Chicken Villas Limited

Rockingham 1, Plot 9

Geo-environmental site assessment

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1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Chicken Villas Limited to carry out a geo-environmental assessment of the land at Plot 9 of the Rockingham 1 Development site, in South Yorkshire. Rockingham 1 is the first phase of a development that will eventually occupy a much larger development area, which will extend to the south and east. This site forms part of the larger area, which was previously occupied by the Rockingham opencast coal mining site

This report is subject to the RSK service constraints given in Appendix A.

1.1 Objective

The objective of this review is to assess ground conditions and requirements to enable the proposed future redevelopment of the land for commercial end use.

1.2 Scope

The scope of the investigation and layout of this report has been designed with consideration of CLR11 (Environment Agency, 2004a) and BS 10175: 2011 (BSI, 2011) and guidance on land contamination reports issued by the Environment Agency (EA) (2010a). A summary of relevant legislation and policy relating to contaminated land is included in Appendix B.

The scope of works for this report was set out in RSK's proposal reference 322338TL01 dated 21 February 2017. The brief included:

- A study of local geology and hydrogeology, including the provision of historical BGS boreholes.
- The identification of potential geological hazards.
- A study of the land-use, development history and environmental data on and around the site and its surroundings from Envirocheck reports previously ordered for the site, review of the RSK Report covering the wider Rockingham site with the permission of Harworth Estates, online resources and archival Ordnance Survey mapping.
- The identification of aquifer vulnerability rating beneath the site and local water abstraction points from Environment Agency records.
- The identification of potential targets at risk from possible contamination.
- Production of a Preliminary Conceptual Site Model.

1.3 Existing reports

A number of existing reports relating to the larger former opencast site area have been reviewed by RSK. Following a review of these reports, and the completion of intrusive investigation and testing, RSK produced the following reports providing comment on ground conditions across the larger site area:

- RSK Geo-environmental Assessment Report: Rockingham 1, South Yorkshire ref: 321393-R02 (00), dated October 2013.
- RSK Appraisal of Ground Conditions and Coal Mining Review: Rockingham, South Yorkshire, ref: 321393-R02 dated November 2014.
- RSK Ground Settlement Assessment report: Rockingham 1, South Yorkshire ref: 321393-R7, dated March 2016.

These have been summarised in Section 3.

1.4 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.

2 THE SITE

2.1 Site location

The site that is the subject of this report is a small area of land positioned at the western end of the Rockingham 1 development area. Rockingham 1 lies to the northwest of the larger site area, which extends to the south and on both sides of the dual-carriageway link road to the east. Figure 1 shows the site location, which can be found at Ordnance Survey National Grid reference SE 35004 00752. The site occupies an area of approximately 1580 m^2 and is situated at an elevation of approximately 130m above Ordnance Datum (AOD). The site lies between the residential areas of Birdwell and Hoyland in South Yorkshire.

2.2 Site description

The site is bounded to the west by residential properties and to the south by an area of scrubland and the Dearne Valley Parkway A6195. A KFC and Dearne Valley Farm pub is found over an access road to the east of site. Commercial and residential properties are located to the north of the site. The site is presently surface with a layer of hardcore stone.

2.3 Proposed development

It is understood that the site is being considered for redevelopment for commercial purposes. The proposed development plan is included as Figure 3.

3 PREVIOUS RSK REPORTS

3.1 RSK Appraisal of Ground Conditions and Coal Mining Review, ref 321393-R01 (01), dated July 2013

Information for the wider Rockingham 1 site is provided in the RSK Appraisal of Ground Conditions and Coal Mining Review. A brief summary of key information is presented below.

3.1.1 Geology and hydrogeology

Published records indicate that no superficial geological units are present across the site. The bedrock is recorded as being Pennine Middle Coal Measures Formation, comprising mudstone, siltstone and sandstone with coal seams. The bedrock units comprise a Secondary A aquifer.

BGS borehole records for the site and surrounding area that were drilled before the opencast coaling operations generally indicate bedrock to comprise mudstone and siltstone with bands of coal.

There are no groundwater protection zones on or around the site, and there are no groundwater abstractions in the vicinity.

Coal Authority information confirms that substantial underground and opencast mining activity has previously occurred on site. This includes 13 underlying worked coal seams, from shallow depth to 430m below ground level, last worked underground in 1977. Although there are several nearby, there are no recorded mine entries on the Rockingham 1 site.

The worked coal seams at the site dipped gently downwards towards the north-east. Consequently opencast excavations were shallowest along the western part of the site and became progressively deeper to the east and northeast. The opencast workings were carried out by UK Coal (and their predecessor company RJB Mining) and their completion records indicate that the base seam worked at the site was referred to as the unnamed 3 seam (1AQ). Records indicate the base of their workings varied between approximately 3m below existing ground levels to the west of Rockingham 1 to 20m or so at the northeastern boundary.

3.1.2 Environmental database review

There are no landfill sites or waste management facilities within the site boundary, although there are a number of each in the area around the site.

3.1.3 Review of historical maps

The main buildings for Rockingham colliery, locasted off the Rockingham 1 site to the west (approximately 260m from Plot 9). Railway lines were located on-site adjacent to the north western boundary of the Rockingham 1 site, passing across the site, and off-site adjacent to the south eastern boundary. An aerial ropeway passed across the site. After closure of the colliery the site was disused. Opencast works were carried out across the Rockingham 1 area and areas to the south and east during the 1990's and restoration of these were largely complete by 1998. By the time of the OS map dated 2002 there is little evidence of the presence of the former mining (either the colliery or opencast workings) in the area around the site.

3.1.4 Coal Mining Review

Whilst extensive coal mining occurred within the Rockingham 1 site, a review of all data available shows limited opencast coal mining occurred within Plot 9. Dunsll Rider Lower 1AU was the only coal seam noted to be worked within the Plot 9 site area. It was noted that coal seams dip from east to west and therefore any excavations carried out would have been relatively shallow. No historical coal mining shafts are present on site.

3.2 RSK Rockingham 1, South Yorkshire Geo-environmental Site Assessment, ref 321393-R2 (00), Dated October 2013

RSK carried out intrusive investigation and subsequent ground gas and groundwater monitoring between July and September 2013 to confirm the thickness and the composition of fill material across the Rockingham 1 site as a whole, carry out in-situ geotechnical testing, take soil and water samples for laboratory testing and to install monitoring equipment. The findings from this report are summarised below.

Eight boreholes were drilled between 4.8m and 17.2m depth using cable percussive methods through fill materials to the underlying bedrock in order to establish the depth of the made ground across the site. This drilling technique is able to penetrate through cohesive and most granular soils and into bedrock, and carry out Standard Penetration Tests (SPTs) during the drilling in order to test geotechnical characteristics of the soil. Monitoring wells were installed within six of the boreholes. Further to this, one set of magnet extensometers were installed in a borehole (BH6).

Sixteen trial pits were excavated up to depths of 3.6m (using a mechanical excavator) to gain a better understanding of the type of shallow fill material on the site.

The exploratory hole records from this previous phase of site investigation are included in Appendix D of this report. The locations of the intrusive investigations that lie withinin the vicinity of Plot 9 are also shown in Figure 2.

During the investigation and assessment of the wider Rockingham 1 site, two trial pits (TP1 and TP16) and one borehole (BH1) were positioned close to the site boundary of Plot 9. The ground conditions (summarised in Table 1 below) comprised made ground

consisting of firm to stiff sandy gravelly clay of varying consistency overlying grey mudstone bedrock in the south (BH1 and TP1) and very stiff grey mottled grey and orange clay in the north (TP16).

Table 1: Summary of previous ground conditions encountered within close vicinity to Plot 9

Ground Conditions Encountered	
Depth (m bgl)	**Stratum Description**
BH1	
GL to1.50	MADE GROUND: Grass over firm to stiff grey slightly orange friable gravelly clay.
1.50 to 2.50	MADE GROUND: Stiff brown grey gravelly friable clay with occasional cobbles
2.50 to 4.50	MADE GROUND: Stiff grey friable very gravelly clay with occasional cobbles
4.50 to 4.80	Grey MUDSTONE
TP1	
GL to 1.80	MADE GROUND: Grass over firm grey sandy gravelly friable clay with occasional cobbles
1.80 to 2.40	Grey fine grained MUDSTONE
TP16	
GL to1.80	MADE GROUND: Grass over firm to stiff grey sandy gravelly clay with occasional cobbles
1.80 to 3.00	Very stiff grey mottled with dark grey, pale grey and orange closely fissured CLAY

The investigation identified a general thickening of reworked colliery fill from 1.8m in the west of the site up to a maximum thickness of 16.7m in the east. Validation reports relating to the reinstatement of the Rockingham 1 site were provided to RSK and confirm the materials were placed under engineering control. In-situ testing and geotechnical analysis by RSK supported the statement that the materials had been engineered.

Plot 9 is located adjacent to the western boundary of the wider Rockingham 1 site. Therefore, reworked fill is estimated to be between 1.8m and 5.0m in thickness.

The environmental assessment found pollutant linkages between impacted soils and future site users to be absent. Pollutant linkages between groundwater and the underlying Secondary 'A' Aquifer are also deemed to be absent. Potential risks were considered as viable in relation to ground gases and potable water supplies.

3.3 RSK Ground Settlement Assessment report: Rockingham 1, South Yorkshire ref: 321393-R7, dated March 2016.

RSK carried out a ground settlement assessment within Rockingham 1 in March 2015. The loading test was carried out in the west of the site where the greatest thickness of engineered fill was recorded.

The assessment confirmed the presence of competent fill. It was deemed unlikely that self weight settlement was occurring within the material. The rate of settlement induced by construction of the loading test was rapid, with approximately half of the total maximum recorded settlement having taken place during the 11-day period of construction of the surcharge mound. This rapid settlement will be an advantage, as much of the settlement caused by the placement of engineering fill to create level development platforms will have already taken placed before foundation construction commences. Overall settlements under a distributed load of approximately 100kPa appear to be moderate, with a maximum recorded settlement of 55mm in the overall monitoring period of nearly 200 days.

It is important to note that loading tests were carried out at the eastern end of Rockingham 1, where made ground was identified to 16.7m. The rate and amount of settlement is thought to be, in part, proportionate to the thickness of made ground. Therefore, within Plot 9 any settlement induced from loading is expected to be significantly less than 55mm.

4 INITIAL CONCEPTUAL MODEL

The available information has been used to compile an initial conceptual model. The identified potential sources of contamination, associated contaminants and receptors have been considered with plausible pathways that may link them. The resulting potential pollutant linkages are considered below and are summarised in Table 2. The risk classification has been estimated in accordance with methodology presented in Appendix C.

4.1 Summary of potential contaminant sources

Potential sources and contaminants of concern identified for the site are:

- fill materials used to backfill former opencast voids, both on and off-site. These may have been impacted by the former contaminative activities elsewhere on the Rockingham colliery site prior to their placement at their current location (Heavy metals, PAH compounds, BTEX and other petroleum hydrocarbons and asbestos)
- highly calorific and/or organic soils within fill materials (hazardous ground gases; carbon dioxide, methane etc.)
- naturally occurring concentrations of sulphates and pyrites within reworked coal measure deposits.
- Underlying Coal Measure deposits and any workings within them might be potential sources and migratory pathways for hazardous ground gases
- Due to the previous assessment carried out on the wider Rockingham 1 site, and the absence of sensitive water bodies in the vicinity of the site, the risk to groundwater from potential leaching contaminants is deemed negligible and therefore will not be further assessed

4.2 Sensitive receptors

Sensitive receptors identified for this site include:

- future site occupants
- adjacent site users
- vegetation
- potable water supply pipes

- proposed buildings and infrastructure

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

4.3 Summary of plausible pathways

The plausible pathways are summarised below:

- direct contact (soil, dust and vegetable ingestion, dermal contact, dust and fibre inhalation)
- groundwater and soil gas migration
- vertical and lateral migration including leaching
- root uptake
- chemical attack of infrastructure (including water supply pipes) and buildings.

4.4 Potentially complete pollutant linkages

The outline conceptual model and an estimate of the risk associated with each linkage is summarised in Table 2. The risk classification has been undertaken in accordance with CIRIA C552 (Rudland et al., 2001), a summary of which is included in Appendix C.

Table 2: Risk estimation for potentially complete pollutant linkages

Potential Contaminant	Potential receptor	Possible pathway	Likelihood	Severity	Risk and justification
Fill materials (organic and inorganic contamination)	Future site users	Direct contact	Likely	Medium	**Moderate**: Potential long-term health effect, but exposure not highly likely as commercial development.
	Adjacent site users	Direct contact	Unlikely	Medium	**Low**: Unlikely to be significant dust generation potential once site developed.
	Vegetation	Root uptake	Likely	Minor	**Low**: Low consequence of some vegetation stress at the proposed commercial development.
	Potable water supply pipes	Chemical attack	Low likelihood	Medium	**Moderate/Low**: Long-term health effects for future users possible.
	Groundwater beneath site	Migration	unlikely	Mild	**Very Low**: Previous groundwater testing within the wider Rockingham 1 site showed a pollutant linkage to be absent.
Highly calorific and/or organic soils within fill materials (hazardous ground gas) and gas from underlying bedrock entering and migrating through on-site made ground	Future site users	Ground gas migration	Low likelihood	Severe	**Moderate**: Fill materials controlled and engineered, so gas generation should be minimal.
	Proposed buildings	Ground gas migration	Low likelihood	Medium	**Moderate/Low**: Fill materials controlled and engineered, so gas generation should be minimal.
Naturally occurring sulphates and pyrites (chemical attack)	Proposed buildings	Chemical attack	Highly likely	Mild	**Moderate**: High potential for pyritic ground conditions.

Potential Contaminant	Potential receptor	Possible pathway	Likelihood	Severity	Risk and justification
Asbestos containing materials within made ground present on site	Future site users	Direct contact	Unlikely	Severe	**Moderate/Low:** The proposed development includes hardstanding across the majority of the site. However, a potentially complete pollutant linkage is still deemed to exist within any proposed soft landscaping areas.

The potential pollutant linkages with a risk of moderate/low or above that require further assessment by site investigation works are:

1. Direct contact between future site users and impacted soils
2. Chemical attack and permeation of water supply pipes
3. Migration of ground gases into future buildings on site and inhalation by occupants
4. Migration of ground gases resulting in damage to future buildings on site
5. Chemical attack of buried concrete in building foundations.
6. Direct contact with asbestos containing materials (ACMs) within areas of soft landscaping

5 SITE INVESTIGATION METHODOLOGY

RSK Environment were commissioned to carry out an intrusive investigation required to complete the scope of works summarised in Section 1.2 above. The work completed is presented in this section of the report and the findings in subsequent sections.

The techniques adopted for the investigation have been chosen considering the ground conditions encountered and available information from the earlier phase of investigative works, the existing land use and the proposed form of site development. Investigation locations were chosen to provide the best spread of data across Plot 9.

5.1 Health and safety considerations

Plans showing the routes of any underground services were provided by the client in advance of intrusive works, and all investigation locations were scanned by the RSK Engineer using a cable avoidance tool. To further mitigate risk to underground services, all locations were commenced with a hand dug pit to a depth of 1.2m below ground level.

5.2 Window sampling boreholes

Site works were carried out on 7 March 2017 and included drilling of four window sampling boreholes to a maximum depth of 3.3m below ground level and the installation of three shallow groundwater and ground gas monitoring wells.

The boreholes were drilled to gain a better understanding of the type of shallow fill material on the site, and carry out Standard Penetration Tests (SPTs) during the drilling in order to obtain geotechnical characteristics of the soil. Three boreholes were installed with monitoring standpipes to allow shallow ground gas and groundwater monitoring.

The investigation and the soil descriptions were carried out in general accordance with 'BS 5930:1999. Code of Practice for Site Investigations' (BSI, 1999). The exploratory hole records are presented in Appendix D.

The locations of the intrusive investigations are shown in Figure 2. The window sample boreholes were evenly distributed around the site in order to obtain information about as much of the site as possible.

5.3 Soil sampling, in-situ testing and laboratory analysis

Soils collected for laboratory analysis were retained in a variety of containers appropriate to the anticipated testing suite required. Samples were stored in accordance

with the RSK quality procedures to maintain sample integrity, preservation and to minimise the chance of cross contamination.

All samples are recorded together with their depths on the exploratory hole records in Appendix D. The samples were transported to the laboratory in chilled cool boxes. A selection of representative samples were tested for a range of chemical contaminants, as summarised in Table 3. The results are included in Appendix F.

Table 3: Scheduled geochemical laboratory testing

Sample	Analyte	Rationale
WS1(0.4m), WS2(0.1m) and WS3(0.4m)	Speciated PAH-16MS, TPHCWG, pH, As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn, Total sulphate, water soluble sulphate	To characterise shallow soils present on site
WS1(0.4m), WS2(0.1m) and WS3(0.4m)	Asbestos Screen	To characterise shallow soils present on site
WS1(0.4m), WS2(0.1m) and WS3(0.4m)	Total organic carbon	To characterise shallow soils present on site
WS1(1.1m) and WS3(1.8m)	Pyritic BRE suite	To aid in preliminary foundation design

In situ SPTs were carried out in boreholes at 1.0m depth intervals during the window sample drilling in accordance with part 9 of BS 1377:1990 (BSI, 1990). Test results are given on the borehole records presented in Appendix D. Disturbed and bulk samples were taken for inspection.

Geotechnical testing carried out within boreholes and trial pits on and in close vicinity to Plot 9 have been used to aid the geotechnical assessment and are presented in Appendix J.

5.4 Groundwater monitoring and levelling

Depths to any groundwater were recorded using an electronic dip meter throughout the drilling process and then after the completion of monitoring wells, during the first monitoring visit on 13 March 2017. The monitoring results completed to date are presented alongside the gas monitoring data in Appendix E.

No water sampling was carried out due to information gathered from previous reports from the wider Rockingham 1 site where no complete linkage was deemed to exist between potentially contaminated groundwater and the underlying Secondary A Aquifer.

5.5 Ground gas monitoring

Three ground gas monitoring rounds have been undertaken to date (15, 22 and 28 March 2017) with one further monitoring round to be carried out. Monitoring rounds have been carried out at times of low and falling atmospheric pressure.

An infrared gas meter was used to measure, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume, while hydrogen sulphide (H_2S) and carbon monoxide (CO) were recorded in parts per million. Initial and steady state concentrations were recorded. Gas flow rates have also been recorded.

All monitoring results together with the temporal conditions are contained within Appendix E and discussed in Section 6.

6 GROUND CONDITIONS

The results of the intrusive investigation and subsequent laboratory analysis undertaken are detailed below. 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 D**.**

6.1 Ground conditions

The exploratory holes revealed that the site is underlain by a variable thickness of made ground over Coal Measures Bedrock encountered at depth. This confirms the expected succession presented in earlier sections of this report. For the purpose of discussion, the ground conditions are summarised in Table 4 and the strata discussed in subsequent subsections.

Table 4: General succession of strata encountered

Strata	Exploratory holes encountered	Depth to top of stratum m bgl	Thickness (m)
Made ground (granular)	All exploratory locations	From ground level	0.25 to 0.34
Made ground (engineered fill)	All exploratory locations	0.25 to 0.34	2.65 to 2.98
Coal Measures Bedrock	WS1	2.90	0.40 proven

There was no visual or olfactory evidence of soil contamination during the site investigation works.

6.1.1 Made ground (granular)

The made ground generally comprised a fine to coarse granular soil with a significant proportion of gravel. The gravel was fine to cobble sized brick, concrete and mixed lithologies, including mudstone. The stratum ranged in thickness from 0.25 m to 0.34 m. The in-situ and laboratory test results can be found on the exploratory borehole logs presented in Appendix D. This material is a recently placed granular engineered made ground.

6.1.2 Made ground (reworked clay)

This stratum was encountered beneath the granular made ground and comprised a layer of stiff to very stiff orange mottled grey silty friable clay between 2.65 m and 2.98 m in thickness. This material represents the opencast backfill, which was placed in a controlled and engineered manner.

The in-situ and laboratory test results can be found on the exploratory hole logs in Appendix D.

6.1.3 Coal Measures Bedrock

This stratum was encountered at a depth of 2.90 m within WS1 only and was proven to be at least 0.40 m thick. The stratum was generally characterised as very stiff yellowish grey slightly silty clay, which is considered likely to represent weathered bedrock.

In the remaining boreholes, an SPT refusal (N value <50) was recorded, indicating the depth of the interface between the engineered backfill, and the underlying bedrock.

The in-situ and laboratory test results can be found on the exploratory hole logs in Appendix D.

6.2 In-situ Geotechnical Testing

In-situ tests were undertaken in each exploratory hole in the form of SPT testing, at one metre intervals. The results returned N values between 12 and >50, which support the field descriptions that reported the underlying soils as stiff to very stiff clays. The results of the in-situ testing are recorded on the exploratory logs presented in Appendix D.

6.3 Groundwater

Groundwater was encountered during the site investigation within WS2 only, at a depth of 2.0m below ground level. Groundwater was not encountered within any other intrusive location.

Three groundwater monitoring visits have been completed and ongoing monitoring is proposed which will help to establish both the full range of conditions and any trends in groundwater levels. It should be noted that groundwater levels may fluctuate for a number of reasons including seasonal variations.

Available groundwater monitoring results are summarised in Table 5.

There was no visual or olfactory evidence of groundwater contamination during the site investigation works or subsequent monitoring visits.

6.4 Ground gas regime

The results of the ground gas monitoring and testing carried out are given in Appendix E. The minimum and maximum results are recorded in Table 5.

Table 5: Summary of ground water and ground gas monitoring results

Borehole	Response zone/strata	Probable source(s) of ground gas	Number of monitoring visits	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Flow rate (l/hr)	Water level (m b TOC)	Atmospheric pressure (mbar)
WS1	RC/ CMB	Organic materials within reworked clay	3	<0.1 to 0.1	0.2 to 1.1	19.2 to 21.2	0.0	2.53 to 2.86	981 to 1011
WS2	RC		3	<0.1 to 0.2	0.1 to 11.9	20.9 to 1.5	-0.2 to 0.2	1.1 to 1.4	983 to 1012
WS3	RC		3	<0.1	0.1 to 7.2	9.7 to 21.0	-0.1 to 0.2	1.55 to 2.44	983 to 1013
Note: *MG – Made Ground, RC – Reworked clay, CMB – Coal Measures bedrock. Steady state gas concentrations and flows are presented in this table.*									

6.5 Refinement of the initial conceptual site model

The intrusive investigation carried out on 7 March 2017 comprised the drilling of window sample boreholes down to a maximum depth of 3.3m below ground level. Ground conditions were described as a variable thickness of made ground over reworked friable clay with the Coal Measures bedrock encountered within WS1 at a depth of 2.9m. This confirms ground conditions encountered within previous RSK intrusive investigations over the wider Rockingham 1 site.

Subsequent ground gas monitoring of installed monitoring wells have revealed slightly elevated carbon dioxide concentrations and concentrations of carbon monoxide. A quantitative risk assessment of the ground gas regime identified on site will therefore be undertaken.

As the proposed development includes hardstanding across the entire site, a linkage between future site users and potentially contaminated made ground is unlikely to exist. However for completeness and to assess risk to areas of soft landscaping, this pollutant linkage is included and assessed in Section 7.

The presence of sulphates and acidic ground conditions can contribute to chemically aggressive ground conditions, which may affect buried concrete. Analysis of the potential for chemical attack on buried concrete has been completed for the site but is presented as part of the Geotechnical Site Assessment in Section 8.

7 QUANTITATIVE RISK ASSESSMENT

In line with CLR11 (EA, 2004), there are two stages of quantitative risk assessment, generic and detailed. 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 was undertaken directly against the laboratory results.

7.1 Linkages for assessment

Section 4.4 presents the potentially complete pollutant linkages identified in the initial conceptual model. Based on the recent additional site-specific investigation works a refinement of the conceptual model is discussed in Section 6.4, which identified the linkages that required assessment after the findings of the site investigation had been considered. These linkages together with the method of assessment are presented in Table 6.

Table 6: Linkages for generic quantitative risk assessment

Potentially relevant pollutant linkage	Assessment method
1. Direct contact with impacted soil by future residents	A. direct comparison to the Generic Assessment Criteria (GAC) for a proposed commercial end-use will be undertaken. A copy of the GAC for commercial end-use is included within Appendix G
2. Contaminants permeating potable water supply pipes	Comparison of soil data to GAC in Appendix I for plastic water supply pipes using UKWIR (2010) guidance.
3-5. Concentrations of methane and carbon dioxide in ground gas entering and accumulating in: depressions and excavations that could affect workers enclosed spaces or small rooms in new buildings, which could affect future site users. In the case of methane this could create a potentially explosive atmosphere, while death by asphyxiation could result from carbon dioxide.	Situation A (modified Wilson and Card method) relates to all development types except low-rise housing and, by combining the qualitative assessment of risk with the gas monitoring results, provides a semi-quantitative estimate of risk for a site. The method uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flows for methane and carbon dioxide. Having calculated the worst case GSVs for methane and carbon dioxide, the Characteristic Situation is then determined from Table 8.5 of CIRIA C665. In addition, the gas regime is considered within the context of a conceptual model as required by both aforementioned guidance documents and BS8576
6 Chemical attack on buried	A comparison of BRE sulphate analysis with Table C1 for sites where disturbance to pyrite bearing ground may result

Potentially relevant pollutant linkage	Assessment method
concrete	in the addition of sulphate, BRE Special Digest 1:2005 Concrete in aggressive ground will be carried out.
7. Asbestos containing materials potentially present within made ground identified on site.	Asbestos Screen will be carried out on selected samples of made ground.

7.2 Methodology and results

The methodology and results of the GQRA are presented for each relevant pollutant linkage in turn.

7.2.1 Direct contact with impacted soil by future residents

Non-targeted soil samples were obtained during the site investigation; the results have been evaluated in the following paragraphs.

Chemical results were analysed against RSK's Generic Assessment Criteria (GAC) for a proposed commercial site end-use assuming a conservative soil organic matter (SOM) content of 1%. Whilst metals, PAH and TPH determinants were found to be present within the shallow made ground and the reworked clay across the site, they were not elevated above their relevant GAC. Furthermore, the proposed development includes hardstanding across the entire site and therefore the risk of future site users coming into direct contact with any made ground across the site is deemed negligible. A complete pollutant linkage between future site users and potentially contaminated ground is therefore deemed absent.

A summary of results from chemical testing is detailed in Appendix F.

A summary of RSK's GAC for a commercial end-use is detailed in Appendix G.

7.2.2 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 I 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

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.

7.2.3 Ground gas assessment

The results have been assessed in accordance with the guidance provided in BS8576, NHBC guidance and *CIRIA Report C665*. In the assessment of risks and selection of appropriate mitigation measures, both reports highlight the importance of the conceptual model.

7.2.3.1 Summary of CSM

The initial CSM identified a gas risk associated to potentially organic materials within the reworked clay resulting in potential gas production during degradation (See Section 4.1).

7.2.3.2 General

CIRIA C665 identifies two types of development, termed Situation A (modified Wilson and Card method), appropriate to all development excluding traditional low-rise construction, and Situation B (National House-Building Council, NHBC) only appropriate to traditional low-rise construction with ventilated sub-floor voids.

Both methods are based on calculations of the limiting borehole gas volume flow for methane and carbon dioxide, renamed as the gas screening value (GSV). The GSV (litres of gas per hour) is calculated by multiplying borehole flow rate (litres per hour) and gas concentration (percent by volume).

In both situations, it is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the site conceptual model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

The site is to be redeveloped with a commercial fast food outlet and therefore falls under Situation A.

Situation A relates to all development types except low-rise housing and, by combining the qualitative assessment of risk with the gas monitoring results, provides a semi-quantitative estimate of risk for a site. The method uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flows for methane and carbon dioxide. Having calculated the worst case GSVs for methane and carbon dioxide, the Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

7.2.3.3 Assessment of data

The site is to be redeveloped with a commercial fast food outlet and therefore falls under Situation A. The gas monitoring data has identified a maximum methane concentration of 0.2% and a maximum concentration of carbon dioxide of 11.9%. A maximum gas flow rate of 0.1l/hr has been recorded. The calculated GSV for methane is 0.0002 l/hr and the GSV for carbon dioxide is 0.0119l/hr. Based on the GSVs the site has been characterised as Characteristic Situation 1(CS1). Please note that this classification is subject to change based on one further monitoring visit.

7.2.4 Inhalation exposure of future residents 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 samples of made ground. Whilst the clay found on site is classified as made ground, it is reworked natural materials reducing the potential for asbestos to be present.

7.3 Environmental assessment conclusions

Chemical results were compared directly to their relevant GAC for a proposed commercial end-use. All results were found to be below their relevant threshold level. Furthermore, the proposed development shows hardstanding across the entire site further mitigating risk to future site users.

Shallow soils were visually inspected and screened for potential asbestos fibres. No asbestos fibres were detected.

PVC and PE plastic water utility pipes are deemed suitable for use on site. However, please note that routes of water pipes were not known during the investigation and so further investigation may be needed to confirm material suitability.

Subsequent gas monitoring identified fluctuating carbon dioxide and methane levels. However when compared to the relevant assessment criteria, the site was calculated as Characteristic Situation 1. Therefore, no gas protection measures are deemed necessary. Conclusions to the ground gas assessment will be finalised once the monitoring programme is completed and all data available for assessment.

In summary, all potential pollutant linkages are absent and therefore the site is suitable for the proposed end use.

8 GEOTECHNICAL SITE ASSESSMENT

8.1 Engineering considerations

It is understood that the proposed development is to involve the construction of a 167m^2 single storey commercial property, with roads, pavements, car parking and associated infrastructure. At this stage, no specific information relating to building loads has been provided.

The investigation identified competent reworked fill material from surface down to depths of 3.3m with SPT'N' values ranging from 12 to over 50. The range in SPT'N' value can be attributed to the heterogeneity of the reworked fill. However, values generally increase significantly with depth.

Natural bedrock was identified within one location (WS1) at a depth of 2.90m below ground level. All intrusive locations refused with both the sampler and in-situ testing at between 3.04m and 3.30m below ground level. It is considered likely that this refusal depth is due to the presence of underlying bedrock.

Ground conditions encountered on site and the wider Rockingham 1 site are considered to be the same engineered fill, typically described as a stiff clay and demonstrating moderate to high SPT N profiles.

8.2 Geotechnical hazards

A summary of commonly occurring geotechnical hazards is given in Table 7: together with an assessment of whether the site may be affected by each of the stated hazards.

Table 7: Summary of main potential geotechnical hazards that may affect site

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	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 (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	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
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
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)			✓	Likely to affect ground engineering and foundation design and construction

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	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 sulfides to sulfates)		✓		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.				

8.3 Foundations

8.3.1 General suitability

Based on the ground conditions encountered, SPT data gathered from the intrusive investigation and recommendations from previous reports, it is envisaged that reinforced strip foundations founded within the cohesive reworked fill would be feasible.

8.3.2 Spread foundations

The recommendations for the design and construction of spread foundations in relation to the ground conditions are set out in Table 8.

Table 8: Design and construction of spread foundations

Design/construction considerations	Design/construction recommendations
Founding stratum	Reworked engineered fill
Special design considerations	Owing to the presence of shrinkable clay soils with a low volume change potential, 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. Due to the heterogeneity of the reworked fill and potential for differential settlement, it is recommended that reinforced spread foundations be adopted.
Bearing capacity	A net allowable bearing capacity of 75 kN/m^2 can be assumed for the

Design/construction considerations	Design/construction recommendations
	engineered materials present beneath the site. The allowable bearing capacity includes an overall safety factor of 3 against bearing capacity failure and with total settlements associated with the bearing pressure estimated to be less than 25mm.
Stability of excavations	All boreholes remained stable throughout the investigation.
Dewatering	Groundwater was encountered in one borehole at a depth of 2.0m. Dewatering is unlikely to be required to facilitate foundation excavation. The cohesive nature of the soils encountered suggests that pumping from open sumps should be sufficient to keep the excavations reasonably dry, if required.
Construction considerations	All foundation excavations should be inspected and any soft, organic or otherwise unsuitable materials removed and replaced with mass concrete.

Due to the heterogeneity of the reworked fill material recourse may be given to the adoption of a piled foundation design into the underlying bedrock if heavier loads are proposed.

8.3.3 Foundation works risk assessment

It is anticipated that a foundation works risk assessment report will not be required for the development because concentrations of chemicals of potential concern (COPC) within made ground, natural soils and groundwater were below corresponding GAC. Where exceedances were noted, these were found to be marginal and of the same order of magnitude as the associated GAC. However, due to the reported variability of hazardous ground gases, the associated risks to site staff should be considered and appropriate monitoring and methods for access and egress of excavations adopted for all site personnel.

8.3.4 Floor slabs

The sub-grade soil conditions beneath the footprint of the proposed buildings comprise reworked fill material.

Based on the ground conditions encountered and in-situ test results obtained, ground bearing floor slabs will be appropriate, and a California bearing ratio (CBR) of 3% is recommended for design purposes. Careful examination and rolling of the formation, and replacement of exceptionally hard and soft material with well compacted, suitable granular fill will be necessary.

8.3.5 Roads, hardstanding and drainage

In the 1m to 1.5m below the proposed finished ground level the exploratory holes have revealed a soil profile comprising very stiff reworked clay. The potentially poorest sub-grade material within this profile is the reworked clay.

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

The estimated minimum, equilibrium soil-suction, California bearing ratio (CBR) value for the soils and groundwater conditions described above under a completed pavement is 3%, based upon Table C1 in TRRL (1984) Report LR1132.

The sub-grade soils may be susceptible to improvement by rolling with conventional compaction plant.

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 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 450mm.

8.3.6 Chemical attack on buried concrete

This assessment of the potential for chemical attack on buried concrete is based on current BRE guidance. The desk study and site walkover indicate that, for the purposes of this assessment of the aggressive chemical environment, the site should be considered as a site where disturbance of pyrite-bearing ground could result in additional sulphate. A suite of chemical analyses appropriate to this site classification was carried out on soil samples.

Because of the possible presence of sulphides in the reworked clay, a calculation was made using the measured concentrations of Total Sulphur and Acid Soluble Sulphate of the amount of Oxidisable Sulphide present. A maximum Oxidisable Sulphide content of 1.26% was calculated. Since this value is greater than 0.3% a Total Potential Sulphate concentration of 1.32% (three times the Total Sulphur content) has been calculated. Based on this value, result three for Design Sulphate Class for the site is DS-4.

Based on subsequent groundwater monitoring and ground conditions identified on site, it has been assumed that groundwater conditions are static. From consideration of the characteristic pH value, an Aggressive Chemical Environment for Concrete classification of AC-3s May be assumed for design purposes.

9 REUSE OF MATERIALS AND WASTE

9.1 Reuse of suitable materials

Under the Waste Framework Directive naturally occurring soils are not considered waste if re-used on the site of origin for the purposes of development.

In accordance with the definition provided in the Waste Framework Directive, materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Thus, soils that are not of clean and natural origin, i.e. made ground (whether contaminated or not) and other materials such as recycled aggregate, do not become waste until the aforementioned criteria are met.

The Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2011) (CoP) was developed in consultation with the Environment Agency and development industry to enable the re-use of materials under certain scenarios and subject to demonstrating that specific criteria are met. The current re-use scenarios covered by the CoP comprise:

- Re-use on the site of origin (with or without treatment)
- Direct transfer of clean and natural soils between sites
- Use in the development of land other than the site of origin following treatment at an authorised Hub site (including a fixed Soil Treatment Facility).

The importation of made ground soils (irrespective of contamination status) or crushed demolition materials is not currently permitted under the CoP and requires either a standard rules environmental permit or a U1 waste exemption (see below).

In the context of excavated materials used on sites undergoing development, four factors are considered to be of particular relevance in determining if the material is a waste or when it ceases to be waste:

- the aim of the Waste Framework Directive is not undermined, i.e. if the use of the material will create an unacceptable risk of pollution of the environment or harm to human health it is likely to be waste
- the material is certain to be used
- the material is suitable for use both chemically and geotechnically
- only the required quantity of material will be used.

The CoP requires the preparation of a materials management plan (MMP) that confirms the above factors will be met. This plan needs to be reviewed by a 'Qualified Person' (QP) who will then issue a declaration form to the EA. As the project progresses, data must be collated and on completion a verification report produced that shows the MMP was followed and describes any changes.

The MMP establishes whether specific materials are classified as waste and how excavated materials will be treated and/or re-used in line with the CoP. The MMP is likely to form part of the site waste management plan.

The site has been developed previously and the investigation has confirmed the presence of made ground. Therefore, before any excavation works begin on-site, an MMP will need to be prepared, reviewed by a QP; and a Declaration lodged with the EA.

As noted above, under the Waste Framework Directive naturally occurring soils are not considered waste and therefore arisings of clean natural soils, e.g. from foundation and drainage excavations, may be re-used on the site. However, it is important that these soils should be stockpiled separately and not become cross-contaminated with made ground / contaminated soils or construction wastes.

If it is proposed to import clean and naturally occurring soils direct from another site, the receiving site's MMP would need to be updated in advance of importation.

9.2 Treatment to meet suitable-for-use criteria

Where materials do not meet the suitable for use criteria it may be possible to treat them under an environmental permit (mobile treatment licence) to enable them to be reused onsite.

To enable the treatment options to be determined, an options appraisal and a remediation strategy document will be necessary to support discussion of the issues with regulators and third parties.

9.3 Reuse of waste materials

If material is discarded as waste then its reuse on site may still be possible. Waste soils and recycled aggregate can be reused on site under a standard rules environmental permit or a U1 waste exemption from the Environmental Permitting (England and Wales) Regulations 2010 provided that they are suitable for the proposed use, i.e. not cause harm to human health or the environment. However, it should be noted that these have strict limits on the quantity of material that can be reused.

9.4 Wastes for landfill disposal

Wastes require pre-treatment prior to disposal at landfill. Pre-treatment must be a physical, thermal, chemical or biological process (including sorting) that changes the characteristics of the waste to reduce its volume, reduce its hazardous nature, facilitate its handling and enhance its recovery.

The latest, edition of the EA's 'Technical Guidance WM3' (2015) Guidance on the classification and assessment of waste, requires that within a mixed waste* the separately identifiable wastes are assessed separately. Mixing of different types of

hazardous waste and hazardous waste with other waste substances is prohibited under the Waste Framework Directive. Wastes that have been mixed must be separated whenever possible.

It is best practice to provide your waste carrier (or the disposal site) with details of how the waste has been treated. Your waste carrier may provide a pre-treatment confirmation form or space on the waste transfer note to detail the pre-treatment.

The classification of waste soil is a two-stage process, the first being an assessment of whether the soil is considered hazardous or not following the guidance within Technical Guidance WM3. For off-site disposal to landfill the results of Waste Acceptance Criteria (WAC) testing must then be reviewed to establish if the soil is acceptable at the relevant class of landfill or requires pre-treatment to reduce specific hazardous properties.

9.4.1 Waste acceptance criteria

All inert, stable non-reactive hazardous and hazardous wastes have limit values (waste acceptance criteria) set out in legislation that must be met before that class of landfill can accept the waste. Currently, no WAC are in place for non-hazardous waste.

Soil and other materials that are found not to be hazardous may be classified as either non hazardous or inert. In order to determine whether they can be classed as inert the soil must be tested and found to be below the inert waste acceptance criteria.

9.4.2 Waste sampling plan

Technical Guidance WM3 sets out in Appendix B 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. At this stage RSK consider that the level of soil sampling is sufficient to categorise the material.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to development.

9.4.3 Preliminary waste assessment

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.

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 for potential off-site disposal of materials in the future. The results are presented in Table 9.

Table 9: Results of waste soils characterisation assessment (HASWASTE)

Sample ref/location	Waste classification
WS1 at 0.2m bgl	Hazardous
WS2 at 0.1m bgl	not hazardous
WS3 at 0.4m bgl	not hazardous
Notes:	

HASWASTE analysis of the three samples of shallow made ground on site identified WS1 at 0.2m below ground level to be above threshold limits for total TPH and therefore classified as hazardous waste. However, the other two samples (WS2 at 0.1m and WS3 at 0.4m) of the same material were found to be not hazardous. This represents the heterogeneity of the made ground across site. Is it therefore recommended that further shallow soil samples are taken in order to robustly classify materials for off-site disposal.

9.4.4 Asbestos within waste soils

The latest, edition of 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.

Samples of made ground were collected from site and analysed for the presence of asbestos, the results of which are presented in Appendix F. Analysis confirmed that asbestos is not present within samples WS1 at 0.2m, WS2 at 0.1m, WS3 at 0.2m and WS3 at 0.4m.

If asbestos is encountered during future works, visible asbestos containing material should, where feasible, be separated from soils and classified as stable, non-reactive hazardous waste, which can then be disposed of within a stable non-reactive hazardous waste landfill or a special cell in a non-hazardous waste landfill.

9.5 Landfill tax

Waste producers disposing of material to landfill are required to pay landfill tax by HM Revenue and Customs.

The tax is chargeable by weight (tonnage) and two rates apply, either standard or lower rate. The lower rate only applies to those less polluting wastes as set out in the Landfill Tax (Qualifying Material) Order 2011, which include naturally occurring rock and soil, concrete, some minerals, some furnace slags and ash, and some low-activity organic compounds. Evidence confirming that the waste qualifies for the lower rate will be required, and standard rate tax will apply for the whole waste load for any loads of mixed waste.

Currently (since 1st April 2016), standard rate landfill tax is £84.40 per tonne.

The lower rate of landfill tax applicable to less polluting wastes (i.e. 'inert' wastes) remains at £2.60 per tonne.

Material disposed of at a soil treatment centre will not be subject to landfill tax.

9.6 Groundwater

When there is an intention to discard groundwater, chemical test results will indicate the appropriate disposal options. This could include disposal to treatment facility, via consent (issued by the water authority) to foul sewer or via consent (issued by the EA) to a watercourse or land.

9.7 Recommendations

RSK recommends that consideration as to how potentially waste soils will be dealt with as part of this development/remediation is given as early in the project planning process as possible. Such planning can lead to cost savings where potentially waste soils are viewed as a resource and retained on-site as part of the development. We also recommend, where off-site disposal is being considered, that appropriate facilities are identified and discussions initiated to confirm suitability of the facility to take the material. Potentially, these may include soil treatment facilities as well as landfills.

RSK can provide specialist advice to assist in this process, which can be complex and subject to regular regulatory change.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Environmental

10.1.1 Conclusions

Chemical results were compared directly to their relevant GAC for a proposed commercial end-use. All results were found to be below their relevant threshold level. Furthermore, the proposed development shows hardstanding across the entire site further mitigating risk to future site users.

Shallow soils were visually inspected and screened for potential asbestos fibres. No asbestos fibres were detected.

PVC and PE plastic water utility pipes are deemed suitable for use on site. However, please note that routes of water pipes were not known during the investigation and so further investigation may be needed to confirm material suitability.

Ground gas monitoring rounds to date (three rounds), identified fluctuating carbon dioxide and methane levels. However when compared to the relevant assessment criteria, the site was calculated as Characteristic Situation 1. Therefore, no gas protection measures are deemed necessary. Final recommendations for the measures required to manage risks from ground gases will be provided on completion of the gas monitoring programme.

The results of the environmental assessment for the site indicate that relevant pollutant linkages identified within the initial conceptual site model are absent and therefore the site is suitable for the proposed end use.

10.2 Reuse of materials and waste

10.2.1 Conclusions

A preliminary analysis of materials for potential off-site disposal was carried out using Envirolabs (An RSK Company) HASWASTE waste analysis tool found one of three samples to be elevated with TPH above the threshold for non-hazardous waste and so was classified as hazardous. The two other samples have been classified as non-hazardous.

It is noted that Waste Acceptance Criteria (WAC) testing was not undertaken on any materials and therefore an appropriate landfill site for off-site disposal cannot be recommended.

10.2.2 Recommendations

Further testing of shallow made ground may be required if these materials are planned for off-site disposal.

10.3 Geotechnical

10.3.1 Conclusions

Plot 9 is underlain by the same reworked cohesive fill as that identified within previous reports for the Rockingham 1 site. The Ground Settlement Assessment (321393-R07 (00), dated march 2016) carried out in the west of the site, where reworked fill thickness was identified to 16.7m, recorded a maximum induced settlement of 55mm when a 100kPa surface load was applied. Plot 9 in underlain by approximately 3m of engineered backfill and therefore the settlement induced by a single storey unit is expected to be significantly less and within tolerable limits.

In-situ testing carried out on Plot 9 showed slightly variable conditions, but the field descriptions and SPT'N' values from surface to the full depth of the investigation indicate competent materials to be present. The variability of the in-situ testing is considered to be due to the heterogeneity of the engineered fill located across site.

On the basis of the proposed lightly loaded single storey structure, reinforced strip foundations are considered suitable as a foundation option on this site. Due to the heterogeneity of the engineered fill material recourse may be given to the adoption of piled foundations to underlying bedrock if much greater loads are proposed.

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

The stated ground floor load for ground bearing floor slabs has not been provided. The sub-grade soil conditions beneath the footprint of the proposed buildings comprise reworked fill material. Ground bearing floor slabs are deemed to be appropriate, and a California bearing ratio (CBR) of 3% is recommended for design purposes. Careful examination and rolling of the formation, and replacement of exceptionally hard and soft material with well compacted, suitable granular fill will be necessary.

A Design Sulphate Class of DS-4 is recommended with an Aggressive Chemical Environment for Concrete classification of AC-3s.

10.3.2 Recommendations

If a piled foundation design is required then a deeper intrusive investigation is recommended in order to confirm ground conditions to a minimum depth of 5m below final proposed pile depth.

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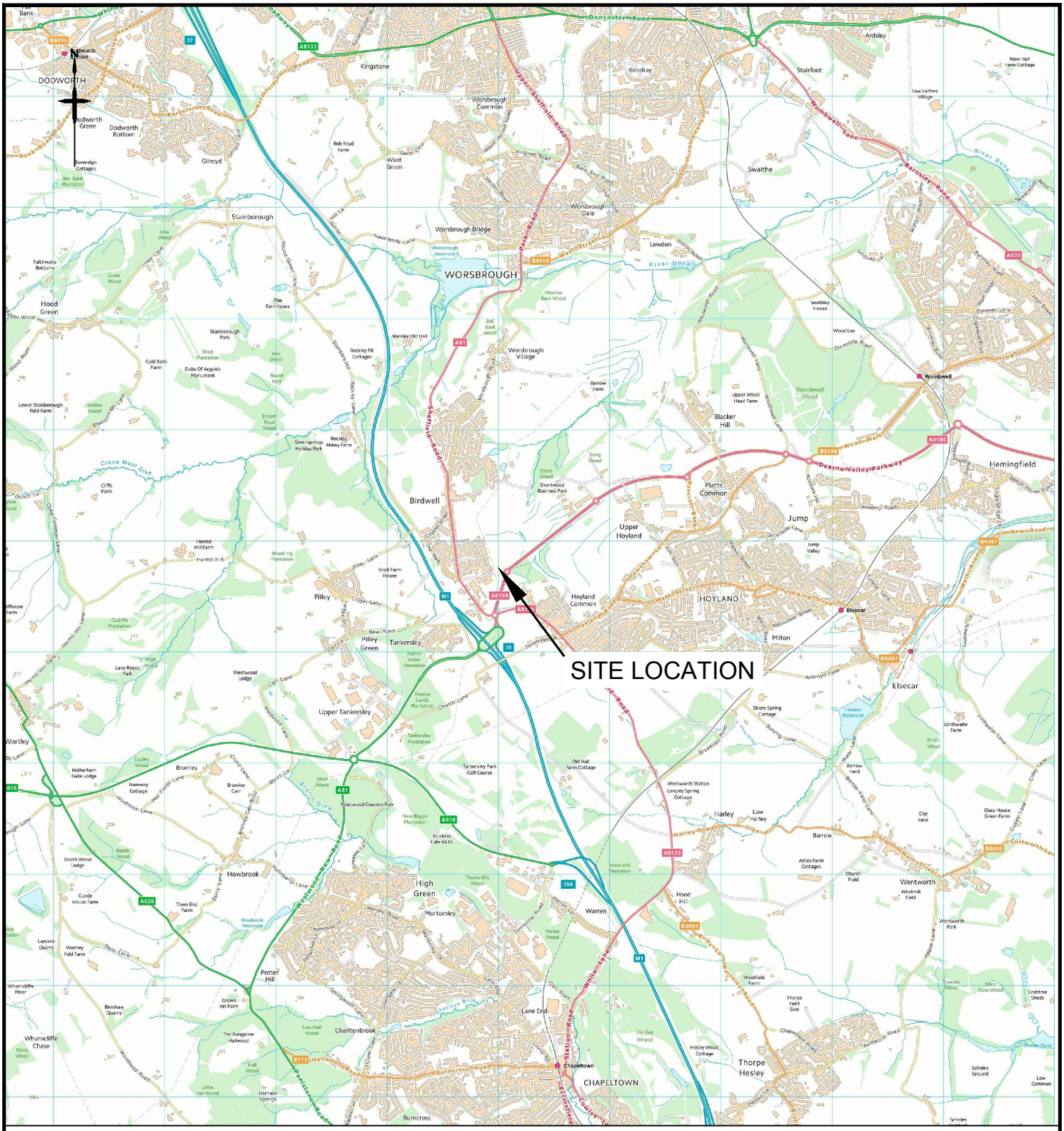
FIGURES



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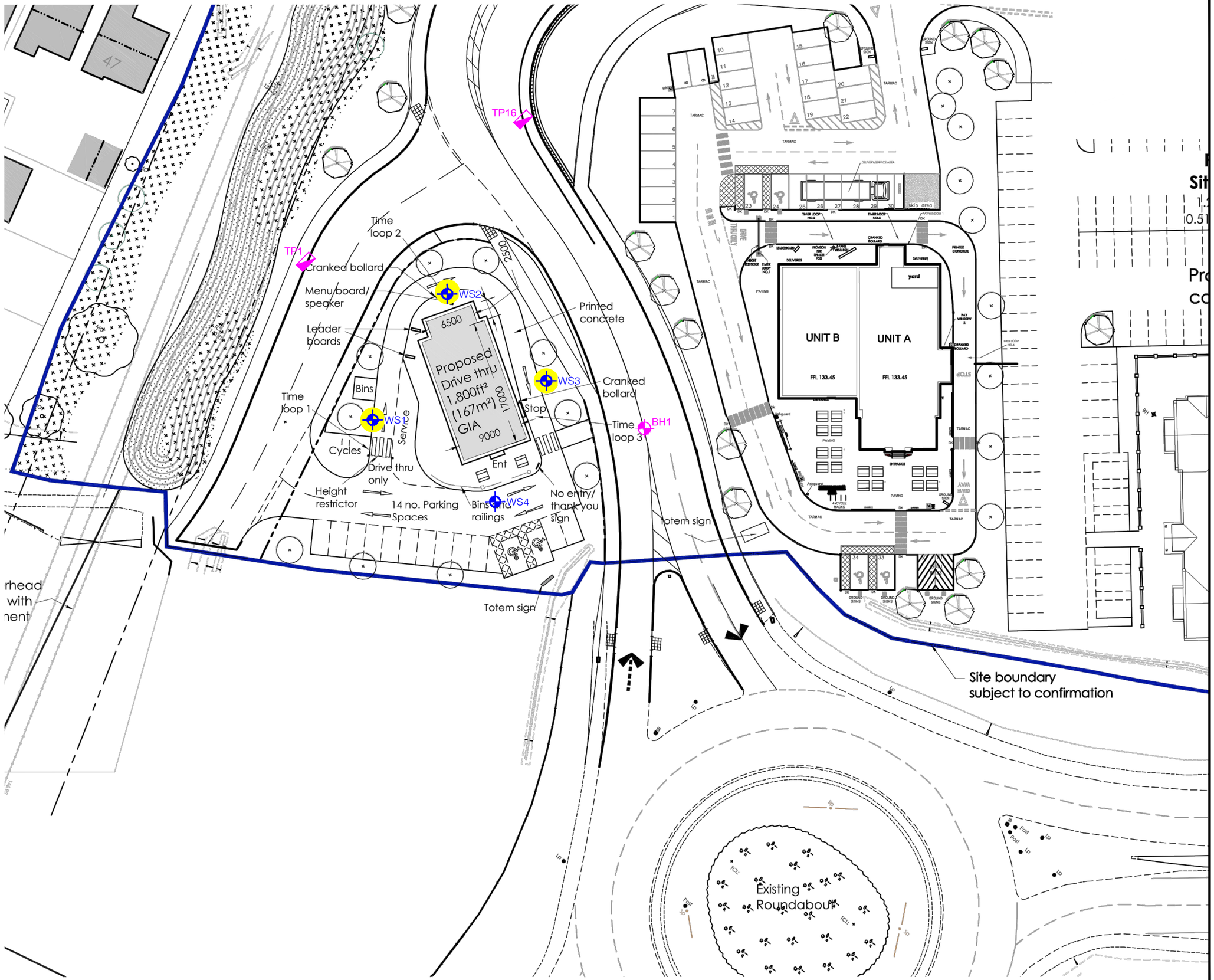
Client	CHICKEN VILLAS LIMITED
Project Title	ROCKINGHAM 1, PLOT 9
Drawing Title	SITE LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date	Project No.	Drawing File
AP	06.04.17	CS	06.04.17	CS	06.04.17	322338	322338-R01(00)D001A

Scale	Orig Size	Dimensions	Drawing No.	Rev.
1:50000	A4	—	FIGURE 1	A



LEGEND:

- RSK window sample location (2017)
- Gas and groundwater monitoring well installed
- RSK exploratory holes (2013)

Notes

Base plan from The Harris Partnership, Drawing No. 11462-042, Revision B, Dated 19.07.16

REV.	DATE	DESCRIPTION	BY	CHD.	APR.
A	06.04.17	FIRST ISSUE	AP	CS	CS

Dimensions	Projection	Scale	Orig Size
m		1:500	A3

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CLIENT: CHICKEN VILLAS LIMITED

PROJECT: ROCKINGHAM 1, PLOT 9

TITLE: EXPLORATORY HOLE LOCATION PLAN

JOB No.:	DRAWING FILE:
322338	322338-R01(00)D002A

BY:	DATE:	CONTRACT NO.		REV:
AP	06.04.17		FIGURE 2	A

Scale 1 : 500

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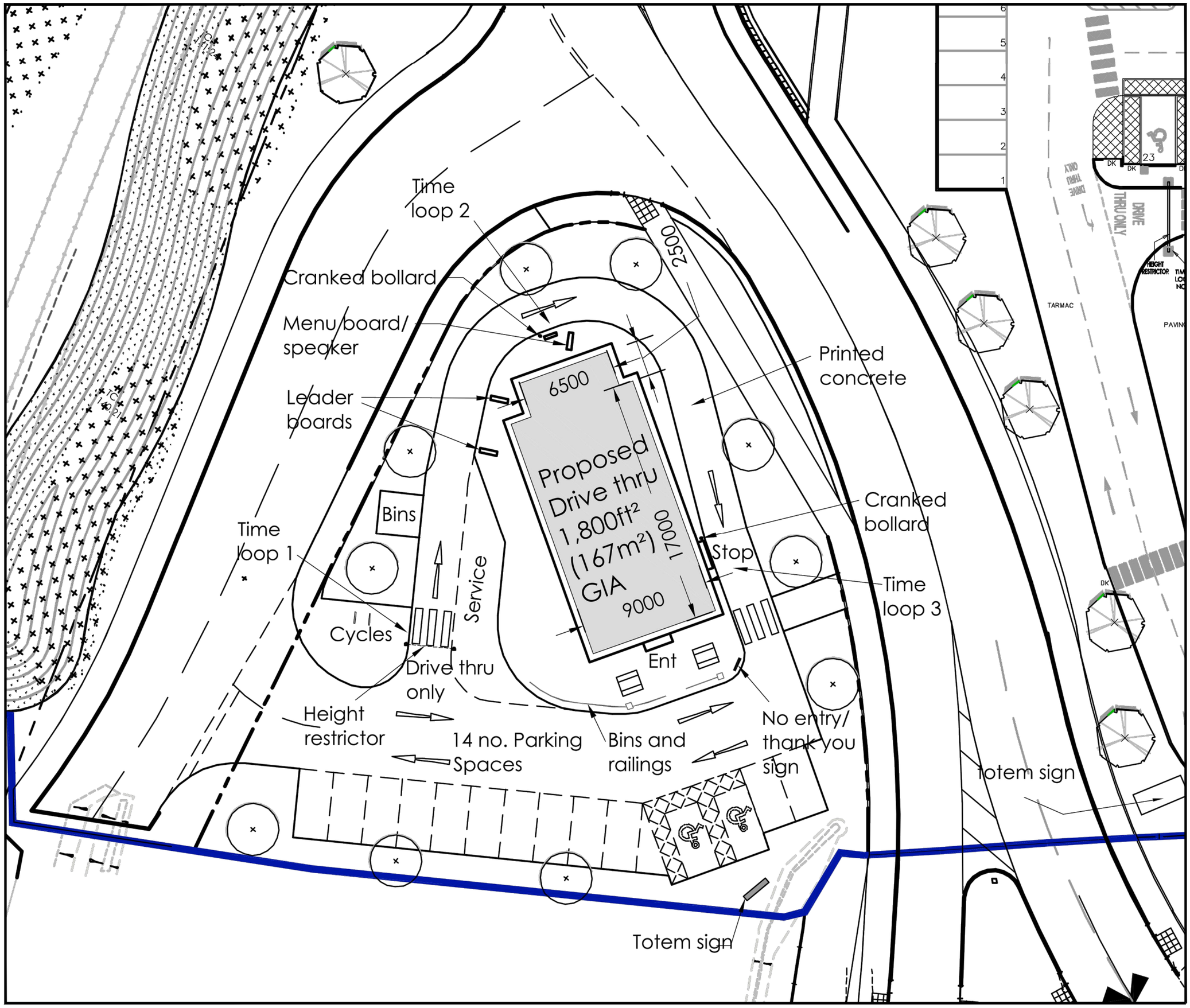

LEGEND:

N

Notes

Base plan from The Harris Partnership, Drawing No. 11462-042, Revision B, Dated 19.07.16

REV.	DATE	DESCRIPTION	BY	CHD.	APR.
A	06.04.17	FIRST ISSUE	AP	CS	CS

Dimensions	Projection	Scale	Orig Size
m		1:250	A3

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CLIENT
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PROJECT
ROCKINGHAM 1, PLOT 9

TITLE
PROPOSED DEVELOPMENT PLAN

JOB No.:	DRAWING FILE:
322338	322338-R01(00)D003A

BY:	DATE:	CONTRACT NO.		REV:
AP	06.04.17		FIGURE 3	A

Scale 1:250

0 2.5 5 7.5 10 12.5m

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Chicken Villas Limited (the "client") in accordance with the terms of a contract between RSK and the "client", dated 21 February 2017. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990 (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA of the EPA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2010 provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2010 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use.

PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF).

The new framework has only limited guidance on contaminated land, as follows:

- *"planning policies and decisions should also ensure that:*
    - *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
    - *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
    - *adequate site investigation information, prepared by a competent person, is presented".*

APPENDIX C
RISK ASSESSMENT METHODOLOGY

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: preliminary, generic quantitative and detailed quantitative. An outline conceptual model should be formed at the preliminary risk assessment stage that collates all the existing information pertaining to a site in text, tabular or diagrammatic form. The outline conceptual model identifies potentially complete (termed possible) pollutant linkages (contaminant–pathway–receptor) and is used as the basis for the design of the site investigation. The outline conceptual model is updated as further information becomes available, for example as a result of the site investigation.

Production of a conceptual model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk. RSK has adopted guidance provided in CIRIA C552 for use in the production of conceptual models.

The likelihood of an event can be classified on a four-point system using the following terms and definitions based on CIRIA C552:

- highly likely: the event appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution
- likely: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term
- low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term
- unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- severe: short term (acute) risk to human health likely to result in ‘significant harm’ as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in ‘Draft Circular on Contaminated Land’, DETR 2000)
- medium: chronic damage to human health (‘significant harm’ as defined in ‘Draft Circular on Contaminated Land’, DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem

- mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment
- minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the probability of an event occurring and its consequences have been classified, a risk category can be assigned according to the table below.

		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

Definitions of these risk categories are as follows together with an assessment of the further work that may be required:

- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability; urgent investigation and remediation are likely to be required.
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required. Remedial works may be necessary in the short term and are likely over the long term.
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term.
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild.
- Very low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.

APPENDIX D
EXPLORATORY HOLE RECORDS

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
Rockingham 1 Plot 9	Chicken Villas Ltd	WS1

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
322338	06.03.17	—	—	1 of 1
	End: 06.03.17			

Progress	Samples / Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
							MADE GROUND: Dark brown slightly gravelly locally clayey SAND. Sand is fine to coarse. Gravel is fine to coarse brick, concrete and of mixed lithologies	0.25	
	0.20	5	ES				MADE GROUND: Very stiff light grey sandy slightly gravelly friable CLAY. Gravel is angular to subangular fine to coarse Mudstone. (Reworked Clay)	(0.75)	
	0.30-1.00	7	B						
	0.40	6	ES					1.00	
	1.10	8	ES				MADE GROUND: Very stiff grey mottled orange gravelly silty friable CLAY. Gravel is fine to coarse angular to subangular Mudstone. (Reworked clay)		
	1.20-1.65	1	SPT	N=26					
	1.20-2.70	9	B						
								(1.90)	
	2.00-2.45	2	SPT	N=17					
							. . . @2.5m Becoming gravelly to very gravelly		
	2.70-3.15	3	SPT	N=38			. . . @2.7m Recovered as a Sand	2.90	
	2.90-3.00	10	D				Very stiff yellowish grey slightly silty CLAY. (Weathered bedrock).		
	3.00-3.20	4	SPT	N:50 for 100mm				(0.40)	
								3.30	

Drilling Progress and Water Observations

Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Inspection pit dug to 1.2m bgl
2. Borehole remained stable
3. No groundwater encountered
4. Standpipe installed 0.5 m plain, 2.5 m slotted

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window	Archway Competitor 130	Earth Engineering	CSutherst	JC

AGS

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
Rockingham 1 Plot 9	Chicken Villas Ltd	WS2

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
322338	06.03.17	—	---	1 of 1
	End: 06.03.17			

Progress	Samples / Tests				Water	Backfill & Instru-mentation	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
	0.10	4	ES				MADE GROUND: Dark brown slightly gravelly slightly clayey SAND. Sand is fine to coarse. Gravel is fine to coarse angular to subrounded br4ick, concrete and mixed lithologies	0.25	
	0.60	5	ES				MADE GROUND: Very stiff light grey slightly gravelly silty friable CLAY. Gravel is fine to coarse angular to subangular Mudstone (Reworked clay) . . . @0.6m Localised orange mottling and becoming gravelly. Gravel is fine to coarse subangular to subrounded mudstone . . . @1.00m to 1.80m Grey mottled dark grey in colour	(2.88)	
	1.20-1.65	1	SPT	N=12					
	1.40	6	ES						
	1.50-3.00	7	B						
	2.00-2.45	2	SPT	N=30					
	3.00-3.13	3	SPT	>50				3.13	

Drilling Progress and Water Observations

Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Inspection pit dug to 1.2m bgl
2. Borehole remained stable
3. Perched groundwater encountered at 2.0 m bgl
4. Standpipe installed 0.5 m plain, 2.5 m slotted

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window	Archway Competitor 130	Earth Engineering	CSutherst	JC

AGS

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
Rockingham 1 Plot 9	Chicken Villas Ltd	WS3

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
322338	06.03.17	---	---	1 of 1
	End: 06.03.17			

Progress	Samples / Tests				Water	Backfill & Instru-mentation	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
							MADE GROUND: Dark brown and grey gravelly SAND. Sand is fine to coarse. Gravel is fine to cobble sized angular to subrounded brick, concrete mudstone and mixed lithologies.	(0.34)	
	0.20	4	ES					0.34	
	0.40	5	ES				MADE GROUND: Very stiff light grey gravelly silty friable CLAY. Gravel is angular to subangular fine to coarse Mudstone. (Reworked clay)		
	1.20-1.65	1	SPT	>50					
								(2.70)	
	1.80	6	ES				. . . @1.80m Black staining identified		
	1.80-3.00	7	B						
	2.00-2.45	2	SPT	N=29					
							. . . @2.2m Mudstone gravel band ~0.07m thick		
							. . . @2.6m Becoming light grey in colour		
	2.70-3.04	3	SPT	N:50 for 185mm					
								3.04	

Drilling Progress and Water Observations					
Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Inspection pit dug to 1.2m bgl
2. Borehole remained stable
3. Groundwater was not encountered
4. Standpipe installed 0.5 m plain, 2.5 m slotted

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window	Archway Competitor 130	Earth Engineering	CSutherst	JC

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
Rockingham 1 Plot 9	Chicken Villas Ltd	WS4

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
322338	06.03.17	---	---	1 of 1
	End: 06.03.17			

Progress	Samples / Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
	0.20	1	ES				MADE GROUND: Brown gravelly slightly clayey SAND. Sand is fine to coarse. Gravel is fine to cobble sized angular to subrounded brick, concrete and mixed lithologies	0.25	
	0.40	2	ES				MADE GROUND: Stiff dark grey gravelly silty friable CLAY. Gravel is fine to coarse angular mudstone and slate (Reworked clay)	(0.35) 0.60	
	1.00	3	ES				MADE GROUND: Very stiff grey mottled orange slightly gravelly silty CLAY. Gravel is fine to coarse angular to subrounded Mudstone		
	1.20-1.65	1	SPT	N=20			. . . @1.2m Becoming light grey in colour		
	1.50	4	D						
	1.60-3.20	5	B					(2.63)	
	2.00-2.45	2	SPT	N=23			. . . @1.9m Becoming gravelly. Gravel is fine to coarse angular to subangular Mudstone		
	2.80-3.23	3	SPT	N:50 for 280mm				3.23	

Drilling Progress and Water Observations

Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Inspection pit dug to 1.2m bgl
2. Borehole remained stable
3. No groundwater encountered
4. Borehole backfilled with arisings

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window	Archway Competitor 130	Earth Engineering	CSutherst	JC

APPENDIX E
GROUND GAS AND GROUNDWATER MONITORING DATA

IN-SITU GAS MONITORING RESULTS

[Pressures]	Previous	During	Start	End	Equipment Used & Remarks
Round G1	-	-	-	-	GA5000 + Weather: Overcast + Ground: Dry + Wind: Medium + Air Temp: 12DegC
Round G2	-	-	-	-	
Round G3	-	-	-	-	

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS1	1	50	G1	3.00	2.92	#REF! to #REF!	13/03/2017 14:15:00	1011	1011	$0.0_{(I)}$	2.86	0.2	0.1	21.1	0.0	0.0	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	15 secs	1011	1011	$0.0_{(SS)}$	2.86	0.2	0.1	21.1	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	30 secs	1011	1011	-	2.86	0.2	0.1	21.1	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	60 secs	1011	1011	-	2.86	0.3	0.1	21.2	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	90 secs	1011	1011	-	2.86	0.3	0.1	21.0	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	120 secs	1011	1011	-	2.86	0.3	0.0	21.0	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	180 secs	1011	1011	-	2.86	0.3	0.0	21.0	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	240 secs	1011	1011	-	2.86	0.3	0.0	21.0	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	300 secs	1011	1011	-	2.86	0.3	0.0	21.0	0.0	-	0.0	0.0
WS1	1	50	G1		2.92	#REF! to #REF!	360 secs	1011	1011	-	2.86	0.3	0.0	21.0	0.0	-	0.0	0.0
WS1	1	50	G2	3.00	2.93	#REF! to #REF!	20/03/2017 14:00:00	981	981	$0.0_{(SS)}$	2.53	0.9	0.0	20.2	-	0.0	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	15 secs	981	981	-	2.53	0.9	0.1	20.1	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	30 secs	981	981	-	2.53	0.8	0.1	19.9	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	60 secs	981	981	-	2.53	0.7	0.1	19.9	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	90 secs	981	981	-	2.53	0.8	0.1	19.9	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	120 secs	981	981	-	2.53	0.8	0.1	19.8	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	180 secs	981	981	-	2.53	0.9	0.1	19.6	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	240 secs	981	981	-	2.53	0.9	0.1	19.5	-	-	0.0	0.0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
Spring Lodge
172 Chester Road
Helsby, Cheshire
WA6 0AR

Compiled By	Date	Checked By	Date
	18/04/17		

Contract Ref: **322338**

Contract: **Rockingham 1 Plot 9**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS1	1	50	G2		2.93	#REF! to #REF!	300 secs	981	981	-	2.53	1.0	0.1	19.3	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	360 secs	981	981	-	2.53	1.1	0.1	19.2	-	-	0.0	0.0
WS1	1	50	G2		2.93	#REF! to #REF!	420 secs	981	981	-	2.53	1.1	0.1	19.2	-	-	0.0	0.0
WS1	1	50	G3	3.00	2.92	#REF! to #REF!	27/03/2017 14:00:00	981	981	$-0.1_{(I)}$	2.56	0.1	0.1	20.7	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	15 secs	1005	1005	$0.0_{(SS)}$	2.56	2.0	0.1	20.5	-	0.0	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	30 secs	1005	1005	-	2.56	0.7	0.1	19.6	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	60 secs	1005	1005	-	2.56	0.4	0.1	20.5	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	90 secs	1005	1005	-	2.56	0.3	0.0	20.6	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	120 secs	1005	1005	-	2.56	0.3	0.0	20.7	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	180 secs	1005	1005	-	2.56	0.2	0.0	20.7	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	240 secs	1005	1005	-	2.56	0.2	0.0	20.7	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	300 secs	1005	1005	-	2.56	0.2	0.0	20.7	-	-	0.0	0.0
WS1	1	50	G3		2.92	#REF! to #REF!	360 secs	1005	1005	-	2.56	0.2	0.0	20.7	-	-	0.0	0.0
WS2	1	50	G1	3.00	2.82	#REF! to #REF!	13/03/2017 14:30:00	1012	1012	$-0.2_{(I)}$	1.10	5.9	0.2	17.3	-	0.0	2.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	15 secs	1012	1012	$0.0_{(SS)}$	1.10	5.9	0.2	12.4	-	-	2.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	30 secs	1012	1012	-	1.10	5.9	0.2	9.8	-	-	3.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	60 secs	1012	1012	-	1.10	6.4	0.2	8.2	-	-	3.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	90 secs	1012	1012	-	1.10	7.7	0.2	5.6	-	-	4.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	120 secs	1012	1012	-	1.10	8.9	0.2	2.8	-	-	4.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	180 secs	1012	1012	-	1.10	9.4	0.3	1.9	-	-	4.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	240 secs	1012	1012	-	1.10	9.5	0.2	1.8	-	-	3.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	300 secs	1012	1012	-	1.10	10.1	0.2	1.7	-	-	3.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	360 secs	1012	1012	-	1.10	11.2	0.2	1.6	-	-	2.0	0.0
WS2	1	50	G1		2.82	#REF! to #REF!	420 secs	1012	1012	-	1.10	11.5	0.2	1.5	-	-	2.0	0.0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
Spring Lodge
172 Chester Road
Helsby, Cheshire
WA6 0AR

Compiled By	Date	Checked By	Date	Contract Ref:
	18/04/17			**322338**

Contract: **Rockingham 1 Plot 9**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS2	1	50	G1		2.82	#REF! to #REF!	500 secs	1012	1012	-	1.10	11.9	0.2	1.5	-	-	2.0	0.0
WS2	1	50	G2	3.00	2.82	#REF! to #REF!	20/03/2017 14:00:00	983	983	$-0.1_{(I)}$	1.40	0.1	0.0	20.9	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	15 secs	983	983	$0.0_{(SS)}$	1.40	0.1	0.0	20.9	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	30 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	60 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	90 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	120 secs	983	983	-	1.40	0.1	0.0	20.7	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	180 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	240 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	300 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	360 secs	983	983	-	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G2		2.82	#REF! to #REF!	420 secs	983	983	$0.1_{(I)}$	1.40	0.1	0.0	20.8	-	-	0.0	0.0
WS2	1	50	G3	3.00	2.80	#REF! to #REF!	27/03/2017 14:00:00	1007	1007	$0.2_{(SS)}$	1.14	0.1	0.0	20.7	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	15 secs	1007	1007	-	1.14	3.4	0.0	19.5	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	30 secs	1007	1007	-	1.14	2.7	0.0	17.1	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	60 secs	1007	1007	-	1.14	2.3	0.0	17.4	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	90 secs	1007	1007	-	1.14	2.2	0.0	17.7	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	120 secs	1007	1007	-	1.14	2.2	0.0	17.7	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	180 secs	1007	1007	-	1.14	2.2	0.0	17.7	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	240 secs	1007	1007	-	1.14	2.1	0.0	17.7	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	300 secs	1007	1007	-	1.14	2.3	0.0	17.5	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	360 secs	1007	1007	-	1.14	2.4	0.0	17.3	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	420 secs	1007	1007	-	1.14	2.6	0.0	17.0	-	-	0.0	0.0
WS2	1	50	G3		2.80	#REF! to #REF!	480 secs	1007	1007	-	1.14	2.6	0.0	17.0	-	-	0.0	0.0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
Spring Lodge
172 Chester Road
Helsby, Cheshire
WA6 0AR

Compiled By	Date	Checked By	Date
	18/04/17		

Contract Ref: **322338**

Contract: **Rockingham 1 Plot 9**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS3	1	50	G1	3.00	2.88	#REF! to #REF!	13/03/2017 15:00:00	1014	1013	$0.0_{(I)}$	2.44	0.2	0.0	20.6	-	-	0.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	15 secs	1014	1013	0.1	2.44	3.3	0.0	16.7	-	-	7.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	30 secs	1014	1013	-	2.44	3.2	0.0	12.9	-	-	9.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	60 secs	1014	1013	-	2.44	2.5	0.0	14.6	-	-	7.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	90 secs	1014	1013	-	2.44	2.1	0.0	15.7	-	-	6.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	120 secs	1014	1013	-	2.44	1.8	0.0	16.5	-	-	5.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	180 secs	1014	1013	-	2.44	1.5	0.0	17.4	-	-	4.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	240 secs	1014	1013	-	2.44	1.4	0.0	17.4	-	-	4.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	300 secs	1014	1013	-	2.44	1.3	0.0	17.4	-	-	3.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	360 secs	1014	1013	-	2.44	1.3	0.0	17.4	-	-	3.0	0.0
WS3	1	50	G1		2.88	#REF! to #REF!	420 secs	1014	1013	-	2.44	1.3	0.0	17.4	-	-	3.0	0.0
WS3	1	50	G2	3.00	2.85	#REF! to #REF!	20/03/2017 14:00:00	1014	1013	$-0.1_{(I)}$	2.09	0.1	0.0	21.0	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	15 secs	1014	1013	$-0.1_{(SS)}$	2.09	6.0	0.0	18.0	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	30 secs	1014	1013	-	2.09	4.8	0.0	9.7	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	60 secs	1014	1013	-	2.09	3.4	0.0	13.1	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	90 secs	1014	1013	-	2.09	2.6	0.0	15.1	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	120 secs	1014	1013	-	2.09	2.3	0.0	16.0	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	180 secs	1014	1013	-	2.09	2.1	0.0	16.7	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	240 secs	1014	1013	-	2.09	2.2	0.0	16.6	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	300 secs	1014	1013	-	2.09	2.1	0.0	16.9	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	420 secs	1014	1013	-	2.09	2.2	0.0	16.8	-	-	0.0	0.0
WS3	1	50	G2		2.85	#REF! to #REF!	480 secs	1014	1013	-	2.09	2.2	0.0	16.8	-	-	0.0	0.0
WS3	1	50	G3	3.00	2.72	#REF! to #REF!	27/03/2017 14:00:00	1008	1008	$0.1_{(I)}$	1.55	0.1	0.0	20.5	-	0.0	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	15 secs	1008	1008	$0.2_{(SS)}$	1.55	7.2	0.0	15.9	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	30 secs	1008	1008	-	1.55	5.8	0.0	9.6	-	-	0.0	0.0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Compiled By	Date	Checked By	Date	Contract Ref:
	18/04/17			**322338**

Contract: **Rockingham 1 Plot 9**

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	LEL (%)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS3	1	50	G3		2.72	#REF! to #REF!	60 secs	1008	1008	-	1.55	4.5	0.0	11.6	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	90 secs	1008	1008	-	1.55	4.1	0.0	12.7	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	120 secs	1008	1008	-	1.55	3.9	0.0	13.2	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	180 secs	1008	1008	-	1.55	3.6	0.0	13.6	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	240 secs	1008	1008	-	1.55	3.5	0.0	13.8	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	300 secs	1008	1008	-	1.55	3.5	0.0	13.9	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	360 secs	1008	1008	-	1.55	3.5	0.0	14.0	-	-	0.0	0.0
WS3	1	50	G3		2.72	#REF! to #REF!	420 secs	1008	1008	-	1.55	3.5	0.0	14.0	-	-	0.0	0.0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
Spring Lodge
172 Chester Road
Helsby, Cheshire
WA6 0AR

Compiled By	Date	Checked By	Date	Contract Ref:
	18/04/17			322338

Contract: **Rockingham 1 Plot 9**

APPENDIX F
LABORATORY CERTIFICATES FOR SOIL ANALYSIS

envirolab
Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 17/01730
Issue Number: 1 **Date:** 23 March, 2017

Client:
RSK Environment Helsby
Spring Lodge
172 Chester Road
Helsby
Cheshire
UK
WA6 0AR

Project Manager: Charlie Sutherst/Jon Clayton
Project Name: Rockingham 1 Plot 9
Project Ref: 322338
Order No: N/A
Date Samples Received: 07/03/17
Date Instructions Received: 09/03/17
Date Analysis Completed: 23/03/17

Prepared by:
Melanie Marshall
Laboratory Coordinator

Approved by:
Iain Haslock
Analytical Consultant

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME
UKAS TESTING 1247

Envirolab Job Number: 17/01730

Client Project Name: Rockingham 1 Plot 9

Client Project Ref: 322338

Lab Sample ID	17/01730/1	17/01730/2	17/01730/3	17/01730/5	17/01730/8	17/01730/9	17/01730/10	17/01730/14	Units	Method ref
Client Sample No										
Client Sample ID	WS1	WS1	WS1	WS2	WS3	WS3	WS3	WS4		
Depth to Top	0.20	0.40	1.00	0.10	0.20	0.40	1.80	1.00		
Depth To Bottom										
Date Sampled	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	4A	6A	6A	4A	4A	7	6A	6A		
% Stones >10mm$_A^{\#}$	18.1	10.9	2.5	33.6	-	34.2	4.7	14.0	% w/w	A-T-044
pH$_D^{M\#}$	9.33	-	-	9.68	-	8.47	-	-	pH	A-T-031s
pH BRE$_D^{M\#}$	-	-	8.26	-	-	-	7.65	-	pH	A-T-031s
Sulphate (water sol 2:1)$_D^{M\#}$	0.07	-	-	0.09	-	0.28	-	-	g/l	A-T-026s
Sulphate BRE (water sol 2:1)$_D^{M\#}$	-	-	<10	-	-	-	229	-	mg/l	A-T-026s
Sulphate (acid soluble)$_D^{M\#}$	1100	-	-	1000	-	670	-	-	mg/kg	A-T-028s
Sulphate BRE (acid sol)$_D^{M\#}$	-	-	0.07	-	-	-	0.06	-	% w/w	A-T-028s
Sulphur BRE (total)$_D$	-	-	0.07	-	-	-	0.44	-	% w/w	A-T-024s
Total Organic Carbon$_D^{M\#}$	3.51	-	-	2.99	-	0.54	-	-	% w/w	A-T-032s
Arsenic$_D^{M\#}$	8	6	-	2	-	4	-	3	mg/kg	A-T-024s
Cadmium$_D^{M\#}$	1.3	1.2	-	0.9	-	1.1	-	2.2	mg/kg	A-T-024s
Copper$_D^{M\#}$	48	28	-	42	-	15	-	21	mg/kg	A-T-024s
Chromium$_D^{M\#}$	34	24	-	37	-	21	-	13	mg/kg	A-T-024s
Lead$_D^{M\#}$	86	25	-	43	-	12	-	18	mg/kg	A-T-024s
Mercury$_D$	0.67	<0.17	-	0.41	-	<0.17	-	<0.17	mg/kg	A-T-024s
Nickel$_D^{M\#}$	17	26	-	20	-	27	-	40	mg/kg	A-T-024s
Selenium$_D$	<1	<1	-	<1	-	<1	-	2	mg/kg	A-T-024s
Zinc$_D^{M\#}$	72	61	-	58	-	62	-	78	mg/kg	A-T-024s

Envirolab Job Number: 17/01730

Client Project Name: Rockingham 1 Plot 9

Client Project Ref: 322338

Lab Sample ID	17/01730/1	17/01730/2	17/01730/3	17/01730/5	17/01730/8	17/01730/9	17/01730/10	17/01730/14	Units	Method ref
Client Sample No										
Client Sample ID	WS1	WS1	WS1	WS2	WS3	WS3	WS3	WS4		
Depth to Top	0.20	0.40	1.00	0.10	0.20	0.40	1.80	1.00		
Depth To Bottom										
Date Sampled	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	4A	6A	6A	4A	4A	7	6A	6A		
Asbestos in Soil (inc. matrix)										
Asbestos in soil$_A^{\#}$	NAD	-	-	NAD	NAD	NAD	-	-		A-T-045
Asbestos ACM - Suitable for Water Absorption Test?	N/A	-	-	N/A	N/A	N/A	-	-		

Envirolab Job Number: 17/01730

Client Project Name: Rockingham 1 Plot 9

Client Project Ref: 322338

Lab Sample ID	17/01730/1	17/01730/2	17/01730/3	17/01730/5	17/01730/8	17/01730/9	17/01730/10	17/01730/14	Units	Method ref
Client Sample No										
Client Sample ID	WS1	WS1	WS1	WS2	WS3	WS3	WS3	WS4		
Depth to Top	0.20	0.40	1.00	0.10	0.20	0.40	1.80	1.00		
Depth To Bottom										
Date Sampled	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	4A	6A	6A	4A	4A	7	6A	6A		
PAH 16										
Acenaphthene$_A^{M\#}$	8.20	-	-	1.56	-	0.61	-	-	mg/kg	A-T-019s
Acenaphthylene$_A^{M\#}$	0.30	-	-	0.15	-	0.02	-	-	mg/kg	A-T-019s
Anthracene$_A^{M\#}$	11.1	-	-	2.66	-	0.90	-	-	mg/kg	A-T-019s
Benzo(a)anthracene$_A^{M\#}$	16.5	-	-	7.02	-	1.45	-	-	mg/kg	A-T-019s
Benzo(a)pyrene$_A^{M\#}$	14.7	-	-	8.30	-	1.21	-	-	mg/kg	A-T-019s
Benzo(b)fluoranthene$_A^{M\#}$	15.8	-	-	8.96	-	1.41	-	-	mg/kg	A-T-019s
Benzo(ghi)perylene$_A^{M\#}$	7.48	-	-	4.11	-	0.47	-	-	mg/kg	A-T-019s
Benzo(k)fluoranthene$_A^{M\#}$	7.02	-	-	3.33	-	0.52	-	-	mg/kg	A-T-019s
Chrysene$_A^{M\#}$	18.2	-	-	7.17	-	1.36	-	-	mg/kg	A-T-019s
Dibenzo(ah)anthracene$_A^{M\#}$	1.61	-	-	0.78	-	0.13	-	-	mg/kg	A-T-019s
Fluoranthene$_A^{M\#}$	33.8	-	-	14.7	-	3.85	-	-	mg/kg	A-T-019s
Fluorene$_A^{M\#}$	7.56	-	-	1.22	-	0.47	-	-	mg/kg	A-T-019s
Indeno(123-cd)pyrene$_A^{M\#}$	8.38	-	-	4.56	-	0.57	-	-	mg/kg	A-T-019s
Naphthalene$_A^{M\#}$	11.5	-	-	1.22	-	0.35	-	-	mg/kg	A-T-019s
Phenanthrene$_A^{M\#}$	40.9	-	-	9.25	-	3.55	-	-	mg/kg	A-T-019s
Pyrene$_A^{M\#}$	30.2	-	-	14	-	3.24	-	-	mg/kg	A-T-019s
PAH (total 16)$_A^{M\#}$	233	-	-	88.9	-	20.1	-	-	mg/kg	A-T-019s

Envirolab Job Number: 17/01730

Client Project Name: Rockingham 1 Plot 9

Client Project Ref: 322338

Lab Sample ID	17/01730/1	17/01730/2	17/01730/3	17/01730/5	17/01730/8	17/01730/9	17/01730/10	17/01730/14	Units	Method ref
Client Sample No										
Client Sample ID	WS1	WS1	WS1	WS2	WS3	WS3	WS3	WS4		
Depth to Top	0.20	0.40	1.00	0.10	0.20	0.40	1.80	1.00		
Depth To Bottom										
Date Sampled	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17	06-Mar-17		
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil		
Sample Matrix Code	4A	6A	6A	4A	4A	7	6A	6A		
TPH CWG										
Ali >C5-C6$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Ali >C6-C8$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Ali >C8-C10$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Ali >C10-C12$_A^{\#}$	1.1	-	-	0.6	-	1.8	-	-	mg/kg	A-T-023s
Ali >C12-C16$_A^{\#}$	9.1	-	-	8.5	-	2.5	-	-	mg/kg	A-T-023s
Ali >C16-C21$_A^{\#}$	27.4	-	-	31.6	-	6.0	-	-	mg/kg	A-T-023s
Ali >C21-C35$_A^{\#}$	114	-	-	254	-	111	-	-	mg/kg	A-T-023s
Total Aliphatics$_A$	152	-	-	295	-	121	-	-	mg/kg	A-T-023s
Aro >C5-C7$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Aro >C7-C8$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Aro >C8-C9$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Aro >C9-C10$_A^{\#}$	0.04	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
Aro >C10-C12$_A^{\#}$	46.6	-	-	2.3	-	1.8	-	-	mg/kg	A-T-023s
Aro >C12-C16$_A^{\#}$	154	-	-	17.5	-	3.0	-	-	mg/kg	A-T-023s
Aro >C16-C21$_A^{\#}$	331	-	-	111	-	10.8	-	-	mg/kg	A-T-023s
Aro >C21-C35$_A^{\#}$	476	-	-	358	-	114	-	-	mg/kg	A-T-023s
Total Aromatics$_A$	1010	-	-	488	-	129	-	-	mg/kg	A-T-023s
TPH (Ali & Aro)$_A$	1160	-	-	783	-	250	-	-	mg/kg	A-T-023s
BTEX - Benzene$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
BTEX - Toluene$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
BTEX - Ethyl Benzene$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
BTEX - m & p Xylene$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
BTEX - o Xylene$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s
MTBE$_A^{\#}$	<0.01	-	-	<0.01	-	<0.01	-	-	mg/kg	A-T-022s

REPORT NOTES

General:
This report shall not be reproduced, except in full, without written approval from Envirolab.
All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and interpretations expressed are outside the scope of our accreditation.
If results are in italic font they are associated with an AQC failure. These are not accredited and are unreliable.
A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:
All results are reported as dry weight (<40°C).
For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.
For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any “A” subscripts
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:
Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Asbestos:
Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis.
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

Predominant Matrix Codes:
1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.
Secondary Matrix Codes:
A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal, E = contains roots/twigs.

Key:
IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.

APPENDIX G HUMAN HEALTH GENERIC ASSESSMENT CRITERIA FOR COMMERCIAL END USE

Generic assessment criteria for human health: commercial scenario

Background

RSK's generic assessment criteria (GAC) were initially prepared following the publication by the Environment Agency (EA) of soil guideline value (SGV) and toxicological (TOX) reports, and associated publications in 2009[1]. RSK GAC were updated following the publication of GAC by LQM/CIEH in 2009[2]. RSK GAC are periodically revised when updated information on toxicological, land use or receptor parameters is published.

Updates to the RSK GAC

In 2014, the publication of Category 4 Screening Levels (C4SL)[3,4], as part of the Defra-funded research project SP1010, included modifications to certain exposure assumptions documented within EA Science Report SC050221/SR3 (herein after referred to as SR3)[5] used in the generation of SGVs.

C4SL were published for six substances (cadmium, arsenic, benzene, benzo(a)pyrene, chromium VI and lead) for a sandy loam soil type with 6% soil organic matter, based on a low level of toxicological concern (LLTC; see Section 2.3 of research project report SP1010[3]). Where a C4SL has been published, the RSK GAC duplicates the C4SL published values using all input parameters within the SP1010 final project report[3] and associated appendices[6], and adopts them as GAC for these six substances.

For all other substances the only C4SL exposure modification relevant to a commercial end use are daily inhalation rates.

The RSK GAC have also been revised with updated toxicology published by LQM/CIEH in 2015[7] or by the USEPA[14], where a C4SL has not been published.

RSK GAC derivation for metals and organic compounds

Model selection

Soil assessment criteria (SAC) were calculated using the Contaminated Land Exposure Assessment (CLEA) tool v1.071, supporting EA guidance[5,8,9] and revised exposure scenarios published for the C4SL[3]. Groundwater assessment criteria (GrAC) protective of human health via the inhalation pathway were derived using the RBCA 2.51 model with the Johnson and Ettinger model for soil and groundwater volatilisation. RSK has updated the inputs within RBCA to reflect EA guidance[1,5,8,9]. The SAC and GrAC collectively are termed GAC.

Pathway selection

In accordance with SR3[5] the commercial scenario considers risks to a female worker who works from the age of 16 to 65 years. It should be noted that this end use is not suitable for a workplace nursery but may be appropriate for a sports centre or shopping centre where children are present. In accordance with Box 3.5, SR3[5] the pathways considered for production of the SAC in the commercial scenario are

- direct soil and dust ingestion
- dermal contact with soil both indoors and outdoors

- indoor air inhalation from soil and vapour and outdoor inhalation of soil and vapour.

The pathway considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by residents while indoors. Figure 2 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air. Within RBCA, the solubility limit of the chemical restricts the extent of volatilisation, which in turn drives the indoor air inhalation pathway. While the same restriction is not built into the CLEA model, the CLEA model output cells are flagged red where the soil saturation limit has been exceeded.

With respect to volatilisation, the CLEA model assumes a simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase[9]. The upper boundaries of this partitioning are represented by the maximum aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA model estimates saturated soil concentrations where these limits are reached[9]. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous- or vapour-based soil saturation limits. Model output cells are flagged red where the saturated soil concentration has been exceeded and the contribution of the indoor and outdoor vapour pathway to total exposure is greater than 10%. In this case, further consideration of the following is required[9]:

- Free phase contamination may be present.
- Exposure from the vapour pathways will be over-predicted by the model, as in reality the vapour phase concentration will not increase at concentrations above saturation limits
- Where the vapour pathway contribution is greater than 90%, it is unlikely the relevant health criteria value (HCV) will be exceeded at soil concentrations at least a factor of ten higher than the relevant HCV.

Where the vapour pathway is the predominant pathway (contributes greater than 90% of exposure) or the only exposure route considered and the cell is highlighted red (SAC exceeds saturation limit), the risk based on the assumed conceptual model is likely to be negligible as the vapour risk is assumed to be tolerable at maximum possible soil concentrations. In such circumstances, the vapour pathway exposure should be considered based on the presence of free phase or non-aqueous phase liquid sources and the measured concentrations of volatile organic compounds (VOC) in the vapour phase. Screening could be considered based on setting the SAC as the modelled soil saturation limits. However, as stated within the CLEA handbook[9], this is likely to not be practical in many cases because of the very low saturation limits and, in any case, is highly conservative.

It should also be noted that for mixtures of compounds, free phase may be present where soil (or groundwater) concentrations are well below saturation limits for individual compounds.

Where the vapour pathway is only one of the exposure pathways considered, an additional approach can then be utilised as detailed within Section 4.12 of the CLEA model handbook[9], which explains how to calculate an effective assessment criterion manually.

SR3[5] states that, as a general rule of thumb, it is recognised that estimating vapour phase concentrations from dissolved and sorbed phase contamination by petroleum hydrocarbons are at least a factor of ten higher than those likely to be measured on-site. RSK has therefore applied an empirical subsurface to indoor air correction factor of 10 into the CLEA model chemical database and to outputs from the RBCA model for all petroleum hydrocarbon fractions (including

BTEX, trimethylbenzenes and the polycyclic aromatic hydrocarbons (PAH) naphthalene, acenaphthene and acenaphthylene) to reduce this conservatism.

Input selection

The most up-to-date published chemical and toxicological data was obtained from EA Report SC050021/SR7[10], the EA TOX[1] reports, the C4SL SP1010 project report and associated appendices[3,6], the 2015 LQM/CIEH report[7] or the USEPA IRIS database[14]. Where a C4SL has been published, the RSK GAC have duplicated the C4SL published values using all input parameters within the SP1010 final project report[3] and associated appendices[6], and has adopted them as GAC for these six substances. Toxicological and specific chemical parameters for aromatic hydrocarbon C_8–C_9 (styrene), 1,2,4-trimethylbenzene and methyl tertiary-butyl ether (MTBE) were obtained from the CL:AIRE Soil Generic Assessment Criteria report[11].

For TPH, aromatic hydrocarbons C_5–C_8 were not modelled, as this range comprises benzene and toluene, which are modelled separately. The aromatic C_8–C_9 hydrocarbon fraction comprises ethylbenzene, xylene and styrene. As ethylbenzene and xylene are being modelled separately, the physical, chemical and toxicological data for aromatic C_8–C_9 have been taken from styrene.

For the GrAC, the HCV used in the modelling were derived using the toxicological data for the SAC amended as follows:

- An adult weighing 70kg and breathing 15.7m^3 air per day in accordance with the revised exposure parameters used in the SP1010 final project report for the Category 4 Screening Levels (C4SL) (Table 3.2[3]) and USEPA data[12]
- Background inhalation (mean daily intake(MDI)) for an adult (Age Class 17).

Physical parameters

For the commercial end use, the CLEA default pre-1970s three-storey office building was used. SR3[5] notes this commercial building type to be the most conservative in terms of protection from vapour intrusion. The default input building parameters presented in Table 3.10 of SR3[5] have been used.

The parameters for a sandy loam soil type were used in line with Table 4.4 of SR3[5]. This includes a value of 6% for the percentage of soil organic matter (SOM) within the soil. In RSK's experience, this is rather high for many sites. To avoid undertaking site-specific risk assessments for this SOM, RSK has produced an additional set of GAC for SOM of 1% and 2.5% for all substances using the CLEA tool.

For the GrAC, the depth to groundwater was taken as 2.5m based on RSK's experience of assessing the volatilisation pathway from groundwater. The GrAC were produced using the input parameters in Table 3. Inhalation rates have not been updated.

Summary of modifications to the default CLEA SR3[5] input parameters for a commercial land use

In summary, the RSK commercial GAC were produced using the default input parameters for soil properties, the air dispersion model, building properties and the vapour model detailed in SR3[5]. Modifications to the default SR3[5] exposure scenarios based on the C4SL exposure scenarios[3]

are presented in Table 2 below. The sole modification to the default commercial input parameters is the updated inhalation rate.

The final selected GAC are presented by pathway in Table 4 with the combined GAC in Table 5.

Figure 1: Conceptual model for CLEA commercial scenario

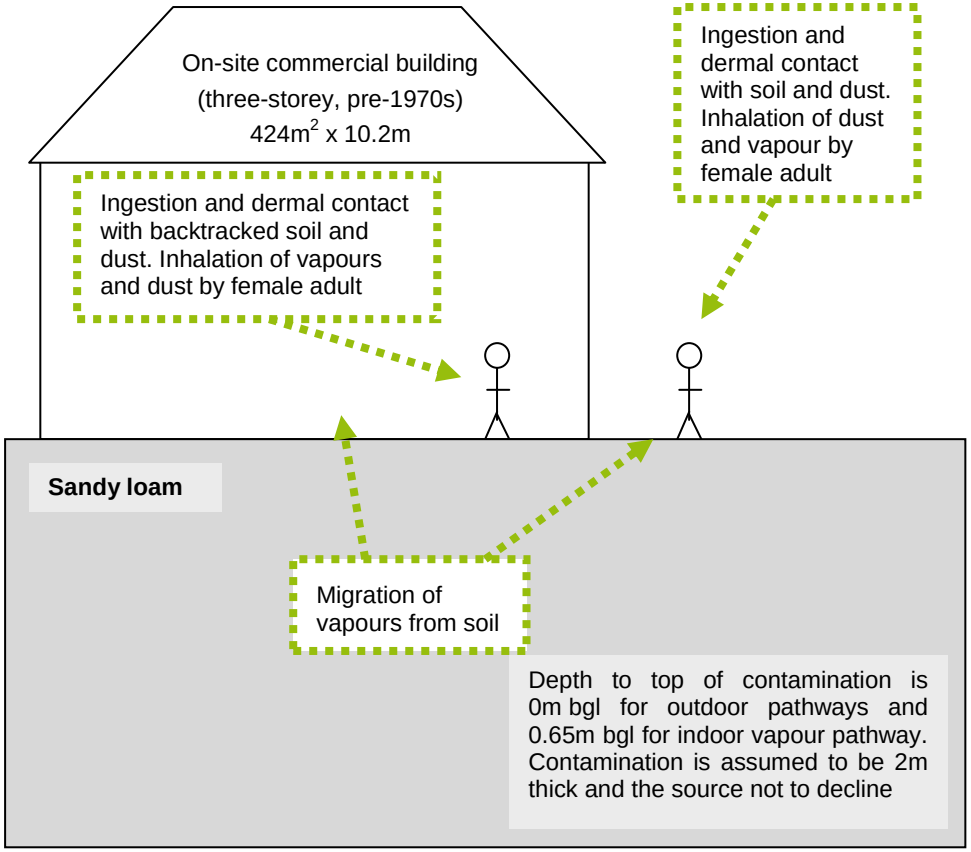

Table 1: Exposure assessment parameters for commercial scenario – inputs for CLEA model

Parameter	Value	Justification
Land use	Commercial	Chosen land use
Receptor	Female worker	Taken as female adult exposed over 49 years from age 16 to 65 years, Box 3.5, SR3[5]
Building	Office (pre-1970)	Key generic assumption given in Box 3.5, SR3[5]. Pre-1970s three-storey office building chosen as it is the most conservative in terms of protection from vapour intrusion (Section 3.4.6, SR3[5])
Soil type	Sandy loam	Most common UK soil type (Section 4.3.1, Table 4.4, SR3[5])
Start age class (AC)	17	AC corresponding to key generic assumption that the critical receptor is a working female adult exposed over a 49-year period from age 16 to 65 years. Assumption given in Box 3.5, SR3[5]
End AC	17	
SOM (%)	6	Representative of sandy loam according to EA guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents'[13]
	1	To provide SAC for sites where SOM < 6% as often observed by RSK
	2.5	
pH	7	Model default

Table 2: Commercial – modified receptor inputs

Parameter	Unit	Value	Justification
Inhalation rate (AC17)	m^3 day^{-1}	15.7	Mean value USEPA, 2011[12]; Table 3.2, SP1010[3]

Figure 2: GrAC conceptual model for RBCA commercial scenario

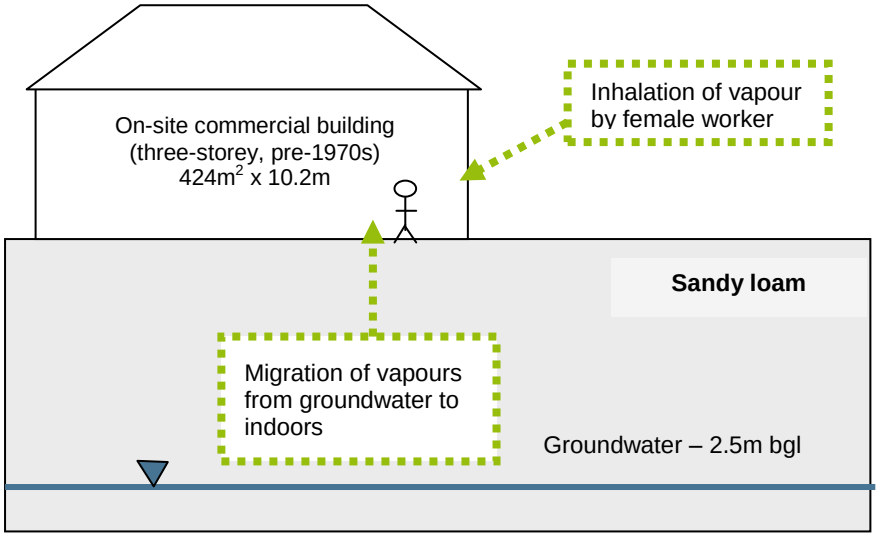

Table 3: Commercial – RBCA inputs

Parameter	Unit	Value	Justification
Receptor			
Averaging time	Years	49	From Box 3.5, SR3[5]
Receptor weight	kg	70	Female adult, Table 4.6, SR3[5]
Exposure duration	Years	49	From Box 3.5, SR3[5]
Exposure frequency	Days/yr	86.25	Weighted using occupancy period of 9 hours per day for 230 days of the year ((9hours x 230 days)/24 hours)
Soil type – sandy loam			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3[5]
Volumetric water content	-	0.33	
Volumetric air content	-	0.20	

Parameter	Unit	Value	Justification
Dry bulk density	g cm^{-3} or kg/L	1.21	
Vertical hydraulic conductivity	cm s^{-1}	3.56E-3	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3[5] equivalent to 307 cm/day
Vapour permeability	m^2	3.05E-12	Calculated for sandy loam using equations in Appendix 1, SR3[5]
Capillary zone thickness	m	0.1	Professional judgement
Building			
Building volume/area ratio	m	9.6	Table 3.10, SR3[5]
Foundation area	m^2	424	Table 3.10, SR3[5]
Foundation perimeter	m	82.40	Based on square root of building area being 20.59m
Building air exchange rate	d^{-1}	24	Table 3.10, SR3[5] Building air exchange rate equivalent to 2.8E-04 s^{-1}
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	Table 3.10, SR3[5]
Foundation crack fraction	-	3.89E-04	Calculated from floor crack area of 0.165m^2 and building footprint of 424m^2 in Table 4.21, SR3[5]
Volumetric water content of cracks	-	0.33	Assumed equal to underlying soil type in assumption that cracks become filled with soil over time. Parameters for sandy loam from Table 4.4, SR3[5]
Volumetric air content of cracks	-	0.2	
Indoor/outdoor differential pressure	Pa	4.4	From Table 3.10, SR3[5] Equivalent to 44 g/cm/s^2

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GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 4

Human health generic assessment criteria by pathway for commercial scenario

Compound	Notes	GrAC (µg/l)	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Metals														
Arsenic	(a,b)	-	6.35E+02	1.25E+03	NR	NR	6.35E+02	1.25E+03	NR	NR	6.35E+02	1.25E+03	NR	NR
Cadmium	(a)	-	7.73E+02	8.57E+02	4.10E+02	NR	7.73E+02	8.57E+02	4.10E+02	NR	7.73E+02	8.57E+02	4.10E+02	NR
Chromium (III) - trivalent	(c)	-	3.31E+05	8.57E+03	NR	NR	3.31E+05	8.57E+03	NR	NR	3.31E+05	8.57E+03	NR	NR
Chromium (VI) - hexavalent	(a,d)	-	9.62E+02	4.91E+01	NR	NR	9.62E+02	4.91E+01	NR	NR	9.62E+02	4.91E+01	NR	NR
Copper		-	1.89E+05	8.96E+04	6.83E+04	NR	1.89E+05	8.96E+04	6.83E+04	NR	1.89E+05	8.96E+04	6.83E+04	NR
Lead	(a)	-	2.32E+03	NR	NR	NR	2.32E+03	NR	NR	NR	2.32E+03	NR	NR	NR
Elemental Mercury (Hg^0)	(d)	5.60E+01	NR	1.54E+01	NR	4.31E+00	NR	3.26E+01	NR	1.07E+01	NR	5.80E+01	NR	2.58E+01
Inorganic Mercury (Hg^{2+})		-	1.18E+03	1.97E+04	1.12E+03	NR	1.18E+03	1.97E+04	1.12E+03	NR	1.18E+03	1.97E+04	1.12E+03	NR
Methyl Mercury (Hg^{4+})		1.00E+05	3.38E+02	2.13E+03	2.92E+02	7.33E+01	3.38E+02	3.87E+03	3.11E+02	1.42E+02	3.38E+02	7.33E+03	3.23E+02	3.04E+02
Nickel	(d)	-	3.06E+03	9.83E+02	NR	NR	3.06E+03	9.83E+02	NR	NR	3.06E+03	9.83E+02	NR	NR
Selenium	(b)	-	1.23E+04	NR	NR	NR	1.23E+04	NR	NR	NR	1.23E+04	NR	NR	NR
Zinc	(b)	-	7.35E+05	1.97E+08	NR	NR	7.35E+05	1.97E+08	NR	NR	7.35E+05	1.97E+08	NR	NR
Cyanide (free)		-	6.56E+02	7.51E+04	6.53E+02	NR	6.56E+02	7.51E+04	6.53E+02	NR	6.56E+02	7.51E+04	6.53E+02	NR
Volatile Organic Compounds														
Benzene	(a)	1.36E+05	1.09E+03	2.79E+01	2.72E+01	1.22E+03	1.09E+03	5.19E+01	4.96E+01	2.26E+03	1.09E+03	1.08E+02	9.80E+01	4.71E+03
Toluene		5.90E+05	4.24E+05	6.49E+04	5.63E+04	8.69E+02	4.24E+05	1.43E+05	1.07E+05	1.92E+03	4.24E+05	3.24E+05	1.84E+05	4.36E+03
Ethylbenzene		1.80E+05	1.91E+05	5.89E+03	5.71E+03	5.18E+02	1.91E+05	1.38E+04	1.28E+04	1.22E+03	1.91E+05	3.21E+04	2.75E+04	2.84E+03
Xylene - m		2.00E+05	3.43E+05	6.26E+03	6.15E+03	6.25E+02	3.43E+05	1.47E+04	1.41E+04	1.47E+03	3.43E+05	3.44E+04	3.12E+04	3.46E+03
Xylene - o		1.73E+05	3.43E+05	6.73E+03	6.60E+03	4.78E+02	3.43E+05	1.57E+04	1.50E+04	1.12E+03	3.43E+05	3.65E+04	3.30E+04	2.62E+03
Xylene - p		2.00E+05	3.43E+05	6.03E+03	5.92E+03	5.76E+02	3.43E+05	1.41E+04	1.36E+04	1.35E+03	3.43E+05	3.28E+04	3.00E+04	3.17E+03
Total xylene		1.73E+05	3.43E+05	6.03E+03	5.92E+03	6.25E+02	3.43E+05	1.41E+04	1.36E+04	1.47E+03	3.43E+05	3.28E+04	3.00E+04	3.46E+03
Methyl tertiary-Butyl ether (MTBE)		4.80E+07	5.72E+05	7.54E+04	6.66E+04	2.04E+04	5.72E+05	1.22E+05	1.01E+05	3.31E+04	5.72E+05	2.31E+05	1.65E+05	6.27E+04
Trichloroethene		3.73E+03	9.53E+02	1.23E+00	1.23E+00	1.54E+03	9.53E+02	2.58E+00	2.57E+00	3.22E+03	9.53E+02	5.72E+00	5.69E+00	7.14E+03
Tetrachloroethene		3.43E+04	1.12E+04	1.86E+01	1.86E+01	4.24E+02	1.12E+04	4.17E+01	4.16E+01	9.51E+02	1.12E+04	9.57E+01	9.49E+01	2.18E+03
1,1,1-Trichloroethane		1.30E+06	1.14E+06	6.60E+02	6.60E+02	1.43E+03	1.14E+06	1.35E+03	1.35E+03	2.92E+03	1.14E+06	2.96E+03	2.95E+03	6.39E+03
1,1,1,2 Tetrachloroethane		1.60E+05	1.10E+04	1.09E+02	1.08E+02	2.60E+03	1.10E+04	2.53E+02	2.47E+02	6.02E+03	1.10E+04	5.88E+02	5.59E+02	1.40E+04
1,1,2,2-Tetrachloroethane		1.63E+05	1.10E+04	2.81E+02	2.74E+02	2.67E+03	1.10E+04	5.75E+02	5.46E+02	5.46E+03	1.10E+04	1.26E+03	1.13E+03	1.20E+04
Carbon Tetrachloride		5.47E+03	7.62E+03	2.87E+00	2.87E+00	1.52E+03	7.62E+03	6.29E+00	6.28E+00	3.32E+03	7.62E+03	1.43E+01	1.42E+01	7.54E+03
1,2-Dichloroethane		5.71E+03	2.29E+02	6.73E-01	6.71E-01	3.41E+03	2.29E+02	9.71E-01	9.67E-01	4.91E+03	2.29E+02	1.67E+00	1.65E+00	8.43E+03
Vinyl Chloride		3.82E+02	2.67E+01	5.95E-02	5.94E-02	1.36E+03	2.67E+01	7.70E-02	7.67E-02	1.76E+03	2.67E+01	1.18E-01	1.17E-01	2.69E+03
1,2,4-Trimethylbenzene		5.59E+04	NR	3.29E+02	NR	4.74E+02	NR	6.41E+02	NR	1.16E+03	NR	1.04E+03	NR	2.76E+03
1,3,5-Trimethylbenzene	(e)	-	NR	NR	NR	2.30E+02	NR	NR	NR	5.52E+02	NR	NR	NR	1.30E+03
Semi-Volatile Organic Compounds														
Acenaphthene		4.11E+03	1.10E+05	2.75E+06	1.06E+05	5.70E+01	1.10E+05	5.36E+06	1.08E+05	1.41E+02	1.10E+05	8.83E+06	1.08E+05	3.36E+02
Acenaphthylene		7.95E+03	1.10E+05	2.68E+06	1.05E+05	8.61E+01	1.10E+05	5.23E+06	1.07E+05	2.12E+02	1.10E+05	8.65E+06	1.08E+05	5.06E+02
Anthracene		-	5.49E+05	1.13E+07	5.23E+05	1.17E+00	5.49E+05	2.35E+07	5.36E+05	2.91E+00	5.49E+05	4.13E+07	5.42E+05	6.96E+00
Benzo(a)anthracene		-	2.84E+02	4.08E+02	1.67E+02	1.71E+00	2.84E+02	4.47E+02	1.74E+02	4.28E+00	2.84E+02	4.67E+02	1.76E+02	1.03E+01
Benzo(b)fluoranthene		-	7.13E+01	1.17E+02	4.43E+01	1.22E+00	7.13E+01	1.20E+02	4.47E+01	3.04E+00	7.13E+01	1.21E+02	4.49E+01	7.29E+00
Benzo(g,h,i)perylene		-	6.29E+03	1.05E+04	3.93E+03	1.54E-02	6.29E+03	1.06E+04	3.95E+03	3.85E-02	6.29E+03	1.07E+04	3.96E+03	9.23E-02
Benzo(k)fluoranthene		-	1.88E+03	3.11E+03	1.17E+03	6.87E-01	1.88E+03	3.17E+03	1.18E+03	1.72E+00	1.88E+03	3.21E+03	1.19E+03	4.12E+00
Chrysene		-	5.67E+02	8.89E+02	3.46E+02	4.40E-01	5.67E+02	9.25E+02	3.52E+02	1.10E+00	5.67E+02	9.47E+02	3.55E+02	2.64E+00
Dibenzo(a,h)anthracene		-	5.67E+00	9.32E+00	3.53E+00	3.93E-03	5.67E+00	9.52E+00	3.55E+00	9.82E-03	5.67E+00	9.64E+00	3.57E+00	2.36E-02
Fluoranthene		-	2.29E+04	1.89E+06	2.26E+04	1.89E+01	2.29E+04	2.72E+06	2.27E+04	4.73E+01	2.29E+04	3.32E+06	2.27E+04	1.13E+02
Fluorene		-	7.31E+04	4.55E+05	6.30E+04	3.09E+01	7.31E+04	1.06E+06	6.84E+04	7.65E+01	7.31E+04	2.24E+06	7.08E+04	1.83E+02
Indeno(1,2,3-cd)pyrene		-	8.10E+02	1.31E+03	5.01E+02	6.13E-02	8.10E+02	1.35E+03	5.06E+02	1.53E-01	8.10E+02	1.37E+03	5.09E+02	3.68E-01
Phenanthrene		-	2.28E+04	5.35E+05	2.19E+04	3.60E+01	2.28E+04	1.09E+06	2.24E+04	8.96E+01	2.28E+04	1.86E+06	2.25E+04	2.14E+02
Pyrene		-	5.49E+04	4.47E+06	5.42E+04	2.20E+00	5.49E+04	6.46E+06	5.44E+04	5.49E+00	5.49E+04	7.91E+06	5.45E+04	1.32E+01
Benzo(a)pyrene	(a)	-	7.68E+01	2.04E+02	5.58E+01	9.11E-01	7.68E+01	2.09E+02	5.61E+01	2.28E+00	7.68E+01	2.11E+02	5.63E+01	5.46E+00
Naphthalene		1.90E+04	3.64E+04	1.87E+03	1.78E+03	7.64E+01	3.64E+04	4.39E+03	3.92E+03	1.83E+02	3.64E+04	9.94E+03	7.81E+03	4.32E+02
Phenol		-	1.10E+06	2.65E+04	2.59E+04	2.42E+04	1.10E+06	3.04E+04	2.96E+04	3.81E+04	1.10E+06	3.46E+04	3.35E+04	7.03E+04

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 4

Human health generic assessment criteria by pathway for commercial scenario

Compound	Notes	GrAC (µg/l)	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Total petroleum hydrocarbons														
Aliphatic hydrocarbons EC5-EC6		3.59E+04	4.77E+06	3.19E+03	3.19E+03	3.04E+02	4.77E+06	5.86E+03	5.86E+03	5.58E+02	4.77E+06	1.21E+04	1.21E+04	1.15E+03
Aliphatic hydrocarbons >EC6-EC8		5.37E+03	4.77E+06	7.79E+03	7.78E+03	1.44E+02	4.77E+06	1.74E+04	1.74E+04	3.22E+02	4.77E+06	3.97E+04	3.96E+04	7.36E+02
Aliphatic hydrocarbons >EC8-EC10		4.27E+02	9.53E+04	2.02E+03	2.00E+03	7.77E+01	9.53E+04	4.91E+03	4.85E+03	1.90E+02	9.53E+04	1.17E+04	1.13E+04	4.51E+02
Aliphatic hydrocarbons >EC10-EC12		3.39E+01	9.53E+04	9.97E+03	9.69E+03	4.75E+01	9.53E+04	2.47E+04	2.29E+04	1.18E+02	9.53E+04	5.89E+04	4.73E+04	2.83E+02
Aliphatic hydrocarbons >EC12-EC16		7.59E-01	9.53E+04	8.26E+04	5.88E+04	2.37E+01	9.53E+04	2.04E+05	8.17E+04	5.91E+01	9.53E+04	4.81E+05	9.02E+04	1.42E+02
Aliphatic hydrocarbons >EC16-EC35	(b)	-	1.58E+06	NR	NR	8.48E+00	1.75E+06	NR	NR	2.12E+01	1.83E+06	NR	NR	5.09E+01
Aliphatic hydrocarbons >EC35-EC44	(b)	-	1.58E+06	NR	NR	8.48E+00	1.75E+06	NR	NR	2.12E+01	1.83E+06	NR	NR	5.09E+01
Aromatic hydrocarbons >EC8-EC9 (styrene)		2.90E+05	2.29E+04	3.66E+04	1.41E+04	6.26E+02	2.29E+04	8.39E+04	1.80E+04	1.44E+03	2.29E+04	1.93E+05	2.04E+04	3.35E+03
Aromatic hydrocarbons >EC_9-EC_{10}		6.46E+04	3.81E+04	3.55E+03	3.46E+03	6.13E+02	3.81E+04	8.66E+03	8.11E+03	1.50E+03	3.81E+04	2.05E+04	1.70E+04	3.58E+03
Aromatic hydrocarbons >EC10-EC12		2.45E+04	3.81E+04	1.92E+04	1.62E+04	3.64E+02	3.81E+04	4.69E+04	2.79E+04	8.99E+02	3.81E+04	1.10E+05	3.42E+04	2.15E+03
Aromatic hydrocarbons >EC12-EC16		5.75E+03	3.81E+04	2.02E+05	3.62E+04	1.69E+02	3.81E+04	4.76E+05	3.73E+04	4.19E+02	3.81E+04	1.03E+06	3.78E+04	1.00E+03
Aromatic hydrocarbons >EC16-EC21	(b)	-	2.82E+04	NR	NR	5.37E+01	2.83E+04	NR	NR	1.34E+02	2.84E+04	NR	NR	3.21E+02
Aromatic hydrocarbons >EC21-EC35	(b)	-	2.84E+04	NR	NR	4.83E+00	2.84E+04	NR	NR	1.21E+01	2.84E+04	NR	NR	2.90E+01
Aromatic hydrocarbons >EC35-EC44	(b)	-	2.84E+04	NR	NR	4.83E+00	2.84E+04	NR	NR	1.21E+01	2.84E+04	NR	NR	2.90E+01

Notes:

EC - equivalent carbon. GrAC - groundwater screening value. SAC - soil screening value.

The CLEA model output is colour coded depending upon whether the soil saturation limit has been exceeded.

Calculated SAC exceeds soil saturation limit and may significantly affect the interpretation of any exceedances as the contribution of the indoor and outdoor vapour pathway to total exposure is >10%. This shading has also been used for the RBCA output where the theoretical solubility limit has been exceeded.

Calculated SAC exceeds soil saturation limit but the exceedance will not affect the SAC significantly as the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.

Calculated SAC does not exceed the soil saturation limit.

For consistency where the theoretical solubility limit within RBCA has been exceeded in production of the GrAC, these cellls have also been hatched red and the GrAC set at the solubility limit.

The SAC for organic compounds are dependant upon soil organic matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58. 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, PAHs napthalene, acenaphthene and acenaphthylene, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway (Section 10.1.1, SR3)

(a) SAC for arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead are derived using the C4SL toxicology data.

(b) SAC for selenium should not include the inhalation pathway as no expert group HCV has been derived; aliphatic and aromatic hydrocarbons >EC16 should not include inhalation pathway due to their non-volatile nature and inhalation exposure being minimal (oral, dermal and inhalation exposure is compared to the oral HCV); arsenic should only be based on oral contribution (rather than combined) owing to the relative small contribution from inhalation in accordance with the SGV report. The Oral SAC should be adopted for zinc and benzo(a)pyrene.

(c) SAC for CrIII should be based on the lower of the oral and inhalation SAC (see LQM/CIEH 2015 Section 6.8)

(d) SAC for elemental mercury, chromium VI and nickel should be based on the inhalation pathway only.

(e) SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data, SAC for 1,2,4 trimethylbenzene may be used.

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 5
Human Health Generic Assessment Criteria for Commercial Scenario

Compound	GrAC for Groundwater (µg/l)	SAC for Soil SOM 1% (mg/kg)	SAC for Soil SOM 2.5% (mg/kg)	SAC for Soil SOM 6% (mg/kg)
Metals				
Arsenic	-	640	640	640
Cadmium	-	410	410	410
Chromium (III) - trivalent	-	8,600	8,600	8,600
Chromium (VI) - hexavalent	-	49	49	49
Copper	-	68,000	68,000	68,000
Lead	-	2,300	2,300	2,300
Elemental Mercury (Hg^0)	56	15 (4)	33 (11)	58 (26)
Inorganic Mercury (Hg^{2+})	-	1,120	1,120	1,120
Methyl Mercury (Hg^{4+})	100000	290 (73)	310 (142)	320
Nickel	-	980	980	980
Selenium	-	12,000	12,000	12,000
Zinc	-	740,000	740,000	740,000
Cyanide (free)	-	650	650	650
Volatile Organic Compounds				
Benzene	136190	27	50	98
Toluene	590000	56,000 (869)	107,000 (1,916)	184,000 (4,357)
Ethylbenzene	180000	6,000 (518)	13,000 (1,216)	27,000 (2,844)
Xylene - m	200000	6,200 (625)	14,100 (1,474)	31,200 (3,457)
Xylene - o	173000	6,600 (478)	15,000 (1,120)	33,000 (2,618)
Xylene - p	200000	5,900 (576)	13,600 (1,353)	30,000 (3,167)
Total xylene	173000	5,900 (625)	13,600 (1,474)	30,000 (3,457)
Methyl tertiary-Butyl ether (MTBE)	48000000	67,000 (20,400)	101,000 (33,100)	165,000 (62,700)
Trichloroethene	3730	1	3	6
Tetrachloroethene	34310	20	40	90
1,1,1-Trichloroethane	1300000	700	1,300	3,000
1,1,1,2 Tetrachloroethane	160000	110	250	560
1,1,2,2-Tetrachloroethane	162840	270	550	1,130
Carbon Tetrachloride	5470	2.9	6.3	14.2
1,2-Dichloroethane	5710	0.67	0.97	1.65
Vinyl Chloride	382	0.06	0.08	0.12
1,2,4-Trimethylbenzene	55900	330	640	1,040
1,3,5-Trimethylbenzene	-	NR	NR	NR
Semi-Volatile Organic Compounds				
Acenaphthene	4110	110,000	110,000	110,000
Acenaphthylene	7950	110,000	110,000	110,000
Anthracene	-	520,000	540,000	540,000
Benzo(a)anthracene	-	170	170	180
Benzo(b)fluoranthene	-	44	45	45
Benzo(g,h,i)perylene	-	3,900	3,900	4,000
Benzo(k)fluoranthene	-	1,200	1,200	1,200
Chrysene	-	350	350	350
Dibenzo(a,h)anthracene	-	3.5	3.6	3.6
Fluoranthene	-	23,000	23,000	23,000
Fluorene	-	63,000 (31)	68,000	71,000
Indeno(1,2,3-cd)pyrene	-	500	510	510
Phenanthrene	-	22,000	22,000	23,000
Pyrene	-	54,000	54,000	54,000
Benzo(a)pyrene	-	77	77	77
Naphthalene	19000	1,800 (76)	3,900 (183)	7,800 (432)
Phenol	-	440*	690*	1,300*
Total Petroleum Hydrocarbons				
Aliphatic hydrocarbons EC_5-EC_6	35900	3,200 (304)	5,900 (558)	12,100 (1,150)
Aliphatic hydrocarbons >EC_6-EC_8	5370	7,800 (144)	17,400 (322)	39,600 (736)
Aliphatic hydrocarbons >EC_8-EC_{10}	427	2,000 (78)	4,800 (190)	11,300 (451)
Aliphatic hydrocarbons >EC_{10}-EC_{12}	34	9,700 (48)	22,900 (118)	47,300 (283)
Aliphatic hydrocarbons >EC_{12}-EC_{16}	0.759	59,000 (24)	82,000 (59)	90,000 (142)
Aliphatic hydrocarbons >EC_{16}-EC_{35}	-	1,000,000**	1,000,000**	1,000,000**
Aliphatic hydrocarbons >EC_{35}-EC_{44}	-	1,000,000**	1,000,000**	1,000,000**
Aromatic hydrocarbons >EC_8-EC_9 (styrene)	290000	14,000 (626)	18,000 (1,440)	20,000 (3,350)
Aromatic hydrocarbons >EC_9-EC_{10}	64600	3,500 (613)	8,100 (1,503)	17,000 (3,580)
Aromatic hydrocarbons >EC_{10}-EC_{12}	24500	16,000 (364)	28,000 (899)	34,000 (2,150)
Aromatic hydrocarbons >EC_{12}-EC_{16}	5750	36,000 (169)	37,000	38,000
Aromatic hydrocarbons >EC_{16}-EC_{21}	-	28,000	28,000	28,000
Aromatic hydrocarbons >EC_{21}-EC_{35}	-	28,000	28,000	28,000
Aromatic hydrocarbons >EC_{35}-EC_{44}	-	28,000	28,000	28,000

Notes:

'-' Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data.

NR - SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data, SAC for 1,2,4 trimethylbenzene may be used

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

* The GAC for Phenol is based on a threshold which is protective of direct contact (SC050021/Phenol SGV report)

** Denoted SAC calculated exceeds 100% contaminant, hence 100% (1,000,000mg/kg) has been taken as SAC

The SAC for organic compounds are dependent on Soil Organic Matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58.
1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC and GrAC for TPH fractions, PAHs napthalene, acenaphthene and acenaphthylene, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3.

(VALUE IN BRACKETS) The SAC has been set as the model calculated SAC with the saturation limit shown in brackets.
RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIEH whereby the concentration modelled for each petroleum hydrocarbon fraction has been tabulated as the SAC with the corresponding solubility or vapour saturation limits given in brackets.

For consistency where the GrAC exceeds the solubility limit, GrAC has been set at the solubility limit. The GrAC is conservative since concentrations of the chemical are very unlikely to be at sufficient concentration to result in an exceedance of the health criteria value at the point of exposure (i.e. indoor air) provided free-phase product is absent.

APPENDIX H
GENERIC ASSESSMENT CRITERIA FOR PHYTOTOXIC EFFECTS

Several compounds can inhibit plant growth; hence it is important to have generic assessment criteria (GAC) to promote healthy plant growth. In the absence of other published GAC, the GAC have been obtained from legislation (UK and European) and guidance related to the use of sewage sludge on agricultural fields.

The Council of European Communities Sewage Sludge Directive (86/278/EEC) dated 1986, has been transposed into UK law by Statutory Instrument No. 1263, The Sludge (use in Agriculture) Regulations 1989 (Public Health England, Wales and Scotland), as ammended in 1990 and The Sludge (use in Agriculture) Regulations (Northern Ireland) SR No, 245, 1990. In addition the Department of Environment (DoE) produced a Code of Practice (CoP) (Updated 2nd Edition) in 2006 which provided guidance on the application of sewage sludge on agricultural land (however the status of this document is unclear as it is on the archive section of the Defra website).

The directive seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to "***prevent harmful effects on soil, vegetation, animals and man".*** To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone "biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use". To provide protection against potential health risks from residual pathogens, sludge must not be applied to soil in which fruit and vegetable crops are growing, or less than ten months before fruit and vegetable crops are to be harvested. Grazing animals must not be allowed access to grassland or forage land less than three weeks after the application of sludge.

The specified limits of concentrations of selected elements in soil are presented in Table 4 of the updated 2nd Edition of the DoE Code of Practice and are designed to protect plant growth. It is noted that these values are more stringent than the values set in current UK regulations. However since they were ammended following recommendations from the Independent Scientific Committee in 1993. (MAFF/DOE 1993). The GAC are presented in Table 1.

Table 1: Generic assessment criteria

Determinant	Generic assessment criteria (mg/kg)			
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0
Zinc	200	200	200	300
Copper	80	100	135	200
Nickel	50	60	75	110
Lead	300	300	300	300
Cadmium	3	3	3	3
Mercury	1	1	1	1
Note: Only compounds with assessment criteria documented within the Directive 86/278/EEC have been included, although criteria for 5 additional compounds have been presented within the 2006 CoP.				

APPENDIX I
GENERIC ASSESSMENT CRITERIA FOR POTABLE WATER SUPPLY PIPES

A range of pipe materials is available and careful selection, design and installation is required to ensure that water supply pipes are satisfactorily installed and meet the requirements of the Water Supply (Water Fittings) Regulations 1999 in England and Wales, the Byelaws 2000 in Scotland and the Northern Ireland Water Regulations. The regulations include a requirement to use only suitable materials when laying water pipes and laying water pipes without protection is not permitted at contaminated sites. The water supply company has a statutory duty to enforce the regulations.

Contaminants in the ground can pose a risk to human health by permeating potable water supply pipes. To fulfil their statutory obligation, UK water supply companies require robust evidence from developers to demonstrate either that the ground in which new plastic supply pipes will be laid is free from specific contaminants, or that the proposed remedial strategy will mitigate any existing risk. If these requirements cannot be demonstrated to the satisfaction of the relevant water company, it becomes necessary to specify an alternative pipe material on the whole development or in specific zones.

In 2010, UK Water Industry Research (UKWIR) published *Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (Report Ref. No. 10/WM/03/21). This report reviewed previously published industry guidelines and threshold concentrations adopted by individual water supply companies.

The focus of the UKWIR research project was to develop clear and concise procedures, which provide consistency in the pipe selection decision process. It was intended to provide guidance that can be used to ensure compliance with current regulations and to prevent water supply pipe failing prematurely due to the presence of contamination.

The report concluded that in most circumstances only organic contaminants pose a potential risk to plastic pipe materials and Table 3.1 of the report provides threshold concentrations for polyethylene (PE) and polyvinyl chloride (PVC) pipes for the organic contaminants of concern. The report also makes recommendations for the procedures to be adopted in the design of site investigations and sampling strategies, and the assessment of data, to ensure that the ground through which water supply pipes will be laid is adequately characterised.

Risks to water supply pipes have therefore been assessed against the threshold concentrations for PE and PVC pipe specified in Table 3.1 of Report 10/WM/03/21, which have been adopted as the GAC for this linkage and are reproduced in Table A3 below.

Since water supply pipes are typically laid at a minimum depth of 0.75m below finished ground levels, sample results from depths between 0.5m and 1.5m below finished level are generally considered suitable for assessing risks to water supply. Samples outside these depths can be

used, providing the stratum is the same as that in which water supply pipes are likely to be located. The report specifies that sampling should characterise the ground conditions to a minimum of 0.5m below the proposed depth of the pipe.

It should be noted that the assessment provided in this report is a guide and the method of assessment and recommendations should be checked with the relevant water supply company.

Table A3: Generic assessment criteria for water supply pipes

		Pipe material	
		GAC (mg/kg)	
	Parameter group	**PE**	**PVC**
1	Extended VOC suite by purge and trap or head space and GC-MS with TIC (Not including compounds within group 1a)	0.5	0.125
1a	• BTEX + MTBE	0.1	0.03
2	SVOCs TIC by purge and trap or head space and GC-MS with TIC (aliphatic and aromatic C_5–C_{10}) (Not including compounds within group 2e and 2f)	2	1.4
2e	• Phenols	2	0.4
2f	• Cresols and chlorinated phenols	2	0.04
3	Mineral oil C_{11}–C_{20}	10	Suitable
4	Mineral oil C_{21}–C_{40}	500	Suitable
5	Corrosive (conductivity, redox and pH)	Suitable	Suitable
Specific suite identified as relevant following site investigation			
2a	Ethers	0.5	1
2b	Nitrobenzene	0.5	0.4
2c	Ketones	0.5	0.02
2d	Aldehydes	0.5	0.02
6	Amines	Not suitable	Suitable
Notes: where indicated as ‘suitable’, the material is considered resistant to permeation or degradation and no threshold concentration has been specified by UKWIR.			

APPENDIX J
CERTIFICATES OF GEOTECHNICAL ANALYSIS

TESTING VERIFICATION CERTIFICATE

1774

The test results included in this report are certified as:-

ISSUE STATUS: **FINAL**

In accordance with Structural Soils Ltd Laboratory Quality Assurance Manual, Issue 6, January 2010 all results sheets and summaries of results issued by the laboratory are checked by an approved signatory. This check will also involve checking of at least 10% of calculations for each test type to ensure that data has been correctly entered into the computer and calculated. The integrity of the test data and results are ensured by control of the computer system employed by the laboratory as part of the Software Verification Program as detailed in the Laboratory Quality Assurance Manual.

This testing verification certificate covers all testing compiled on or before the following datetime: **12/09/2013 12:08:04**.

Testing reported after this date is not covered by this Verification Certificate.

Approved Signatory
Mark Athorne (Laboratory Quality Manager)

STRUCTURAL SOILS
The Potteries
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W. Yorkshire WF10 1NJ

Contract:	Job No:
Rockingham	**780970**

STRUCTURAL SOILS LTD

TEST REPORT

Report No. 780970 R02

Date 12-September-2013 Contract Rockingham

Client RSK Environment Ltd
Address Spring Lodge
172 Chester Road
Helsby
Cheshire WA6 0AR

For the Attention of Claire Lawrence

Samples submitted by client	01/08/2013	Client Reference	321393
Testing Started	01/08/2013	Client Order No.	
Testing Completed	29/08/2013	Instruction Type	Written

Ukas Accredited Tests Underatken

Moisture Content (oven drying method) BS1377:Part 2:1990,clause 3.2
Liquid Limit (definitive method) BS1377:Part 2:1990,clause 4.3
Plastic Limit BS1377:Part 2:1990,clause 5.3
Plasticity Index Derivation BS1377:Part 2:1990,clause 5.4
Particle Size Distribution wet sieve method BS1377:Part 2:1990,clause 9.2
Dry density/moisture content relationship 2.5kg rammer method BS1377:Part 4:1990 clause 3.3/3.4
Dry density/moisture content relationship 4.5kg rammer method BS1377:Part 4:1990 clause 3.5/3.6

Please Note: Remaining samples will be retained for a period of one month from today and will then be disposed of

SUMMARY OF SOIL CLASSIFICATION TESTS

In accordance with clauses 3.2,4.3,4.4,5.3,5.4,7.2,8.2,8.3 of BS1377:Part 2:1990

Exploratory Position ID	Sample Ref	Sample Type	Depth (m)	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	% <425um	Description of Sample
BH3	1	D	0.30	9.0	47	22	25	48	Grey slightly sandy slightly gravelly CLAY
BH7	1	D	0.40	7.5	39	21	18	72	Grey brown slightly sandy slightly gravelly CLAY

STRUCTURAL SOILS LTD

Contract: **Rockingham**

Contract Ref: **780970**

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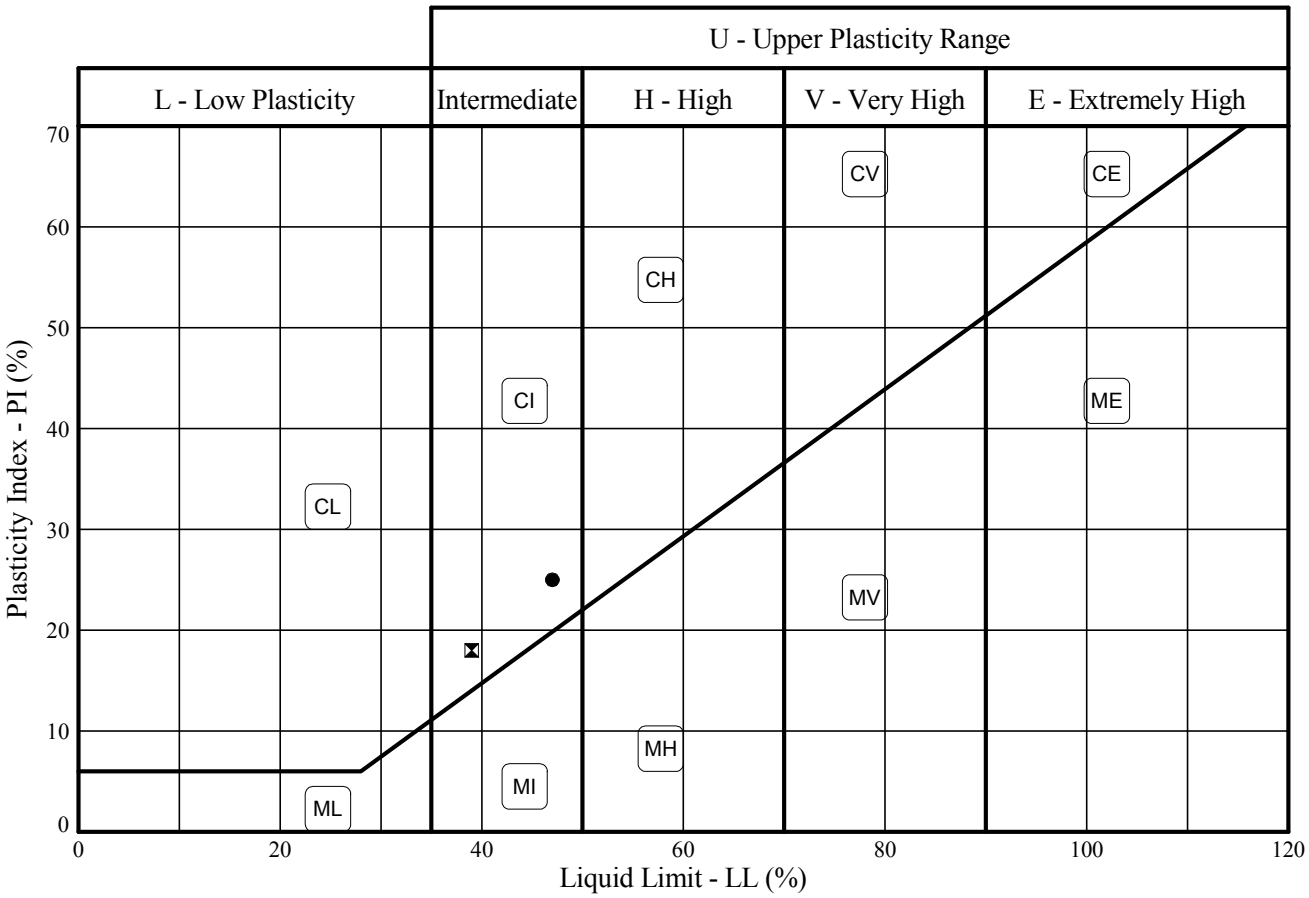
PLASTICITY CHART - PI Vs LL

In accordance with clause 42.3 of BS5930:1999
Testing in accordance with BS1377-2:1990



Sample Identification				BS Test Method #	Preparation Method +	MC %	LL %	PL %	PI %	<425um %
	Exploratory Position ID	Sample	Depth (m)							
●	BH3	1D	0.30	3.2/4.3/5.3/5.4	4.2.4	9.0	47	22	25	48
⊠	BH7	1D	0.40	3.2/4.3/5.3/5.4	4.2.4	7.5	39	21	18	72

Tested in accordance with the following clauses of BS1377-2:1990.

3.2 - Moisture Content
4.3 - Cone Penetrometer Method
4.4 - One Point Cone Penetrometer Method
4.6 - One Point Casagrande Method
5.3 - Plastic Limit Method
5.4 - Plasticity Index

+ Tested in accordance with the following clauses of BS1377-2:1990.

4.2.3 - Natural State
4.2.4 - Wet Sieved

Key: * = Non standard test, NP = Non plastic.

Approved Signatories: D. TROWBRIDGE J. BARRETT M. ATHORNE A. FROST M. RANDERSON R. CLARKSON M. FISHER C. COLE

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Compiled By		Date
C Cole	CATHERINE COLE	28/08/13

Contract	Contract Ref:
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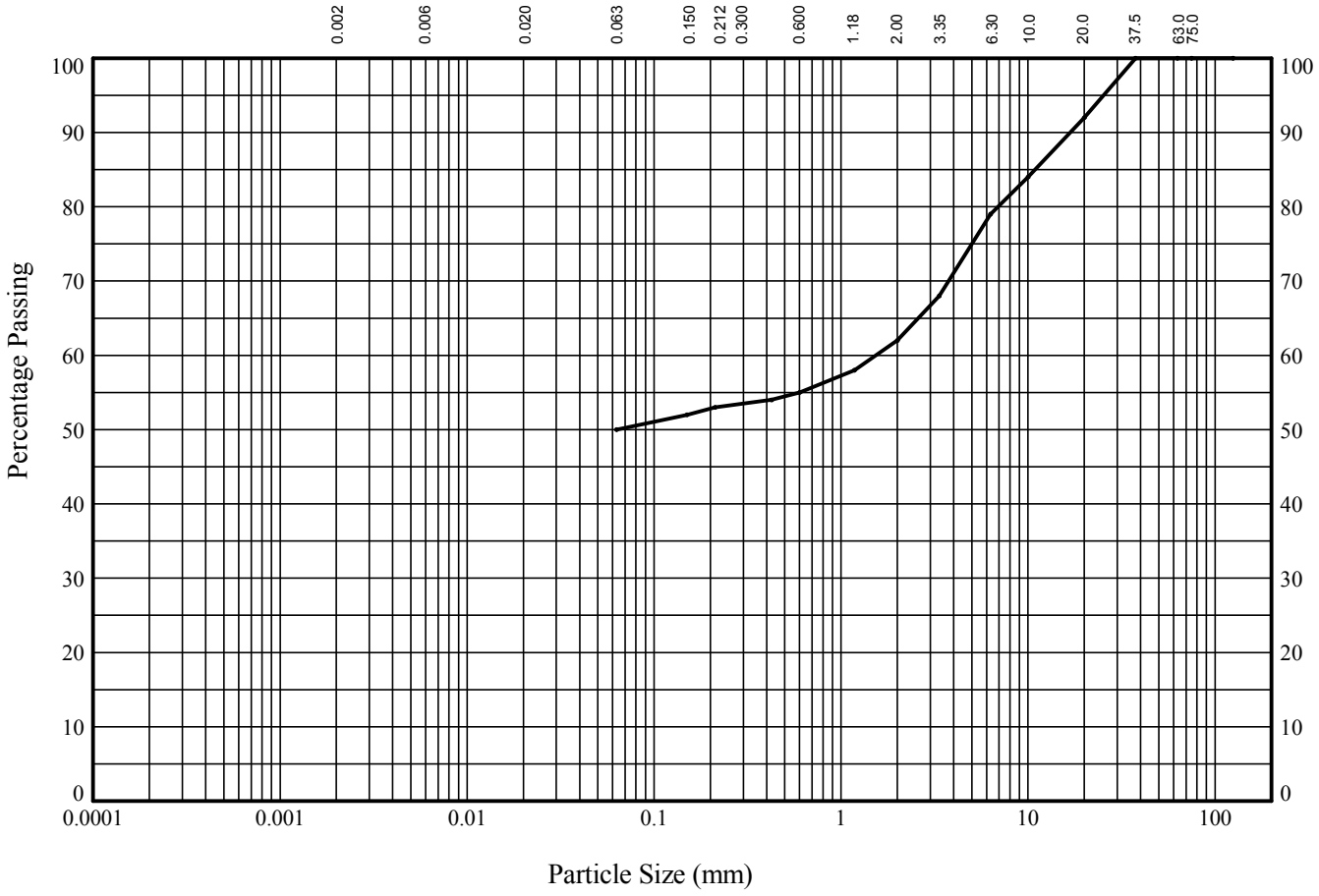
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Borehole : **BH2** Sample Ref: **1** Sample Type: **B** Depth (m): **4.50**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	100
37.5	100
20.0	92
10.0	84
6.30	79
3.35	68
2.00	62
1.18	58
0.600	55
0.425	54
0.212	53
0.150	52
0.063	50

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
GRAVEL	**38**
SAND	**12**
SILT/CLAY	**50**

Soil Description:
Grey slightly sandy gravelly CLAY

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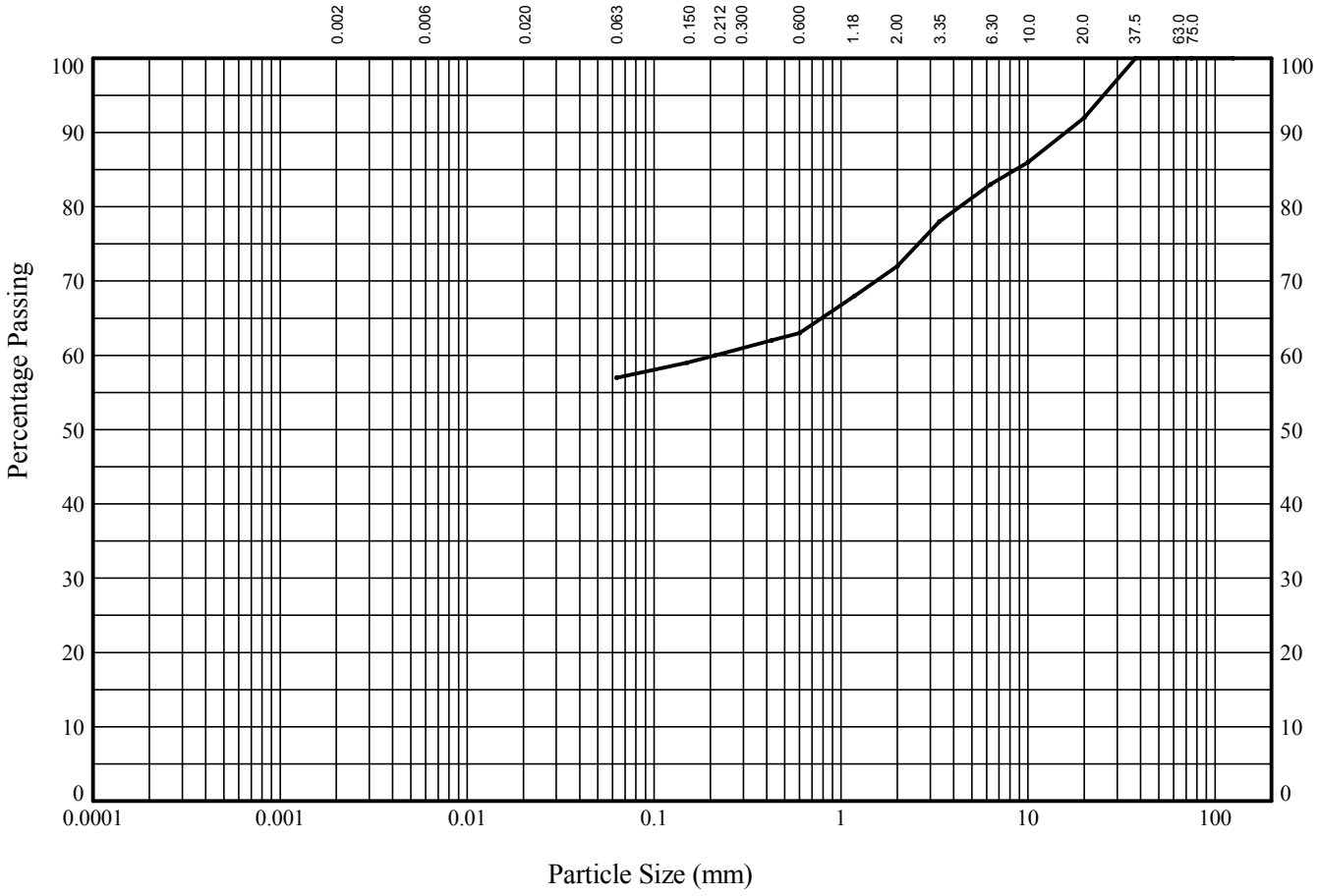
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Borehole : **BH3** Sample Ref: **2** Sample Type: **B** Depth (m): **3.00**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	100
37.5	100
20.0	92
10.0	86
6.30	83
3.35	78
2.00	72
1.18	68
0.600	63
0.425	62
0.212	60
0.150	59
0.063	57

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
GRAVEL	**28**
SAND	**15**
SILT/CLAY	**57**

Soil Description:
Grey slightly sandy slightly gravelly CLAY

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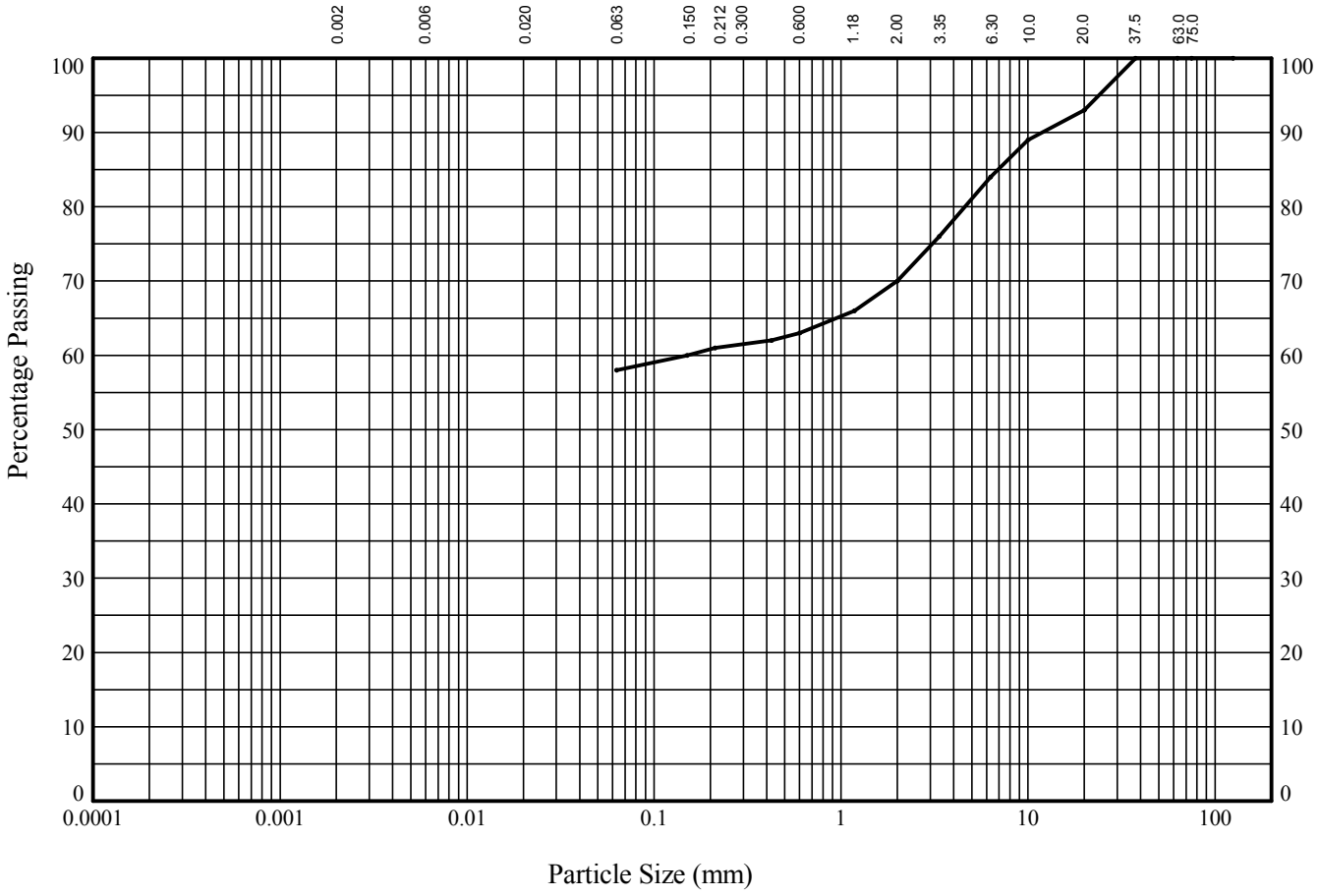
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Borehole : **BH4** Sample Ref: **1** Sample Type: **B** Depth (m): **6.00**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	100
37.5	100
20.0	93
10.0	89
6.30	84
3.35	76
2.00	70
1.18	66
0.600	63
0.425	62
0.212	61
0.150	60
0.063	58

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
GRAVEL	**30**
SAND	**12**
SILT/CLAY	**58**

Soil Description:
Grey slightly sandy slightly gravelly CLAY

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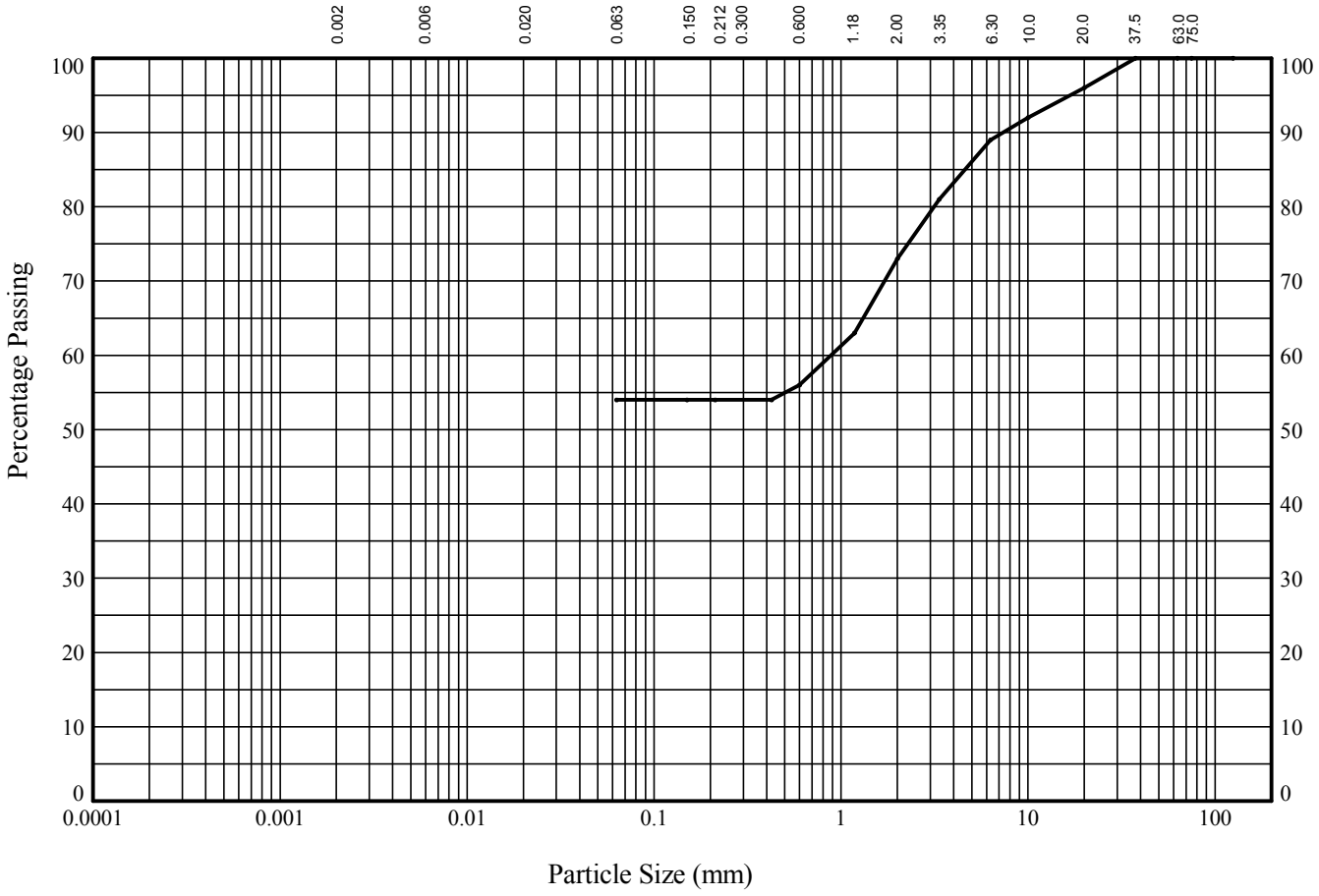
Contract	Contract Ref:
Rockingham	**780970**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Borehole : **BH5** Sample Ref: **1** Sample Type: **B** Depth (m): **7.50**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	100
37.5	100
20.0	96
10.0	92
6.30	89
3.35	81
2.00	73
1.18	63
0.600	56
0.425	54
0.212	54
0.150	54
0.063	54

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
GRAVEL	**27**
SAND	**19**
SILT/CLAY	**54**

Soil Description:
Grey brown slightly sandy slightly gravelly CLAY

Approved Signatories: D. TROWBRIDGE J. BARRETT M. ATHORNE A. FROST M. RANDERSON R. CLARKSON M. FISHER C. COLE

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Compiled By		Date
M. Fisher	**MAUREEN FISHER**	**28/08/13**

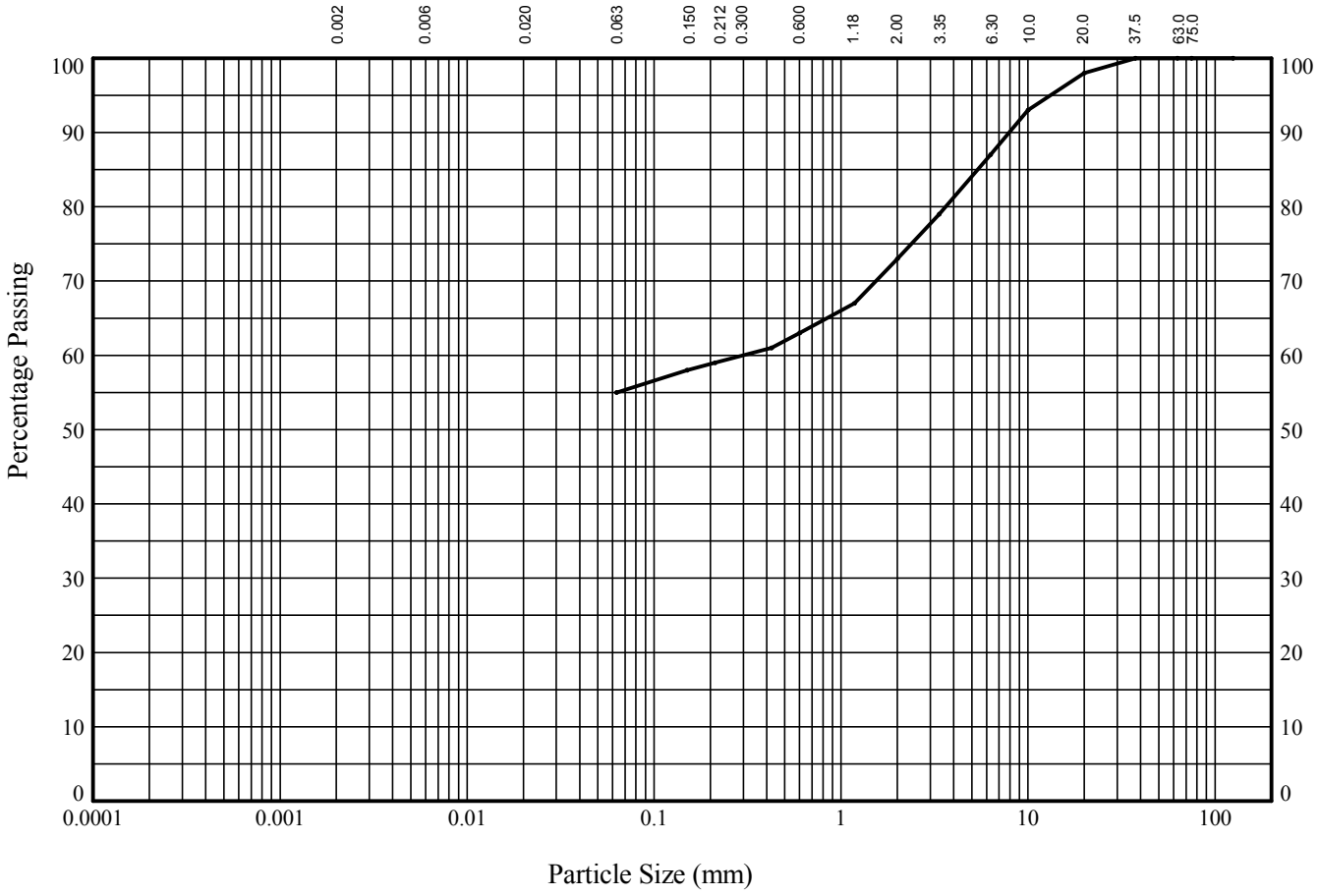
Contract	Contract Ref:
Rockingham	**780970**

AGS

PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Borehole : **BH6** Sample Ref: **1** Sample Type: **B** Depth (m): **9.00**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	100
37.5	100
20.0	98
10.0	93
6.30	87
3.35	79
2.00	73
1.18	67
0.600	63
0.425	61
0.212	59
0.150	58
0.063	55

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
GRAVEL	**27**
SAND	**18**
SILT/CLAY	**55**

Soil Description:
Grey slightly sandy slightly gravelly CLAY

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Compiled By		Date
M. Fisher	**MAUREEN FISHER**	**28/08/13**

Contract	Contract Ref:
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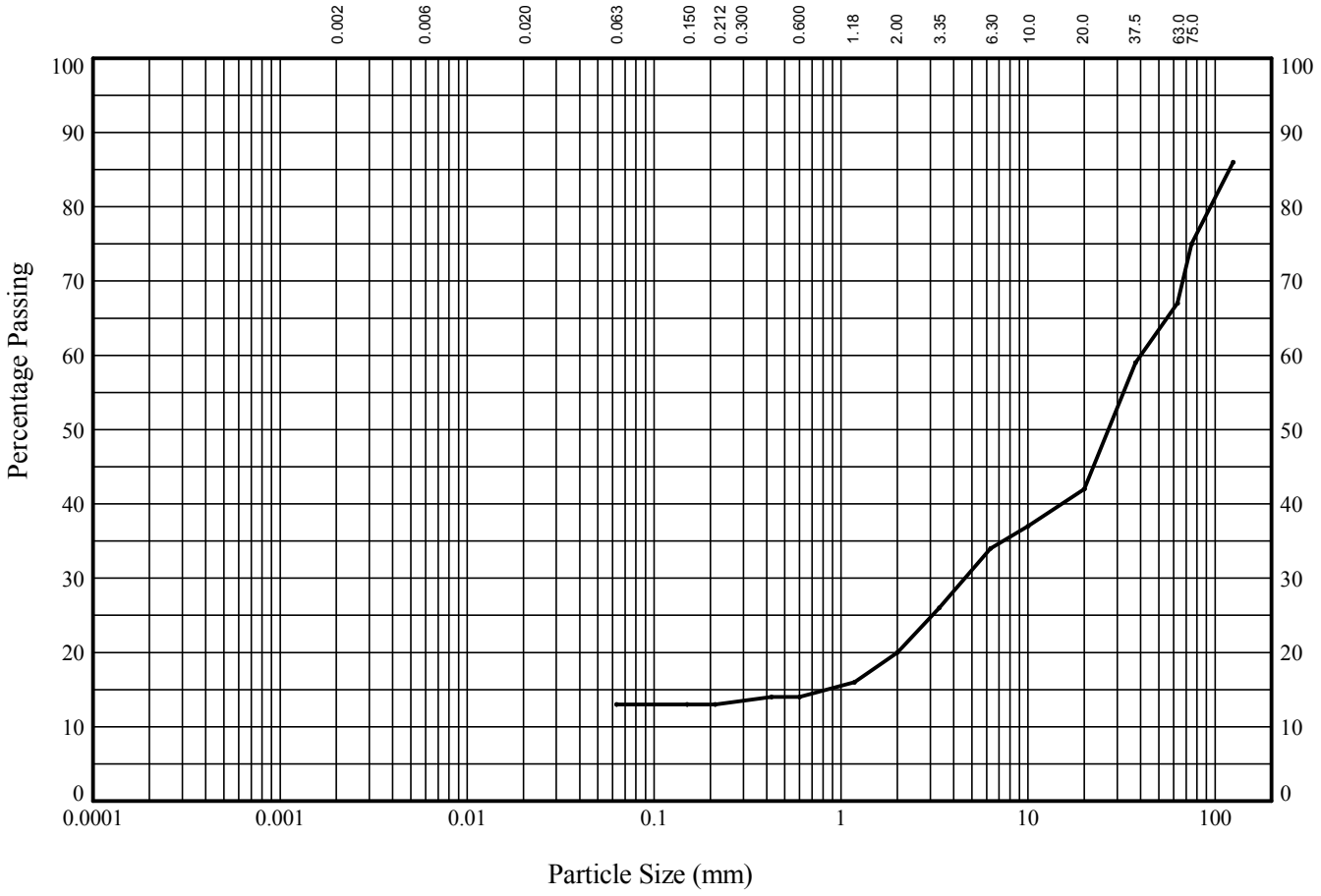
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Trial Pit : **TP8** Sample Ref: **1** Sample Type: **B** Depth (m): **3.30**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	86
75.0	75
63.0	67
37.5	59
20.0	42
10.0	37
6.30	34
3.35	26
2.00	20
1.18	16
0.600	14
0.425	14
0.212	13
0.150	13
0.063	13

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
COBBLES	**33**
GRAVEL	**47**
SAND	**7**
SILT/CLAY	**13**

Soil Description:
Grey clayey sandy GRAVEL with some cobbles

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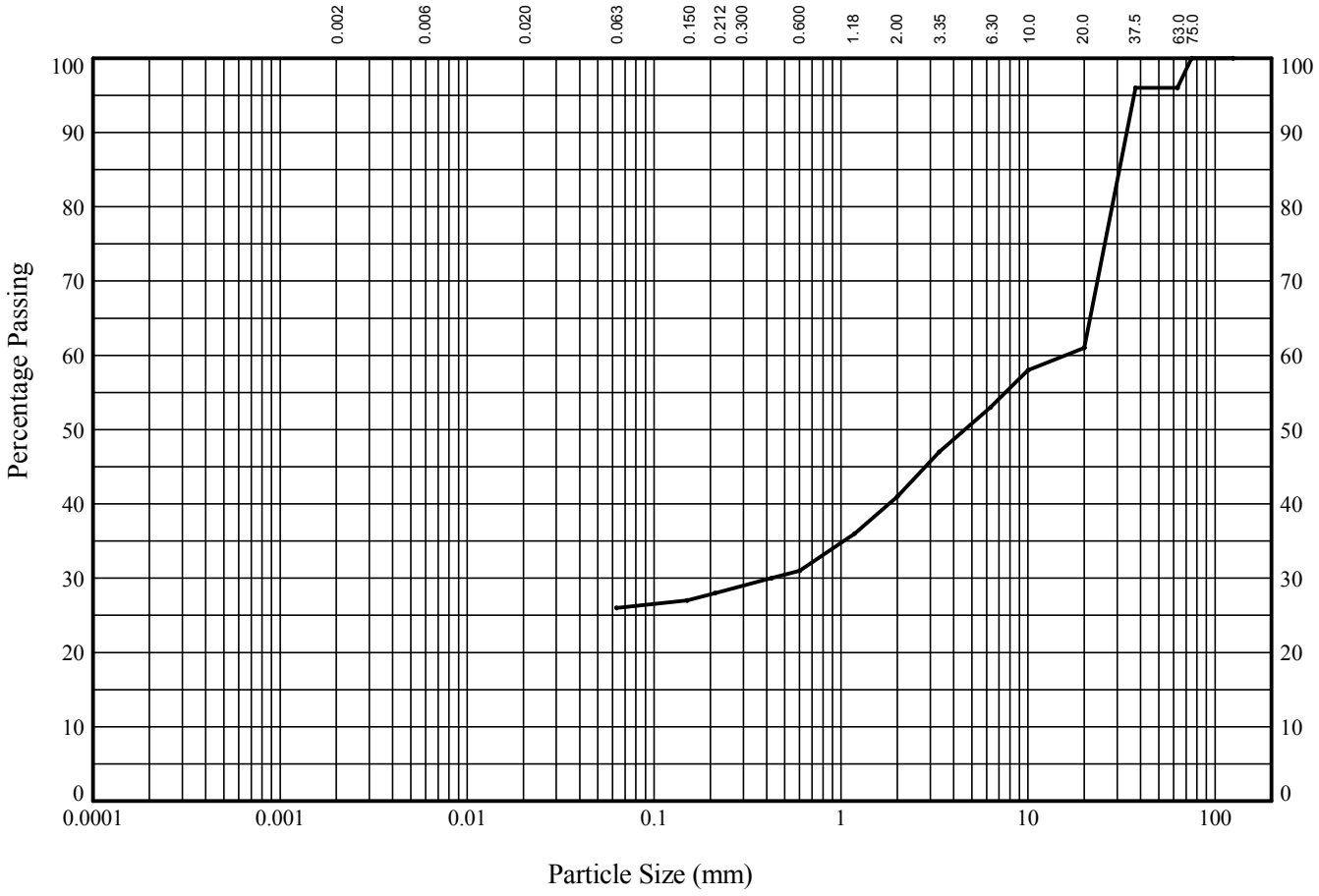
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Trial Pit : **TP13** Sample Ref: **1** Sample Type: **B** Depth (m): **1.20**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	100
63.0	96
37.5	96
20.0	61
10.0	58
6.30	53
3.35	47
2.00	41
1.18	36
0.600	31
0.425	30
0.212	28
0.150	27
0.063	26

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
COBBLES	**4**
GRAVEL	**55**
SAND	**15**
SILT/CLAY	**26**

Soil Description:
Dark grey slightly sandy gravelly CLAY with occasional cobbles

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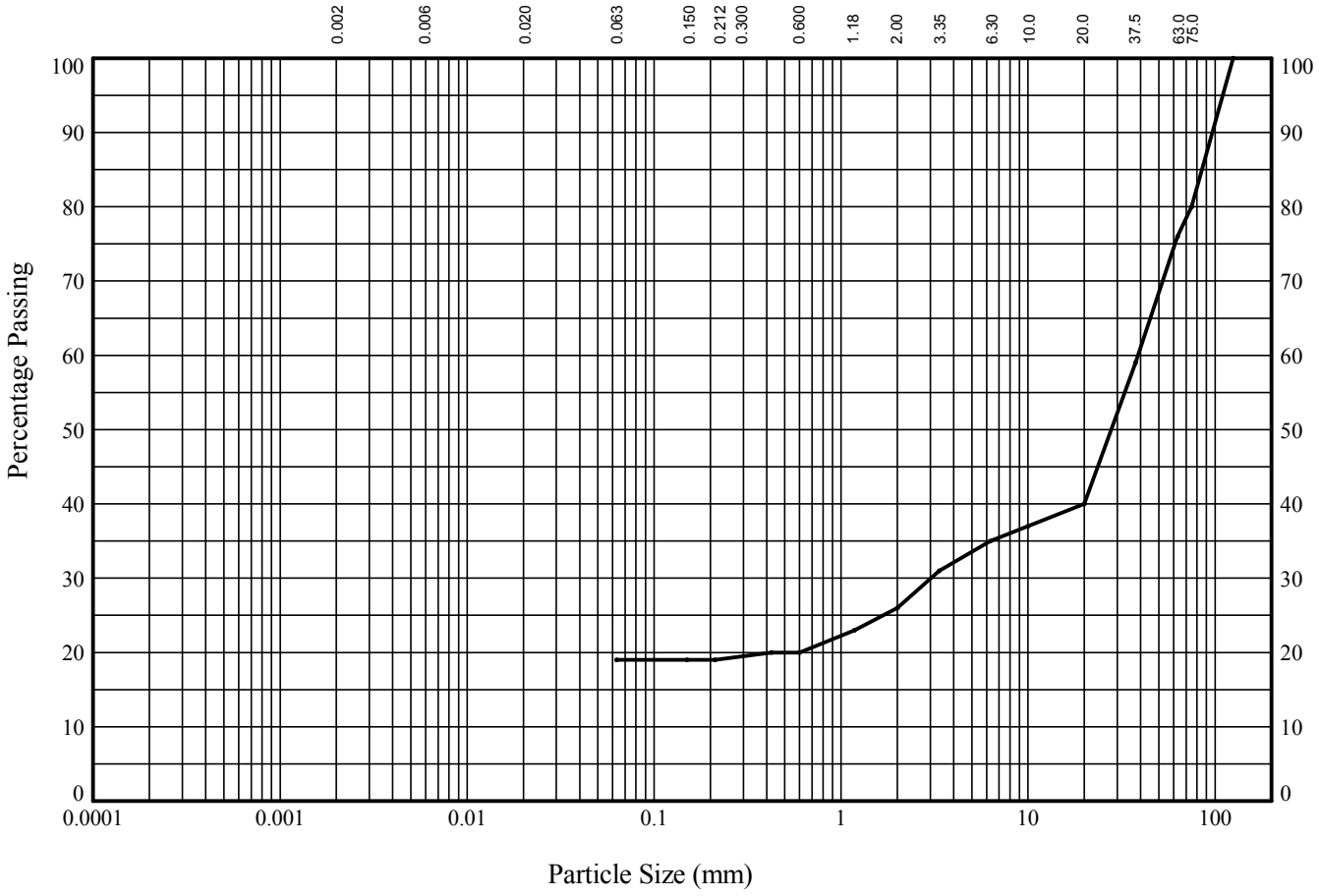
PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.5 of BS1377:Part 2:1990

Trial Pit : **TP15** Sample Ref: **1** Sample Type: **B** Depth (m): **1.70**



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve (mm)	Percentage Passing
125.0	100
75.0	80
63.0	76
37.5	59
20.0	40
10.0	37
6.30	35
3.35	31
2.00	26
1.18	23
0.600	20
0.425	20
0.212	19
0.150	19
0.063	19

Particle Diameter	Percentage Passing

Soil Fraction	Sieve Percentage
COBBLES	**24**
GRAVEL	**50**
SAND	**7**
SILT/CLAY	**19**

Soil Description:
Grey slightly sandy gravelly CLAY with many cobbles

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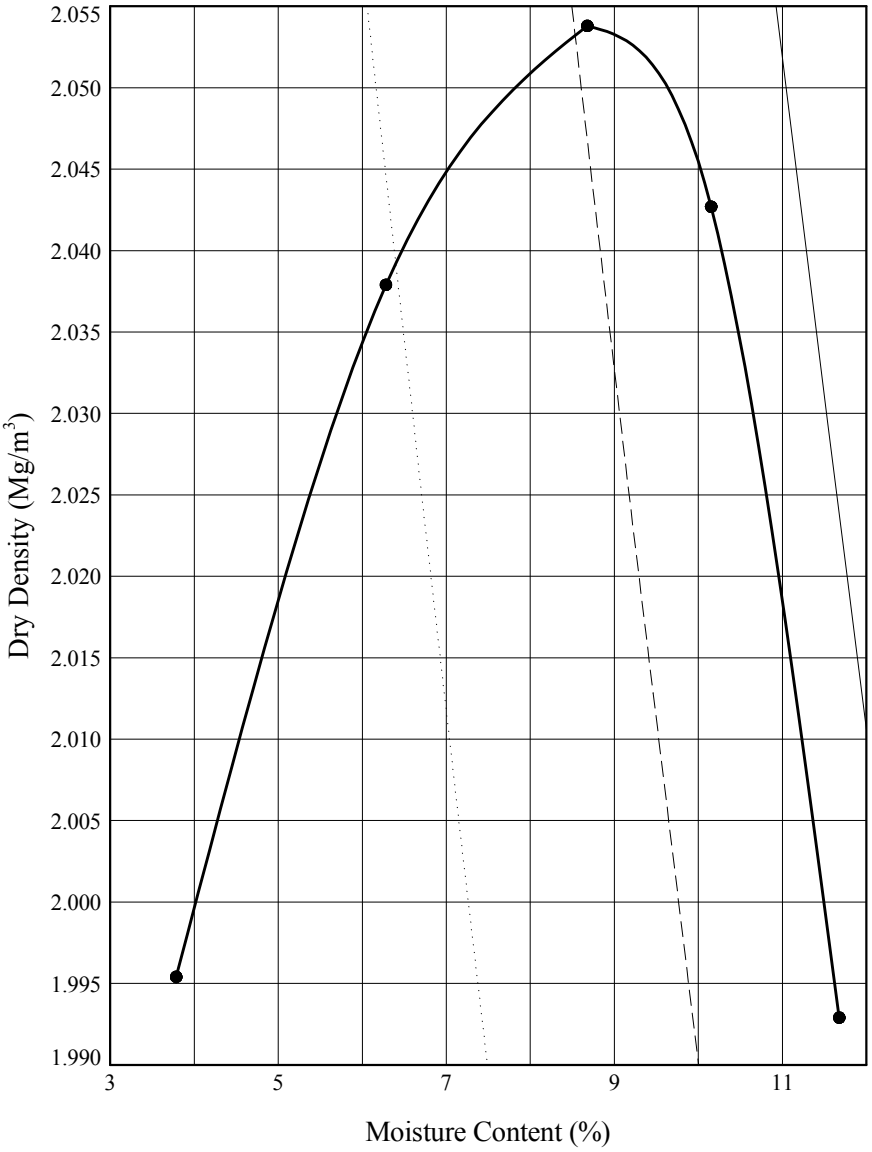
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

In accordance with clauses 3.3,3.4,3.5,3.6,3.7 of BS1377:Part 4:1990

Trial Pit : **TP3** Sample Ref: **1** Sample Type: **B** Depth (m): **2.10**



Initial Sample Conditions		Test Details		Test Results	
Initial Moisture Content (%)	: **8.7**	Compaction Type	: **Heavy**	Maximum Dry Density (Mg/m^3)	: **2.04**
% Retained on 37.5mm BS Sieve	: **0**	Mass of Rammer (kg):	**4.5**	Optimum Moisture Content (%)	: **10**
% Retained on 20.0mm BS Sieve	: **6**	Type of Mould	: **CBR**	Method Used:	**Clause 3.6**
Particle Density - assumed (Mg/m^3)	: **2.65**			Remarks:	
Size of Soil Pieces	: **<20mm**	Separate samples were used.			

Sample Description	Key to Air Voids Lines		
Brown clayey SAND with fine to coarse gravel	——— 0%	– – – – 5%	····· 10%

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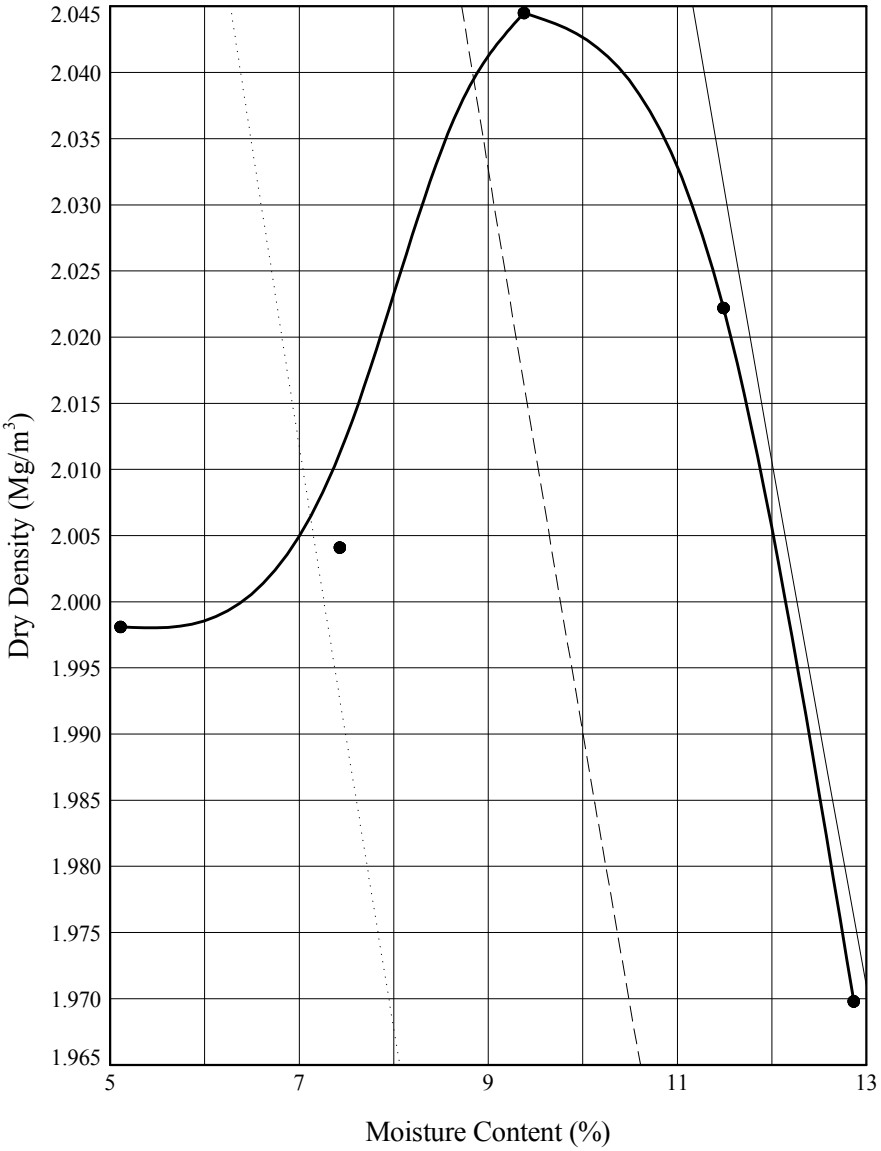
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

In accordance with clauses 3.3,3.4,3.5,3.6,3.7 of BS1377:Part 4:1990

Trial Pit : **TP4** Sample Ref: **2** Sample Type: **B** Depth (m): **0.30**



Initial Sample Conditions		Test Details		Test Results	
Initial Moisture Content (%)	: **5.1**	Compaction Type	: **Light**	Maximum Dry Density (Mg/m^3)	: **2.04**
% Retained on 37.5mm BS Sieve	: **0**	Mass of Rammer (kg):	**2.5**	Optimum Moisture Content (%)	: **10**
% Retained on 20.0mm BS Sieve	: **30**	Type of Mould	: **CBR**	Method Used: **Clause 3.4**	
Particle Density - assumed (Mg/m^3)	: **2.65**			Remarks:	
Size of Soil Pieces	: **<20mm**	Single sample was used.			

Sample Description	Key to Air Voids Lines		
Grey clay with mudstone	——— 0%	– – – – 5%	····· 10%

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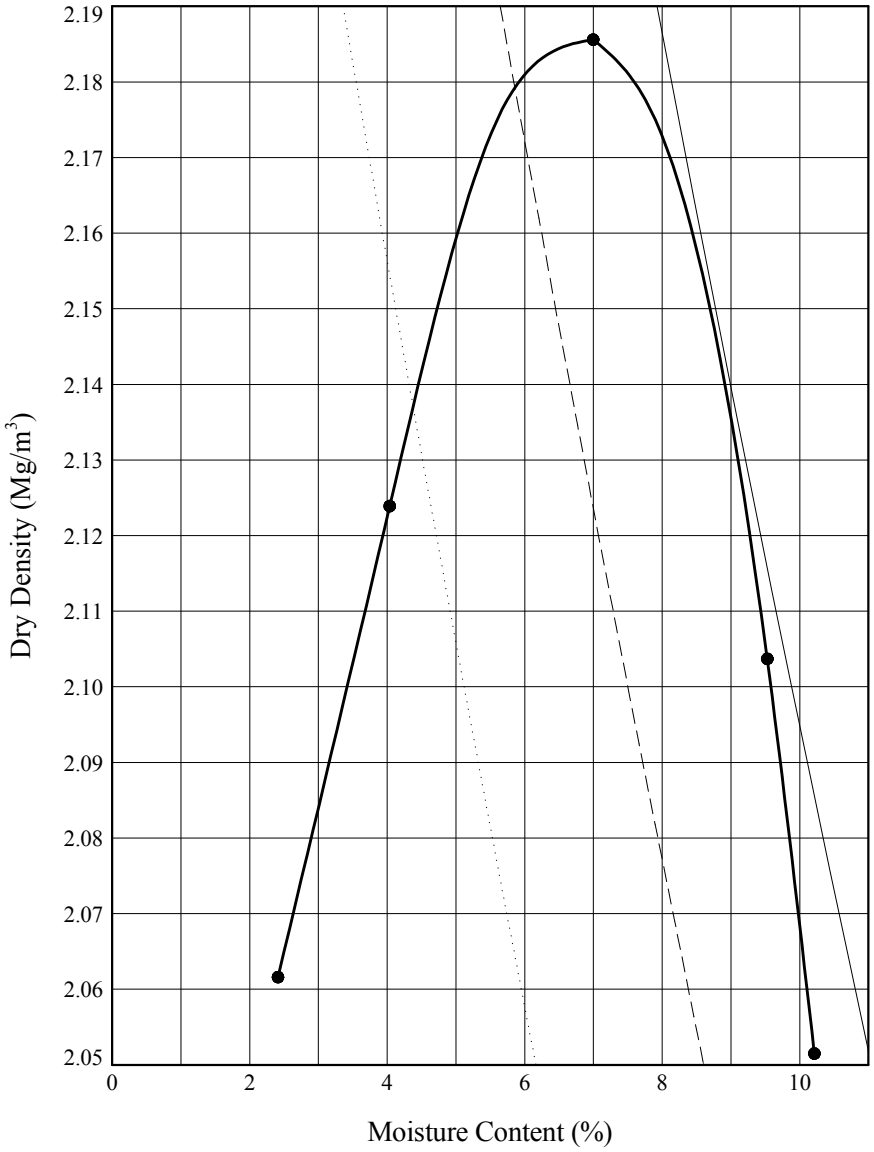
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

In accordance with clauses 3.3,3.4,3.5,3.6,3.7 of BS1377:Part 4:1990

Trial Pit : **TP7** Sample Ref: **2** Sample Type: **B** Depth (m): **0.50**



Initial Sample Conditions		Test Details		Test Results	
Initial Moisture Content (%)	: **7.0**	Compaction Type	: **Heavy**	Maximum Dry Density (Mg/m^3)	: **2.19**
% Retained on 37.5mm BS Sieve	: **0**	Mass of Rammer (kg):	**4.5**	Optimum Moisture Content (%)	: **7**
% Retained on 20.0mm BS Sieve	: **26**	Type of Mould	: **CBR**	Method Used: **Clause 3.6**	
Particle Density - assumed (Mg/m^3)	: **2.65**			Remarks:	
Size of Soil Pieces	: **<20mm**	Single sample was used.			

Sample Description	Key to Air Voids Lines		
	——— 0%	– – – – 5%	····· 10%

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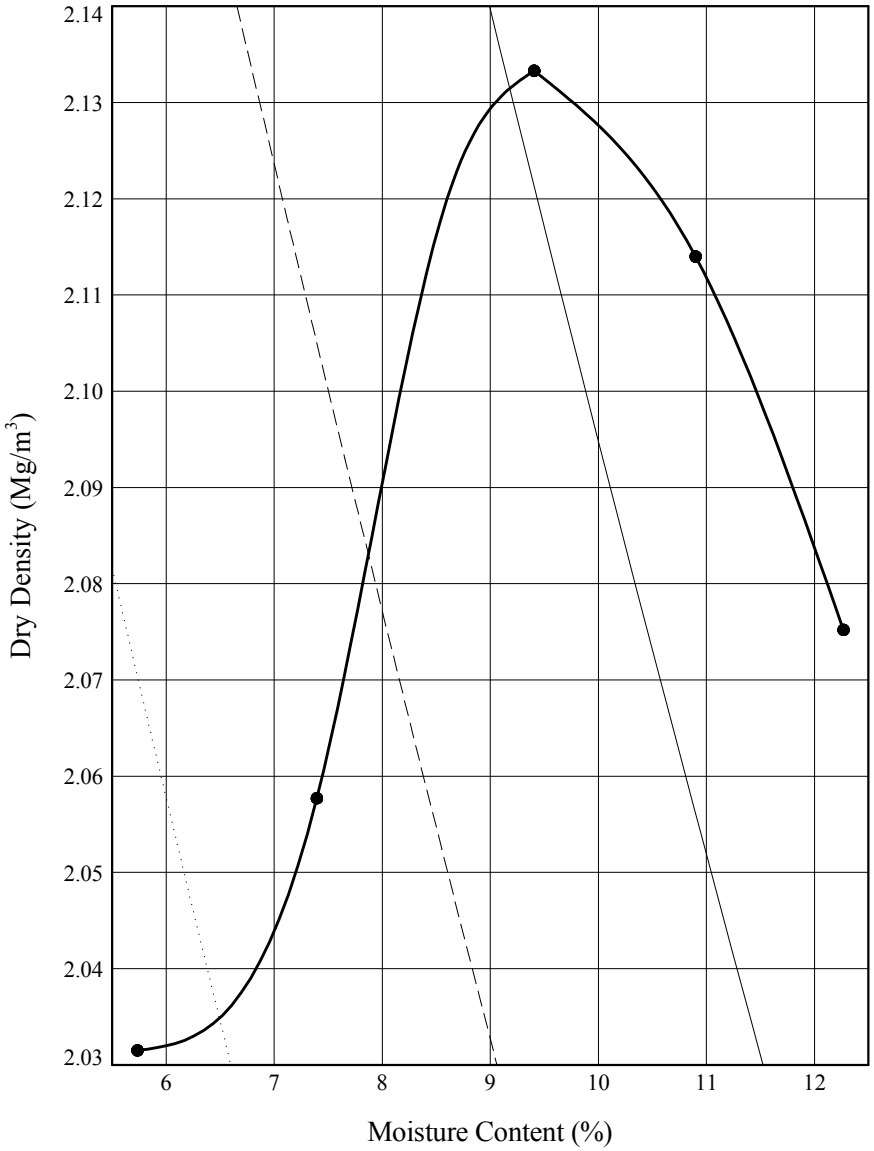
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

In accordance with clauses 3.3,3.4,3.5,3.6,3.7 of BS1377:Part 4:1990

Trial Pit : **TP12** Sample Ref: **1** Sample Type: **B** Depth (m): **1.80**



Initial Sample Conditions		Test Details		Test Results	
Initial Moisture Content (%)	: **5.7**	Compaction Type	: **Light**	Maximum Dry Density (Mg/m³)	: **2.13**
% Retained on 37.5mm BS Sieve	: **0**	Mass of Rammer (kg):	**2.5**	Optimum Moisture Content (%)	: **9**
% Retained on 20.0mm BS Sieve	: **30**	Type of Mould	: **CBR**	Method Used: **Clause 3.4**	
Particle Density - assumed (Mg/m³)	: **2.65**			Remarks:	
Size of Soil Pieces	: **<20mm**	Separate samples were used.			

Sample Description	Key to Air Voids Lines		
Grey CLAY/MUDSTONE	——— 0%	– – – – 5%	····· 10%

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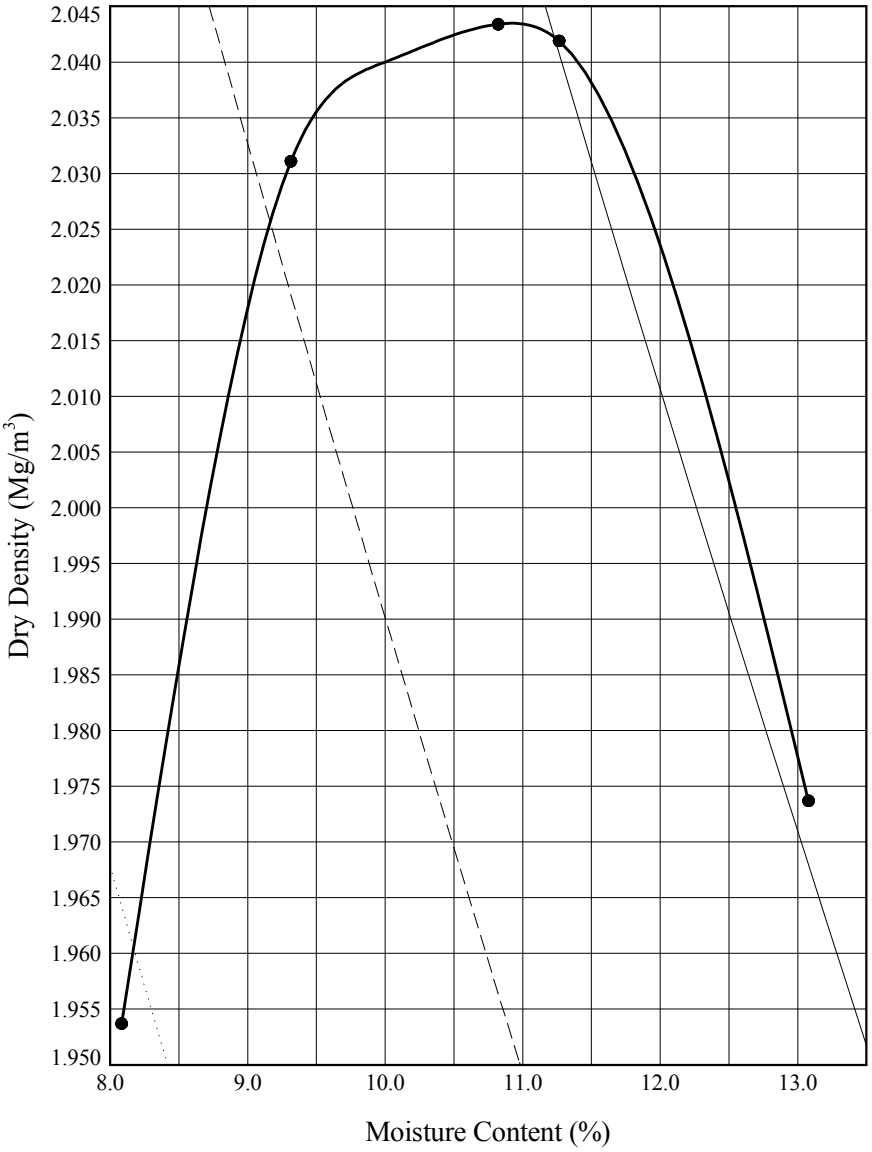
DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

In accordance with clauses 3.3,3.4,3.5,3.6,3.7 of BS1377:Part 4:1990

Trial Pit : **TP14** Sample Ref: **1** Sample Type: **B** Depth (m): **1.40**



Initial Sample Conditions			Test Details			Test Results		
Initial Moisture Content (%)	:	**8.1**	Compaction Type	:	**Light**	Maximum Dry Density (Mg/m³)	:	**2.04**
% Retained on 37.5mm BS Sieve	:	**0**	Mass of Rammer (kg):		**2.5**	Optimum Moisture Content (%)	:	**11**
% Retained on 20.0mm BS Sieve	:	**29**	Type of Mould	:	**CBR**	Method Used: **Clause 3.4**		
Particle Density - assumed (Mg/m³)	:	**2.65**				Remarks:		
Size of Soil Pieces	:	**<20mm**	Separate samples were used.					

Sample Description	Key to Air Voids Lines		
Grey CLAY/MUDSTONE	——— 0%	– – – – 5%	····· 10%

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