



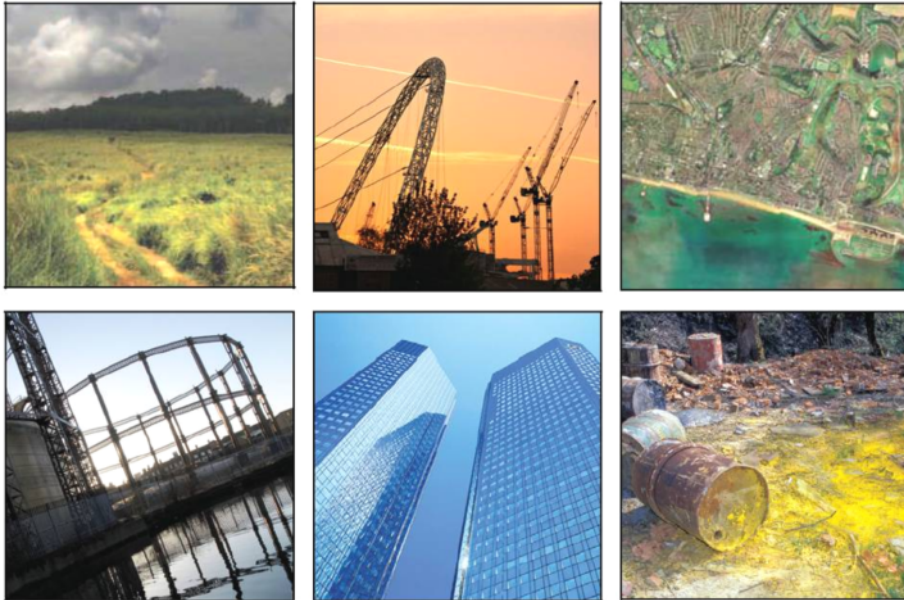
Mill Road, Hertford

Phase II

Geo-Environmental and Geotechnical Site Investigation

For



BRB Residuary



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HLEI 17433/002R
December 2011

<p>This report has been prepared within the RPS Group Quality Management System to British Standard EN ISO 9001 : 2000.</p>			
Report Type:		Phase II Geo-Environmental and Geotechnical Site Investigation	
Report Status:		DRAFT	
Project Reference:		HLEI 17433	
	Consultant	Signature	Date
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Technical Review:	Rob Glavin		December 2011

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1.0 EXECUTIVE SUMMARY

BRB Residuary (the client) plan to redevelop the site of Mill Road, Hertford SG14 1SW as two, three and four storey residential apartments with associated areas of soft landscaping, car parking areas and access roads.

RPS Health, Safety & Environment (RPS) has been commissioned to undertake a Phase II intrusive site investigation and subsequent risk assessment to determine the likely redevelopment constraints, risk of future liability, the potential risk to the current and future users of the site and its environs, as well as the wider environment. The investigation will also highlight geotechnical constraints and offer preliminary advice on foundation, floor slab and pavement design.

The site investigation comprised the advancement of five cable percussive boreholes to depths ranging from 10.0m bgl to 20.0m bgl. Eight trial pits were excavated by mechanical methods and two trial pits were excavated by hand in order to obtain shallow soil samples for contamination testing. Ground gas and groundwater monitoring wells were installed in all boreholes. In-situ geotechnical testing was undertaken at regular intervals within all boreholes. Disturbed soil samples were collected for both geotechnical and chemical analysis.

A variable thickness of Made Ground was encountered from ground surface at most exploratory hole locations on site. Made Ground was encountered underlying tarmac or concrete hardstanding in a limited number of exploratory holes. Kempton Park Gravels were encountered underlying hardstanding in the majority of exploratory holes. Lewes Nodular Chalk was encountered in cable percussive boreholes only. Groundwater was encountered at depths ranging from 5.5m bgl to 6.1m bgl within cable percussive boreholes during drilling works. Groundwater was recorded at depths ranging from 4.6m bgl to 5.9m bgl during the subsequent monitoring program.

PAH determinands have been detected within shallow soils on site at concentrations significantly in excess of adopted AC. It is considered by RPS that this is associated with the presence of a generally limited thickness of Made Ground present across the site area. One sample of Made Ground collected from borehole BH4 at a depth of 2.3m bgl contained a concentration of lead in excess of AC for residential land use. Laboratory analysis of natural soil samples underlying the Made Ground did not detect contaminant concentrations in excess of adopted AC. This indicates that the measured contaminant concentrations are not impacting deeper strata.

Lead and PAH contaminants are not significantly volatile and the exposure pathways of direct contact, inhalation and ingestion of soil or dust particles would not be active where contamination is present underlying proposed building footprints and areas of hardstanding. In proposed garden areas, it is recommended that a clean cover of 600mm validated, imported topsoil is placed to break the exposure pathway to future site users. An anti-dig geotextile membrane should be placed below the topsoil to prevent future exposure to deeper soils. If located in a proposed area of communal landscaping, the thickness of clean imported soil can be reduced to 150mm.

Water samples collected from monitoring wells during the first return visit to site did not contain contaminant concentrations in excess of EQS or DWS screening criteria.

Concentrations of methane, carbon dioxide and volatile organic compounds detected during a subsequent monitoring visit were low and ground gas protection measures are not considered necessary as part of the proposed development.

Based on the findings of the site investigation, the potential risk to site users, controlled waters and other environmental receptors is considered to be **LOW**.

Given the variable nature of Made Ground, it is recommended that this is not used as a bearing stratum.

It is understood at this stage that three storey apartments are proposed in the south and east of the site, with higher rise, four storey apartments proposed for the north and west sections. It is considered that traditional strip and pad foundations bearing within the Kempton Park Gravels is likely to be the most suitable foundation solution to support lightly to moderately loaded structures, up to three storeys in height. Settlement underlying a traditional strip or pad foundation bearing within the Kempton Park Gravel at a pressure of 150kN/m² is anticipated to be in the order of 10mm. For more heavily loaded structures, in excess of three storeys in height, it is likely that piled foundations will be required.

In accordance with NHBC guidelines, ground bearing floor slabs should be suitable for the proposed development where the depth of untreated Made Ground does not exceed 0.6m bgl. In areas where Made Ground exceeds 0.6m in thickness, it is recommended that either suspended floor slabs are adopted or that Made Ground is excavated and replaced in a controlled manner.

It is anticipated that a CBR value of 10% may be adopted for a preliminary design value for the Kempton Park Gravels. A lower value of 3% should be adopted if Made Ground

is present at pavement founding level. This should be confirmed by testing at the construction stage.

It is recommended that a concrete design class of DS-2 and an ACEC class of AC-2 is adopted on site.

2.0 INTRODUCTION

2.1 Preamble

BRB Residuary (the client) plan to redevelop the site of Mill Road, Hertford SG14 1SW as two, three and four storey residential apartments with associated areas of soft landscaping, car parking areas and access roads.

RPS Health, Safety & Environment (RPS) has been commissioned to undertake a Phase II intrusive site investigation and subsequent risk assessment to determine the likely redevelopment constraints, risk of future liability, the potential risk to the current and future users of the site and its environs, as well as the wider environment. The investigation will also highlight geotechnical constraints and offer preliminary advice on foundation, floor slab and pavement design.

2.2 Previous Investigations

RPS have previously undertaken a Phase I Environmental Assessment at the subject site, dated June 2011, reference HLEI17433/001R. The report is summarised as follows:

- At the time of the assessment, the north and the west of the site comprised an operational waste transfer station. A Speedy hire centre and goods yard was present in the west and the south and east of the site was heavily vegetated.
- The site comprised railway sidings from at least 1881 until approximately 1960. Two railway tracks remained since this time, although they were no longer operational. A gravel pit was present in the east of the site from 1881, extending off-site to the south. This is shown as being backfilled in maps from 1898 onwards.
- Historic surrounding land uses include a gasworks and various engineering works to the north of the site, gravel pits to the north, east and south and railway land to the south.
- The site was considered to be in a sensitive environmental setting due to the presence of Secondary (A) Aquifers underlying the site, relating to the Kempton Park Gravels and underlying Lewes Nodular Chalk.
- The report concludes that there is potential for localised contamination present on site to impact future site users and controlled water receptors and that mitigation measures may be required as part of the proposed development.

2.3 Potential Areas of Concern

On Site Sources

Based upon the site history, previous investigation reports and initial desk study, the following potential sources of on-site contamination have been identified. These key areas are outlined below and will form the basis of the intrusive site investigation with respect to soil and groundwater contamination.

- Review of historical maps indicates that the subject site comprised railway sidings from at least 1881 until approximately 1960, when the site was no longer operational. Contaminants associated with railway land uses include hydrocarbons, metals and asbestos.
- The nature of material used to infill a former gravel pit in the east of the site is unknown. However, contaminants potentially associated with backfill material of this age include hydrocarbons, metals and asbestos.

Off-Site Sources

Neighbouring historical land uses within a 250m radius of the site have included engineering works, railway land, a gas works, a vehicle depot, gravel pits and a gas works.

It is anticipated that groundwater flow beneath the site is towards the River Lea to the north-west of the site. This is considered to limit the potential for contaminants associated with neighbouring land uses to impact the site, as the majority of these are located to the north of the site. However, contaminants from nearby railway land to the south have the potential to impact the site.

2.4 Preliminary Conceptual Model

The following potentially significant sources of contamination have been identified on site and in the neighbouring area as part of the preliminary desk study.

Table 1: Preliminary Conceptual Site Model

Sources	Pathways	Receptors
Waste Transfer Depot Hydrocarbons, metals, asbestos Former Railway Land Hydrocarbons, metals, asbestos Historic Infilled Gravel Pit Hydrocarbons, metals, asbestos	Human Health -Dermal contact -Inhalation of soil dust -Ingestion of soil dust -Inhalation soil vapour	-Current site users -Construction workers -Future site users -Off-site receptors
Historic Off-Site Engineering Works Hydrocarbons Historic Off-Site Gas Works Hydrocarbons Historic Off-Site Electricity Works Hydrocarbons	Controlled Waters -Leaching of mobile contaminants -Vertical and lateral migration of mobile contaminants in permeable strata. -Migration along subsurface structures.	- Secondary (A) Aquifers (Kempton Park Gravels and Lewes Nodular Chalk) - River Lea
	Infrastructure -Direct contact with soils -Migration of ground gas	-Underground concrete/brick structures. -Underground utility services -Above ground structures

The site investigation works were targeted to provide further detailed information on the potential Pollutant Linkages in this preliminary CSM.

3.0 SITE INVESTIGATION

3.1 Objectives

The objectives of the site investigation were to assess:

1. Ground conditions and the geotechnical properties of the strata underlying the site.
2. The contamination status of shallow soils and groundwater underlying the site; and
3. The ground gas regime on site.

3.2 Description of Works

The site investigation was carried out between 7th and 11th November 2011 and comprised:

- Two boreholes advanced by cable percussive techniques to a depth of 10.0 metres below ground level (m bgl) and three boreholes to 20.0m bgl.
- In-situ standard penetration testing (SPT) at regular intervals throughout the depth of the borehole.
- Collection of disturbed and undisturbed soil samples for environmental and geotechnical laboratory analysis.
- Installation of a groundwater/gas monitoring wells within all boreholes.
- Trial pitting in ten locations in order to collect soil samples for contamination testing.

Borehole and Trial Pit logs are presented as Appendix A. Figure 2 shows the location of all exploratory holes.

The soil arisings from each hole were carefully examined for visual and olfactory evidence of contamination.

Soil samples were collected in clean jars and tubs for chemical laboratory testing and forwarded to a UKAS accredited laboratory for analysis.

Disturbed soil samples were collected for geotechnical laboratory analysis and forwarded to a UKAS accredited laboratory.

Three ground gas monitoring visits were undertaken from 17th November to 2nd December 2011. Installations were monitored for concentrations of methane, carbon dioxide and oxygen. In addition the flow rate and barometric pressure were recorded.

3.3 Laboratory Testing

Environmental Laboratory Testing

Seven samples of Made Ground and four samples of natural strata were analysed for a wide range of determinands as follows:

Asbestos, pH, arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, sulphide, sulphate, cyanide, phenols, polyaromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH).

Groundwater samples were collected on the first monitoring visit to site and submitted for laboratory testing for a similar range of determinands.

Certificates of the chemical analyses are presented as Appendix B.

Geotechnical Laboratory Testing

Three samples of Made Ground and three samples of natural strata were collected and submitted to a geotechnical testing laboratory. The following tests were undertaken:

- Four BRE Suite SD1
- Four Particle Size Distribution

Certificates of the geotechnical analyses are presented as Appendix E.

3.4 Ground Conditions

Geology

Strata encountered are summarised in Table 2 and described in the following section:

Table 2: Encountered Strata

Strata	Depth to Top of Strata (m bgl)	Thickness (m)
Made Ground	Ground level – 0.2	0.3 – 2.6
Kempton Park Gravels	0.3 – 2.6	3.8 – 7.8 (where proven)
Lewes Nodular Chalk	5.4 – 8.5 (where encountered)	Not proven

A variable thickness of Made Ground was encountered from ground surface at most exploratory hole locations on site. Made Ground was encountered underlying tarmac or concrete hardstanding in a limited number of exploratory holes. Kempton Park Gravels were encountered underlying hardstanding in the majority of exploratory holes. Lewes Nodular Chalk was encountered in cable percussive boreholes only.

Descriptions of the strata encountered during the intrusive investigation are summarised below:

Made Ground

Made Ground was encountered within all exploratory holes undertaken on site. The stratum varied in thickness and was encountered to a maximum depth of 2.6m bgl within borehole BH4. The thickness of Made Ground was not proven in hand pits TP9 and TP10.

The Made Ground was variable in nature, but generally comprised soft, brown, sandy, gravelly clay. Gravel constituents comprised ash, flint, brick, concrete and rare, slag, ceramic, glass and metal. Reference should be made to the exploratory hole logs within Appendix A of this report for full descriptions of this stratum.

Standard Penetration Testing (SPTs)

Two SPT test results obtained from within the cohesive Made Ground within borehole BH4 at depths of 1.0m bgl and 2.0m bgl gave results of $N = 10$ and $N = 14$. Using the correlation by Stroud, this approximately relates to shear strength values of 50kN/m^2 and 70kN/m^2 , which is indicative of a soft to firm material.

A plot of SPT values *versus* depth is included as figure 3 of this report.

Grading

Particle size distribution (PSD) testing was undertaken on two samples collected from the Made Ground from within borehole BH1 at a depth of 0.5m bgl – 1.0m bgl and from

borehole BH4 at a depth of 0.7m bgl – 1.0m bgl. The constituents of the samples are summarised below:

- Gravel: 23.3% - 67.1%
- Sand: 22.8% - 53.8%
- Silt and Clay: 10.1% - 22.9%

Kempton Park Gravels

Kempton Park Gravels were encountered underlying Made Ground in the majority of exploratory holes. The stratum generally comprised sandy gravel of medium to coarse, sub-rounded to sub-angular flint. Reference should be made to the exploratory hole logs within Appendix B of this report for full descriptions of this stratum.

Standard Penetration Testing (SPTs)

SPT test results obtained from within the Kempton Park Gravels ranged between N = 10 and N < 50, which is indicative of a medium dense to very dense granular material.

A plot of SPT values *versus* depth is included as figure 3 of this report.

Grading

Particle size distribution (PSD) testing was undertaken on two samples collected from the Kempton Park Gravels from within borehole BH1 at a depth of 3.5m bgl – 4.0m bgl and from borehole BH2 at a depth of 7.5m bgl – 8.0m bgl. The constituents of the samples are summarised below:

- Gravel: 73.8% - 87.4%
- Sand: 12.5% - 26.0%
- Silt and Clay: 0.0% - 0.2%

Lewes Nodular Chalk

Lewes Nodular Chalk was encountered within all cable percussive boreholes at depths ranging from 5.4m bgl to 8.5m bgl. The chalk was generally recovered as a gravel of medium to coarse, off-white chalk and angular flint.

Standard Penetration Testing (SPTs)

SPT test results obtained from within the Lewes Nodular Chalk ranged between N = 5 and N = 34 and generally increase with depth.

A plot of SPT values *versus* depth is included as figure 3 of this report.

Field Evidence of Contamination

Ash like materials were noted within Made Ground in exploratory holes BH1, BH3, TP1, TP2, TP3, TP4 and TP8. Ash is associated with furnace waste and often contains increased concentrations of hydrocarbon contaminants.

Fragments of slag were observed within Made Ground in trial pit TP4. Slag is a waste product of foundry processes and is associated with increase concentrations of metals.

Groundwater

Groundwater was encountered at depths ranging from 5.5m bgl to 6.1m bgl within cable percussive boreholes during drilling works. Gas and groundwater monitoring wells were installed within all boreholes. Dual monitoring wells were installed within boreholes BH1 and BH4. The groundwater monitoring results are summarised in Table 3.

Table 3: Groundwater Monitoring Results

Monitoring Well	Well Screen Depth (m bgl)	Depth to Water (m bgl)		
		17 th November 2011	25 th November 2011	2 nd December 2011
BH1 (Shallow)	1.00 – 1.50	-	-	-
BH1 (Deep)	2.00 – 8.50	5.56	5.53	5.55
BH2	1.00 – 8.30	5.43	5.88	5.65
BH3	1.00 – 5.40	4.59	5.80	5.75
BH4 (Shallow)	1.00 – 2.60	-	-	-
BH4 (Deep)	3.00 – 6.40	5.28	5.33	5.35
BH5	1.00 – 7.20	5.80	5.84	5.83

It is considered that this is representative of a continuous groundwater table within the Kempton Park Gravels.

4.0 GEOTECHNICAL ANALYTICAL DATA

4.1 Proposed Development

BRB Residuary Ltd (the client) plan to redevelop the site at Mill Road, Hertford as three to four storey residential apartments. It is understood at this stage that no significant change in site levels is proposed as part of the development. If significant cut and fill operation is planned, then the conclusions and recommendations within this section should be reassessed.

4.4 Foundation and Basement Design

Traditional Foundations

Given the variable nature of Made Ground, it is recommended that this is not used as a bearing stratum.

It is understood at this stage that three storey apartments are proposed in the south and east of the site, with higher rise, four storey apartments proposed for the north and west sections. It is considered that traditional strip and pad foundations bearing within the Kempton Park Gravels is likely to be the most suitable foundation solution to support lightly to moderately loaded structures, up to three storeys in height. Based on exploratory hole logs the majority of strip foundations are likely to bear within granular soils at a depth of 1.0m bgl to 2.0m bgl. Footing depths may have to be increased locally in the area of borehole BH4 to 3.0m bgl, where an increased thickness of Made Ground was encountered. Based on SPT results achieved within this stratum, an allowable bearing pressure of 150kN/m² is likely to be achievable.

Using the method specified by Schultze and Sherif, settlement underlying a traditional strip or pad foundation bearing within the Kempton Park Gravel at a pressure of 150kN/m² is anticipated to be in the order of 10mm. This is based on an average SPT value within the gravels of N = 18 and a strip foundation 1.0m in width.

Piled Foundations

For more heavily loaded structures, in excess of three storeys in height, it is likely that piled foundations will be required. It is anticipated that both bored and driven piles will be suitable on the subject site from a geotechnical viewpoint. Driven piles produce less spoil and can mobilise higher base bearing capacities. However, they may be unsuitable from a noise/nuisance point of view due to nearby residential neighbours. Anticipated pile bearing capacities are detailed in Table 4 below:

Table 4: Anticipated Pile Capacities (kN)

Pile length (m)	Pile Diameter				
	300mm	450mm	600mm	750mm	900mm
12	100	195	315	465	645
14	105	205	335	495	690
16	130	260	430	645	900
18	145	290	485	730	1025

A factor of safety of 3.0 has been used to calculate these pile capacities.

These pile capacity estimates are preliminary and are based on a conservative soil profile derived from exploratory holes undertaken on site. The adopted pile profile is summarised as follows:

- Made Ground: Ground level – 1.0m bgl.
- Kempton Park Gravels: 1.0m bgl – 6.0m bgl.
- Lewes Nodular Chalk: 6.0m bgl to a maximum proven depth of 20.0m bgl.

Due to the variability of the Made Ground, the strength contribution offered by these strata has been ignored in the pile capacity calculation. However, consideration should be given to the action of negative skin friction on the pile shaft by consolidating Made Ground. This has not been assessed as part of this investigation.

Preliminary pile capacity calculations are based on single piles and do not take into account of the action of piles in groups. This should be considered at the detailed design stage.

Exact pile bearing capacities should be confirmed by the piling contractor at the detailed design stage, as they are dependant upon the pile type adopted.

4.3 Floor Slabs

In accordance with NHBC guidelines, ground bearing floor slabs should be suitable for the proposed development where the depth of untreated Made Ground does not exceed 0.6m bgl. In areas where Made Ground exceeds 0.6m in thickness, it is recommended that either suspended floor slabs are adopted or that Made Ground is excavated and replaced in a controlled manner (i.e. is placed and compacted in layers not exceeding 150mm). It is recommended that discussions are held with the NHBC at an early stage in the development process regarding this matter.

Settlement underlying ground bearing floor slabs is anticipated to be within acceptable limits (<25mm). This value is based on a floor slab pressure of 20kN/m² and a

thickness of untreated Made Ground no greater than 0.6m in thickness underlying the slab. Settlement within properly placed Made Ground and the underlying Kempton Park Gravel is anticipated to be low compared to settlement within untreated Made Ground.

4.4 Chemical Attack on Buried Concrete

Ten samples of Made Ground and natural soils and five groundwater samples were submitted for analysis for pH and water soluble sulphate content. The results are presented in Table 5, below:

Table 5: Results of BRE sulphate testing

Sample Location (m)	Sample Type	pH	Water soluble (2:1 extract) sulphate (mg/l)	Design Sulphate Class	ACEC Class
BH1 1.5-2.0	Kempton Park Gravels	6.7	29	DS-1	AC-1
BH2 2.5-3.0	Kempton Park Gravels	8.3	29	DS-1	AC-1
BH3 0.2-0.3	Made Ground	7.8	54	DS-1	AC-1
BH5 8.2	Lewes Chalk	8.3	33	DS-1	AC-1
TP1 0.2	Made Ground	8.2	140	DS-1	AC-1
TP3 0.4	Made Ground	8.4	1200	DS-2	AC-2
TP4 0.2	Made Ground	8.4	71	DS-1	AC-1
TP5 0.5	Made Ground	6.9	16	DS-1	AC-1
TP7 1.0	Kempton Park Gravels	8.2	23	DS-1	AC-1
TP8 0.3	Made Ground	8.6	38	DS-1	AC-1
BH1 Deep	Groundwater	7.2	37	DS-1	AC-1
BH2	Groundwater	7.1	1100	DS-2	AC-2
BH3	Groundwater	7.1	130	DS-1	AC-1
BH4 Deep	Groundwater	7.2	55	DS-1	AC-1
BH5	Groundwater	7.2	27	DS-1	AC-1

Based on the available data for the soils beneath the site, the design sulphate class for buried concrete should be DS-2, and the ACEC class should be AC-2. However, further testing of shallow soils at the construction stage may allow a lesser sulphate class to be adopted in some site areas.

4.5 Pavements

Upon review of the ground conditions within the top 1.0m bgl on site, it is anticipated that a CBR value of 10% may be adopted for a preliminary design value for the Kempton Park Gravels. A lower value of 3% should be adopted if Made Ground is

present at pavement founding level. This should be confirmed by testing at the construction stage.

Time average pavement loading is not anticipated to be significant for the proposed development. Therefore, settlement underlying external pavement areas is likely to be minimal.

4.6 Temporary Works and Excavations

Excavation should be possible with conventional earth moving plant. Groundwater was encountered from depths of 5.5m bgl during the site investigation phase. Subsequent groundwater monitoring recorded groundwater at depths ranging from 4.6m bgl to 5.8m bgl.

Dewatering works will therefore be required for deep excavations in excess of 4.6m depth. It may be possible to obtain consent to discharge groundwater to the local sewer system during dewatering works. The Environment Agency should be consulted at an early stage to obtain necessary consents, should this be required.

Significant dewatering works are not anticipated to be necessary. However, if limited quantities of shallow, perched groundwater is encountered, limited pumping may be required from a localised sump.

If perched groundwater is encountered during excavation, significant degradation of the formation may occur. The formation should therefore be adequately protected from seepages and shielded from adverse weather conditions.

5.0 CHEMICAL ANALYTICAL DATA

5.1 Soil Assessment Criteria

The soil analytical data has initially been assessed using Site Specific Assessment Criteria (AC) derived using CLEA v1.06 software. These AC are protective of human health receptors. The assessment has been based upon residential land use with a female child being the most sensitive receptor.

The following exposure pathways were assumed to be potentially active:

- Dermal contact with soil and soil dust (indoor & outdoor);
- Ingestion of soil and soil dust (indoor & outdoor);
- Inhalation of soils and soil dust (indoor & outdoor); and
- Inhalation of soil vapour (indoor & outdoor).
- Soil attached to and consumption of home grown vegetables.

The key model input values were as follows:

- Land use (generic): Residential land use;
- Building type (generic): Small terraced house
- Receptor (generic): Female receptor (1 - 6 years of age);
- Exposure (generic): 49 years;
365 days/year;
23 hrs/day indoors & 1 hrs/day outdoors;
- Soil Type (generic): Sand;
- Soil pH (specific): 7.98 (mean – analytical data);
- Soil Organic Matter (specific): 3.31% (mean – analytical data);

A complete copy of the CLEA model input values and output values are presented as Appendix C.

5.2 Soil Analytical Data

Seven samples of Made Ground four samples of Kempton Park Gravels and one sample of Lewes Nodular Chalk were analysed for a wide range of determinands as listed in Section 3.3.

Soil Properties

Soil pH ranged from 6.9 to 8.6 in samples of Made Ground and 6.7 to 8.3 in natural strata with a mean soil pH value of 7.98.

Inorganic Determinands

Eleven soil samples were analysed for a wide range of inorganic determinands. Concentrations of inorganic determinands detected were generally below adopted AC. One soil sample collected from borehole BH4 at a depth of 2.3m bgl contained lead concentrations in excess of AC for residential land use (340mg/kg).

Polyaromatic Hydrocarbons

Ten soil samples were analysed for speciated (16) polyaromatic hydrocarbons (PAH). Concentrations of a number of PAH determinands, including naphthalene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were detected in samples of Made Ground taken from exploratory holes BH3, TP3, TP4 and TP8. PAH contamination was associated with ash content within Made Ground at each of the listed exploratory hole locations.

Petroleum Hydrocarbons

Ten soil samples were analysed for carbon banded hydrocarbons with an aliphatic/aromatic split. Aromatic Hydrocarbons were not detected at concentrations in excess of adopted AC.

Other Organic Contaminants

Ten soil samples were analysed for concentrations of total phenols. No concentrations were detected in excess of the laboratory limit of detection (<2 mg/kg).

Asbestos

Four samples of Made Ground were screened for asbestos containing materials (ACMs). No ACMs were detected.

Summary of Soil Analytical Data

PAH determinands have been detected within shallow soils on site at concentrations significantly in excess of adopted AC. It is considered by RPS that this is associated with the presence of a generally limited thickness of Made Ground present across the site area. Laboratory analysis of natural soil samples underlying the Made Ground did not detect contaminant concentrations in excess of adopted AC. This indicates that the measured contaminant concentrations are not impacting deeper strata.

One sample of Made Ground collected from borehole BH4 at a depth of 2.3m bgl contained a concentration of lead in excess of AC for residential land use.

5.3 Groundwater Analysis

Five groundwater samples were collected from monitoring wells BH1 Deep, BH2, BH3, BH4 Deep and BH5 during a return monitoring visit to site on 17th November 2011. Contaminant concentrations within groundwater have been compared against Environmental Quality Standard (EQS) and UK Drinking Water Standard (DWS) screening values. No contaminants were detected in excess of EQS or DWS screening criteria.

5.4 Ground Gas Monitoring Results

A ground gas monitoring wells were installed within all cable percussive boreholes on site. Dual installations were installed within boreholes BH1 and BH4, whereby separate monitoring wells were screened within Made Ground and within the Kempton Park Gravels in each borehole.

Ground gas monitoring was undertaken on three occasions from 17th November to 2nd December 2011. Installations were monitored for concentrations of methane, carbon dioxide and oxygen. In addition the flow rate and barometric pressure were recorded.

Concentrations of methane recorded were below the detection limit of the equipment used (<0.1%). Carbon dioxide was recorded at a maximum concentration of 2.9% within monitoring well BH2 on 17th November 2011. Ground gas flow rates were below the detection limit for the equipment used (<0.1l/hr) within all monitoring wells.

The lowest recorded oxygen concentration was 18.2% within monitoring well BH2. Atmospheric pressure ranged from 1015mb to 1021mb.

The CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' outlines indicative guideline concentrations for carbon dioxide and methane in association with gas flow rates for which gas protection measures may be required in new residential or commercial developments. The methodology is based on the Modified Wilson and Card approach that characterises the gas regime into a series of Characteristic Situations (1 to 5), with corresponding indicative gas protection measures. Using this methodology, the ground gas regime at this site corresponds to Characteristic Situation 1, whereby no specific gas protection measures are required.

6.0 ENVIRONMENTAL RISK ASSESSMENT

The UK approach to the management of land contamination is risk-based, as implemented by PPS23. The risk assessment methods adopted by PPS23 reflect those adopted by Part IIA of the Environmental Protection Act (1990). Part IIA identifies that harm to human health and the environment arises not solely from the presence of contaminating substances or 'sources', but from their migration along a 'pathway' to where they can impact a 'receptor'.

6.1 Current & Future Site Users

PAH contamination has been detected within shallow soils on site at concentrations significantly in excess of adopted AC. It is considered by RPS that this is associated with the presence of a generally limited thickness of Made Ground present across the site.

A concentration of lead in excess of adopted AC was detected within a sample of Made ground collected from borehole BH4 at 2.30m bgl.

TPH was detected within Made Ground in a number of exploratory hole locations, although it wasn't detected at concentrations in excess of adopted AC.

Based on the findings of the site investigation, the potential risk to site users is considered to be **MODERATE**. The lead and PAH contaminants are not significantly volatile and in areas of building and hardstanding cover, the exposure pathways of direct contact, inhalation and ingestion of soil or dust particles would not be active. However, in proposed residential gardens and landscaped areas, mitigation measures are likely to be required to reduce the risk to future site users.

In proposed garden areas, it is recommended that a clean cover of 600mm of validated, imported topsoil is placed to break the exposure pathway to future site users. An anti-dig geotextile membrane should be placed below the topsoil to prevent future exposure to deeper soils. In proposed areas of communal landscaping, the thickness of clean imported soil can be reduced to 300mm.

Depending on the proposed site levels, it may be appropriate to excavate the existing Made Ground for off-site disposal prior to placement of clean soil. Excavated material should be sent to an appropriately licensed landfill using a licensed waste carrier.

6.2 Construction/Maintenance Workers

Ground workers involved in site maintenance/redevelopment activities may potentially be exposed to inorganic and organic contamination present in shallow soils. CLEA V1.06 cannot be used to assess the acute (short term exposure) risk that personnel in close contact with exposed soils may experience during demolition, redevelopment or site maintenance duties.

The risks can easily be controlled by the use of appropriate personnel protective equipment (disposable coveralls, gloves and particulate/vapour masks) and by adopting high levels of personal hygiene. Providing contractors undertake and implement a site specific risk assessment and such measures are taken, based on the available information, the potential risk to ground workers is considered to be **LOW**.

6.3 Off-Site Receptors

Laboratory testing of samples collected from Made Ground indicate that concentrations of PAH, significantly in excess of adopted AC are present on site. Analysed samples of natural soils underlying Made Ground on site do not contain contaminant concentrations in excess of adopted screening criteria. Detected contaminants are not significantly volatile or soluble within groundwater.

Volatile contaminants were not detected in significant concentrations during subsequent monitoring works. Water samples collected from monitoring wells did not contain contaminant concentrations in excess of EQS or DWS screening criteria. Groundwater was recorded at a relatively deep level during investigation works, within the Kempton Park Gravels.

It is therefore considered that potential soil based, aqueous and volatile phase contaminants beneath the site are unlikely to come into contact with off-site receptors due to the absence of a viable source-pathway-receptor linkage.

Based on the findings of the site investigation, the potential risk to off-site receptors is considered to be **LOW**.

During excavation works when soils are exposed and susceptible to weathering there is the potential for soil dust to become airborne during periods of particularly dry or windy weather. The risk can easily be mitigated by adopting dust mitigation measures.

6.4 Groundwater

Five groundwater samples were collected from monitoring wells BH1 Deep, BH2, BH3, BH4 Deep and BH5 during a return monitoring visit to site on 17th November 2011. Water samples did not contain contaminant concentrations in excess of EQS or DWS screening criteria.

Elevated concentrations of lead and PAH contaminants were recorded in samples collected from the Made Ground across the site. Detected contaminants are not significantly soluble within groundwater.

Given the absence of groundwater contamination and the lack of significant contamination within natural soils on site, the risk to the underlying Secondary (A) Aquifer is considered to be **LOW**.

6.5 Surface Water

The River Lea is present within the vicinity of the site.

Elevated concentrations of lead and PAH contaminants were recorded in samples collected from the Made Ground across the site. Detected contaminants are not significantly soluble within groundwater and are considered unlikely to migrate off-site.

Therefore, the risk to surface waters posed by the site is considered to be **LOW**.

6.6 Structures and Infrastructure

Buildings (on-site and off-site)

The CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' outlines indicative guideline concentrations for carbon dioxide and methane in association with gas flow rates for which gas protection measures may be required in new residential or commercial developments. The methodology is based on the Modified Wilson and Card approach that characterises the gas regime into a series of Characteristic Situations (1 to 5), with corresponding indicative gas protection measures. Using this methodology, the ground gas regime at this site corresponds to Characteristic Situation 1, whereby no specific gas protection measures are required.

The risk associated with ground gas is considered to be **LOW**.

Underground Concrete Structures

Based on the concentrations of sulphate identified in soils, there is the potential for sulphate to impact underground concrete structures in some areas on site.

Based on the available data for the soils beneath the site, the design sulphate class for buried concrete should be DS-2, and the ACEC class should be AC-2. However, further testing of shallow soils at the construction stage may allow a lesser sulphate class to be adopted in some site areas.

Providing appropriate mitigation measures are adopted during the construction of new units and appropriate concrete qualities are met, the risk associated with sulphate is considered to be **LOW**.

Polymeric Utility Pipes

Hydrocarbons present within Made Ground may potentially permeate plastic (polymeric) water pipes. It is recommended that barrier pipe is adopted on site for new potable water supply pipes or that pipes are placed in over sized trenches and backfilled with clean, inert material. Assuming appropriate mitigation measures are adopted where necessary, the potential risk to plastic pipes is considered to be **LOW**.

6.7 Conceptual Model

The potential source-pathway-receptor linkages at the subject site discussed above are summarised in the table below.

Table 6: Updated Conceptual Model

Pathway: Receptor:	Dermal contact / ingestion of contaminants & soils	Inhalation of contaminants & soils	Sub-surface migration of Contaminants
Site Users	MODERATE Site wide PAH contamination detected in Made Ground. External areas to be covered by hardstanding or clean soil as part of development	LOW No significant Volatile contamination identified.	LOW Lead and PAH contamination detected within Made Ground on site is not highly mobile or soluble in groundwater.
Off-site Receptors	LOW Lead and PAH contamination detected within Made Ground on site is not highly mobile or soluble in groundwater.	LOW No significant Volatile contamination identified.	LOW Lead and PAH contamination detected within Made Ground on site is not highly mobile or soluble in groundwater.
Groundwater	LOW Significant concentrations of contaminants in excess of EQS and DWS guidelines not detected in groundwater.	-	LOW Significant concentrations of contaminants in excess of EQS and DWS guidelines not detected in groundwater.
Surface Water	-	-	LOW Significant concentrations of contaminants in excess of EQS and DWS guidelines not detected in groundwater.
Infrastructure	LOW Assuming suitable potable water pipes and concrete class are adopted. Low ground gas risk factor.	-	LOW Significant contamination not found

The risk assessment is based upon the available information relating to the site. Should ground conditions inconsistent with those outlined in this report be encountered RPS should be contacted to enable further assessment.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The site investigation comprised the advancement of five cable percussive boreholes to depths ranging from 10.0m bgl to 20.0m bgl. Eight trial pits were excavated by mechanical methods and two trial pits were excavated by hand in order to obtain shallow soil samples for contamination testing. Ground gas and groundwater monitoring wells were installed in all boreholes. In-situ geotechnical testing was undertaken at regular intervals within all boreholes. Disturbed soil samples were collected for both geotechnical and chemical analysis.

A variable thickness of Made Ground was encountered from ground surface at most exploratory hole locations on site. Made Ground was encountered underlying tarmac or concrete hardstanding in a limited number of exploratory holes. Kempton Park Gravels were encountered underlying hardstanding in the majority of exploratory holes. Lewes Nodular Chalk was encountered in cable percussive boreholes only. Groundwater was encountered at depths ranging from 5.5m bgl to 6.1m bgl within cable percussive boreholes during drilling works. Groundwater was recorded at depths ranging from 4.6m bgl to 5.9m bgl during the subsequent monitoring program.

PAH determinands have been detected within shallow soils on site at concentrations significantly in excess of adopted AC. It is considered by RPS that this is associated with the presence of a generally limited thickness of Made Ground present across the site area. One sample of Made Ground collected from borehole BH4 at a depth of 2.3m bgl contained a concentration of lead in excess of AC for residential land use. Laboratory analysis of natural soil samples underlying the Made Ground did not detect contaminant concentrations in excess of adopted AC. This indicates that the measured contaminant concentrations are not impacting deeper strata.

Lead and PAH contaminants are not significantly volatile and the exposure pathways of direct contact, inhalation and ingestion of soil or dust particles would not be active where contamination is present underlying proposed building footprints and areas of hardstanding. In proposed garden areas, it is recommended that a clean cover of 600mm validated, imported topsoil is placed to break the exposure pathway to future site users. An anti-dig geotextile membrane should be placed below the topsoil to prevent future exposure to deeper soils. If located in a proposed area of communal landscaping, the thickness of clean imported soil can be reduced to 150mm.

Water samples collected from monitoring wells during the first return visit to site did not contain contaminant concentrations in excess of EQS or DWS screening criteria.

Concentrations of methane, carbon dioxide and volatile organic compounds detected during a subsequent monitoring visit were low and ground gas protection measures are not considered necessary as part of the proposed development.

Based on the findings of the site investigation, the potential risk to site users, controlled waters and other environmental receptors is considered to be **LOW**.

Given the variable nature of Made Ground, it is recommended that this is not used as a bearing stratum.

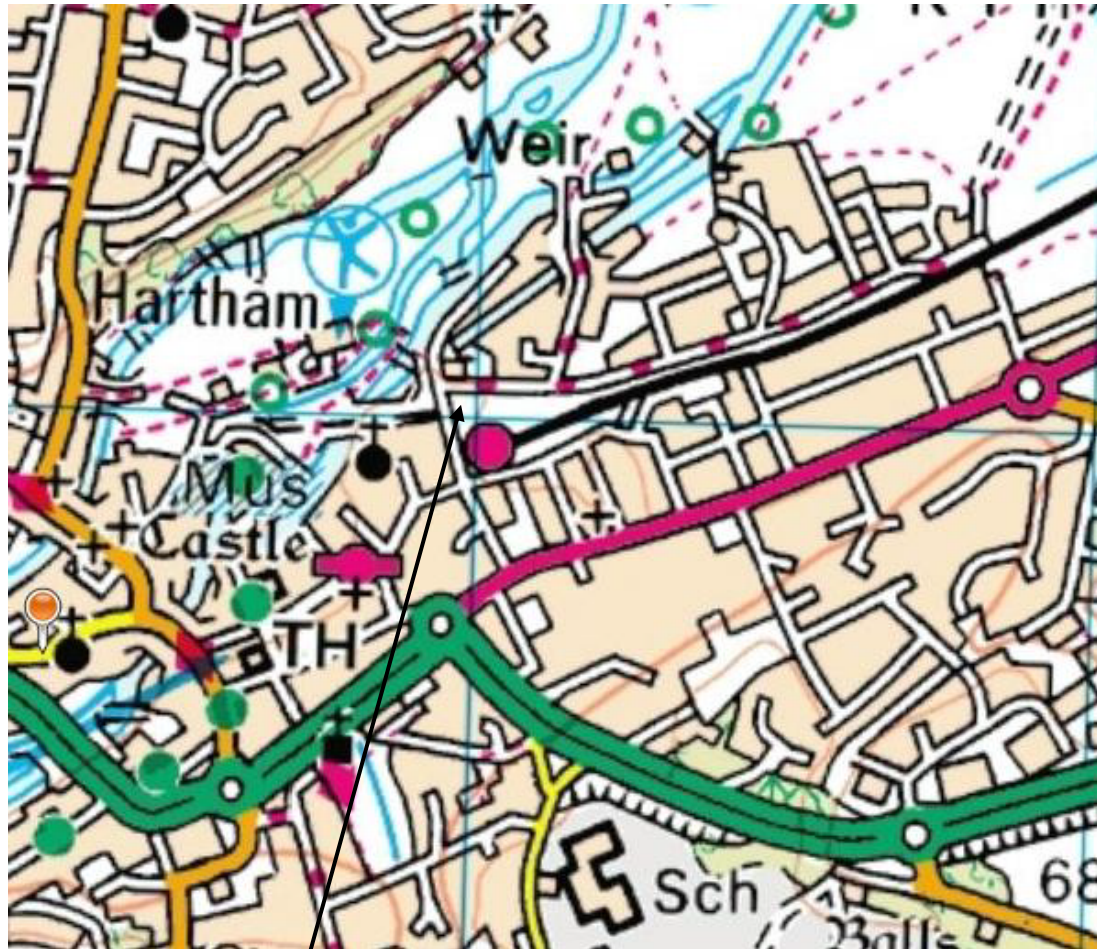
It is understood at this stage that three storey apartments are proposed in the south and east of the site, with higher rise, four storey apartments proposed for the north and west sections. It is considered that traditional strip and pad foundations bearing within the Kempton Park Gravels is likely to be the most suitable foundation solution to support lightly to moderately loaded structures, up to three storeys in height. Settlement underlying a traditional strip or pad foundation bearing within the Kempton Park Gravel at a pressure of 150kN/m^2 is anticipated to be in the order of 10mm. For more heavily loaded structures, in excess of three storeys in height, it is likely that piled foundations will be required.

In accordance with NHBC guidelines, ground bearing floor slabs should be suitable for the proposed development where the depth of untreated Made Ground does not exceed 0.6m bgl. In areas where Made Ground exceeds 0.6m in thickness, it is recommended that either suspended floor slabs are adopted or that Made Ground is excavated and replaced in a controlled manner.

It is anticipated that a CBR value of 10% may be adopted for a preliminary design value for the Kempton Park Gravels. A lower value of 3% should be adopted if Made Ground is present at pavement founding level. This should be confirmed by testing at the construction stage.

It is recommended that a concrete design class of DS-2 and an ACEC class of AC-2 is adopted on site.

FIGURES



Site Location

<p>Project: Mill Road, Hertford</p> <p>Project Ref: HLEI 17433</p> <p>Figure 1: Site Location Plan</p> <p>Map Date: Current</p> <p>Scale: Not to scale</p> <p><small>Based on Ordnance Survey maps with the sanction of the Controller of H M Stationery Office. Crown Copy Right Reserved. Licence No. AL854522</small></p>	<div data-bbox="1209 1688 1342 1756" data-label="Image"> </div> <p>14 Cornhill London EC3V 3ND</p> <p>☎ 020-7280-3200 📠 020-7283-9248 🌐 www.rpsgroup.com</p>
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APPENDIX A: EXPLORATORY HOLE LOGS

APPENDIX B: CHEMICAL ANALYTICAL DATA

APPENDIX C: SOIL ASSESSMENT CRITERIA

APPENDIX D: FIELD MONITORING DATA

Ground Gas

Boreholes BH1 – BH5 were monitored for methane, carbon dioxide and oxygen concentrations on three occasions between 17th November 2011 and 2nd December 2011.

Ground Gas Concentrations on 17th November 2011

BH ID	Flow Rate (l/hr)		Methane (% vol)		Carbon Dioxide (% vol)		Oxygen (% vol)	PID (ppm)	
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady
BH1 (Shallow)	<0.1	<0.1	<0.1	<0.1	0.3	0.3	20.4	-	-
BH1 (Deep)	<0.1	<0.1	<0.1	<0.1	0.4	2.2	18.5	-	-
BH2	<0.1	<0.1	<0.1	<0.1	2.9	2.9	18.2	-	-
BH3	<0.1	<0.1	<0.1	<0.1	1.6	1.6	19.7	-	-
BH4 (Shallow)	<0.1	<0.1	<0.1	<0.1	0.4	0.5	20.8	-	-
BH4 (Deep)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	21.2	-	-
BH5	<0.1	<0.1	<0.1	<0.1	1.6	1.6	19.0	-	-

Atm. Pressure – 1015mb

Ground Gas Concentrations on 25th November 2011

BH ID	Flow Rate (l/hr)		Methane (% vol)		Carbon Dioxide (% vol)		Oxygen (% vol)	PID (ppm)	
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady
BH1 (Shallow)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.9	-	-
BH1 (Deep)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20.8	-	-
BH2	<0.1	<0.1	<0.1	<0.1	0.5	0.9	19.9	-	-
BH3	<0.1	<0.1	<0.1	<0.1	1.5	1.7	19.5	-	-
BH4 (Shallow)	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	20.8	-	-
BH4 (Deep)	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	21.0	-	-
BH5	<0.1	<0.1	<0.1	<0.1	0.4	1.0	19.8	-	-

Atm. Pressure – 1021mb

Ground Gas Concentrations on 2nd December 2011

BH ID	Flow Rate (l/hr)		Methane (% vol)		Carbon Dioxide (% vol)		Oxygen (% vol)	PID (ppm)	
	Peak	Steady	Peak	Steady	Peak	Steady		Peak	Steady
BH1 (Shallow)	<0.1	<0.1	<0.1	<0.1	0.1	0.1	21.1	-	-
BH1 (Deep)	<0.1	<0.1	<0.1	<0.1	0.5	0.5	20.8	-	-
BH2	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	21.3	-	-
BH3	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	21.3	-	-
BH4 (Shallow)	<0.1	<0.1	<0.1	<0.1	0.2	0.3	21.3	-	-
BH4 (Deep)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	21.6	-	-
BH5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	21.6	-	-

Atm. Pressure – 1011

Groundwater

Boreholes BH1 – BH5 were monitored for groundwater level on three occasions between 17th November 2011 and 2nd December 2011.

Monitoring Well	Well Screen Depth (m bgl)	Depth to Water (m bgl)		
		17 th November 2011	25 th November 2011	2 nd December 2011
BH1 (Shallow)	1.00 – 1.50	-	-	-
BH1 (Deep)	2.00 – 8.50	5.56	5.53	5.55
BH2	1.00 – 8.30	5.43	5.88	5.65
BH3	1.00 – 5.40	4.59	5.80	5.75
BH4 (Shallow)	1.00 – 2.60	-	-	-
BH4 (Deep)	3.00 – 6.40	5.28	5.33	5.35
BH5	1.00 – 7.20	5.80	5.84	5.83

APPENDIX E: GEOTECHNICAL ANALYTICAL DATA

APPENDIX F: SITE INVESTIGATION GENERAL NOTES

RPS CONSULTANTS SITE INVESTIGATIONS - GENERAL NOTES

1. The assessments made in this report are based on the ground conditions as revealed by intrusive investigations, together with the results of any field or laboratory testing or chemical analysis undertaken and other relevant data which may have been obtained including previous site investigations. In any event, ground contamination often exists as small discrete areas of contamination ("hot spots") and there can be no certainty that any or all such areas have been located and/or sampled.
2. There may be special conditions appertaining to the site which have not been taken into account in the report. The assessment may be subject to amendment in the light of additional information becoming available.
3. Where any data supplied by the Client or from other sources, including that from previous site investigations, have been used it has been assumed that the information is correct. No responsibility can be accepted by RPS Companies for inaccuracies within the data supplied by other parties.
4. Whilst the report may express an opinion on possible ground conditions between or beyond trial pit or borehole locations, or on the possible presence of features based on either visual, verbal or published evidence this is for guidance only and no liability can be accepted for the accuracy thereof.
5. Comments on groundwater conditions are based on observations made at the time of the investigation unless otherwise stated. Groundwater conditions may vary due to seasonal or other effects.
6. This report is prepared and written in the context of the agreed scope of work and should not be used in a different context. Furthermore, new information, improved practices and changes in legislation may necessitate a re-interpretation of the report in whole or part after its original submission.
7. The copyright in the written materials shall remain the property of the RPS Company but with a royalty-free perpetual licence to the client deemed to be granted on payment in full to the RPS Company by the client of the outstanding amounts.
8. The report is provided for sole use by the Client and is confidential to them and their professional advisors. No responsibility whatsoever for the contents of the report will be accepted to any person other than the Client.
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