

BAIRD'S FARM, CROOKTHORNE LANE, CLIMPING, LITTLEHAMPTON



GROUND INVESTIGATION REPORT

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BAIRD'S FARM, CROOKTHORNE LANE, CLIMPING, LITTLEHAMPTON

GROUND INVESTIGATION REPORT

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**Text****Page No**

EXECUTIVE SUMMARY	i
PART ONE – INTRODUCTION	1
1.0 INTRODUCTION AND OBJECTIVES	1
1.1 Introduction	1
1.2 Objectives	1
PART TWO – STAGE 1 INVESTIGATION	2
2.0 SITE RECONNAISSANCE	2
2.1 Site Walkover	2
2.2 Invasive Plant Survey	2
3.0 APPRAISAL OF EXISTING INFORMATION	3
3.1 General Information	3
3.2 History of Land Use	3
3.3 General Geology	4
3.4 Mining and Quarrying	4
3.5 Ground Stability	4
3.6 Potentially Contaminative Site Uses	5
3.7 Hydrogeology	5
3.8 Hydrology	6
3.9 Pollution Incidents	6
3.10 Landfills and Waste	6
3.11 Naturally Occurring Radon	6
3.12 Sensitive Land Uses	7
3.13 Unexploded Ordnance (UXO) Risk	7
3.14 Chemical Contamination and Gas Emissions	7
4.0 STAGE 1 PRELIMINARY QUALITATIVE RISK ASSESSMENT	9
4.1 Stage 1 Preliminary Qualitative Risk Assessment	9
4.2 Objectives of the Site Investigation and Methodology	11
PART THREE – STAGE 2 INVESTIGATION	12
5.0 SITE INVESTIGATIONS	12
5.1 Programme of Works and Investigation Rationale	12
5.2 Contamination Assessment Sampling Protocols	13
PART FOUR – GEOTECHNICAL	14
6.0 SITE GEOLOGY	14
6.1 General	14
6.2 Made Ground	14
6.3 Natural Deposits	14
6.4 Solid Geology	14
6.5 Groundwater	15
7.0 ENGINEERING CHARACTERISTICS OF THE SUPERFICIAL AND SOLID MATERIALS	16
7.1 General	16
7.2 Natural Superficial Deposits-Cohesive	16
7.3 Natural Superficial Deposits-Granular	16
7.4 Solid Strata-Chalk	16
7.5 Laboratory Testing	16

8.0	FOUNDATION DESIGN CONSIDERATIONS	17
8.1	General	17
8.2	Made Ground	17
8.3	Natural Deposits	17
8.4	Rock Strata	18
8.5	Ground Dissolution	18
8.6	Buried Concrete Design	18
8.7	Excavations and Groundwater	19
8.8	Percolation Testing	19
8.9	Road and Pavement Design	20
8.10	General Site Development	20
	PART FIVE – CHEMICAL CONTAMINATION AND GAS EMISSIONS ASSESSMENT	21
9.0	STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT - CHEMICAL CONTAMINATION	21
9.1	Introduction	21
9.2	Risk Assessment	21
9.3	Summary	23
10.0	GAS EMISSIONS RISKS	24
10.1	General	24
10.2	Analysis of Results	24
10.3	Risk Assessment and Conclusions	25
11.0	RECOMMENDATIONS FOR CHEMICAL CONTAMINATION AND GAS	26
11.1	Validated Conceptual Site Model & Requirement for Remedial Measures	26
11.2	Selection of Remedial Actions	26
11.3	Reuse of On-site Materials	26
11.4	Disposal of Waste Materials to Landfill	27
11.5	Chemical Contamination	27
11.6	Site Personnel	27
11.7	Buildings and Services	27
11.8	Gas and Vapour Emissions	27
11.9	Invasive Plant Survey	28
	APPENDICES	29
Appendix 1	Drawings	
Appendix 2	Groundsure Enviro+Geo Insight Report	
Appendix 3	Historical Plans	
Appendix 4	Third Party Detailed UXO Report	
Appendix 5	Trial Pit Logs - JPB September 2020	
Appendix 6	Borehole Logs - JPB September 2020	
Appendix 7	Windowless Sample Logs - JPB September 2020	
Appendix 8	CBR Pit Logs - JPB September 2020	
Appendix 9	Results of in-situ Soakaway Tests - JPB September 2020	
Appendix 10	Results of in-situ CBR Tests	
Appendix 11	Geotechnical Test Results	
Appendix 12	Chemical Test Results	
Appendix 13	Results of Ground Gas and Groundwater Monitoring - JPB	
Appendix 14	Methodology for Exposure Assessment and Ground Gas Risk Assessment	



Drawings Appendix 1

Client Supplied	Proposed Site Plan (Drawing No. M9316_APL003 dated May 2018, prepared by Hunters)
G/UC468/01	Site Location Plan
G/UC468/03	Location of Site Investigation Works

EXECUTIVE SUMMARY

Johnson Poole & Bloomer Limited (JPB) were commissioned by Brackley Investments Limited, to prepare a Ground Investigation Report for the site at Baird's Farm, Crookthorne Lane, Climping, Littlehampton. The site is centred on National Grid Reference 499957 101727 and occupies an area of approximately 0.78 ha. The purpose of the report was to appraise the ground conditions at the site and to determine what impact these may have on a proposed residential Dementia Care Home development land use for the site.

This section provides a brief summary of the investigation findings in relation to the geotechnical, mining, chemical contamination and gas emissions constraints at the site.

Historical Background

On Site	Off Site
Greenfield /occasional Camping Ground	Residential development, Farm Shop, Camping Ground, Farm complex

Invasive Plants

An invasive plant survey was not carried out during the investigation works and a survey of the site by an ecologist is recommended prior to commencement of works at the site.

Geology

The investigation has indicated the site to be underlain by a localised mantle of naturally-derived Made Ground located in the north-east site area.

The natural soils, elsewhere from surface, were found to comprise a combination of both cohesive and granular soils which display both variable consistency and relative density, which decrease with depth and are interpreted to represent anticipated undifferentiated River Terrace Deposits.

Chalk was proven to underlie the natural Superficial soil deposits, the depth to the chalk strata varying between 3.60 and 7.00 metres across the site.

Foundation Solution

Deposit Type	Foundation Option	Allowable Bearing Capacity based on a 0.6m wide foundation
Made Ground	Only local occurrences. Not suitable for spread foundations	N/A
Undifferentiated River Terrace Deposits-Superficial Soils	Variable engineering characteristics and very shallow groundwater table recorded preclude use of spread foundations.	N/A
Chalk Rock Strata	Foundation loads extended into Chalk strata using piled foundations. It is advised that further discussions are held with specialist Contractors to confirm the preferred piled foundation design solution at the site. Consideration should be given to undertaking a geophysical survey in order to confirm that ground dissolution in the underlying Chalk is not a geo-hazard to overall building development and foundation /road design.	N/A

Chemical Contamination and Gas Emissions

Based on the risk assessments carried out and in recognition of the validated conceptual site model the following measures are required to address risks posed by chemical contamination and ground gas emissions.

Receptor		Measures required
<i>Chemical Contamination</i>		
Human Health	Contact with soil	No remedial measures are required.
Human Health	Inhalation of Dust and Vapours	No remedial measures are required.
Plant Growth		No remedial measures are required.
Invasive Plants		An invasive plant survey of the site by an ecologist is required.
Building/ Services	Concrete	pH values and sulphate concentrations indicate that the ground conditions fall within design sulphate class DS-1 and ACEC class AC-1 as defined in BRE Special Digest 1, 2005. Therefore, an appropriate concrete specification is required to protect building elements in contact with these conditions.
Building/ Services	Water supply pipes	No contaminant concentrations were identified which are considered to permeate water pipes or impact on their integrity. Therefore, no restriction is made on the type of water pipes which can be used on the site.
Surface Water		No remedial measures considered necessary based on proven soil chemistry.
Groundwater		No remedial measures considered necessary based on proven soil chemistry.
<i>Ground Gas Emissions</i>		
Human Health & Buildings/ Services		The following account of the gas conditions at the site is based on the first three rounds of gas monitoring and as such these are provisional. The final gas conditions will be confirmed following the completion of the full period of gas monitoring. No remedial measures required based on readings to date.
<i>Radon</i>		
Human Health		Groundsure Report indicates that the site is not within an area where radon protection is required, and, therefore, no radon protective measures are required.

Road Construction

Selective CBR test were carried out in proposed road/car park areas at anticipated formation levels which recorded in-situ values ranging between 8.4 and 11.6%. In view of very shallow groundwater table recorded it is recommended that a more "conservative" design CBR value in the range 5 to 6 % be adopted.

PART ONE – INTRODUCTION

1.0 INTRODUCTION AND OBJECTIVES

1.1 Introduction

Brackley Investments Limited are assessing the potential of a site located at Baird's Farm, Crookthorne Lane, Climping, Littlehampton (JPB Drawing G/UC468/01). It is understood that the intended land use is a 64 bedroom two-storey residential Dementia Care Home with access road, car park and communal gardens and landscaping areas. A Client supplied drawing showing the current development proposals is given in Appendix 1.

This Report incorporates the findings of a Stage 1 Desk Study based upon archival researches of internal and external published data and also Stage 2 intrusive Ground Investigations.

This report has been prepared and written on behalf of Brackley Investments Limited in the context of the purpose stated above and should not be used in any differing context. No duty of care extends to any third party that may make use of the information unless written confirmation has been provided by Johnson Poole & Bloomer. In addition, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore, with any change in circumstances, or after the expiry of one year from the date of the report, it should be referred to us for reassessment and, if necessary, amendment. No action or proceedings can be commenced against the JPB after the expiry of 6 years from the date of this report.

The copyright in this report and accompanying drawings is owned by Johnson Poole & Bloomer Limited and may not be reproduced, published or adapted without our consent. Subject to satisfaction of copyright conditions required by Ordnance Survey and British Geological Survey, complete copies may, however, be made and distributed by the client as appropriate in dealing with matters directly related to its commission.

1.2 Objectives

JPB were commissioned by Brackley Investments Limited, to undertake site investigation works. The aim of the investigation was to provide information to identify environmental and geotechnical constraints which may have consequences in the design of the development and to provide information to be submitted as part of the planning process and in obtaining regulatory approvals.

Therefore, the investigations had the following main objectives:

- To identify any chemical contamination constraints;
- To examine the ground gas regime and any constraints posed by gas emissions;
- To determine a foundation horizon and potential foundation solution; and
- To identify any mining constraints (from the findings of archival researches only).

The investigation of the geotechnical and chemical contamination conditions is now complete and this report presents the factual inv

At the time of writing, a ground gas and groundwater monitoring exercise is still ongoing. The current findings of the ground gas monitoring exercise are also contained in this report. However, the findings and conclusions of the monitoring exercise will be presented in an Addendum to this Report.

It is anticipated that during the course of any redevelopment works various local authority departments will become involved. We, therefore advise that, where appropriate, our report and associated information are submitted to the regulatory bodies and approval obtained before detailed design, site works or other irrevocable actions are embarked upon.

PART TWO – STAGE 1 INVESTIGATION

2.0 SITE RECONNAISSANCE

2.1 Site Walkover

The development site is located approximately 2.5 kilometres to the west of the town centre of Littlehampton in the village of Climping; the site being defined by the approximate National Grid Reference 499957 101727, as shown on our Drawing No. G/UC468/01.

The area of investigation comprises an irregular-shaped parcel of land covering an area of approximately 0.78 hectares, currently consisting of a field together with some hard standings associated with and to the side and rear of the Baird's Farm Shop/ "Maidenhead Aquatics" building, which is located immediately to the north and north-west of the site. (Drawing No. G/UC468/03).

The site is bounded to the north by the aforementioned building and the main A259 Crookthorne Lane road; to the east by the Woodpecker and Home Camping Field; to the south-west by a pond and small Blacksmith building with adjacent walled garden; to the south by buildings associated with Hobbs Farm and to the west by a garden and residential property (The Cottages) fronting Climping Street.

The entrance to the site is located adjacent to the east of the Farm Shop building from the car park via a farm gate.

The site surface displays a gentle slope down from north to south with a maximum elevation of the order of 8m to a minimum of the order of 5mAOD.

The surface of the site is covered with grass and is bound with large mature hedgerows on the eastern, western and southern site boundaries. The area of the site adjacent to the east of the site entrance is currently more overgrown mainly with brambles and long grass.

In the north-east of the site there is a small rectangular area of hardstanding associated with the adjacent shop.

It is understood that the site is occasionally used as a Camping Ground as an overspill area to the field located immediately to the east of the site.

2.2 Invasive Plant Survey

An invasive plant survey was not carried out during the investigation works and a survey of the site by an ecologist is recommended prior to commencement of works at the site.

3.0 APPRAISAL OF EXISTING INFORMATION

3.1 General Information

Initial research undertaken prior to the site investigation works included a routine examination of available geological maps, past and present editions of the Ordnance Survey and relevant in-house data. A summary of information obtained from our researches is presented below:

- British Geological Survey Sheet 317 and 322 at 1:50,000 scale.
- British Geological Survey's (BGS) Website for geological data.
- Review of Mining Instability in Great Britain, Arup, 1990.
- BRE Report BR 211 (2015).

Reference has also been made to the Groundsure Enviro + Geo Insight Report (reference GS-6920023 and dated 28/07/2020), otherwise known as the Groundsure Report, and Historical Map coverage obtained from Groundsure Insights, included in Appendices 2 and 3, respectively.

Reference has also been made to the "Zetica UXO" Unexploded Bomb Risk Map for the site. "Zetica" states that "the map indicates the potential for Unexploded Bombs (UXB) to be present as a result of World War 2 (WWII) bombing".

In addition to the above we have consulted the findings of a Detailed Unexploded Ordnance (UXO) Risk Assessment Report prepared by 1st Line Defence, Reference DA11479-00 dated 9 July 2020, a copy of which was provided by the Clients Engineer in advance of Stage 2 works commencing. A copy of the report is included in Appendix 4.

No other liaisons with external organisations/regulatory bodies, etc., have been undertaken in preparing this report.

3.2 History of Land Use

An investigation of the past usage of the site can often provide an indication of the presence of potentially contaminated soils arising from processes associated with former land uses. These researches can help to identify any potential constraints to developments upon which physical investigations can then concentrate. Past copies of Ordnance Survey Maps and air photos were examined, with particular attention being given to the industrial heritage of the study area and the changing land use of the site. The summary of the historical land uses identified on and adjacent to the site are described below.

Ordnance Survey Edition (Appendix 3)	On Site	Surrounding Area
1876	Greenfield. Site formed part of a larger field parcel	Crookthorne Lane and Climping Street "roads" had been constructed to the north and west, respectively. "Hobbs Farm" with its various buildings was located to the south. Residence with garden located to the west. Two small ponds located to the west and immediately to the south-west. Residences and Post Office located along Climping Street (at Climping village) to south-east.
1898	As 1876	Pump located in Hobbs Farm complex.
1912	As 1898	As 1898.
1937	As 1912	Additional agricultural buildings including a long row of presumed animal pens constructed beyond the southern/south-eastern site boundary. Additional residential development constructed between Hobbs Farm and Climping village to south-east.
1950	As 1937	Small-scale part plan only. Area to north and north-west recorded, broadly similar to in 1937.
1957	As 1950	Small scale plan. Generally as 1937. Reference to "Ford Airfield" located well to the north-east of site.
1972/1974	As 1950	Crookthorne Lane (A259) road realigned to north together with junction with Climping Street to north-west, with Electrical Substation to west. Site entrance created for future development of Farm Shop structure to north.

Ordnance Survey Edition (Appendix 3)	On Site	Surrounding Area
		Residence to west annotated "The Cottages". Reference to Ford "HM Prison" and to a plant "Nursery" located at Horsemere Green, both well to north of Crookthorne Lane.
1980	As 1972/1973	Generally as 1972/1974. "Ford Aerodrome" apparently expanded in area to north and north-west.
1991	As 1980	Small-scale plan. Building located in area immediately to the north-west of site in current position of "Maidenhead Aquatics".
2003	As 1991	As 1991. (Post 2003, extension of the building has occurred to east closer to site boundary at an undetermined time).
2010	As 2003	Small-scale plan. Generally as 2003.
2020	As 2010	Small-scale plan. Generally as 2010.

3.3 General Geology

The published geology plans (Sheet 317 and 322 at 1:50,000 scale) record the site to be underlain by natural superficial soils comprising Aeolian Deposits ("Brickearth") described as "mainly silts, in part contaminated with gravel" but lying close to the superficial soils geological boundary with 1st Raised Beach Deposits (Sands and Gravels) located just to the east.

At depth, the site is underlain by solid strata of the Upper Chalk Group of Upper Cretaceous age. The Upper Chalk Group is made up of the Lewes Nodular, Seaford, Newhaven, Tarrant, Spetisbury and Portsdown Chalk Members.

The British Geological Survey's Website records the site to be underlain by natural superficial soils comprising River Terrace Deposits (Undifferentiated Sand, Silt and Clay), overlying solid strata consisting of Undifferentiated Chalk of the Lewes Nodular, Seaford, Newhaven, Culver and Portsdown Chalk Formations, of Cretaceous age.

Littlehampton Anticline lies approximately 2.3km to the north of the site with its axis trending in an approximately east-west direction due north of the site. This results in the solid strata down dipping to the south away from the anticlinal axis and towards the coast (site).

On the basis of the land use history, significant accumulations of Made Ground would not be anticipated, other than associated with the area of hard standing to the north-east close to the Farm Shop building, whilst local disturbance of the upper natural soils associated with possible former farming activities in the field in the past may be expected.

3.4 Mining and Quarrying

On the basis of the "Review of Mining Instability in Great Britain" funded by the Department of the Environment, the site lies within an area with no evidence of underground mining for coal and associated minerals, and concludes that "mining need not be regarded as a planning consideration".

In view of the geological structure beneath the site area, underground mining is not considered to be a criterion for foundation design and selection.

The Groundsure Report (Appendix 2) records two data entries for Surface Ground Workings within 250 metres of the site. They relate to Ponds located 3m to the south-west and a Sewage Works located 122m to the east of the site.

Examination of historical land use plans has recorded no evidence of "quarrying" activity beneath, or in the immediate vicinity of, the site (Appendix 3).

3.5 Ground Stability

The Groundsure Report (Appendix 2) uses data provided by the British Geological Survey (BGS) to obtain information on Ground Stability conditions. It should be noted that these BGS designations are typically for the regional geological conditions rather than specifically for the ground conditions on-site.

The Groundsure report presents a maximum "Negligible" on-site ground stability "hazard" rating to occur in relation to the potential for:-

- Compressible Deposits

The same report presents a maximum "Very Low" on-site ground stability "hazard" rating to occur in relation to the potential for:-

- Landslides
- Ground Dissolution of Soluble Rocks

The Groundsure report presents a maximum "Low" on-site ground stability "hazard" rating to occur in relation to the potential for:-

- Shrink Swell Clays
- Running Sands
- Collapsible Deposits

3.6 Potentially Contaminative Site Uses

The Groundsure Report does not record any Sites Determined as Contaminated Land under Part 2A EPA 1990 within 500 metres of the site (Appendix 2).

The same report records 3 No. Historical Industrial Land Use entries within 250 metres of the site. These relate to an Electric Substation 102-103m to the west (1978 and 1991); Sewage Works 122m to the east (1992) and an Unspecified Works 122m to the east (1974-1981).

The same report under Historical Energy Features records 3 No. duplicated data entries within 250 metres of the site. They relate to an Electricity Sub Station 115-116m to the west of the site.

The Groundsure Report records 2 No. Current Industrial Sites data entries within 250 metres of the site. The entries both relate to Electricity Sub Stations located 116m to the west and 234m to the west (Appendix 2).

On the basis of the site history forming part of an agricultural field and occasional use as an overspill Camping ground, the site is considered to have a low potentially Contaminative past land use and therefore, it is unlikely that any significant contamination will be present on-site (subject to confirmation by undertaking intrusive site investigations).

3.7 Hydrogeology

The Groundsure Report (Appendix 2) records the site to lie within a Groundwater Vulnerability area with the site having a Secondary Superficial Aquifer designation with both a High Vulnerability rating: Leaching Class High and a Medium Vulnerability rating: Leaching Class Intermediate.

Information obtained from the Groundsure Report in relation to Aquifer Designation data indicates that the Bedrock Geology beneath the site is recorded as a Principal Aquifer Designation (Appendix 2).

The same report indicates that the Superficial Geology beneath the site is recorded as a Secondary (A) Aquifer Designation.

There is one licensed Groundwater Abstraction recorded within 1 kilometre of the site, located 775 metres to the south-west of the site; it is Active and used for general Farming & Domestic purposes (Appendix 2).

No Potable Water Abstraction Licences are recorded within 1500 metres of the site (Appendix 2).

The Groundsure Report does not record any Source Protection Zones within 500 metres of the site (Appendix 2).

The same Report has recorded areas both on the site and within 50m of the site that are High Risk to Groundwater Flooding.

3.8 Hydrology

The Groundsure Report indicates that the nearest recorded surface water feature to the site lies 5 metres to the south-west of the site boundary. It relates to a small Pond. A second small Pond is also recorded on the opposite side of Climping Street in close proximity (Appendix 2).

The same report records 1 No. Water Framework Directive (WFD) Surface Water Body Catchment area on site. The WFD aims to protect inland surface waters, estuaries, coastal waters, and groundwater. It is referenced Ryebank Rife. Ryebank Rife watercourse (stream) is located 414 metres to the south of the site. It recorded a "Good" Chemical Rating; "Moderate" Ecological Rating and "Moderate" Overall Rating (in 2016) (Appendix 2).

The same report has recorded a WFD Groundwater Bodies data entry on site. It is referenced Littlehampton Anticline West and it recorded a "Good" Chemical Rating; "Poor" Quantitative Rating and a "Poor" Overall Rating (in 2015) (Appendix 2).

The Groundsure Report records two Surface Water Abstraction data entries on site. One is recorded as having Historical Status and the other as Active Status, both for Direct Spray Irrigation by line from Ryebank Rife and Elmer Rife (Appendix 2). It is considered possible that the water Abstraction is taken from the pond located immediately to the south-west of the site as Ryebank Rife stream is located over 400m distant to the south.

The same report indicates that the site is not recorded as lying within 50 metres of a River and Coastal Zone 2 or Zone 3 Floodplain as designated by the Environment Agency.

The site is not recorded lying within 250 metres of a Historical Flood Event or within 50 metres of a Risk of Flooding from Rivers and Sea (RoFRaS) (Appendix 2).

The Groundsure Report in relation to Surface Water Flooding records the highest risk on site to be a 1 in 250 year flood risk (0.1 to 0.3m) and within 50 metres of the site boundary records a 1 in 30 year flood risk (0.3 to 1.0m) (Appendix 2).

3.9 Pollution Incidents

The Groundsure Report indicates that there is no recorded Pollutant release to Surface Waters (Red List) or to a Public Sewer located within 500 metres of the site boundary (Appendix 2).

The same Report records 1 No. Environment Agency Pollution Incident within 500 metres of the site. It related to Asbestos pollution 448 metres to the north-west in 2003 and resulted in a Category 3 "Minor Impact" on Land and Category 4 "No Impact" on Water and Air (Appendix 2).

3.10 Landfills and Waste

The Groundsure Report does not record any Active or Recent Landfills or Historical (BGS Records, Local Authority or Mapping Records and Environment Agency) Landfill sites within 500 metres of the site (Appendix 2).

The same report records one Historical Waste Site within 500 metres of the site, located 413 metres to the north. It is referenced as a Scrap Yard and was active in 1983 (Appendix 2).

The same report records three (duplicated) Licensed Waste Sites located 313 to 315 metres north of the site (Appendix 2). It is referenced Ford Waste Recycling at Rudford Industrial Estate and it accepted household, commercial and industrial waste (Transfer Station).

There are numerous Waste Exemption data entries within 250 metres of the site, from two farm locations, namely Home Farm, The Street located 166 metres to the south-east and Rigates, Climping Street, located 186 metres to the south-east (e.g. for burning waste, storing waste, aerobic composting, treatment of wood and chippings, spreading waste, use of mulch, recovery of scrap metal etc.) (Appendix 2).

3.11 Naturally Occurring Radon

The Groundsure Report states that it is estimated that "less than 1%" of properties are affected by Radon gas and that no Radon Protection Measures are required (Appendix 2).

In the 2015 Edition of BRE Report 211, the site area underlies annotation on the map and therefore no conclusion can be drawn from this document. (Appendix A in the aforementioned document).

3.12 Sensitive Land Uses

The Groundsure Report records a Site of Special Scientific Interest (SSSI) Impact Risk Zone to development proposals, on site (Appendix 2).

The same report records an Agricultural Land Classification on site as Grade 1 (excellent quality agricultural land) in the north-east area and Grade 2 (very good quality agricultural land) over the remaining site area (Appendix 2).

The Groundsure Report records a Priority Habitat Inventory for Deciduous Woodland 32 metres to the north and the need for a Tree Felling Licence (Clear Fell (conditional)) 36 metres to the north (Appendix 2).

3.13 Unexploded Ordnance (UXO) Risk

The findings of a third party Detailed Unexploded Ordnance (UXO) Risk Assessment Report have been consulted (Appendix 4).

This report states that "there is a Low - Medium Risk from items of German aerial delivered UXO and a Negligible Risk from items of Allied UXO across the site".

The conclusion in respect to German Aerially Delivered Ordnance is based on the following summary; a low bombing density within the Rural District of Chichester; written records providing no positive evidence suggesting the site or its immediate surroundings had been subject to bombing; OS mapping and "WWII-era" imagery indicating no signs of significant bombing damage or cratering at the site and the site was likely to have elevated access and monitoring during WWII due to its proximity to Hobbs Farm and Crookthorne Lane leading to some level of vigilance/checks.

The conclusion in respect to Allied Ordnance is based on the following summary; no evidence that the site was used for military occupation or usage and the condition for ordnance projectiles to have fallen unnoticed at the site are similar to that of German ordnance reported above.

The Report concluded that the following "Risk Mitigation Measures" are recommended at the site:

- UXO Risk Management Plan.
- Site Specific Awareness Briefings to all personnel conducting site operations.

3.14 Chemical Contamination and Gas Emissions

Chemical Contamination

Our researches have indicated that the site has been occupied by essentially undeveloped land throughout its history with a local mantle of Made Ground close to the site entrance in the north-east corner. It is less likely, therefore, that any significant chemical contamination will be present on site. However, testing for general contamination should be carried out to confirm ground conditions.

JPB examined DoE Industry Profiles for the various site usages where appropriate. The typical contaminants associated with the historical and current land uses of the site are as follows.

Previous site uses including greenfield and occasional camping ground	
<i>Metals and metalloids</i>	Toxic metals and metalloids including; arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc.
<i>Inorganic</i>	Sulphides, sulphates, cyanides.
<i>Organics</i>	Petroleum hydrocarbons, PAHs, phenols.
<i>Others</i>	Asbestos.



Ground Gas

On Site Sources

The site has been essentially undeveloped throughout its history and is indicated to be underlain by undifferentiated River Terrace Deposits, acknowledged to be a very low gas generation potential material. It is, therefore, unlikely that significant amounts of made ground or other sources of ground gas emissions will be present on site and, as a result, elevated ground gas concentrations are not expected in the shallow soil deposits.

Off Site Source

The site does not lie within close proximity to any recorded landfill sites and therefore investigations are not required to determine the level of risk posed by such an off-site gas source.

Deep Seated Gas

The site is in an area where there is the potential for ground gases from the underlying Chalk strata to occur in the form of Carbon Dioxide, which could impact the whole site, therefore, investigations are required to determine the level of risk posed by this gas source.

Radon

The Groundsure Report indicates that the site is not within an area where radon protection is required and therefore, no radon protective measures are required.

4.0 STAGE 1 PRELIMINARY QUALITATIVE RISK ASSESSMENT

4.1 Stage 1 Preliminary Qualitative Risk Assessment

In assessing the research information, a Stage 1 Preliminary Qualitative risk assessment has been carried out in order to develop an Initial Conceptual Site Model for the site. The Conceptual Site Model (CSM), is generated in accordance with Guide to Good Practice for the Development of Conceptual Models and the Selection and Application of Mathematical Models of Contaminant Transport Processes in the Subsurface - National Groundwater & Contaminated Land Centre report NC/99/38/2 – Environment Agency 2001.

In the Stage 1 Preliminary Quantitative Risk Assessment the next step in assessing environmental risks and constraints for the site is to use the available research information to develop a Conceptual Site Model (CSM). The CSM describes how potential chemical sources at the site could contribute to increased levels of risk to potentially sensitive receptors. The CSM identifies the sources of contamination, the likely receptors and the potential pathways present which may link them. Where it appears that a pathway links a source to a receptor, this potential significant contaminant linkage should be the focus of site investigations.

The CSM is developed at an early stage and constantly reassessed in light of investigative findings. The first step in producing such a model is to identify whether there are potential hazards on site through desk top research together with the application of professional expertise and judgement. In addition, information regarding the site-specific environmental setting including geology, hydrogeology, hydrology etc., is gathered to identify the environmental resources which could be impacted by potential contaminants at the site. Within this context, a hazard is defined as a property that has the potential to cause harm to a receptor group.

A summary of this preliminary assessment is presented in the following ICSM table which summarises the individual source, pathway and receptors considered to be present.

SPR item	SPR item present based on desk study (Yes/No)	Comment
Sources		
S1 – Contamination from former land use	Yes	Site recorded to be essentially Greenfield, but occasionally used as a Camping Ground. Significant made ground is not anticipated, therefore, no major source of contaminants anticipated. Further investigations required to clarify extent and magnitude of risks.
S2 – Contamination from adjacent land use	Yes	Farm Shop and car park adjacent to northern site boundary. Possible small Blacksmith and Farm activities located to south-west and south. Further investigations required.
S3 – Ground gas	Yes	Local mantle of made ground could be present beneath site which could contain biodegradable material and could degrade to produce elevated levels of gas. Underlying chalk strata could be a potential source of elevated carbon dioxide. Further investigations required.
S4 – Leachable contaminants	Yes	Some potential made ground contaminants may be leachable or mobile. Further investigations required.
S5 – Contamination groundwater in mineworkings	No	Mining is not present under site.
S6 – Contamination from substation	No	Nearest recorded substation located in excess of 100m from site.
Pathways		
P1 – Contact with soil	Yes	Site is to be a residential Care Home development with communal gardens and, therefore, there is the potential for site occupiers/users to come into contact with the soils.
P2 – Ingestion of vegetables	Yes	The site is to be a Care Home with communal gardens, therefore only limited potential for site occupiers to grow their own produce.
P3 – Inhalation of dusts/vapours	Yes	Site residents may be exposed to dusts or vapours from any contaminants present.
P4 – Ingestion of groundwater	Yes	Potential for contact with groundwater.
P5 – Building contact with soil	Yes	Site is to be developed and, therefore, buildings will be present on site.

SPR item		SPR item present based on desk study (Yes/No)	Comment
P6 – Migration via services		Yes	Site is to be developed and, therefore, buildings and associated infrastructure will be present on site.
P7 – Perched groundwater		Yes	Local made ground could be present. Natural River Terrace Deposits could contain clay strata within more permeable horizons; therefore, perched groundwater may be present.
P8 – Vertical migration		Yes	Natural Granular deposits (River Terrace Deposits) may be present allowing vertical contaminant migration.
P9 – Migration of gas		Yes	Potentially elevated levels of gas could migrate through granular soils from underlying chalk or any made ground.
P10 – Groundwater flow through mine workings		No	No mine workings present beneath the site.
Receptors			
<i>Human Receptors</i>			
R1	Adults	Yes	The site is to be a Care Home development and contact with the soil is anticipated to be limited to during construction or in communal garden and landscaping areas.
R2 – Workers & trespassers		Yes	The site is to be developed and, therefore, workers and potentially trespassers on site.
R3 – Adjacent land users		Yes	Adjacent developments include Farm shop and Camping ground, residential and Farm developments.
<i>Plant Receptors</i>			
R4 – Plants		Yes	Site is to be a Care Home development with communal gardens and, therefore, there is the potential for plant growth.
<i>Buildings/services receptors</i>			
R5 – Buildings and infrastructure		Yes	The site is to be developed and, therefore, buildings will be present on site.
<i>Water environment – surface waters</i>			
R6 – Major River		No	There are no major surface water features within influencing distance of the site. In view of the distance to a major surface water body, and the localised nature of any made ground on site it is considered that there is no significant pathway present. In the absence of a significant pathway there is no significant contaminant linkage present and no further assessment is necessary.
R7 – Minor River/ Canal/Pond		Yes	A small pond abuts south-west site boundary. Ryebank Rife (stream) is located in excess of 400m to the south.
<i>Water environment – groundwater abstraction</i>			
R8 – Shallow perched groundwater		No	No groundwater abstractions recorded within 750m. In addition, any perched water in the made ground on site is unlikely to meet the criteria outlined in the WAT-PS-10-01 (Assigning Groundwater Assessment Criteria for Pollutant Inputs) and UKTAG (i.e. that in order to qualify as a body of groundwater an aquifer must be capable of supplying 10m ³ /day or 50 people on a continuous basis). Therefore, in the absence of a receptor or water body no further assessment is required.
R9 – Continuous groundwater in soil		No	No groundwater abstractions recorded within 750m and no Source Protection Zones within 500m. Although natural superficial deposits (River Terrace Deposits) likely to include permeable granular deposits, in the absence of a receptor no further assessment is required.
R10 – Continuous groundwater in rock		No	No groundwater abstractions recorded within 750m and no Source Protection Zones within 500m. Although the underlying rock is noted to be sedimentary chalk and groundwater within this strata may be classed as a water body, in the absence of an abstraction receptor no further assessment is required.
<i>Water environment – groundwater resource</i>			
R8 – Shallow perched groundwater		No	Any perched water in the made ground on site is unlikely to meet the criteria outlined in the WAT-PS-10-01 (Assigning Groundwater Assessment Criteria for Pollutant Inputs) and UKTAG (i.e. that in order to qualify as a body of groundwater an aquifer must be capable of supplying 10m ³ /day or 50 people on a continuous basis). The perched water in the made ground is not considered to be a groundwater body and as such is not a receptor.
R9 – Continuous groundwater in soil		Yes	The natural superficial deposits are indicated to be granular and as such any water in the natural soils on site may meet the criteria outlined in the WAT-PS-10-01 (Assigning Groundwater Assessment Criteria for Pollutant Inputs) and UKTAG (i.e. that in order to qualify as a body of groundwater an aquifer must be capable of supplying 10m ³ /day or 50 people on a continuous basis). It is considered that there is a potential receptor

SPR item	SPR item present based on desk study (Yes/No)	Comment
		present and further assessment is necessary with regard to the continuous groundwater in soils
R10 – Continuous groundwater in rock	Yes	The rock strata are indicated to be sedimentary and are likely to be overlain by permeable superficial strata. As such any water in the deeper aquifer may meet the criteria outlined in the WAT-PS-10-01 (Assigning Groundwater Assessment Criteria for Pollutant Inputs) and UKTAG (i.e. that in order to qualify as a body of groundwater an aquifer must be capable of supplying 10m ³ /day or 50 people on a continuous basis). Further investigations are required to confirm the level of risk to this receptor.
<i>Water environment – groundwater dependent terrestrial ecosystem (GDTE or wetland)</i>		
R11 – GDTE/Wetland	No	No Conserved Wetland (Ramsar sites) areas within 2 kilometres of the site.

4.2 Objectives of the Site Investigation and Methodology

The initial conceptual site model was used to inform the design of the site investigation. Where chemical analysis data has been obtained for soils and waters JPB's risk assessment methodology comprises an initial comparison of potential contaminant concentrations with Stage 2 Risk Assessment generic assessment criteria. The concentrations of contaminants exceeding these criteria and contaminants for which authoritative Stage 3 Risk Assessment criteria were not available are assessed in Stage 3 Risk Assessment, a site-specific quantitative risk assessment.

The Stage 3 Risk Assessment comprises a quantitative risk assessment of contaminant concentrations performed using appropriate risk assessment models and tools. These assessments are discussed in more detail in the later sections of this report.

In order to test and develop the initial CSM, the site investigations had the following objectives:

- To identify the extent of any made ground at the site (potential contaminant source).
- To identify the nature, extent and concentration of contaminants in soil.
- To examine the ground gas regime at the site.
- To determine what threat the site contaminants pose to off site human receptors (occupants of adjacent properties).
- To determine what threat the site poses to on site human receptors (workers and occupants).
- To determine geotechnical properties of soils.
- To determine foundation solutions for development.
- To determine buried concrete design.
- To determine the soakaway properties of the soils.
- To determine road/pavement design CBR values.

In order to achieve these objectives, the investigation was designed to include the following; trial pitting, in-situ soakaway tests, cable percussive boreholes with standpipes installed, windowless sampling with standpipes installed, in-situ CBR tests and specialist laboratory testing of recovered soil and water samples for geotechnical and chemical characteristics. Monitoring of ground gas concentrations and groundwater levels in standpipes was also undertaken. These investigations are described in more detail in the following section of this report.

PART THREE – STAGE 2 INVESTIGATION

5.0 SITE INVESTIGATIONS

5.1 Programme of Works and Investigation Rationale

The design and performance of this site investigation takes cognisance of the guidance given in BS 10175 – Investigation of Potentially Contaminated Sites – Code of Practice – BSI 2011 and BS5930. Investigation points were located where access, ground conditions and underground services allowed. It should be noted that soil and rock conditions are highly variable and may differ between sampling points and this may affect interpolation. Additional features may exist buried at depth and undetected by investigation.

The locations of all investigation positions on site were surveyed in by JPB using a hand held GPS monitor and are shown on JPB Drawing No. G/UC468/03.

Work Item	Description	Appendix
Trial pit excavations	5 No. trial pits , to between 0.50m and 1.50m depth, undertaken by a Johnson Poole & Bloomer Geologist on 15 September 2020. The approximate locations and depths were selected by the Clients Drainage Engineer in order to facilitate Soakaway Testing.	Appendix 5
Rationale	To investigate the nature, extent and engineering properties of the shallow soils underlying the site; to recover soil samples for chemical analysis and to allow in-situ soakaway testing.	
Soakaway tests	Undertaken in 5 No. trial pits (TP1, TP2, TP3, TP4, and TP5) in accordance with BRE Digest 365.	Appendix 9
Rationale	To investigate the potential for discharge of surface run off to soakaways and permeable paviers.	
Cable Percussive Boreholes	3 No. boreholes (BH1 to BH3), to depths of between 10.45m and 21.0m, were sunk across the site between 14 and 21 September 2020. Combined ground gas and groundwater monitoring standpipes were installed in each borehole.	Appendix 6
Rationale	To investigate the nature, extent and engineering properties of the shallow and deep soils underlying the site; recover soil samples for geotechnical analysis and to allow deep monitoring standpipes to be installed.	
Windowless Samper Holes	6 No. windowless sampler holes (WS1, WS2, WS3, WS4, WS5, WS6), to 4.00m depth, undertaken by a Johnson Poole & Bloomer Geologist on 17 September 2020. Combined ground gas and groundwater standpipes were installed in WS1, WS4 and WS5.	Appendix 7
Rationale	To investigate the nature, extent and engineering properties of the shallow soils underlying the site; to recover soil samples for geotechnical and chemical analysis and to allow installation of shallow monitoring standpipes.	
In-situ CBR Test Pits and Results	5 No. in-situ CBR tests (CBR1, CBR2, CBR3, CBR4 and CBR5) conducted in the base of shallow trial pits at 0.50m depth supervised by a Johnson Poole & Bloomer Geologist on 16 September 2020. The approximate locations on site were selected by the Clients Engineer.	Appendix 8 and 10
Rationale	To obtain initial design information using CBR tests to facilitate future road construction thicknesses.	
Geotechnical testing	Geotechnical laboratory testing of soil samples was performed by Geo Site and Testing Services Limited (GSTL) and included the following: i) 6 No. Moisture Content and Atterberg Limits. ii) 1 No. Unconsolidated-Undrained Triaxial compression test-Single Stage. iii) 3 No. Particle Size Distribution (PSD)-Wet Sieve.	Appendix 11
Rationale	To determine the engineering properties of the soils underlying the site.	
Chemical contamination testing	7 No. soil samples from the trial pits, windowless sampler holes and boreholes (7 natural) were analysed by Derwentside Environmental Testing Services Limited (DETS) at our instruction. The soil testing programme comprised the following chemical parameters; pH, total sulphate, water soluble sulphate, total sulphide, monohydric phenols, total cyanide, speciated Polyaromatic Hydrocarbons (PAH), arsenic, mercury, selenium, lead, total chromium, hexavalent chromium, cadmium, copper, nickel, zinc and percentage soil organic matter (SOM).	Appendix 12

Work Item	Description	Appendix
	In addition, a selection of samples was scheduled for the following: i) 6 No. Asbestos Screen. ii) 13 No. pH and water soluble sulphate. 3 No. groundwater samples from the boreholes were analysed. The groundwater testing programme comprised the following chemical parameters; pH, sulphate and chloride.	
Rationale	To determine concentrations of potential chemical contaminants in the shallow soils and to facilitate buried concrete design taking into account of soil and groundwater parameters.	
Gas and water monitoring	Gas and water monitoring at standpipes installed in six facilities, namely Boreholes BH1, 2 and 3 and Windowless Samples WS1, 4 and 5, was carried out. Levels of methane, carbon dioxide, oxygen, nitrogen, carbon monoxide, hydrogen sulphide and atmospheric pressure were recorded. Flow rates were also recorded. Following the collection of the gas data the depth to any water present within the standpipes installed in the boreholes was measured using a dip meter	Appendix 13
Rationale	To determine the shallow and deeper groundwater and ground gas regimes at the site	

5.2 Contamination Assessment Sampling Protocols

JPB's sampling protocol and site specific sampling details are discussed below.

Soil Sampling

For this investigation non-targeted investigation approaches was used. In the investigations, locations were spread across the site to achieve appropriate site coverage. For main investigations BS10175 indicates that "typical" densities can vary between 10m and 25m centres. However, given the predominantly greenfield nature of the vast majority of the site throughout its history, JPB consider that investigations at between 25m and 50m centres is more appropriate. This was confirmed by investigation locations which showed that soils at the site predominantly comprised natural deposits, with only occasional localised predominantly naturally-derived made ground located in the north-east site area.

PART FOUR – GEOTECHNICAL

6.0 SITE GEOLOGY

6.1 General

The general geological conditions beneath the site were assessed from the available information including a review of geological maps.

The recent investigations appear to confirm the anticipated geological conditions with undifferentiated superficial River Terrace Deposits overlying Chalk strata at depth.

6.2 Made Ground

Made Ground was encountered in only two of the site investigation locations, in the shallow hand excavated CBR test pits located in the north-east site area (CBR1 and CBR3). The Made Ground comprised essentially of naturally-derived gravelly sands with local inclusions of brick and clinker. The horizon was proven to a depth of at least 0.50 metres below ground level, but the base of the unit was not identified at these two locations.

6.3 Natural Deposits

The site was typically covered by a horizon of light brown, locally dark brown and brown grey, slightly gravelly sandy silt or silty sand Topsoil which varies in thickness from 0.10 to 0.45m but more typically extends between 0.20 to 0.30m in thickness across the site.

This is generally underlain by an upper variable horizon of stiff and very stiff yellow brown sandy silty clays or a medium dense clayey sandy silt or clayey silty sand, with gravel, of predominantly flint. Below typical depths of 1.00 to 1.50m the more clayey horizons recorded a firm and firm to stiff consistency.

With depth, a medium dense yellow brown locally orange brown grey and cream/off white gravelly silty sand or a gravelly clayey sandy silt/silty sand was recorded, the gravel comprising more of flint and chalk.

In WS1, WS2, WS3, WS4, WS5, WS6 and BH1, below typical depths of 1.80 to 2.50m the strata was either recorded as loose or soft and soft to firm in-situ to typical depths of the order of 3.00 to 3.50m (between 1.80 and 2.30 m below ground level in WS6).

In BH2 between a depth of 3.50 and 4.00m a very dark brown slightly sandy silty clay and organic peat horizon was recorded.

The base of the recorded superficial deposits was highly irregular in its depth, and varied between 3.60 metres (WS5) and 7.00m (BH2) below ground level.

6.4 Solid Geology

The underlying Chalk deposit was recorded in WS5 (at 3.60m), BH3 (4.90m), BH1 (6.00m) and BH2 (7.00m); the horizon only being proven to a limited depth of 4.00m in WS6 (the terminating depth of the hole).

For the purpose of our descriptions within the chalk strata, we have followed the principles outlined in CIRIA publication "Engineering in Chalk" C574, London 2012 in order to determine appropriate Chalk grade, using either a Dm or Dc grade classification, but also acknowledging limitations that the chalk was recovered from small diameter boreholes.

In its upper horizons the chalk comprised a medium dense locally dense off white (locally yellow close to its sub surface boundary) gravelly silt containing gravel and local cobble size fragments of chalk with dark grey flint, in a fines matrix. (DM grade Chalk after CIRIA). The DM grade chalk was recorded extending to depths of 7.50 metres below ground level in BH3, to 10.00m in BH2 and to 17.00m in BH1.

The strata below such depths graded into a DC grade Chalk (see above). The strata consisted of medium dense locally dense off white sandy gravel and/or with cobbles of chalk and dark grey flint in a silty fines matrix.

Below typical depths of the order of 17.00 and 18.00m below ground level in BH1 and BH2, the chalk recorded a very dense relative density.

The chalk was proven to a maximum depth of 10.45m in BH3 and to greater depths of 20.40m in BH1 and 21.00m in BH2, below ground level.

6.5 Groundwater

Groundwater was recorded in the following site investigation locations during the investigation, as follows. The remainder were recorded as dry.

Windowless Sampler/Borehole	Depth (m)	Comment
WS2	3.00	Soils recorded as "damp" in superficial soils
WS4	3.20	Soils recorded as "damp/wet" in superficial soils
WS6	3.00	Soils recorded as "damp" in superficial soils
BH1	8.50	Strike in Chalk. Rose to 5.85m in 20 minutes
BH2	5.50	Strike in superficial deposits. Rose to 4.09m in 20 minutes
BH3	4.00	Strike in superficial deposits. Rose to 3.59m in 20 minutes
BH3	8.00	Strike in Chalk. Rose to 4.62m in 20 minutes

The standpipes installed during the investigation were subsequently monitored and the results are summarised in the following table.

BH	Approx /Surface level (mAOD)	Response Zone	Response Materials	Water Depths Recorded (m)					
				08/10/20	05/11/20	27/11/20			
WS1		1m to 4m	Superficial	2.32	1.64	1.05			
WS4		1m to 4m	Superficial	2.23	1.37	0.81			
WS5		1m to 4m	Superficial and Chalk	2.22	1.21	0.77			
BH1		2m to 20.4m	Superficial and Chalk	2.14	1.79	1.07			
BH2		1.5m to 10m	Superficial and Chalk	2.29	1.44	0.85			
BH3		1m to 5m	Superficial	2.18	1.39	0.88			

Results of the ongoing groundwater monitoring to date has recorded standing groundwater levels at depths of between 0.77 and 2.32 metres below existing ground level. This confirms the presence of a shallow water table within the superficial materials. All monitoring standpipes record a general shallowing of the groundwater table from October to the end of November 2020.

7.0 ENGINEERING CHARACTERISTICS OF THE SUPERFICIAL AND SOLID MATERIALS

7.1 General

The results of the laboratory geotechnical testing of the samples recovered during the recent investigations are included in Appendix 11. The soil parameters from the in situ testing of samples are summarised below.

7.2 Natural Superficial Deposits-Cohesive

Seven Standard Penetration Tests were carried out within the more cohesive Superficial deposits. These indicated uncorrected N values of between 8 and 27.

Five in-situ California Bearing Ratio Tests were conducted in superficial deposits (and possibly in naturally-derived Made Ground in CBR 1 and 3) at depths of 0.50 metres below ground level. Test results of between 8.4 and 11.6% were recorded (Appendix 10).

7.3 Natural Superficial Deposits-Granular

Twenty-seven Standard Penetration Tests were carried out within the more granular Superficial deposits. These indicated uncorrected N values of between 8 and 34 and also partial penetration test results of 50 blows for between 260 and 225mm after seating, which indicates a loose to very dense state of compaction.

7.4 Solid Strata-Chalk

Twenty Standard Penetration Tests were carried out within the Chalk deposits. These indicated uncorrected N values of between 10 and 41 and also partial penetration test results of 50 blows for between 295 and 210mm after seating, which indicates a medium dense to very dense state of compaction.

7.5 Laboratory Testing

The soil parameters from the laboratory testing of samples are summarised in the following tables.

Material Type	<i>Cohesive</i>
Natural Moisture Content (%)	11 to 21 (7 samples)
Plastic Limit (%)	16 to 22 (6 samples)
Liquid Limit (%)	35 to 44 (6 samples)
Plasticity Index (%)	13 to 28 (6 samples)
Soil type based on plasticity chart	CLAY of Low and Intermediate Plasticity (6 samples)
Range of consistency	Firm to very stiff
Cobble (%)	0 (1 sample)
Gravel (%)	14 (1 sample)
Sand (%)	34 (1 sample)
Silt/Clay (%)	52 (1 sample)
Soil descriptions from PSD	Gravelly sandy SILT/ CLAY (1 sample)
Bulk Density (Mg/m ³)	1.94 (1 sample)
Undrained shear strength (kPa)	32 (1 sample)

Material Type	<i>Granular</i>
Cobble (%)	0 (2 samples)
Gravel (%)	16 to 35 (2 samples)
Sand (%)	40 to 43 (2 samples)
Silt/Clay (%)	25 to 41 (2 samples)
Soil descriptions from PSD	Clayey/silty gravelly SAND/gravelly silty/clayey SAND

8.0 FOUNDATION DESIGN CONSIDERATIONS

8.1 General

It is understood that the site is to be developed for a two-storey residential Care Home located in the main site area to the rear of the current Farm Shop. The building is irregular in footprint and consists of 4 linked “wings”.

The proposed building is of masonry construction with a precast concrete floor slab and designed to develop wall/line loads of the order of 95kN/m run.

Based upon the engineering properties of the soils/rock as discussed in previous sections of this report, we would offer the following comments regarding suitable founding horizons.

8.2 Made Ground

The investigation has indicated the site to be very locally overlain by a mantle of essentially naturally-derived made ground in the north-east site area. Due to the inherent variability of this material it is considered that this horizon would not be very suitable as a founding horizon in its present condition.

The made ground horizon proven does not coincide with the main development footprint of the proposed Care Home but is proven to correspond with the proposed access road and car park areas.

It would be prudent to consider undertaking additional local investigations in this locality to determine the lateral extent, composition and depth of the Made Ground horizon in this area and its potential influence, if any, on future road design.

8.3 Natural Deposits

Atterberg Limits laboratory tests indicate that the near surface natural soils exhibit a Plasticity Index of between 13 and 28% classifying them as soils of Low to Medium shrinkage potential (after NHBC).

Thus, minimum foundation depths of 0.90 metres below ground level based on Medium shrinkability soils would (theoretically) need to be adopted in the context of spread foundations, to protect against seasonal shrinkage/swelling (remote from vegetation) subject to the engineering properties of the soils, and deepened as necessary within the zone of influence of mature vegetation (see proposed piled foundation design solution below).

The investigation works have predominantly recorded a mantle of natural soil deposits which typically vary in both their consistency (firm to very stiff sandy silty clays and clayey silts with gravel) and relative density (medium dense and very dense clayey silty sands with gravels) near surface.

However, at depths varying between 1.80 and 2.50 metres below ground level the natural soils locally decrease in relative density becoming loose or they display a “poorer” soft to firm consistency. This soil horizon is considered to lie within the effective zone of stress likely to be generated by conventional shallow spread foundations and hence could result in excessive total and differential settlement occurring under loading.

In our opinion, as the site investigation works were conducted in late Summer, it is possible that the upper near surface soil horizons may have been subject to a degree of “drying out” (Atterberg Limits tests indicating that five out of six soil samples tested recorded Moisture Contents of between -1 to -9% of their respective Plastic Limits) and hence in the normally wetter Winter months, the soils may appear wetter and display poorer overall consistency and relative density properties.

In BH2 at greater depths of between 3.50 and 4.00 metres below ground level, a clay with organic peat horizon was recorded. This “peat” horizon was only proven in BH2 however its exact lateral extent is not known and hence could extend beneath other site areas. This horizon could also act as a physical constraint to the use of shallow spread foundations if left in-situ.

In addition to the above, groundwater monitoring has recorded a shallow groundwater table in the standpipes extending across the site within the upper natural superficial soils, which will also need to be addressed in any foundation design solution assessment.

Thus, when taking account of the variable load bearing and settlement characteristics displayed in the near surface soils and the shallow groundwater table prevailing, in our opinion consideration should be given to transferring foundation loads into the underlying Chalk strata at depth, using piled foundations.

8.4 Rock Strata

The subsurface interface between the superficial soil deposits and underlying chalk strata varies significantly in depth across the site, between 3.60 metres in WS5 and 7.00m below ground level in BH2.

In the three deeper cable tool boreholes, the upper chalk strata initially displays a Dm weathering grade (after CIRIA) which grades into a Dc weathering grade with depth.

In Borehole 1, the DC chalk grade was estimated to occur at a depth of 17.00m below ground level whilst in BH2 and BH3 the chalk grade "division" occurred at shallower depths of 10.00 metres and 7.50 metres below ground level, respectively.

As a guide, at typical depths of the order of 17.50 and 18.00 below ground level in BH1 and BH2, the relative density of the chalk in the two boreholes increased to dense to very dense, with Standard Penetration Test "N" values ranging between 41 and 50 blows for partial penetration tests.

In our opinion, exact pile lengths will be dependent on foundation loads and the proprietary brand of pile type and size selected, but also taking into account of the variable depths to the chalk likely to be encountered across the building footprint and also its weathering grade in-situ.

When taking account of weathering grade (which will locally influence overall "rock strength"), it is recommended that piles are designed in the chalk to generate the majority of their safe working loads as frictional resistance; the piles not solely relying on end bearing resistance alone.

If consideration was to be given to the use of a pre-cast or cast in-situ driven displacement pile, due consideration will need to be given to environmental impacts, such as excessive noise and vibrations on the adjacent shop building structure and nearby developments.

Therefore, in our opinion, preferred consideration should be given to the use of a cast in-situ bored /augured replacement or displacement pile for the proposed structure, with piles being utilised to support both the main structural foundations and ground floor slab.

It is recommended that prior to finalising a piled foundation scheme for the building, a specialist piling contractor is approached to confirm the load bearing and "installation" capabilities of their various brands of pile, but it is concluded that relatively high loadings could be accommodated within the higher grade chalk proven at depth.

It is possible that piling through the underlying aquiclude may open a pathway for migration of contamination. In order to avoid any doubt, all piling works should be carried out in accordance with the requirements of the Environment Agency document "Piling and Penetrative Ground Improvement Methods or Land Affected by Contamination: Guidance on Pollution Prevention". Based on the guidance it will be a requirement for the designated piling contractor to generate a Foundation Works Risk Assessment Report for the proposed works depending on the scope of the foundation design.

8.5 Ground Dissolution

The Groundsure Report (Appendix 2) indicate that the site lies in a "Very Low" on-site ground stability hazard area in respect to dissolution of soluble rocks, which will include the underlying chalk strata.

However, in our opinion, consideration should be given to undertaking a geophysical survey at the site in order to assess the overall integrity of the chalk mass and to ensure that no solution features exist in the chalk which could otherwise impact upon the future structural integrity of the proposed building, particularly in the context of the use of piled foundations and also at surface, below future road, car park and garden areas.

It is also recommended that during site development, inspection of any deep services be closely examined for the presence of any potential "anomalous" ground related conditions which may represent possible natural solution features.

In the north-east site area (between CBR 1 and 2) a small circular depression was noted at surface (which could possibly coincide with an old borehole). Thus, subject to the findings of the geophysical survey, it may be prudent to further investigate this local anomaly/feature to ensure that it does not impact upon future road design and construction.

8.6 Buried Concrete Design

pH values and sulphate levels were recorded above laboratory reporting limits therefore an assessment was carried out in accordance with BRE Special Digest 1.

Representative samples of the shallow soils, deeper chalk strata and groundwater have been submitted for pH and sulphate analyses.

The results indicate slightly acidic to alkaline pH values in the soils and groundwater, ranging between 6.6 and 9.0 (soils) and 7.1 and 7.6 (groundwater) across the site, with a calculated Characteristic Value for pH (based on soil) of 6.92.

Low total and water soluble sulphate concentrations were recorded, with maximum concentrations of 0.13% and 940 mg/litre, respectively, with a calculated Characteristic Value for soil of 355mg/litre rounded up to 400mg/litre and 160mg/litre rounded up to 200 mg/litre for groundwater.

Low total sulphur levels were recorded in the shallow natural soils (maximum of 0.06%) indicating that Total Potential Sulphate is not considered a design criteria for buried concrete in such soils.

In accordance with BRE SD-1, 2005, buried concrete should be designed to Design Sulphate Class DS-1 and the site allocated an ACEC classification of AC-1 due to the site being classified as "worst case" Brownfield with mobile groundwater conditions.

8.7 Excavations and Groundwater

Excavations for foundations and services at the site should be feasible using conventional mechanical excavation techniques; however the shallow groundwater table could act as a physical constraint.

During site works, should any localised softening of the soils be encountered then these materials should be removed and replaced with well compacted hardcore. In addition, it is imperative that the foundation excavations are kept dry to ensure the integrity of the superficial deposits as both the "clay" and "sand" material within is very sensitive to wetting.

Standing groundwater was encountered during the ongoing monitoring exercise at depths as shallow as less than 1.00m below ground level. As such this could be encountered in any excavations during the site development works (and particularly in the normally wetter winter months). Therefore, during the design of any excavations at the site due consideration should be given to the control of surface water and possible ground inflow and sidewall stability, with all necessary precautions being taken to ensure safe working conditions. This should be carried out in accordance with Health & Safety and CDM Guidance.

Due to the composition of ground conditions proven and presence of groundwater, excavation sides could potentially collapse and therefore consideration should be given to shoring of any temporary excavations at the site; adopting appropriate groundwater control and with a possible need to adopt a "dig and pour" approach for the placement of buried concrete.

8.8 Percolation Testing

A total of five in-situ Soakaway Tests were undertaken at the site (referenced TP1 to TP5) following the general principles of BRE Digest 365:2016 (Appendix 9).

The tests were conducted on site at the locations and at target depths selected in advance by the Clients appointed Drainage Engineer.

In the five Soakaway test pits only single cycle tests were able to be conducted due to the "slow" drainage rates experienced, rather than the three test cycles recommended in the above Digest.

The Soakaway test pits were excavated to depths varying between 0.50 metres (TP5) and 1.50 metres (TP3) below ground level, with targeted response zones in the natural soil deposits.

BRE Digest 365 recommends calculation of infiltration rates from the time taken for the water volume to fall from 75% to 25% of the effective storage depth of the pit.

In TP1, TP3 and TP5 due to the lower drainage rates achieved individual pit drainage did not achieve 50% of the effective storage depth and therefore no soil infiltration rates have been calculated.

In TP2 and TP4, whilst full drainage in the two test pits was not recorded, higher drainage rates were achieved, of 62.9% and 67.1%, respectively, and thus we have provided calculated Infiltration Rates for these two soakaway tests in the table below.

However, as a result, the following values for soakaway design should be utilised with caution.

Trial Pit	Recorded Range(s) of Infiltration Rates (m/s)	Additional Remarks
TP2	6.58×10^{-6}	taking account of full undrained area of test pit
TP4	7.29×10^{-6}	taking account of full undrained area of test pit

In our opinion, the "low" Infiltration Rates generally recorded in the near surface soils are likely to reflect the fines (clay/silt) matrix displayed and the potential for a shallow groundwater regime to occur.

8.9 Road and Pavement Design

A programme of 5 No. In-situ California Bearing Ratio (CBR) tests have been undertaken at the site in shallow trial pits excavated in both the naturally-derived Made Ground (CBR 1 and CBR3) and upper natural soils below the topsoil horizons (Appendix 10).

The tests were undertaken at depths of 0.50 metres below ground level, at horizons anticipated to coincide with approximate proposed road formation levels.

In-situ CBR test values ranging between 8.4% (CBR 4) and 11.6% (CBR 1) have been recorded (with in-situ moisture contents at the test locations ranging between 9.1 and 14%).

In our opinion the silty sand with gravel composition of the soils at test depths are likely to account for the relatively high CBR test results recorded.

However, more recent groundwater monitoring has recorded the potential for shallow groundwater levels to occur at the site of locally less than 1.00m below ground level. Therefore if similar shallow groundwater levels were to occur beneath proposed road and car park areas, this could impact upon (reduce) in-situ CBR values and also impact on overall road construction design/carriageway thickness.

In view of the above, whilst higher in-situ CBR values have been locally recorded on-site, it is recommended that a more "conservative" CBR value of the order of 5-6% be adopted for initial pavement design, following close inspection of the soils, the removal and infilling of any "soft spots" with granular stone and proof rolling of the formation.

The local presence of soils recording more significant clay and silt content within near surface is such that for the purposes of road design the upper natural soils should be considered to be frost susceptible.

8.10 General Site Development

Site Operatives During Construction of the Development

No elevated contaminants were recorded and the risks from exposure to any contaminated materials are considered to be low. Normal Health and Safety precautions should be implemented during the works. Site personnel should maintain vigilance to detect any unpleasant odours, strangely coloured made ground, made ground other than generally observed during this investigation, fibrous materials or chemical residues in order that they can be assessed by suitably qualified personnel.

Roads Maintenance Workers in the Completed Development

While no specific unusual risks have been identified, any works should be carried out in accordance with the Construction Industry Research and Information Association (CIRIA) Report 132 entitled "A Guide for Safe Working on Contaminated Sites 1996".

General

As with any construction or maintenance activity, risks to workers should be managed by appropriate health and safety risk assessments/COSHH undertaken in the normal manner by the employer prior to works being undertaken as required by health and safety legislation.

PART FIVE – CHEMICAL CONTAMINATION AND GAS EMISSIONS ASSESSMENT

9.0 STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT - CHEMICAL CONTAMINATION

9.1 Introduction

The Stage 2 generic quantitative assessment of risk to human health, property, ecology, surface water and ground water considers the potential for exposure based on comparison of the results to conservative generic criteria. JPB's risk assessment methodology is discussed in detail in Appendix 14 and is summarised in the flow chart presented in that appendix.

In terms of human health, the guideline concentration appropriate to the proposed end use of the site is used in the interpretation of the results. The site is proposed for development as a residential Care Home with communal gardens, therefore, the most relevant criteria; those for a residential without plant uptake development have been adopted. At Stage 2 all soil contaminant concentrations are compared with GACs. If necessary, at Stage 3 representative soil contaminant concentrations are calculated and used for comparison with assessment criteria.

9.2 Risk Assessment

The following tables summarise the results of the Stage 2 assessment.

Human Health - Chemical Contamination

Parameter	Concentration range (mg/kg)	Concentration range exceeding JPB GAC (mg/kg)	GAC Residential without plant uptake (mg/kg)	Source of GAC	No. and location of exceedences
Arsenic	7.7-8.9	None	40	C4SL	None
Cadmium	0.2-0.7	None	150	C4SL	None
Chromium (III)	16-30	None	910	S4UL	None
Hexavalent Chromium (Chromium (VI))	Below Detectable Limits <1.0	None	21	C4SL	None
Copper	16-20	None	7100	S4UL	None
Lead	13-23	None	310	C4SL	None
Mercury (Inorganic mercury)	<0.05-0.07	None	56	S4UL	None
Nickel	11-20	None	180	S4UL	None
Selenium	Below Detectable Limits <0.5	None	430	S4UL	None
Zinc	48-74	None	40000	S4UL	None
Cyanides	<0.1-0.2	None	24.5	JPB GAC	None
Phenols	<0.3-0.4	None	440	S4UL	None
Naphthalene	Below Detectable Limits <0.03	None	2.3	S4UL	None
Acenaphthylene	Below Detectable Limits <0.03	None	2900	S4UL	None
Acenaphthene	Below Detectable Limits <0.03	None	3000	S4UL	None
Fluorene	Below Detectable Limits <0.03	None	2800	S4UL	None
Phenanthrene	Below Detectable Limits <0.03	None	1300	S4UL	None
Anthracene	Below Detectable Limits <0.03	None	31000	S4UL	None
Fluoranthene	<0.03-0.05	None	1500	S4UL	None
Pyrene	<0.03-0.05	None	3700	S4UL	None
Benz(a)anthracene	*	*	*	*	*
Chrysene	*	*	*	*	*

Parameter	Concentration range (mg/kg)	Concentration range exceeding JPB GAC (mg/kg)	GAC Residential without plant uptake (mg/kg)	Source of GAC	No. and location of exceedences
Benzo(b)fluoranthene	*	*	*	*	*
Benzo(k)fluoranthene	*	*	*	*	*
Benzo(a)pyrene	Below Detectable Limits <0.03	None	5.3	C4SL	None
Indeno (1,2,3-CD) pyrene	*	*	*	*	*
Dibenzo(a,h)anthracene	*	*	*	*	*
Benzo(g,h,i)perylene	*	*	*	*	*

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* Parameter assessed using the benzo(a)pyrene surrogate marker approach

PAH ratios have not been calculated as all samples had low or no appreciable PAH contents.

Human Health - Petroleum Hydrocarbons

Six soil samples were scheduled for laboratory testing for the presence of Extractable Petroleum Hydrocarbons (EPH C10-C40) screen. All six soil samples recorded EPH concentrations lying below the detection limit of the analytical technique adopted (<10mg/kg).

Human Health - Asbestos

Six soil samples were scheduled for laboratory testing for the presence of asbestos. Asbestos was not identified within any of the samples scheduled for analysis.

Phytotoxicity – Soils

Parameter	Concentration range (mg/kg)	Concentrations exceeding GAC (mg/kg)	GAC (mg/kg)	Source of GAC	No. and location of exceedences
Copper	16-20	None	pH 6.0-7.0 = 135	MAFF Guidance	None
Zinc	48-74	None	pH 6.0-7.0 = 200	MAFF Guidance	None
Nickel	11-20	None	pH 6.0-7.0 = 75	MAFF Guidance	None
Cadmium	0.2-0.7	None	3	MAFF Guidance	None
Lead	13-23	None	300	MAFF Guidance	None
Mercury	<0.05-0.07	None	1	MAFF Guidance	None
Chromium	16-30	None	400	MAFF Guidance	None
Selenium	Below Detectable Limits <0.5	None	3	MAFF Guidance	None
Arsenic	7.7-8.9	None	50	MAFF Guidance	None

Buildings and Services

Buildings and Services – Soils Effect on Concrete

Parameter	Concentration Range	SSAC BRES1/BRE PBMCL
pH	6.6-9.0	<5 or >8
Total Sulphate	0.03-0.13% as SO ₄	Not Applicable
Water soluble Sulphate	12-940 mg/L as SO ₄	Not Applicable
Total Sulphur	0.01-0.06% as S	Not applicable

Water Environment

Groundwater

Parameter	Concentration Range (mg/L)	Groundwater Receptors		Surface Water receptors	
		RPV/DWS (source) (mg/L unless stated otherwise)	No. and location of exceedences	EQS/MRL (Source) (mg/L)	No. and location of exceedences
Sulphate	43-160	250mg/L	None	400mg/L	None
Chloride	25-180	250mg/L	None	250mg/L	None

9.3 Summary

Human Health

No soil concentrations exceeded human health GACs, therefore, **no remedial measures are required to protect human health from contamination risks.**

Phytotoxicity

No soil concentrations exceeded phytotoxicity GACs, therefore, **no remedial measures are required to protect healthy plant growth.**

Water Environment

Soil contamination levels for sulphate and chloride were low, with no exceedences of GAC recorded.

Buildings and Services

pH values and sulphate concentrations indicated that the ground conditions fall within design sulphate class DS-1 and ACEC class AC-1 as defined in BRE Special Digest 1 (see Paragraph 8.6).

10.0 GAS EMISSIONS RISKS

10.1 General

In order to assess the possible presence of potential gas generation sources at the site, gas monitoring was undertaken at standpipes installed in six of the recently installed Windowless Sampler holes WS1, WS4 and WS5 and Boreholes, BH1 BH2 and BH3 in order to assess both the shallow and deeper ground gas regimes, respectively; the results of the monitoring exercise are included in Appendix 13.

The assessment of ground gas as a potential constraint to development has been the subject of a great deal of research and published guidance. Ground gas can be a concern for several reasons; flammable gases may cause an explosion, accumulation of gases within poorly ventilated areas may lead to asphyxia or toxic gases may cause harm to those exposed to them. Some physical properties of ground gases are tabulated below.

Gas	Explosive Range	Density at 20°C	Toxicity (% by volume in air)*
Methane	5-15% by volume	0.72 kg/m ³	30 (low)
Carbon dioxide	N/A	1.98kg/m ³	0.5 (high)
Carbon monoxide	12.5-74.2% by volume	1.25kg/m ³	0.02 (high)
Hydrogen sulphide	4.2-46% by volume	1.54kg/m ³	0.001 (high)

* short term occupational exposure limits. The long term occupational exposure limit for carbon monoxide is 30ppm and for hydrogen sulphide is 5ppm.

Radon is a naturally occurring radioactive gas that is formed from the decay of uranium and radium present in some types of rocks. It can migrate through cracks and fissures into the soil and by this route into buildings. Radon can accumulate inside structures over the long term posing a risk to health. Long term exposure increases the risk of developing lung cancer, in a building with high levels of radon, long-term exposure can increase the risk to the point where preventative action is necessary.

Gas Emissions Sources

The desk based information and initial CSM identified the following potential gas generation sources at the site;

- Made Ground - low generation potential source.
- Topsoil - potential for high gas concentrations.
- Chalk strata - potential for moderate to high gas concentrations.

These sources are discussed further below, in the light of data obtained during intrusive investigations and monitoring.

10.2 Analysis of Results

The following summary of the gas monitoring results from the site is based on the first three rounds of gas monitoring and is, therefore, provisional. The final gas conditions will be confirmed following the completion of the full period of gas monitoring.

Gas measurements recorded at borehole standpipes are summarised in tabular form in Appendix 13.

A maximum Methane gas concentration of 0.3% was recorded in BH2 on 05 November 2020. All other methane gas concentrations in the other five monitoring standpipes have recorded zero gas readings in the exercise to date.

A maximum Carbon Dioxide gas concentration of 4.4% was recorded to date in WS1 on 05 November 2020. All other standpipes have recorded Carbon Dioxide concentrations ranging between 0.4 and 3.9% to date.

Gas flows ranged between 0L/h and 0.3L/h over the period of monitoring to date.

A maximum Carbon Monoxide gas concentration of 1ppm was recorded in BH3 on 08 October 2020. All other Carbon Monoxide gas concentrations in the other five monitoring standpipes have recorded zero gas readings in the exercise to date.

A maximum Hydrogen Sulphide gas concentration of 1ppm was recorded in WS1 on 05 November 2020. All other Hydrogen Sulphide gas concentrations in the other five monitoring standpipes have recorded zero gas readings in the exercise to date.

10.3 Risk Assessment and Conclusions

Tier 2 ground gas risk assessment

Ground gas monitoring is based on the results of three sets of monitoring data to date.

During the gas monitoring atmospheric pressure varied from 1012mb to 1041mb with no sets of readings undertaken when values were below 1000mb. The monitoring indicated low concentrations of ground gas (methane up to 0.3% by volume and carbon dioxide up to 4.4% by volume).

In both the shallow and deeper groundwater monitoring facilities Groundwater was noted at depths of between 0.85 and 2.29m in the deeper standpipes and at depths of between 0.77 and 2.32m in the shallower standpipes, with the shallowest groundwater being noted in WS5. The shallow groundwater table recorded will result in lower headspace in the monitoring standpipes and could potentially influence flow rates.

In view of the "higher" barometric conditions recorded to date and the shallow groundwater table recorded, in our opinion the ground gas results to date should be taken with some degree of caution.

BS8485 requires that the "worst case" scenario is checked as a precursor to any more detailed assessment. Therefore, maximum recorded gas concentrations and flow rates and Characteristic Situation evaluations based on the modified Wilson and Card approach outlined in CIRIA C665 are summarised in the table below. In these calculations we have used the term Hazardous Gas Flow Rate as used in BS8485 this is also known as Gas Screening Value in CIRIA C665.

Gas	Maximum gas concentration (% by volume)	Maximum borehole flow rate (L/h)	Hazardous Gas Flow Rate (L/h)	Site Characteristic Situation
Carbon dioxide	4.4	0.3	0.0132	1
Methane	0.3	0.3	0.0009	1

Based on the recorded methane concentrations the site was found to be a Characteristic Situation 1, while on the basis of the carbon dioxide concentrations the site was found to be a Characteristic Situation 1 site. It is, therefore, considered that overall the site is a Characteristic Situation 1 site and **there is no significant source, no intact contaminant linkages are present and remedial works are not required to mitigate gas levels.**

Risks Posed By Carbon Monoxide

A positive carbon monoxide concentration was recorded at BH3 on a single occasion; the highest concentration recorded being 1ppm by volume, a concentration below toxic levels. The concentrations recorded are considerably below carbon monoxide's lower explosive limit of 12% by volume and levels at which carbon monoxide would be considered to be toxic by inhalation. Therefore, the levels of carbon monoxide recorded at BH3 are **not considered to represent a source of gas emissions and no remedial measures are required.**

Radon

The Groundsure Report (Appendix 2) indicates that the site is not within an area requiring radon protection and, therefore, **no additional protective measures are required.**

11.0 RECOMMENDATIONS FOR CHEMICAL CONTAMINATION AND GAS

11.1 Validated Conceptual Site Model & Requirement for Remedial Measures

A reassessment of the initial conceptual site model in the light of information gained from both the site investigations and risk assessments has been undertaken and a resultant validated conceptual site model compiled. As the potential sources identified in the initial CSM table have now been either identified to be present or absent the source terms and contaminant linkages are re-assessed below.

SPR item	SPR item present based on site investigations (Yes/No)	Comment
Sources		
S1 – Contamination from former land use - Human Health	No	Risk assessment found no significant risks to human health. No remedial measures are required.
S1 – Contamination from former land use - Phytotoxic	No	Risk assessment found no phytotoxic risk at the site. No remedial measures are required.
S1 – Contamination from former land use - Water Pipes	No	No contaminant concentrations were identified which are considered to permeate water pipes or impact on their integrity. Therefore, no restriction is made on the type of water pipes which can be used on the site.
S1 – Contamination from former land use - Concrete Specification	No	pH values and sulphate concentrations indicated that the ground conditions fall within design sulphate class DS-1 and ACEC class AC-1 as defined in BRE Special Digest 1. Therefore, concrete specifications should be such as to protect building elements in contact with these conditions.
S2 – Contamination from adjacent land	No	No evidence was encountered of contamination migration onto site from adjacent land. No remedial measures are required.
S3 – Ground gas	No	Risk assessment found no significant ground gas risks at the site and the site is not within a radon affected area. No remedial measures required.
S4 – Leachable/mobile contaminants	No	Low soil concentrations recorded at the site in respect to metals, inorganics and PAH/EPH with no significant risks posed to water environment receptors. No remedial measures required.

11.2 Selection of Remedial Actions

The reassessment of the conceptual site model has confirmed that none of the source pathway receptor linkages are complete and, therefore, there is no requirement for any remedial actions based on the investigations carried out to date.

However, it should be noted that the ground gas monitoring exercise is still ongoing and as such the requirement for remedial actions, if any, in relation to ground gas will need to be reviewed upon completion of the exercise.

11.3 Reuse of On-site Materials

In general, if materials are to avoid becoming waste, they must be suitable to be reused within an existing site boundary without resulting in an unacceptable risk of harm to human health or pollution of the environment.

To be suitable for reuse materials must also meet the following general conditions outlined below;

1. The use is a necessary part of the planned works.
2. The material is suitable for that use.
3. The material does not require any processing or treatment before it is reused.
4. No more than the quantity necessary is used.
5. The use of the material is not a mere possibility but a certainty.
6. The use of the soil will not result in pollution of the environment or harm to human health.

Materials which require treatment (such as bioremediation) to make them suitable for use may potentially be reused on site, however, the treatment will require to be licensed or permitted under waste legislation.

It should be noted that in relation to "Reuse of materials" asbestos is not considered to be a suitable material for backfilling or other construction purposes. "Bulk" asbestos must not be backfilled or otherwise reused in site works.

However, the investigation works have not identified any asbestos in the soils on site.

11.4 Disposal of Waste Materials to Landfill

Waste soil or made ground materials which cannot be accommodated at the site or and is not suitable for reuse at another site should be removed to an appropriately licensed landfill site or "soil hospital/hub site" facility. Such material should be disposed of in accordance with the current waste regulations..

Waste Classification and Waste Acceptance Criteria Testing

All waste material disposed of to landfill from the site will require to undergo testing in order to characterise the waste properties of the material and to determine an appropriate disposal route. This process will require the assessment of general chemical test results to characterise any hazardous properties the waste may have. Depending on the circumstances, the process may also include assessment of Waste Acceptance Criteria (WAC) testing in order to aid the selection of appropriate disposal route. These tests are a legal obligation and no material will be able to be accepted at a landfill unless the results of the tests are available. The time taken for this testing should be factored into any programme for the site.

The vast majority of the soils recorded on site are likely to be natural soils and thus in our opinion are unlikely to be problematic for offsite disposal, subject to confirmation of WAC testing (see above).

As a guide in relation to Soil Organic matter (SOM), concentrations recorded in the Topsoil do not exceed the 3% Waste Limit Value for Total Organic Carbon, for Inert Waste.

11.5 Chemical Contamination

No elevated contaminants in relation to human health and plant growth were recorded and, therefore, no remedial measures are required.

However, a clean topsoil/soil forming medium should be used in garden and landscaped areas to generally encourage plant and vegetation growth and be locally deepened as necessary associated with the planting of larger shrubs and tree species around root bowls.

11.6 Site Personnel

The generation of dust during site works may expose site operatives or the occupiers of adjacent properties to health risks and should be managed by the provision of appropriate PPE and adoption of appropriate site practices as described in CIRIA document 132 "A guide for safe working on contaminated sites".

No elevated contaminants were recorded and the risks from exposure to any contaminated materials are considered to be low. Normal Health and Safety precautions should be implemented during the works. Site personnel should maintain vigilance to detect any unpleasant odours, strangely coloured made ground, made ground other than generally observed during this investigation, fibrous materials or chemical residues in order that they can be assessed by suitably qualified personnel.

It should be noted that care should be taken during the site development works to ensure that no spillage of fuel or other liquids or detrimental material occur on site. This is due to the fact that any spilled material has a high probability of contaminating the ground and surface waters.

11.7 Buildings and Services

pH values and sulphate concentrations indicated that the ground conditions fall within design sulphate class DS-1 and ACEC class AC-1 as defined in BRE Special Digest 1. Therefore, concrete specifications should be such as to protect building elements in contact with these conditions.

No contaminant concentrations were identified which are considered to permeate water pipes or impact on their integrity. Therefore, in our opinion, no restriction is likely to be made on the type of water pipes which can be used on the site.

11.8 Gas and Vapour Emissions

The following recommendations for the site for Ground Gas are based on the first three rounds of gas monitoring and are, therefore, provisional. Recommendations should be updated following the completion of the full period of gas monitoring.

Radon

The Groundsure Report indicates that is estimated that "less than 1%" of properties are affected by Radon gas and that no Radon Protection Measures are required.

Ground Gas

Based on the gas levels encountered to date no special precautions or remedial works are required to protect against ground gas emissions.

The ground gas monitoring exercise is still ongoing and as such the requirement for remedial actions will need to be reviewed upon completion of the exercise.

11.9 Invasive Plant Survey

An invasive plant survey was not carried out during the investigation works and a survey of the site by an ecologist is recommended prior to commencement of works at the site.



APPENDICES

Appendix 1 Drawings



Appendix 2 Groundsure Enviro+Geo Insight Report



Appendix 3 Historical Plans



Appendix 4 Third Party Detailed UXO Report



Appendix 5 Trial Pit Logs - JPB September 2020



Appendix 6 Borehole Logs - JPB September 2020



Appendix 7

Windowless Sample Logs - JPB September 2020



Appendix 8 CBR Pit Logs - JPB September 2020



Appendix 9 Results of in-situ Soakaway Tests - JPB September 2020



Appendix 10 Results of in-situ CBR Tests



Appendix 11 Geotechnical Test Results



Appendix 12 Chemical Test Results



Appendix 13 Results of Ground Gas and Groundwater Monitoring - JPB



Appendix 14 Methodology for Exposure Assessment and Ground Gas Risk Assessment



GEO-ENVIRONMENTAL & MINERALS