, the wastes should be disposed of in accordance with the Duty of Care Regulations. Additional Waste Acceptance Criteria (WAC) analysis will be required to determine the most appropriate disposal facility for the waste in accordance with the requirements of the current Landfill Directive.