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## KINGSMERE PHASE 2, BICESTER

Combined Phase I & Phase II Geo-Environmental Assessment Report  
Countryside Properties (Bicester) Ltd

14/02/2013

# Quality Management

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# KINGSMERE PHASE 2, BICESTER

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14/02/2013

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## 4 SITE INVESTIGATION

### 4.1 Fieldwork

The site investigation works were completed between 1<sup>st</sup> and 10<sup>th</sup> October 2012 under the supervision of a WSP engineer. The works were as detailed in **Section 1.5**. An exploratory hole location plan and detailed logs showing the ground conditions encountered are presented in **Appendix A** and **Appendix C** respectively.

The ground investigation was undertaken in accordance with techniques outlined in BS EN 1997-2, BS5930:1999 + A2:2010 Code of Practice for Site Investigations and BS10175: 2011 Code of Practice for the Investigation of Potentially Contaminated Sites. In advance of the works, each exploratory hole location was cleared of services by a specialist contractor, as detailed within the WSP Health, Safety and Environmental Plan.

### 4.2 Rationale for Exploratory Hole Locations

Table 4.1 below gives a summary of the exploratory holes completed as part of the ground investigation, along with the rationale for each technique.

Table 4.1: Exploratory Hole Rationale.

Element of investigation	Details	Rationale
<b>Trial Pits and Soakaway Tests</b>	TP701 to TP720.  TP02, TP05, TP06 and TP51 (12370178/001/01, 2007)	To allow inspection of shallow soils and to allow the retrieval of samples for geotechnical and analytical laboratory testing.  Soakaway tests were performed in trial pits TP701, TP705C, TP716 and TP720 to provide an indication of whether infiltration drainage may be feasible in the proposed development. A soakaway test was also previously undertaken in TP05.
<b>Rotary Boreholes</b>	BH701 to BH707.	Drilling of seven boreholes to a maximum depth of 8.1m bgl to provide geotechnical design parameters of the deeper strata and to allow the installation ground gas and groundwater monitoring wells.
<b>Windowless Sample Boreholes</b>	WS701 to WS711.	Progression of eleven windowless sample boreholes to investigate the near-surface soils and to provide geotechnical design parameters.  Soil samples were recovered for analytical and geotechnical laboratory testing.  Gas and groundwater monitoring wells were installed within four of the boreholes to target shallow, weathered strata.
<b>In-situ Testing</b>	Standard Penetration Tests (SPTs) were undertaken at 1.0m or 1.5m intervals within both rotary boreholes and windowless sample boreholes.	To provide geotechnical design parameters for foundation design.

Element of investigation	Details	Rationale
<b>Installation of gas and groundwater monitoring wells</b>	<p>Installations within five rotary boreholes with four response zones within the Forest Marble Formation and one along the boundary of the Cornbrash Formation and Forest Marble Formation.</p> <p>Installations within four windowless sample boreholes with response zones within the Cornbrash Formation.</p>	<p>To provide information to characterise the ground gas regime and groundwater conditions.</p>
<b>Geotechnical Laboratory Testing</b>	<p>Selected soil samples were submitted to Geo Site and Testing Services Ltd., a UKAS accredited laboratory, for geotechnical testing.</p>	<p>To determine geotechnical soil and rock parameters, to aid classification and to provide information for use in foundation design.</p> <p>Geotechnical testing included pH, sulphate, atterberg limits, moisture content, maximum dry density (2.5 kg hammer/vibrating hammer), particle size distribution, particle density, CBR (remoulded), and point load.</p>
<b>Chemical Laboratory Analysis</b>	<p>Selected soil samples were submitted to ALcontrol UK Ltd., a UKAS and MCERTS accredited laboratory, for chemical analysis.</p> <p>Groundwater samples were collected from 6 of the monitoring wells installed during the investigatory works and submitted to ALcontrol UK Ltd., a UKAS and MCERTS accredited laboratory, for chemical analysis.</p>	<p>To provide information on potentially contaminated material at the site and to allow the assessment of potential risks to identified receptors to be undertaken.</p> <p>Determinands tested for included; metals and semi-metals, pH, sulphate, soil organic matter, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, volatile organic compounds and pesticides and herbicides.</p> <p>To provide information on the groundwater beneath the site and to allow the assessment of potential risks to controlled waters.</p> <p>Determinands tested for included; metals, ammoniacal nitrogen, hardness, pH, sulphate, petroleum hydrocarbons, volatile and semi-volatile organic compounds, pesticides and herbicides.</p>

# 5 GROUND CONDITIONS

## 5.1 General

The ground conditions encountered in the exploratory holes are broadly consistent with the geological sequence as described in the British Geological Survey map for the Site and are described below. In addition, the ground conditions encountered are consistent with previous phases of investigation undertaken previously by WSP across the Kingsmere development.

Made Ground was not observed across the Site. A thin horizon of topsoil was encountered across the Site beneath which is the Cornbrash Formation which was observed as very clayey gravel or a stiff to very stiff consistency, gravelly clay. Underlying the Cornbrash Formation is the Forest Marble Formation which was observed as alternating horizons of limestone and clay/mudstone.

In general, the depth to the base of the Cornbrash Formation/top of the Forest Marble Formation reduces to the southwest across the Site. In the northern part of the Site, the base of the Cornbrash Formation was recorded at 2m bgl and in the central and western areas of the Site the base of the Cornbrash Formation is up to 2.7m bgl. However, in the south-western part of the Site, the base of the Cornbrash Formation was recorded at 1.0m bgl. The base of the Forest Marble Formation was not proven.

## 5.2 Summary of Ground Conditions

The table below provides a summary of ground conditions encountered with the associated exploratory hole logs provided in **Appendix C**. A plan indicating the positions of the exploratory holes is provided as **Figure 2** within **Appendix A**.

Table 5.1: Summary of Ground Conditions

Strata	Depth range to top of stratum (m bgl)	Depth to base of stratum (m bgl)	Brief Description
<b>Topsoil</b>	Ground level	0.20 to 0.50	Topsoil was typically a dark brown slightly sandy slightly gravelly silty clay with frequent rootlets. The gravel fraction typically comprised fine to medium subangular limestone.
<b>Cornbrash Formation</b>	0.15 to 0.50	0.40 to 3.60*	Orange brown clayey to very clayey sandy fine to coarse subangular limestone GRAVEL.  Locally the Cornbrash Formation was recorded as a stiff to very stiff consistency, orange brown, slightly sandy, gravelly to very gravelly CLAY. The gravel fraction typically comprised fine to medium subangular limestone and lithorelics.
<b>Forest Marble Formation</b>	0.80 to 3.00	> 8.10*	Alternating horizons of clay/mudstone and limestone.  The clay horizons were generally recorded as a very stiff to hard, dark bluish grey, silty CLAY. In places the clay had not weathered back to clay and so was recorded as an extremely weak mudstone.  The limestone horizons were generally recorded as a medium strong to strong, light grey fine grained limestone.

\* Base not proven



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### 5.3 Visual and Olfactory Evidence of Contamination

No visual or olfactory indicators of contamination were encountered during the ground investigation.

### 5.4 Groundwater

Minor seepages of water were noted in several exploratory holes at depths of between 0.6m bgl and 1.9m bgl.

Groundwater at the site was encountered at elevations of between 68.8m above Ordnance Datum (AOD) and 77.2m AOD during drilling within the Forest Marble Formation. In several instances within the central region of the Site, within BH704, BH705 and BH706, groundwater was observed to be under artesian pressure within the Forest Marble Formation and rose to a maximum height of 1.7m agl (above ground level).

Subsequent monitoring within the standpipes installed within several exploratory holes recorded groundwater between 0.5m and 3.0m bgl. Groundwater elevation is indicated to be between 80.70m AOD in the north of the site and 72.70m AOD in the southwestern region. Ground levels fall towards the southeast from approximately 82.5m AOD in the northwest to approximately 74m AOD in the southeast. From the monitoring undertaken it appears that groundwater follows the topography and flows to the southeast.

Groundwater samples were collected from six of the borehole standpipes installed during the investigatory works and tested for a range of determinands to enable an assessment of the risk to human health and controlled waters.

### 5.5 Ground Gas

Ground gas monitoring has been completed from monitoring standpipes on three occasions following the completion of the investigation. A full ground gas monitoring record is provided in **Appendix E**.

Where suitable groundwater conditions allow, a number of boreholes (BH706, BH707, WS702 and WS711) have been monitored to assess the representative ground gas condition at the site (provided in **Appendix E**), a brief summary of the monitoring is provided below and is discussed in detail in **Section 7.11**.

- Methane was recorded between 0% and 0.1% v.v;
- Carbon dioxide was recorded between <0.1% and 1.7% v.v;
- Oxygen ranged between 18.7% and 20.8% v.v; and
- Ground gas flow was recorded between <0.1litres per hour (l/hr) and 0.1 l/hr.

### 5.6 Infiltration Assessment

In-situ soakaway tests were performed in trial pits TP701, TP705C, TP716 and TP720 and records of the tests are provided in **Appendix D**.

The soakaway tests were proposed to be undertaken in accordance with BRE Digest 365 'Soakaway Design' 2007. Two tests were completed within trial pits TP701 and TP716, however the water within the remaining trial pits did not drain within the available time constraints.

It has therefore, not been possible to derive suitable soil infiltration rates for the strata in accordance with the guidance in the BRE Digest as the fall in water level and number of repeat tests within the pits was not sufficient. Preliminary, indicative infiltration rates based on an extrapolation of the tests performed are summarised as follows:

- TP701 – Soil infiltration rate of  $3.6 \times 10^{-5}$  m/s.
- TP705C – Insufficient data. Based on the limited data obtained, the anticipated soil infiltration rate is likely to be less than  $1 \times 10^{-9}$  m/s.
- TP716 – Soil infiltration rates of  $1 \times 10^{-4}$  and  $4.2 \times 10^{-5}$  m/s.

- TP720 – Insufficient data. Based on the limited data obtained, the anticipated soil infiltration rate is likely to be less than  $1 \times 10^{-9}$  m/s.
- TP05 (12370178/001/01, 2007) - Insufficient data. Based on the limited data obtained, the anticipated soil infiltration rate is likely to be less than  $1 \times 10^{-9}$  m/s.

It should be noted that the above infiltration rates are preliminary and indicative only and should not be used for the design of infiltration drainage.

On this basis, and with reference to CIRIA C515, the soils at the Site fall in the classification of low permeability to practically impermeable.

As indicated by the soakaway tests performed, infiltration rates are variable across the Site. Accordingly, should infiltration drainage be considered for the development, it is recommended that further soakaway tests be undertaken, in accordance with BRE 365: 2007, based on the final location, invert levels and required storage capacities of soakaway drains.

## 5.7 Geotechnical Soil Parameters

A summary of the geotechnical properties of the strata present at the site is given in the table below. A full copy of geotechnical laboratory data is presented in **Appendix F**.

Table 5.2: Summary of Geotechnical Properties

Geotechnical Properties	Stratum		
	Cornbrash Formation (Granular)	Cornbrash Formation (Cohesive)	Forest Marble Formation
SPT 'N' Value	18 – 50	11 - 50	17 – 50
Moisture content (%)	16 - 18	13 – 39	Not Tested
Plasticity Index (%)	N/A	24 – 35 (Intermediate to high plasticity)	Not Tested
Plastic Limit (%)	N/A	12 - 22	Not Tested
Bulk density (Mg/m <sup>3</sup> )	2.19 – 2.22	2.22	Not Tested
Dry Density (Mg/m <sup>3</sup> )	1.85 – 1.89	1.92	Not Tested
pH	7.53 – 8.53	7.26 – 8.38	Not Tested
Water Soluble Sulphate (g/l)	0.01 – 0.05	<0.01 – 0.06	Not Tested
Maximum Dry Density (2.5Kg Hammer Compaction (Mg/m <sup>3</sup> ))	2.07	1.91 - 2.06	Not Tested
Optimum Moisture Content (%)	12.9	11-15	Not Tested
Particle Density (mg/m <sup>3</sup> )	2.65	2.65 – 2.71	Not Tested
Point Load Index (MPa)	N/A	2.28 – 4.59	Not Tested
California Bearing Ratio (top of sample (%))	1.0-1.5	1.8	Not Tested

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With regard to the recorded CBR values within the granular Cornbrash Formation, it is believed that the test method, whereby only material passing the 20mm sieve forms the sample for testing, is not representative of the in-situ soil, which was predominantly comprised of gravel and cobbles. Therefore, it is considered that the in-situ CBR value of the granular Cornbrash Formation will be significantly higher than that reported above and it is recommended that in-situ CBR tests are undertaken along proposed access roads.

A plot of uncorrected SPT 'N' value verses depth for the strata encountered is presented in **Appendix F**.