The East Malling Trust

Ditton Edge, East Malling

Geo-environmental and Geotechnical Site Investigation

52254-R01 (00)

APRIL 2021

RSK GENERAL NOTES

Project No.: 52254-R01 (00)

Title: Geo-environmental and Geotechnical Site Investigation: Ditton Edge, East Malling, ME20 6ED

Client: The East Malling Trust

Date: April 2021

Office: RSK Environment Limited, Anerley Court, Half Moon Lane, Hildenborough, Tonbridge, TN11 9HU. Tel 01732 833111

Status: Rev 00

Author	Giorgos Tsoutsis / Chris Ball	**Technical reviewer**	Svetislav Trajkovski
Signature		Signature	
Project manager	Svetislav Trajkovski	**Quality reviewer**	Samantha Gower
Signature		Signature	

Revision control sheet

Revision reference	**Date**	**Reason for revision**	**Amended by:**	**Approved by:**
Rev 00	April 2021	First issue	n/a	see above

CONTENTS

1 INTRODUCTION

1.1 Commissioning

RSK Environment Limited (RSK) was commissioned by Savills Plc on behalf of The East Malling Trust (the 'client') to carry out a Geo-environmental and Geotechnical Site investigation of the land at Ditton Edge, East Malling, ME20 6ED. The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 52254-T01 (01), dated 30th November 2020).

RSK's service constraints are shown in **Appendix A** and limitations that may be described through this document.

1.2 Objectives

The objective of the work is:

- to identify any land contamination and/or geotechnical constraints to the proposed development and to support discharge of relevant planning conditions and relevant building control requirements; and
- to identify the need for any additional investigation or remediation works to demonstrate that the site is suitable for its proposed use.

1.3 Scope of works

The scope of this assessment has been developed in accordance with relevant British Standards and authoritative technical guidance as referenced through the report. The assessment of the contamination status of the site is in line with the technical approach presented in Land Contamination Risk Management (LCRM) (Environment Agency, 2020) – which supersedes CLR11 Model Procedures for Land Contamination – and in general accordance with BS 10175: 2011 + A2 2017 (BSI, 2017). It is also compliant with relevant planning policy and guidance.

The scope of the intrusive investigation has been designed in line with the recommendations of BS5930:2015+A1:2020 Code of practice for ground investigations (BSI, 2020), which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. It has also been developed in general accordance with BS 10175: 2011 + A2 2017. Ground gas assessment has been undertaken in general accordance with BS8576: 2013 and BS 8485:2015+A1:2019.

A brief summary of relevant legislation and policy relating to land contamination is given in **Appendix B**.

The scope of works for the assessment has included the following:

Desk Study:

- review of the history of development on the site and surroundings;

- assessment of local geology, hydrogeology and hydrology;
- completion of a site reconnaissance survey to assess the visual condition of the site;
- development of an initial conceptual site model (CSM);
- preliminary consideration of geotechnical constraints and hazards; and
- identification of the need for further action, e.g. intrusive investigations.

Intrusive Investigation

- 17No. machine excavated trial pits to a maximum depth 3.00 m bgl;
- 12No. window sampling to a maximum depth of 3.60 m bgl;
- 10No. dynamic cone penetrometer tests;
- three return visits to undertake groundwater and ground gas monitoring;
- interpretation of data to develop a refined conceptual site model (CSM);
- generic quantitative risk assessment (GQRA) to evaluate potentially complete contaminant linkages;
- interpretation of ground conditions and geotechnical data to provide preliminary recommendations with respect to foundations and infrastructure design; and
- preparation of this factual and interpretative report.

1.4 Existing reports

No existing reports relevant to the site assessment have been provided to RSK.

1.5 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised. Asbestos is often present in soils in discrete areas. Whilst asbestos-containing materials have not been encountered during the fieldworks or supporting laboratory analysis, asbestos may be present in localised areas and could be encountered during more extensive ground works.

Preliminary geotechnical recommendations are presented, and these should be verified in a Geotechnical Design Report once proposed construction and structural design proposals are confirmed.

2 SITE DETAILS

2.1 Site location

The Site is located to the south of Ditton village and can be located at a National Grid reference 570976 N, 157685 E, as shown in **Figure 1**. Site location details are presented in **Table 1**.

Table 1 Site location details

Site name	Ditton Edge, East Malling
Full site address and postcode	Ditton Edge, East Malling, ME20 6ED
National Grid reference (centre of site)	570976 N, 157685 E

2.2 Site description

The site covers an area of approximately 10 hectares and is broadly rectangular in shape. The site boundary and current site layout are shown on **Figure 2**.

The site is currently occupied by open agricultural land, believed to be orchard plantations, with an old barn located along the centre of the southern boundary and a paved public footpath dissecting the site northeast to southwest. Vehicular and pedestrian access is gained via the south western and north western corners of the site.

The site is generally level with a gradual reduction in elevation from a maximum of 22 meters above ordnance datum (mAOD) in the south to a minimum of 17 mAOD along the northern boundary.

A mature tree is present in the centre of the northern boundary and the south western corner of the site. Mature and semi-mature hedgerows are also present along the centre of the northern and southern boundary as well as at the western boundary of the site.

2.3 Surrounding land uses

The site is located to the east of Kiln Barn Road, and approximately 200 m from Ditton Community Centre. The immediate surrounding land uses are described in **Table 2**.

Table 2 Surrounding land uses

North	Adjacent predominantly residential developments. Ditton Recreation Ground (northeast) and mixed developments (northwest and northeast). Motorway (M20) beyond.
East	Abounding Kiln Barn Road with predominantly residential developments. Ditton allotments and Ditton Quarry park. Industrial and retail park beyond.
South	Predominantly open field/agricultural land and horticultural and agricultural research institute beyond.

West	Adjacent detached and semi-detached residential developments and Communigrow charity. Polytunnels and developments (part of research institution) located north west. Lake and open field/agricultural land beyond.

2.4 Development plans

It is understood that the site is being considered for construction of 300 dwellings and associated infrastructure, however, at this early stage of assessment, further details of the proposed development were not available.

3 DESK-BASED ASSESSMENT

The desktop study was designed generally to meet the objectives of a preliminary (Phase 1) investigation, as defined by BS 10175:2011 (BSI, 2017) and this assessment relates to LCRM Stage 1, Tier 1 preliminary risk assessment. The "vicinity" of the site for the purposes of this report is defined as locations situated within an approximate 250 m radius of the site, although certain sources and/ or sensitive targets further than 250 m may also have been considered.

The study aims principally to identify and assess the potential risks and liabilities associated with contamination of the ground, on and in the vicinity of the site. While this includes consideration of current operations and housekeeping on the site, the report does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

3.1 Site history

3.1.1 Historical development record

The development history of the site and surrounding area based upon assessment of historical plans and records is detailed in **Table 3**. The historical maps are shown within the environmental database report in **Appendix C**.

Table 3 Summary of historical development

Date from	Date to	Historical Land Use (on-site)	Area of site
1884	1896	Open green fields with orchards trees along the centre of the site. Public footpath dissecting from north east to south west. boundary stone to the south west of the site	centre of the site south west
1896	1909	open fields/agricultural land orchard trees	north western part and eastern part remainder of the site
1909	1938	orchards plantations	eastern part of the site
1938	1962	Field path (believed to be private) dissecting from north to south. Cadastral parcels throughout the site.	throughout the site
1962	1969	two unnamed minor structures adjacent to the footpath orchards plantations no longer present	adjacent to the southern boundary eastern part of the site

1969	1973	unnamed development believed to be a barn one of the minor structure adjacent to the southern boundary no longer present orchard plantations present only to the north western part of the site conifer trees around the barn and along the public footpath	southern boundary southern boundary north western part southern boundary and along the north to south footpath
1973	1983	orchard plantations along the centre and north west part of the site plant nurseries	centre and north western part of site eastern and western part of site
1983	1999	Orchard plantations of East Malling Research Station (Horticultural), particularly north western and eastern part (Aerial photography 1999).	across the site
Date from	**Date to**	**Historical Land Use (off-site)**	**Distance (m) and orientation**
1869	1898	‘Park House’ and ‘Fishpond’ approximately 200m to the west. The fishpond feeds a steam running south west north east approximately 100m north west of site. ‘The Rectory’ ‘Holt Wood’ / ‘Holt Hill’ park land The on site orchards extend beyond the northern site boundary. To the north of the orchards is what appears to be a collection of farm buildings approximately 100m north of the site. Beyond the farm is the village of ‘Ditton.’ open agricultural land	adjacent to the western boundary adjacent the north eastern boundary >200m north east adjacent the northern boundary adjacent the south west, southern and south eastern boundary
1898	1909	a ‘Weir’ is indicated on the map between ‘Fishpond’ and stream ‘Park House’ renamed to ‘Bradbourne Park Farm’	>100m west to north west adjacent to the north west

1909	1934	'Waterfall' marked on the map along the stream to the north of the 'Wier'. Three additional structures (possibly residential) have been constructed to the east of the farm 100m north of site. Orchards have been extended to the south of the site.	100m north west 100m north adjacent southern boundary
1934	1938	A second 'Waterfall' is indicated on the map near to 'Ditton Court'. 'Continued predominately residential developments as part of Ditton expansion' 'Bradgate Quarry (Granite)' Orchards to the south of site have been further extended along the southern boundary.	>100m north adjacent and >50m north. <50m east adjacent southern boundary
1938	1948	'Bradgate Quarry (Granite)' and minor structures extended up to the eastern site boundary.	<50m east
1948	1962	Further residential developments.	>100m north
1962	1969	'Walnut Row' and 'Park Farm Cottage' developments 'Nurseries' indicated to the west of site 'Works' indicated north of site Small unknown 'Tank' Bradgate Quarry renamed to 'Ditton Court Quarry (Ragstone)'. Quarry House and a pond within the Ditton Court Quarry area.	>50m west and >30m north west >100m west adjacent northern boundary adjacent to the south adjacent east and >40m north east of the site
1969	1974	The 'Works' has been extended and is labelled 'Vegetable Cannery'. An Electrical substation and a number of tanks are associated with the 'Vegetable Cannery'. Pond within Ditton Court Quarry no longer present. Further predominately residential developments.	>50m north >100m east >50m north

1974	1989	Holt Wood park occupied by residential developments. Further predominately residential and mixed developments. Minor developments within Ditton Court Quarry and a ‘Sludge bed’ south of the quarry.	>100m north east >100m east
1989	1999	‘Electrical substation’ and an unknown ‘Tank’ marked on the map ‘Community Centre and Recreation Ground’ ‘Sludge bed’ no longer present within Ditton Quarry. ‘East Malling Research Station’ plantations	50m north west adjacent north eastern boundary >100m south east located adjacent the south west boundary of the site
1999	2006	‘Ditton Court Quarry’ marked as ‘disused’ and partly occupied by residential developments.	adjacent eastern site boundary
2006	Present (2021)	‘Vegetable Cannery’ occupied by residential developments ‘Allotment’ gardens and open recreational land occupy remainder of Ditton Quarry.	>50m north >150m east of site
Relevant information sources: Historical OS maps ☒ Town plans ☒ Information from the Local Planning Authority ☐ Aerial photography ☒ Previous reports ☐			
Note: Reference to published historical maps provides invaluable information regarding the land use history of the site, but historical evidence may be incomplete for the period pre-dating the first edition and between successive maps.			

3.1.2 Unexploded ordnance

A review of publicly available unexploded ordnance (UXO) risk maps indicates that the site is located in an area with medium potential for wartime bombs to be present (Zetica, 2021).

The Preliminary UXO Risk Assessment undertaken for the site **(Appendix D)** confirmed the above, indicating the risk for the site to be significantly higher than the background risk of finding UXO within this part of the country.

3.2 Information from environmental database report

Relevant environmental permits and incidents detailed within the environmental database report (see **Appendix C**) are summarised below in **Table 4**.

Table 4 Summary of environmental permits, landfills and incidents

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Agency and hydrological				
Environmental permits – incorporating Integrated Pollution Prevention and Control, Integrated Pollution Controls, Local Authority Integrated Pollution Prevention and Control	-	-	11	827m east, Cleansing Service Group Ltd, temporary storage of hazardous waste, involving physico-chemical treatment and waste oils, Ref. MP3835AJ, date: 27th April 2015.
Enforcement and prohibition notices	-	-	-	N/A
Pollution incidents to controlled waters, Prosecutions relating to controlled waters, Substantiated pollution incident register, Water Industry Act referrals	-	2	4	Off-site <250m: 167m west, relating to miscellaneous, caused by natural causes. Minor incident (Category 3), Ref: 94T057, dated: 5th May 1994. 188m north, relating to inorganic chemicals, caused by human actions. Minor incident (Category 3), Ref: 3641, dated: 18th October 1999. Off-site >250m: 254m west, relating to miscellaneous chemicals, caused by other pollution type. Minor incident (Category 3), Ref: 94T041, dated: 27th April 1994
Discharge consents	-	1	3	Off-site <250 m: 100m north, relating to Freshwater stream/river operated by Blue Cap Foods ltd, Status: Pre-National Rivers Legislation, Ref: K02009. Off-site >250m: 480m southeast, relating to Freshwater stream/river operated by Gateway Foodmaker's Ltd, Status: Pre-National Rivers, Ref: P02268

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Registered radioactive substances	-	-	7	600m south, Horticultural Research International East Malling relating to disposal of Radioactive waste, Dated 27th October 2003, Permit Ref: Bv6838
Landfill and waste				
Active landfills	-	-	-	N/A
Historic / closed landfills	-	1	2	Off-site <250m: 238m southeast, Redland Purle, Ditton Court Quarry, relating to inert deposit and liquid sludge. Evidence of historical quarrying. Area now predominantly occupied by Ditton quarry park, residential developments and Priory park. Off-site >250m: 670m west, Watermeadows Estate, relating to inert waste. No evidence of historical quarrying. Area now predominantly occupied by residential development.
Other waste management licences	-	-	3	749m east, Safety Kleen UK Ltd relating to special waste, License status Modified, dated 1995
Potentially in-filled land (pit, quarry, pond, marsh, river, stream, dock etc)	1	-	7	*Non-Water* On-site: east, unknown filled ground (Pit, Quarry), dated: 1989 *Water* Off-site: 427m west, Unknow filled ground (Pond, marsh, river, stream), dated: 1989
Hazardous substances/ industrial land uses				
Control of Major Accident Hazards (COMAH) sites	-	-	-	N/A

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Explosives sites, Notification of Installations Handling Hazardous Substances (NIHHS), Planning hazardous substance consents/ enforcements	-	-	-	N/A
Contaminated land Part 2A register entries and notices	**-**	**-**	**-**	N/A
Contemporary trade directory entries	-	11	12	three (3no.) 'active', the closest of which is located 307m north relating to packing cases. Other 'active' entries include paper & cardboard packing and car dealers located 431m W and 491m NW, respectively. Remaining twenty (20no.) 'inactive' entries closest of which include vehicle bodybuilders & repairers, engineers - general, road haulage services, furniture - repairing & restoring, concrete products and car dealers.
Fuel station entries	-	-	3	568m northwest, Larkfield Auto serve, Status: Obsolete.
Note: Entries have only been included within the table where they are located within a 250m radius of the site or, where they fall outside of this radius but are considered to comprise a significant entry.				

In summary, items that have been identified to represent an on-going potential source of contamination that could affect the site comprise the historical quarry (Ditton court quarry), adjacent to the eastern site boundary. This potential source of contamination has been carried forward for consideration within the initial conceptual site model contained in Section 6.

3.2.1 Site services

Buried utility services and their backfill can provide preferential pathways for gas, vapour or groundwater to migrate along to another part of the site or to a receptor. They can also represent significant constraints to development. Service plans obtained from utility companies either by RSK are contained in **Appendix E**.

3.3 Site geology

3.3.1 Anticipated geological sequence

Published records (British Geological Survey, Sheet 288, 1976) for the area and available historical borehole logs indicate the geology of the site to be characterised by the succession recorded in **Table 5**.

Table 5 Site geology

Strata	Description	Estimated thickness	Permeability
Hythe Formation	Sandy limestones (Ragstone) and glauconitic sandy mudstones.	>10 m	Permeable
Sandgate Formation[1)]	Fine sands, silts and silty clays, commonly glauconitic	>20m	Permeable
Relevant information sources: BGS Geoindex ☒ BGS borehole logs ☐ Previous SI reports ☐			
Note: [1)] north-western part of the site.			

No faulting and landslip geology have been mapped as present within or within close proximity to the subject site.

With reference to the historical data, artificial infilled ground is likely to be present within close proximity to the east of the subject site, believed to be related with the historical Ditton Court Quarry.

3.3.2 Radon

The environmental database report indicates that the site is not located within an 'Affected Area'. An 'Affected Area' is one with 1% or more homes above the radon Action Level of 200 Bq m^{-3}, and therefore the risk of significant ingress of radon into structures on-site is considered low and protection measures are not necessary in the construction of non-domestic buildings.

Although the radon data used in production of the ukradon indicative atlas comes from measurements in homes, the maps indicate the likely extent of the local radon hazard in all buildings.

3.4 Mining, quarrying and landfilling

Evidence has been sought to identify any mining, quarrying, landfilling and land reclamation operations, past and present, which have taken place within 500 m of the site.

Historical mapping data identified Ditton Court quarry (commodity - Ragstone) located approximately 20 m east of the site since the early 1900's. A part of the quarry is landfilled at the end of the 1980s, partly occupied by residential developments until late 1990s, until finally restored as a recreation ground towards the early 2000's.

Envirocheck report data identified a second historical landfill located >500 m west of the site. This historical landfill was irregular in shape with waste specified as ‘inert‘ , assumed to be linked with any demolition/construction phases.

The subject site is not located within a coal mining affected area.

3.5 Hydrogeology

A summary of the hydrogeological setting of the site, with respect to the anticipated geological sequence set out in Section 3.3 is presented below in **Table 6.**

Table 6 Summary of hydrogeological setting

Condition	Description
Aquifer characteristics	The Hythe Formation: Principal aquifer with ‘High’ groundwater vulnerability and ‘Intermediate’ pollution speed. The Sandgate Formation: Secondary A aquifer, with ‘High’ groundwater vulnerability and ‘Intermediate’ pollution speed.
Depth to groundwater and flow	The anticipated depth to the shallow groundwater table is likely to be around 3 m below ground level based on observations contained within available BGS (TQ75NW309) borehole logs (see **Appendix D**).
Rising groundwater levels	Not applicable
Groundwater recharge/ attenuation	Most of the site is currently unsurfaced and will therefore drain directly to ground.
Historical implications for hydrogeology	A lake and a pond are located >50m and >100m west and east of the site, respectively.
Licensed groundwater abstractions	The environmental database report indicates that there is a single current licensed groundwater abstraction relating to paper and printing by South East Water Ltd. within a 1km radius of the site.
Source protection zones	Information available in the Envirocheck report indicates that the site lies within Zone 2 (Outer Zone) of the groundwater Source Protection Zone (SPZ).

3.6 Hydrology

A summary of the hydrology within the site area is summarised in **Table 7**.

Table 7 Summary of hydrology in site area

Condition	Description
Surface watercourses / features	Nearest water feature is located c. 82 m northwest relating to a stream connected with an unnamed lake (100m) west of site via a weir. The stream is indicated on historical maps to flow from south west to north east. Medway River flowing in a north easterly direction is located ~ 1.5 km northeast of the subject site.
Surface water abstractions	The environmental database report indicates that there are 3no. current licensed surface water abstractions within a 1 km radius of the site. The closest of these, which is located c.180 m to the northwest is operated by Horticulture Research International and is utilised for spray irrigation.
Site drainage	The site is predominantly covered by soft landscape, therefore surface drainage from the site would infiltrate directly into underlying soils.
Preliminary flood risk assessment	A minor part adjacent to the north western boundary of the site is located within an area at risk of flooding from surface water. The south eastern corner of the site is situated within an area with potential for groundwater flooding of property. A flood risk assessment (FRA) is outside the scope of this assessment.

3.7 Sensitive land uses

Based on the environmental database report, no environmentally sensitive areas are present within 500 m of the site.

4 SITE RECONNAISSANCE FINDINGS

A site reconnaissance survey was completed on 7th December 2020 by RSK. The characteristics of the site observed during the walkover and from current Ordnance Survey maps are summarised in **Table 8**.

A site plan is provided in **Figure 2** with photographic records included in **Appendix F** detailing the main features identified below.

Whilst the walkover summary includes consideration of current operations and housekeeping on the site as potential sources of contamination, it does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

Table 8 Site reconnaissance findings

Feature	Description
Physical characteristics	
Access constraints	Gated vehicular and pedestrian access from unnamed minor road, south western corner and north western corner of the site.
Site topography	At the time of the walkover, the site was in general good condition and relatively flat.
Surface cover	Soft-landscaped - open greenfield throughout. Type 1 material was noted around the old barn. Furthermore, public footpath made up by tarmac hardstand dissecting the site from northeast to southwest.
Site drainage	Land drain was identified close to the old barn, therefore assumed within the surface drainage. Remaining of the site infiltrate directly into ground.
Surface water	None identified on-site. The nearest water surface feature appears to be a stream located approximately 100 m northwest of the subject site.
Trees and hedges	Mature and semi-mature hedgerows are present along the centre of the northern and southern boundary as well as to the western boundary of the site. Furthermore, solitary trees are located in the front gate and towards the footpath.
Invasive species	Based upon the walkover survey obvious evidence of Japanese Knotweed or other invasive species has not been identified on-site. However, it should be noted that a detailed survey of the possible presence or absence of invasive species is outside of the scope of investigation and consideration should be given to commissioning a specialist survey.
Existing buildings on-site	The site contains a single storey old barn adjacent to the southern boundary.
Retaining walls and adjacent buildings on or close to site boundary	Residential houses are located adjacent the northern boundary and the north western corner of the site.
Basements on-site	None present.

Feature	Description
Made ground, earthworks and quarrying	None observed. Potential beneath the old barn and the public footpath dissecting the site from northeast to southwest.
Potentially unstable slopes on or close to site	None observed.
Buried and overhead services present	None observed within the site. An electricity meter was noted within a small brick structure located on the northern boundary. Furthermore, a water hydrant was identified adjacent to the north east corner of the barn (believed to extend towards the south).
Environmental characteristics	
Underground/ above ground storage tanks and pipework	None observed.
Potentially hazardous materials storage and use	None observed. Few IBC tanks were noted west of the old barn (unknown use) as well as mulch film and steel rods for agricultural use.
Asbestos-containing materials (ACM)	ACM (Asbestos- containing material) was identified in the roof of the old barn structure located to the southern boundary of the site.
Waste storage	There is a waste a filled skip in the front of the barn used for agricultural disposal.
Fly-tipping	None observed, except the agricultural materials around the old barn.
Electricity sub-stations/ transformers	None observed on site.
Evidence of possible land contamination on-site	None observed.
Potential off-site sources of ground contamination	No significant source of off-site contamination was noted at the time of the site walkover.

In summary, items that have been identified to represent environmental and/or geotechnical hazards that could affect the site comprise ACM contained within the roof of the old barn structure and potential Made Ground associated with the old barn and public footpath.

5 PRELIMINARY GEOTECHNICAL CONSTRAINTS

5.1 Design class

BS EN 1997-1 defines three different Geotechnical Categories that structures may fall into, which are summarised as follows:

- Category 1: Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations; with negligible risk.
- Category 2: Conventional types of structure and foundation with no exceptional risk or difficult ground or loading conditions.
- Category 3: Structures or part of structures, which fall outside limits of Geotechnical Categories 1 and 2. Examples include very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

Based on the information provided above on the proposed development and in view of the anticipated ground conditions, a Geotechnical Category of 2 has been assumed for the purposes of designing the geotechnical investigation. This should be reviewed at all stages of the investigation and revised where necessary.

5.2 Preliminary geotechnical hazards assessment

A summary of commonly occurring geotechnical hazards associated with the anticipated geology outlined in Section 3.5 above is given in **Table 9** together with an assessment of whether the site may be affected by each of the stated hazards.

Table 9 Summary of preliminary geotechnical risks that may affect site

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	☒	☐	Likely to affect ground engineering and foundation design and construction
Shrinkable clay soils	☒	☐	Design to NHBC Standards Chapter 4 or similar

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Highly compressible and low bearing capacity soils, (including peat and soft clay)	☐	☒	Likely to affect ground engineering and foundation design and construction
Silt-rich soils susceptible to rapid loss of strength in wet conditions	☒	☐	Likely to affect ground engineering and foundation design and construction
Running sand at and below water table	☒	☐	Likely to affect ground engineering and foundation design and construction
Karstic dissolution features (including 'swallow holes' in Chalk terrain)	☐	☒	May affect ground engineering and foundation design and construction – refer to Section 4.1.2
Evaporite dissolution features and/or subsidence	☐	☒	May affect ground engineering and foundation design and construction
Ground subject to or at risk from landslides	☐	☒	Likely to require special stabilisation measures
Ground subject to peri-glacial valley cambering with gulls possibly present	☒	☐	Likely to affect ground engineering and foundation design and construction
Ground subject to or at risk from coastal or river erosion	☐	☒	Likely to require special protection/stabilisation measures
High groundwater table (including waterlogged ground)	☐	☒	May affect temporary and permanent works
Rising groundwater table due to diminishing abstraction in urban area	☐	☒	May affect deep foundations, basements and tunnels
Underground mining	☐	☒	Likely to require special stabilisation measures
Effects of extreme temperature (e.g. cold stores or brick kilns/furnaces)	☐	☒	Likely to affect ground engineering and foundation design and construction
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	☐	☒	Likely to affect ground engineering and foundation design and construction

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Filled and made ground (including embankments, infilled ponds and quarries)	☒	☐	Likely to affect ground engineering and foundation design and construction
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	☐	☒	May affect ground engineering and foundation design and construction
Site topography	☐	☒	May affect ground engineering and foundation design and construction
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.			

6 INITIAL CONCEPTUAL SITE MODEL

In the UK land contamination is assessed using a risk-based approach taking account of the magnitude (severity of the hazard) and likelihood (probability) of occurrence. A ‘receptor’ is something that could be adversely affected by contamination (e.g. people, an ecological system, property or a water body). A ‘pathway’ is a route or means by which a receptor is or could be exposed to or affected by a contaminant. A ‘contaminant source’ is a hazard but it can only pose a risk to a receptor where a pathway is present. The relationship between sources, pathways and receptors are referred to as a conceptual site model. A risk can only be released where a contaminant source, pathway and receptor are all in place, referred to as a ‘pollutant linkage’.

In line with LCRM (Environment Agency, 2020) and BS 10175: 2011 + A2 2017 (BSI, 2017), RSK has used information in the preceding sections to identify hazards (sources of contaminants), receptors that may be impacted and plausible linking pathways. Where all three are present this is termed a potentially complete contaminant linkage and a qualitative risk estimation is made.

6.1 Potential soil, soil vapour and groundwater linkages

6.1.1 Potential sources of contamination

Potential sources of soil and groundwater contamination identified from current activities and the history of the site and surrounding area are presented in **Table 10**. Ground gas sources are addressed in the next section.

Table 10 Potential sources of soil and groundwater contamination

Potential sources	Contaminants of concern
On-site	
Possible Made ground – associated with the old barn and public footpath.	Unknown fill material but potentially including brick, ash and clinker and containing toxic and phytotoxic metals, inorganics, polycyclic aromatic hydrocarbons (PAHs), asbestos Hazardous ground gases: carbon dioxide and methane
Possible Made ground – localised fill material associated with the historical quarry located adjacent to the east boundary.	
Pesticides, herbicides and fertilisers associated with agricultural land use.	Organochlorines, organophosphorus
Off-site	
Historical landfill located some 200 m to the east assumed to be linked with quarry activities.	Inert waste. Landfill leachate including ammoniacal nitrogen and chloride. Hazardous Ground Gases – including carbon dioxide, methane and volatile organic compounds (VOCs)

Given the anticipated ground conditions (Hythe Formation and Sandgate Formation of intermediate – high permeability), and the proximity of the historic quarry immediately east of the subject site, potential sources of ground gas generation have been identified.

6.1.2 Sensitive receptors and linking exposure/ migration pathways

Sensitive receptors identified at or in the vicinity of the site that could be affected by the potential sources identified above comprise:

- future site users – residential users [oral, dermal and inhalation exposure with impacted soil, soil vapour and dust/fibres, ingestion of home-grown produce, migration and ingress of ground gases into buildings, build-up in confined spaces and explosion/ asphyxiation].
- current adjacent site users – residential, commercial, public open space users [migration of contamination via dust/fibre deposition, vapour or groundwater migration combined with inhalation, migration and ingress of ground gases into buildings, build-up in confined spaces and explosion/ asphyxiation].
- future buildings and services [direct contact with contaminated soils or groundwater and chemical attack, migration and ingress of ground gases into buildings, build-up in confined spaces and explosion].
- existing / future vegetation [direct contact with contaminated soils or groundwater and root uptake leading to phytotoxicity].
- controlled waters: Principal aquifer within Hythe Formation bedrock deposits, source protection zone 2 [leaching from soils/ percolation to aquifer/ lateral migration of dissolved phase/ NAPL etc.].
- controlled waters: surface water features situated circa 82 m northwest and >100 m west associated with unnamed stream and unnamed lake, respectively [lateral migration of dissolved phase/ NAPL etc].

Potential linking pathways are show in brackets for each item above.

Please note that construction workers and future maintenance workers have not been identified in the conceptual model as receptors because risks are considered to be managed through health and safety procedures according to the CDM Regulations.

Ecological receptors are only considered within the conceptual model in the context of statutory protected sites.

6.2 Preliminary risk assessment

The preliminary risk assessment findings and potentially complete contaminant linkages are shown in **Table 11** overleaf. The risk classification based on the combination of hazard consequence and probability using a risk matrix from CIRIA C552 (Rudland et al., 2001), a summary of which is included in **Appendix G**.

Table 11 Risk estimation for potentially complete contaminant linkages

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk	Justification
Possible Made ground – associated with the old barn and public footpath. Possible Made ground – localised fill material associated with the historical quarry located adjacent to the east. Pesticides, herbicides and fertilisers Possibility of ACM materials within the soil.	Future site users	Direct contact (oral, dermal, inhalation)	Low likelihood	Medium	**Moderate/low**	*Low likelihood* of future contact given anticipated localised nature of any potentially impacted Made Ground soils and, anticipated free-draining nature of underlying soils with respect to the potential application of any pesticides, herbicides and fertilisers. *Medium* severity conservatively assigned given unknown extent and chemical composition of any impacted Made Ground soils and, unknown use/concentrations of any potential pesticides, herbicides and fertilisers.
	Current adjacent site users		Unlikely	Medium	**Low**	Future contact *unlikely* assuming construction best practice adopted and adhered to. *Medium* severity conservatively assigned given unknown extent and chemical composition of any impacted Made Ground soils and, unknown use/concentrations of any potential pesticides, herbicides and fertilisers.

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk	Justification
	Future buildings and services	Direct contact (chemical attack on infrastructure and buildings)	Unlikely	Medium	**Low**	Future contact *Unlikely* given anticipated localised nature of - potential impacted Made Ground soils (if any) and, limited impact of contaminant of concern with regards to pesticides, herbicides and fertilisers. *Medium* severity conservatively assigned given unknown extent and chemical composition of any impacted soils.
	Future vegetation	Direct contact (root uptake)	Likely	Mild	**Moderate/Low**	*Likely* given anticipated possible localised nature of potential impacted Made Ground soils (if any) and assuming calculated concentrations of pesticides, herbicides and fertilisers applied (if any) *Mild* severity assigned given conservatively assigned given unknown chemical composition.

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk	Justification
	Controlled waters: Principal aquifer of the Hythe Formation	Vertical and lateral migration including leaching	Low likelihood	Medium	**Moderate/Low**	*Low likelihood* given anticipated possible localised nature of any potential impacted Made Ground soils (if any) and assuming calculated concentrations of pesticides, herbicides and fertilisers applied (if any), with respective of plant uptake. *Medium* severity as the Hythe and Sandgate Formation are classed as principal and secondary A aquifer, respectively, however both lies within SPZ2 and nearest groundwater abstraction located >700m.
	Controlled waters: surface water features c.82m		Low likelihood	Mild	**Low**	*Low likelihood* given anticipated possible localised nature of any potential impacted Made Ground soils (if any), assuming calculated concentrations of pesticides, herbicides and fertilisers applied (if any), with respective of plant uptake and assuming construction best practice adopted and adhered to. *Medium* severity assigned given proximity of nearest surface water features and vicinity of licenced surface water abstractions < 200m of the subject site.
Hazardous Ground Gases – including carbon dioxide,	Future site users	Inhalation – via migration through	Unlikely	Severe	**Moderate/Low**	Unlikely assigned based on anticipated 'low' ground gas

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk	Justification
methane and volatile organic compounds (VOCs)		geology/ made ground, construction joints/cracks or services Potential for build-up of gas within structures leading to explosion				generation potential of off-site sources ('inert' landfill adjacent the northern site boundary). *Severe* severity assigned given he potential for explosive atmosphere and/or asphyxiation

Risk matrix		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

Potentially complete contaminant linkages with a potential risk of moderate to low or higher identified in in **Table 11** comprise:

- direct contact / inhalation of contaminates within the Made Ground, possible ACM, pesticides, herbicides and fertilisers by future site users.
- root update of contaminates within the Made Ground, pesticides, herbicides and fertilisers by future site vegetation.
- vertical and lateral migration including leaching contaminates within the Made Ground, pesticides, herbicides and fertilisers impacting controlled waters including the Principal aquifer of the Hythe Formation.
- inhalation of potentially hazardous ground gases/soil vapours from off-site sources (east) by future site users including risk of hazardous gas build up leading to explosion.

These potentially complete contaminant linkages need to be assessed further through appropriate site investigation to target the identified sources of potential contamination and assess the feasibility of identified pathways.

6.3 Data gaps and uncertainties

Key data gaps and uncertainties identified in the CSM at desk study stage include:

- depth to and soil parameters of the underlying natural geology.
- presence/absence and chemical composition of localised Made Ground.
- depth to/flow direction/chemical composition of groundwater (perched or otherwise).
- presence/absence and composition of ground gas on site and likely flow rates.

7 SITE INVESTIGATION STRATEGY & METHODOLOGY

7.1 Introduction

RSK carried out intrusive investigation works between 9th and 17th December 2020 and subsequent monitoring of boreholes between 6th and 20th January 2021.

7.2 Objectives

The specific objectives of the investigation were as follows:

- to establish the ground conditions underlying the site including the extent and thickness of any potential made ground.
- to determine groundwater depth and ground gas regime underlying the site.
- to assess geotechnical properties of soils.
- to investigate potential sources of contamination of the shallow soils.

7.3 Investigation methods and strategy

The techniques adopted for the investigation were chosen with consideration of the objectives and site constraints, which are described below.

Prior to conducting intrusive works, utility service plans were obtained, and buried service clearance undertaken in line with RSK's health and safety procedures. Copies of statutory service records obtained by RSK as part of the agreed scope of works are contained in **Appendix E.**

The ground investigation was carried out using intrusive ground investigation techniques in general accordance with the recommendations of BS5930:2015+A1:2020, which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. Whilst every attempt was made to record full details of the strata encountered in the boreholes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks.

Windowless sampling method was chosen based on the targeted drill depth, the opportunity to collect disturbed samples and install monitoring wells, also to provide minimal amount of disruption to the site.

This was supplemented by mechanically excavated trial pitting to provide wider site coverage and to achieve greater visibility of the subsoil.

A UXO specialist engineer was present on site during the site investigation to assess the potential for presence of unexploded ordnance.

Details of the investigation locations, installations and rationale are presented in **Table 12**. An exploratory hole location plan is shown on **Figure 3.**

Table 12 Exploratory hole and monitoring well location rationale

Investigation Type	Number	Designation	Monitoring well installation	Rationale Examples below
Boreholes by windowless sampling methods	12	WS1 to WS12	Gas/ groundwater	To prove the shallow and deep geological succession beneath the site and obtain geotechnical data To allow installation of dual-purpose groundwater and gas monitoring wells
Trial-pits excavated by mechanical excavator	17	TP1 to TP17	N/A	To accurately log the upper strata beneath the site and collect samples for geotechnical laboratory analysis
Ground gas and groundwater monitoring installations	6	WS1, WS3, WS5, WS7, WS8, WS10	N/A	To determine the ground gas conditions beneath the site To obtain information on groundwater levels
DCP test	10	TP1, TP2, TP4, TP6, TP8, WS7, WS8, TP12, TP13, TP16	N/A	To provide design parameters for roads and hardstanding design

7.3.1 Implementation of investigation works

The exploratory holes were logged by an engineer in general accordance with the recommendations of BS5930:2015+A1:2020 (which incorporates the requirements of BS EN ISO 14688-1, 14688-2 and 14689-1).

The monitoring well construction and associated response zones are detailed on the exploratory hole records in **Appendix H.** The response zones were installed to target identified gas generation sources or migration pathways detailed in the initial preliminary CSM.

The soil sampling and analysis strategy was designed to characterise each encountered soil strata, permit an assessment of the potential contaminant linkages identified and investigate the geotechnical characteristics. In addition, samples were taken to allow for geo-environmental and geotechnical testing to be undertaken.

Soils collected for laboratory analysis were placed in a variety of containers appropriate to the anticipated testing suite required. They were dispatched to the laboratory in cool boxes under chain of custody documentation. Samples were stored in accordance with the RSK quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination.

Selected samples were placed in polythene bags for headspace screening with a photo-ionisation detector (PID). The PID screening results are presented on the exploratory hole records.

7.4 Monitoring programme

7.4.1 Ground gas monitoring

Three monitoring rounds have been undertaken to provide confirmatory data in support of the anticipated ‘low’ ground gas generation potential of the underlying soils, as identified within the initial conceptual site model.

A calibrated infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume. Initial and steady state concentrations were recorded.

The atmospheric pressure before and during monitoring, together with the weather conditions, were recorded. The monitoring included periods of falling atmospheric pressures and after/during rainfall.

All ground gas monitoring results together with the temporal conditions are contained within **Appendix I**. Equipment calibration certificates are available on request.

7.4.2 Groundwater monitoring

Three rounds of groundwater monitoring using electronic dip meter were undertaken during the ground gas monitoring visits. The monitoring records, including dates, are shown in **Appendix I.**

7.5 Laboratory testing

Laboratory testing was undertaken at a UKAS accredited laboratory with ISO17025 and MCERTS accredited test methods were specified where applicable for contamination testing and as shown in the laboratory test certificates appended.

7.5.1 Chemical analysis of soil samples

The soil sampling strategy was designed to characterise made ground and/or natural strata typically within the upper 1.0 m of the ground profile whilst also characterising deeper strata and the potential for contaminant migration from relevant sources of identified within the preliminary CSM.

The programme of chemical tests undertaken on soil samples obtained from the intrusive investigation is presented in **Table 13** with the laboratory testing results contained in **Appendix J**.

Table 13 Summary of chemical testing of soil samples

Stratum	Tests undertaken	No. of tests
Topsoil	Metals: As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn	11
	Asbestos screening and ID	6
	TPH Total (C6-C40)	6
	TPHCWG (C5-36) with CWG, plus BTEX & MTBE	5
	Speciated PAH EPA16	10
	TOC - total organic carbon	5
	Pest C suite	2
Hythe Formation	Metals: As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn	8
	TPH Total (C6-C40)	8
	Speciated PAH EPA16	8
	TOC - total organic carbon	3
	Pest C suite	1

7.5.2 Geotechnical analysis of soils

Where appropriate disturbed, bulk and undisturbed soil samples were taken for geotechnical classification testing with the depth and nature of samples detailed within the exploratory hole records.

Where appropriate, testing was undertaken in accordance with BS 1377:1990 Method of Tests for Soils for Civil Engineering Purposes or, where superseded, by the relevant part of BS EN ISO 17892:2014 Geotechnical investigation and testing - Laboratory Testing of Soil. Tests carried out in order to classify the concrete class required on-site have been undertaken following the procedures within BRE SD1:2005.

The programme of geotechnical tests undertaken on samples obtained from the intrusive investigation is presented in **Table 14**. The results and UKAS accreditation of tests methods are shown in **Appendix K**.

Table 14 Summary of geotechnical testing undertaken

Strata	Tests undertaken	No. of tests
Hythe Formation	Moisture content %	17
	Liquid/ plastic limits	17
	Sieve analysis	7
	Sedimentation analysis	7
	BRE suite	12

8 SITE INVESTIGATION FACTUAL FINDINGS

The results of the intrusive investigation and subsequent geo-environmental and geotechnical laboratory analysis undertaken are detailed below.

8.1 Ground conditions encountered

The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in **Appendix H.**

The exploratory holes revealed that the site is underlain by a variable thickness of topsoil over Hythe Formation encountered at depth. This appears to confirm the stratigraphic succession described within the preliminary CSM. The CSM identified the potential for the presence of Made Ground on site, however none was identified during the site investigation.

For the purpose of discussion, the ground conditions encountered during the fieldworks are summarised in **Table 15** with the strata discussed in subsequent subsections.

Table 15 General succession of strata encountered

Stratum	Exploratory holes encountered	Depth to top of stratum m bgl (mAOD)	Proven thickness (m)
Topsoil	All	Ground Level	0.20 to 0.50
Hythe Formation	All	0.20 to 0.50 (21.52 to 20.59)	proven to 3.60 mbgl

8.1.1 Topsoil

Beneath the initial surface vegetation, the topsoil generally compromises sandy clay, clayey sand and gravelly sandy clay with rootlets present, and range in thickness from 0.20 m to 0.50 m.

8.1.2 Hythe Formation

The soils believed to be representative of the weathered portion of the Hythe Formation were encountered at all exploratory locations below the cultivated topsoil and proven to the terminal depths of the investigation.

Based on the site description and laboratory testing, the unit comprise variable soils of cream, light brown, orange, gravelly sandy clay, sandy clay, clayey fine to medium sand and gravelly sand was encountered, before refusing on a ragstone boulders in most of the locations.

A summary of the in-situ and laboratory test results recorded in the stratum are presented in **Table 16.**

Table 16 Summary of in-situ and laboratory test results for the Hythe Formation

Soil parameters		Min. Value	Max. Value	Reference
Hythe Formation				
Grading %	Gravel	6	24	**Appendix K**
	Sand	44	66	
	Silt	7	21	
	Clay	9	14	
SPT 'N' values		4	66 (196 inferred value WS2 at 2.0mbgl)	**Appendix H Figure 5**
Hythe Formation - Cohesive units				
Moisture content (%)		12	24	**Appendix K Figure 4**
Modified moisture content (%)		21	40	**Appendix K**
Liquid limit (%)		26	53	
Plasticity limit (%)		17	30	
Plasticity index (%)		6	27	
Modified plasticity index (%)		2.7	23	
Plasticity term		Low	High	
Volume change potential		Low	Medium	
Hythe Formation - Cohesive units				
Consistency term from field description based on SPT 'N' value.		Loose	Very dense	**Appendix H**

8.1.3 Visual/olfactory evidence of soil contamination

No visual or olfactory evidence of contamination was identified within the topsoil and the underlying natural Hythe Formation. The PID results are provided on exploratory logs given in **Appendix H**.

8.2 Groundwater

Groundwater was not encountered during the investigation works. However, standing water was recorded during the monitoring programme at levels summarised in **Table 17** based on the data provided in **Appendix I.**

Table 17 Summary of groundwater monitoring results

Monitoring well	Response zone stratum	TOC elevation (m AOD)	Standpipe installation (mbgl) (mAOD)	Depth to groundwater (mbgl) (mAOD)		
				06/01/2021	12/01/2021	20/01/2021
WS1	Hythe Formation	19.05	3.5 (15.55)	Dry	Dry	3.3 (15.75)
WS3		19.20	2.5 (16.7)	2.4 (16.8)	2.45 (16.75)	2.4 (16.8)
WS5		19.93	1.5 (18.43)	1.45 (18.48)	1.46 (18.47)	1.40 (18.53)
WS7		18.81	1.5 (17.31)	-	-	-
WS8		20.20	1.5 (18.7)	-	-	-
WS10		20.98	2.0 (18.98)	1.90 (19.08)	1.95 (19.03)	1.90 (19.08)

The results recorded shallow groundwater levels within the Hythe Formation, which is considered to be perched water infiltrating through the granular soils and collecting within the standpipe.

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. On-going monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

8.3 Chemical laboratory results

Exceedances were recorded within the soil samples tested in relation to the Phytotoxic Effects. The results of the geo-environmental testing are discussed in Section 9 and presented in **Appendix J.**

8.4 Geotechnical laboratory results

The results of the geotechnical testing are discussed in Section 11 and presented in **Appendix K**.

8.5 Ground gas monitoring

The results of the ground gas monitoring and testing carried out are given in **Appendix I** and discussed in section 9.

9 GEO-ENVIRONMENTAL ASSESSMENT

9.1 Refinement of initial CSM

The ground conditions encountered during the investigation generally confirmed the geological succession anticipated in the preliminary CSM. Topsoil was overlying the natural bedrock geology of the Hythe Formation at depth.

Groundwater was not identified during the site investigation and while water was found to be present within the installations during returning monitoring visits this is considered to be perched water rather than the groundwater table.

With respect to ground gas, very little degradable material was noted within the underlying soils, confirming the anticipated low ground gas generation of the underlying soils.

Due to the absence of made ground on site no chemical testing has been carried out at this stage for the purpose of classifying the material for waste disposal.

Chemical testing for contaminates of concern identified during the CSM has been undertaken in order to confirm the absence of contaminants that may pose a risk to human health, vegetation and groundwater.

9.2 Linkages for assessment

As described in LCRM (Environment Agency, 2020), there are two stages of quantitative risk assessment (QRA), Tier 2 generic (GQRA) and Tier 3 detailed (DQRA). The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed. This comparison can be undertaken directly against the laboratory results or following statistical analysis depending upon the sampling procedure that was adopted. This assessment relates to LCRM Stage 1, Tier 2 generic quantitative risk assessment

Following the refinement of the CSM, the potentially complete contaminant linkages that require further assessment and the methodology of assessment are presented in **Table 18.**

Table 18 Linkages for GQRA

Potentially relevant contaminant linkage	Assessment method
Soil data	
1. Oral, dermal and inhalation exposure with impacted soil, soil vapour and dust by future residents	Human health GAC in **Appendix L** for a proposed residential end use with home-grown produce since the proposed end use includes residential gardens. Sampling locations being non-targeted. Consideration given to the applicability of the use of Statistical Assessment. Methodology for statistical assessment presented in **Appendix G.**

Potentially relevant contaminant linkage	Assessment method
2. Inhalation exposure of future residents to asbestos fibres	Qualitative assessment based on the asbestos minerals present, their form, concentration, location and the nature of the proposed development.
3. Uptake of contaminants by vegetation potentially impacting plant growth (phytotoxicity)	Comparison of soil data to GAC in **Appendix M** for phytotoxicity.
4. Contaminants permeating potable water supply pipes	Comparison of soil data to GAC in **Appendix N** for plastic water supply pipes using UKWIR (2010) guidance.
5. Leaching of soil contaminants and dissolved phase migration impacting the Principal Aquifer of the Hythe formation	Since no leachate data is available the potential for leaching has been considered qualitatively using soil and groundwater results.
Ground Gas	
6. Concentrations of methane and carbon dioxide in ground gas entering and accumulating in enclosed spaces or small rooms in new buildings, which could affect future site users. For methane this could create a potentially explosive atmosphere, while death by asphyxiation could result from carbon dioxide.	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV have been compared with the revised Wilson and Card classification presented in BS8485.

9.3 Methodology and assessment of soil results

The analysis of laboratory results relating to soil samples submitted for testing is included in the following sections.

9.3.1 Oral, dermal and inhalation exposure with impacted soil by future occupants/site users

All results have been compared with the GAC for primary school end use scenario (**Appendix L**). A soil organic matter (SOM) of 1% has been conservatively selected.

Results indicate that all contaminants are below the relevant GAC therefore it is considered that a relevant contaminant linkage does not exist.

9.3.2 Inhalation exposure of future occupants/site users to asbestos fibres

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the shallow soils.

Although no ACM was detected within the soil samples submitted, the use of ACM in the construction of the old barn on the southern boundary has been identified and the presence of localised asbestos cannot be discounted. Care will need to be taken when demolishing this structure to avoid asbestos contamination of the soil. All asbestos should be removed and disposed of by a certified specialist asbestos removal contractor.

9.3.3 Uptake of contaminants by vegetation potentially inhibiting plant growth (phytotoxicity)

The results have been compared with the GAC presented in **Appendix M** for this linkage.

9.3.3.1 Data set 1 – Topsoil

Determinants exceeded the adopted GACs for phytotoxicity have been summarised in **Table 19**.

Table 19 Summary of outliers

Determinant	No. of samples tested	GAC (mg/kg)	No of Exceedances	Maximum concentration (mg/kg)	
				Value	Location/depth (mbgl)
Mercury	19	1	1	3.76	TP7 0.0 - 0.30

The results indicate that a relevant contaminant linkage may exist associated with phytotoxic effects with an exceedance of the Mercury GAC for phytotoxicity at 0.0m to 0.3m in TP7.

There is no obvious source of Mercury contamination in the location of TP7 and it is considered that the contamination is an isolated hotspot. Further testing of surface soils that will be used as a growing medium for future soft landscaping areas should be undertaken to confirm suitability in relation to phytotoxic effects.

9.3.4 Impact of organic contaminants on potable water supply pipes

For initial assessment purposes, the results of the investigation have been compared with the GAC presented in **Appendix N** for this linkage, which are reproduced from *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010).

The results indicate that a relevant linkage is unlikely to exist associated with organic contaminants and therefore pollutant polyethylene (PE) and/or polyvinyl chloride (PVC) water supply pipes are expected to be suitable for use on the development unless remedial measures are implemented that mitigate the risk.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

9.3.5 Leaching of contaminants and dissolved phase migration

Groundwater was not encountered during the site investigation and therefore could not be sampled for testing to confirm the absence of contaminates of concern. Notwithstanding the above the depth to groundwater (known to be greater than 3 mbgl), reduces the risk that contaminants in the surface soil will impact groundwater. In addition to this the presence of cohesive units across the site will reduce vertical migration of contaminants. The introduction of hardstanding as part of the development will further reduce infiltration and therefore vertical migration of contaminants. Chemical testing of soil samples has not identified significant contamination on site, so while no leachate or groundwater testing is available it is considered that the risk of contamination on site having impacted the Principal aquifer is low.

9.4 Ground gas risk assessment

9.4.1 Appropriate guidance

The risks to development from ground gases have been assessed in accordance with BS8485:2015+A1:2019 (BS8485), which provides guidance on ground gas (methane and carbon dioxide) characterisation and hazard assessment, as well as providing a framework for the prescription of protection measures within new buildings.

The process involves characterising the gas hazard from combining the qualitative assessment of risk (using the CSM) with ground investigation data so that a ‘characteristic situation’ (CS) can be derived for the site or zones within the site. Characteristic situations range from CS1 to CS6, the higher the CS, the higher the hazard potential. Gas protection measures within new buildings can be prescribed using a point scoring system, taking into consideration the CS and the proposed building type.

BS8485 indicates that the gas hazard can be characterised using the following methods:

- an empirical semi-quantitative approach using gas monitoring data to determine the ‘characteristic situation’ of the site (or zones of the site) and subsequent protective measures (Wilson and Card approach).
- an empirical semi-quantitative approach using TOC data to determine the ‘characteristic situation’ of the site (or zones of the site) and subsequent protective measures (CL:AIRE RB17 approach) or
- detailed quantitative assessment methodologies.

For the purpose of this assessment, the first approach above has been used to characterise the gas hazard and provide advice on the protective measures likely to be required within new buildings at the site.

9.4.2 Empirical semi-quantitative approach using borehole monitoring data (Wilson and Card approach, BS8485)

9.4.2.1 Background

The empirical semi quantitative approach using gas monitoring data requires the designation of a gas screening value (GSV) for the entire site or zones within the site, which informs the hazard potential and associated prescribed ground gas protection measures within new buildings (where necessary). BS8485 defines the GSV as the *'flow rate (l/hr) of a specific hazardous gas **representative of a site or zone**, derived from assessment of borehole concentration and flow rate measurements and taking account of all other influencing factors, in accordance with a conceptual site model'.*

BS8485 Section 6.3.1 outlines the process for developing a GSV for the site or a zone as follows:

- borehole hazardous gas flow rate (Q_{hg}) is calculated for each borehole standpipe for each monitoring event. The borehole hazardous gas flow rate is defined in BS8485 as the *'flow rate of a specific hazardous gas, either methane or carbon dioxide, from a borehole standpipe'*. The Q_{hg} is calculated from individual borehole measurements of total gas flow and the concentration of the specific hazardous gas. BS8485 states in Section 6.3.4 that the **maximum** gas concentration recorded during the monitoring event should be used, together with **steady-state** values of gas flows.
- the reliability of the measured gas flow rates and concentrations are assessed taking into account borehole construction.
- decisions are made about how to deal with any temporal or spatial shortages in the data.
- judgements are made about what GSV to designate for use for design purposes taking all relevant information and the conceptual site model into account.

Once the Q_{hg} has been calculated for methane and carbon dioxide, individual borehole measurements are compared to the thresholds presented in Table 2 of BS8485 which inform the CS that directly relates to each individual measurement. Taking into account the site data (i.e. borehole gas concentration and flow rate to calculate the Q_{hg}) and all other influencing factors in accordance with the CSM, a decision can then be made regarding the GSV that is considered to be representative of the site or a zone within it.

Typical threshold concentrations of methane (1% v/v) and carbon dioxide (5% v/v), and flow rates (>70 l/h), are also considered when designating the GSV for the site or zone, which in turn dictates the hazard potential and CS. It is important to note that the site or zone characteristic GSV and maximum concentration or flow thresholds are guideline values and not absolute. The thresholds may be exceeded in certain circumstances, if the CSM indicates it is safe to do so.

9.4.2.2 Designation of a GSV for the site or zone

The results of the ground gas monitoring and testing undertaken, alongside site conditions at the time of monitoring, are given in **Appendix I.**

A summary of the maximum recorded concentrations per borehole (or minimum for oxygen) is presented in **Table 20** overleaf. This table also presents details of the response zone, maximum recorded initial and steady state flow rates and minimum recorded depth to water across all monitoring rounds.

The range of atmospheric pressure over the three monitoring rounds completed was 989 mbar to 1018 mbar. The atmospheric pressure was recorded to be falling at the time of third round.

Table 20 Summary of ground gas monitoring results

Exploratory position ID	Response zone top (mbgl)	Response zone base (mbgl)	Response zone geological unit	No. of monitoring rounds	Peak CH_4 max. (%/vol)	Steady-state CH_4 max. (%/vol)	Peak CO_2 max. (%/vol)	Steady-state CO_2 max. (%/vol)	Oxygen min. (%/vol)	Peak gas flow max. (l/hr)	Steady-state gas flow max. (l/hr)	Depth to water min. (m)	Depth to water max. (m)	Atm. pressure min. (mb)	Atm pressure max. (mb)
WS1	0.50	3.50	Hythe Formation	3	0.0	0.0	0.3	0.1	19.6	0.0	0.0	3.40	3.45	989	1016
WS3	0.50	2.50	Hythe Formation	3	0.0	0.0	2.6	0.1	16.9	0.0	0.0	2.40	2.45	990	1018
WS5	0.50	1.50	Hythe Formation	3	0.0	0.0	0.3	0.1	19.6	0.0	0.0	1.40	1.46	990	1016
WS7	0.50	1.50	Hythe Formation	3	0.0	0.0	0.2	0.1	19.4	0.0	0.0	dry		990	1016
WS8	0.50	1.50	Hythe Formation	3	0.0	0.0	0.3	0.1	19.4	0.0	0.0	dry		989	1017
WS10	0.50	2.00	Hythe Formation	3	0.0	0.0	0.2	0.2	19.7	0.0	0.0	1.90	1.95	990	1016

BS8485 suggests that the GSV should be derived by multiplying the worse credible (worst case) recorded flow value in any standpipe in that strata or zone with the maximum gas concentration in any other standpipe in that strata or zone. Further guidance is given in BS8485 section 6.3.

Considering the assessment of the gas monitoring results the maximum GSVs derived for the both, methane and carbon dioxide are 0.1 l/hr.

Based on the calculated GSVs and the method for determining the CS presented within Table 2 of BS8485, the site has been characterised as CS1. Considering the foregoing and in accordance with BS8485, ground gas protective measures are not considered necessary within proposed buildings.

9.5 Uncertainties and implications in refined CSM and GQRA

In accordance with good practice, data gaps and uncertainties in the refined CSM have been identified at this stage. These are summarised in **Table 21** along with the likely implications.

Table 21 Data gaps and uncertainties

Data gap/ uncertainty	Details	Implications
Topsoil contain anthropogenic materials such as fine brick debris	Elevated mercury encountered within TP7	The extent of contamination identified within TP7 has not been delineated
Asbestos containing materials (ACM)	Although not encountered to date, asbestos containing material (ACM) is still present in the old barn structure	Vigilance should be maintained for any potential ACM or fibrous material during excavation works

10 PRELIMINARY WASTE ASSESSMENT

In accordance with the definition provided in the Waste Framework Directive (WFD), materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Naturally occurring soils are not considered waste if reused on the site of origin for the purposes of development. Soils such as made ground that are not of clean and natural origin (irrespective of whether they are contaminated or not) and other materials such as recycled aggregate, do not become waste until the criteria above are met. Further background information is provided in **Appendix G.**

Excavation arisings from the development may therefore be classified as waste if surplus to requirements or unsuitable for reuse. The following assessments assume the material tested is classified subsequently as waste.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to any material being excavated. Given the level of data obtained, scale of the development and heterogeneity of the site soils, the following assessment should be considered indicative and further assessment should be undertaken following the preparation of a waste sampling plan.

10.1 Hazardous waste assessment

Technical Guidance WM3 (EA, 2018) sets out in its **Appendix G** requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. The preliminary assessment provided below is based only upon the available sample results and may not be sufficient to adequately classify the waste.

10.1.1 Chemical contaminants

Envirolab, an RSK company, has developed a waste soils characterisation assessment tool (HASWASTE), which follows the guidance within Technical Guidance WM3. The analytical results have been assessed using this tool to assess the hazardous properties to support potential off-site disposal of materials in the future presented in **Appendix O.** Note that it is ultimately for landfills to confirm what wastes they are able to accept within the constraints of their permit.

No samples were found to have hazardous properties based on this assessment. This suggests that if applicable the waste would require disposal at a suitably permitted inert or non-hazardous waste landfill.

It is recommended prior of site disposal WAC testing should be carried out to confirm the above classification.

10.1.2 Asbestos within waste soils

Technical Guidance WM3 requires that within a mixed waste the separately identifiable wastes be assessed separately.

For instance, where waste soil contains identifiable pieces of asbestos (visible to the naked eye) the asbestos should, where feasible, be separated from the soil and classified separately. This should be disposed of within a hazardous, stable non-reactive hazardous waste landfill or a special cell in a non-hazardous waste landfill.

Samples of potential asbestos containing material were collected from site and analysed for the presence of asbestos, the results of which are presented in **Appendix J.**

Analysis confirmed that asbestos is not present within samples and visible asbestos containing material was not identified on-site, therefore the waste can be disposed of within a non-hazardous waste landfill which is able to accept asbestos at non-hazardous concentrations. Notwithstanding the above, ACM were used in the construction of the barn and the presence of asbestos in the soil cannot be fully discounted.

11 GEOTECHNICAL ASSESSMENT

11.1 Proposed development

It is understood that the proposed works intended for site comprise of construction of 300 dwellings properties and associated infrastructure.

At this stage no specific information relating to building loads has been provided and therefore column loads

11.2 Key geotechnical hazards / development constraints

The key risks identified from the available ground investigation data are discussed below:

- ***Sudden lateral changes in ground conditions***

The investigation encountered significant variability of the weathered Hythe Formation, both laterally and with depth.

- ***Shrinkable clay soils***

The cohesive Hythe Formation is with low to medium volume change potential.

- ***Silt-rich soils susceptible to rapid loss of strength in wet conditions***

The Hythe Formation soils are with variable, and locally significant silt content.

- ***Ground subject to peri-glacial valley cambering with gulls possibly present***

The investigation encountered variable and loose / soft soils within the weathered Hythe Formation, and variable depths to refusal, indicating that valley cambering process is likely to be occurring on-site. (See Section 11.3.1).

11.3 Foundations

11.3.1 Foundation options

As stated in previous section, the Hythe Formation in this area is subject to valley cambering, which is a periglacial process occurring where deepening of the valley by river erosion causes large 'ragstone' blocks of the Hythe Formation to collapse inward toward the river along the valley, causing large sets of fractures (termed 'gulls') principally running parallel (and perpendicular) to the river course. These gulls either form voids or by collapse of overlying materials are loosely infilled with unconsolidated 'hassock' sand or more recent deposits.

The presence of relatively soft / loose soils and variable refusal depths in the window sampling boreholes are an indication of the valley cambering at the site. The former was found generally at shallow depths, while the depths of refusal vary from 1.20 m to 3.60 m, indicating either presence of a ‘ragstone’ block or the competent sandstone / limestone of the Hythe Formation.

Due to possible residual risk of valley cambering, it is recommended that, once the proposed development layout is known, further targeted investigation is carried out to establish the presence / absence of gulls along the proposed foundations.

Considering the above, and based on the current available ground investigation information, it is considered that conventional strip foundations would provide suitable foundation solution for the lightly loaded structures in areas of low risk of gulls. However, in areas of high risk and where the presence of gulls will be identified, rafted foundations or piles end bearing within the competent Hythe Formation should be considered.

Any voiding encountered in the foundation excavations should be inspected by a suitably qualified geotechnical engineer and suitable precautions taken to minimise its risk to stability of the proposed foundation.

It is important to contact the geotechnical engineer should the ground conditions differ to those described and expected before further excavation occurs.

11.3.2 Spread foundations

The recommendations for the design and construction of spread foundations in relation to the ground conditions are set out in **Table 22.**

Table 22 Design and construction of spread foundations

Design/construction considerations	Design/construction recommendations
Founding stratum	Weathered Hythe Formation (slightly gravelly sandy clay, clayey sand, slightly sandy clay, medium dense to dense gravelly sand)
Depth	Foundations should be taken to a minimum depth of 1.0 m below the final or existing ground level, whichever is lower, and at least 0.2m into the founding stratum below any overlying made ground or to any greater depth required in respect of the special design considerations given below.
Special design considerations	
Shrinkable soils	Owing to the presence of shrinkable clay soils, foundations should be designed taking into account all the normal precautions, including minimum founding depths, to minimise the risk of future foundation movements in accordance with NHBC standards or similar. The findings of the ground investigation indicate that foundations should be designed for shrinkable soils of medium volume change potential.
Variable founding soils	Owing to the significant lateral and vertical variability of the founding strata, consideration should be given to incorporating appropriate reinforcement into the strip foundations to minimise the risk of future differential foundation movements.

Design/construction considerations	Design/construction recommendations
Presumed bearing capacity	Strip/trench fill foundations with a width of up to 1.0m and constructed on the Weathered Hythe Formation at a minimum depth of 1.00 m may be designed using a presumed bearing capacity of 90 kN/m^2. The presumed bearing capacity includes a partial factor on bearing resistance of 3 against bearing capacity failure. Total settlements associated with the presumed bearing pressure are anticipated to be less than 25 mm.
Construction considerations	All foundation excavations should be inspected, and any made ground and soft, organic or otherwise unsuitable materials removed and replaced with mass concrete. The proposed founding stratum is a relatively silt-rich soil, hence susceptible to rapid softening once exposed. Hence all foundation excavations should immediately be blinded with concrete or the full foundation constructed.

11.3.3 Floor slabs

Ground bearing floor slabs may be adopted with a suitable sub-base layer for the proposed development. Careful examination and rolling of the formation, and replacement of exceptionally hard and soft material with well compacted, suitable granular fill will be necessary.

11.4 Roads and hardstanding

In the 1 m to 1.5 m below the proposed finished ground level the exploratory holes have revealed a soil profile comprising topsoil over Hythe Formation.

In pavement design terms, the groundwater conditions are anticipated to comprise a low water table, at least 1 m below the pavement formation level.

The results of in-situ testing are summarised in **Table 23.**

Table 23 Summary of CBR values derived from in-situ DCP tests

Test location	Material type	Minimum CBR value determined at or just below anticipated formation level
DCP1	Topsoil	1.8
	Hythe Formation	7.7
DCP2	Topsoil	1.3
	Hythe Formation	2.9
DCP3	Topsoil	2.1
	Hythe Formation	4.6
DCP4	Topsoil	1.7
	Hythe Formation	3.5
DCP5	Topsoil (slightly gravelly)	2.3

	Hythe Formation	2.9
DCP6	Topsoil (sandy clay)	2.1
	Hythe Formation	2.8
DCP7	Topsoil	2
	Hythe Formation	4.1
DCP8	Topsoil (granular)	2.1
	Hythe Formation	3.8
DCP9	Topsoil	3
	Hythe Formation	2.7
DC10	Topsoil	2.5
	Hythe Formation	3.4

The recommended sub-grade soil CBR value for road pavement design is therefore 3% %. This value assumes that during construction the formation level will be carefully compacted, and any soft spots removed and replaced with well-compacted granular fill.

The sub-grade condition at the time of construction should be confirmed by testing at the final formation level by in situ CBR testing.

The sub-grade soils can be regarded as frost-susceptible, based upon the criteria given in Appendix 1 of TRRL (1970) Report Road Note 29. When the sub-grade is frost-susceptible the thickness of sub-base must be sufficient to give a total thickness of non-frost-susceptible pavement construction over the soil of not less than 450 mm.

11.5 Excavations for foundations and services

Generally, the trial pits and window sampling locations remained stable during excavation, which indicates that foundation excavations should also remain stable in the short term. However, given the anticipated inherent instability of the granular portion of the Hythe Formation, consideration should be given to the use of trench support systems.

Man entry into any excavations should not be undertaken without provision of suitable shoring and support and dewatering or suitable regrading and battering of side slopes to safe angles. Confined spaces protocols for the Health and Safety of personnel should always be used where man entry into excavations is to be undertaken as low oxygen conditions may be present.

Groundwater was not encountered; dewatering is therefore unlikely to be required to facilitate foundation excavation.

Excavation should be possible using conventional site plant.

11.6 Chemical attack on buried concrete

This assessment of the potential for chemical attack on buried concrete at the site is based on BRE Special Digest 1: Concrete in aggressive ground, which represents the most up-to-date guidance on this topic currently available in the UK.

The desk study and site reconnaissance indicate that, for the purposes of assessing the aggressive chemical environment of the site, the site should be considered as comprising natural ground unlikely to contain pyrite.

Based on testing results, the adopted characteristic pH and water-soluble sulphate content are 7.32 and 32 mg/kg, respectively.

Based on the results above and following the steps outlined in the BRE guidance, a Design Sulphate Class DC-1 and Aggressive Chemical Environment for Concrete classification AC-1 are recommended for the proposed development.

12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Geo-environmental assessment

12.1.1 Environmental:

The results of the Preliminary Risk Assessment (PRA) and the resultant Initial CSM concluded that the risks posed to end-users is ‘moderate/low’ for the following linkages:

- direct contact / inhalation of contaminates within the Made Ground, possible ACM, pesticides, herbicides and fertilisers by future site users.
- root update of contaminates within the Made Ground, pesticides, herbicides and fertilisers by future site vegetation.
- vertical and lateral migration including leaching contaminates within the Made Ground, pesticides, herbicides and fertilisers impacting controlled waters including the Principal aquifer of the Hythe Formation.
- inhalation of potentially hazardous ground gases/soil vapours from off-site sources (east) by future site users including risk of hazardous gas build up leading to explosion.

All samples are below the GAC for human health. Based on the above assessment, no potentially significant risks associated with the soil contamination have been identified and it is considered that the site may be regarded as suitable for the proposed end use.

While no ACM was identified within the soil it has been identified as being used as a building material for a barn on the southern boundary of the site and the presence of isolated fragments of ACM being found on site cannot be ruled out.

The results of the GQRA indicate a single localised exceedance of RSK adopted GACs for phytotoxicity more specifically, mercury within exploratory location TP7. The results indicate that a relevant contaminant linkage may exist associated with phytotoxic effects and further testing of soils intended for use as a growing medium is suggested.

In the absence of any significant site-wide/gross contaminative impact, the potential risks posed to the underlying Principal Aquifer of the Hythe Formation is considered low.

The results of the initial ground gas risk assessment indicate the site has been characterised as CS1, and as such no ground gas protection measures are required as part of any future developments.

Preliminary waste assessment classified the soils as non-hazardous and likely to be suitable for disposal at an inert landfill (assuming it passes the appropriate WAC test) or a site that has a valid exemption from the Environmental Permitting (England and Wales) Regulations 2016 (as amended) registered with the EA. Note that at this preliminary stage of investigation, no samples were submitted for subsequent Waste Acceptance Criteria (WAC) testing.

Should unforeseen contamination be encountered during the development then specialist advice should be sought to determine the appropriate course of action.

12.1.2 Geotechnical

The site investigation has confirmed that the site is underlain by a variable thickness of topsoil to a maximum depth of 0.50 mbgl, over slightly gravelly sandy clay, clayey sand, slightly sandy clay, loose to dense gravelly sand of the Hythe Formation.

Groundwater was not encountered during the investigation and subsequent groundwater monitoring.

it is considered that conventional strip foundations would provide suitable foundation solution for the lightly loaded structures. Strip/trench fill foundations with a width of up to 1.0m and constructed on the Weathered Hythe Formation at a minimum depth of 1.00 m may be designed using a presumed bearing capacity of 90 kN/m2.

Notwithstanding the above there is a risk of 'gulls' and any voiding encountered in the foundation excavations should be inspected by a suitably qualified geotechnical engineer and suitable precautions taken to minimise its risk to stability of the proposed foundation. If gulls are identified, then rafted foundations or piles end bearing within the competent Hythe Formation should be considered. In the case that piles are adopted further investigation through the drilling of deeper boreholes would be required to determine the suitable pile design.

Ground bearing floor slabs may be adopted with a suitable sub-base layer. Careful examination and rolling of the formation, and replacement of exceptionally hard or soft material with well compacted, suitable granular fill will be necessary.

The recommended sub-grade soil CBR values for preliminary road pavement design is 3%. The sub-grade soils can be regarded as frost susceptible.

The Design Sulphate Class within the Hythe Formation is DS-1 with an Aggressive Chemical Environment for Concrete classification of AC-1 can be adopted for the proposed development.

REFERENCES

AGS Interim Guidance (2013), 'Site investigation and asbestos risk assessment for the protection of site investigation and geotechnical laboratory personnel', February.

Baker, K., Hayward, H., Potter, L., Bradley, D. and McLeod, C. (2009), CIRIA Report C682. The VOCs Handbook. Investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination.

Boyle, R. A. and Witherington, P. J. (2007), 'Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present', National House-Building Council and RSK Group.

British Standards Institution (BSI) (1990), 'BS 1377:1990. Methods of test for soils for civil engineering purposes'.

British Standards Institution (BSI) (2020), 'BS 5930:2015+A1:2020. Code of practice for ground investigations'.

British Standard Institution (BSI) (2019), 'BS 8485:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

British Standards Institution (BSI) (2011), 'BS 10175:2011 + A2:2017. Investigation of potentially contaminated sites: Code of practice'.

British Standards Institution (BSI) (2013), BS8576:2013. Guidance on investigations for ground gas – permanent gases and volatile organic compounds (VOCs).

Building Research Establishment (2005), BRE Special Digest 1: Concrete in aggressive ground.

Card G, Wilson S, Mortimer S, (2012). A Pragmatic Approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17. CL:AIRE, London, UK. ISSN 2047- 6450 (Online).

Chartered Institute of Environmental Health (CIEH), (2008), The Local Authority Guide to Ground Gas. Wilson, Card and Haines, September 2008.

CIRIA (2014). Good practice on the testing and verification of protection systems for buildings against hazardous ground gases.

Environment Agency (2018), 'Technical Guidance WM3. Guidance on the classification of and assessment of waste, 1st Edition, v.1.1, May 2018.

Environment Agency (2020), Land contamination risk management, https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm, 8 October 2020

National House Building Council (NHBC) (2016), Technical Extra, April 2016.

Norbury, D. (2010), Soil and Rock Description in Engineering Practice.

Part IIA of the Environmental Protection Act (Contaminated Land Regulations (England)) 2002.

Rudland, D. J., Lancefield, R. M. and Mayell, P. N. (2001), CIRIA C552. Contaminated Land Risk Assessment: A Guide to Good Practice.

Stone, K., Murray, A., Cooke, S., Foran, J., Gooderham, L., (2009) CIRIA C681, Unexploded Ordnance (UXO). A guide or the construction industry.

Transport and Road Research Laboratory, (1970), 'TRRL Road Note 29 (Appendix 1). Road pavement design'.

Transport and Road Research Laboratory (1984), 'TRRL Report LR1132 (Table C1)'.

UK Water Industry Research, (2010), UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites.