SPRINGBOURNE HOMES

MAIN STREET
CARLTON CV13 0BZ

REPORT ON PHASE 2 SITE INVESTIGATION

Contract: 20492

Date: May 2009

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REPORT ON PHASE 2 SITE INVESTIGATION

carried out at

MAIN STREET

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Prepared for

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145 Lutterworth Road
Nuneaton
Warwickshire
CV11 6PY

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EXECUTIVE SUMMARY

On the instructions of Savage Hayward Architects, on behalf of Springbourne Homes, a site investigation was undertaken to determine ground conditions to enable foundation and road/hard standing design to be carried out, together with a contamination risk assessment and a review of gas emissions It is understood that the proposed development comprises a small housing estate

This report should be read in conjunction with the Phase 1 Desk Study which was reported under reference 20384 in May 2008 and our letter report, issued in December 2008 under reference 20469.

The site is situated on Main Street, Carlton, approximately 0.5km to the east of the village centre of Carlton and may be located by National Grid Reference SK399051. At the time of the investigation, the site comprised a working filling station, and associated residential property and garden.

The site work was carried out in two phases; the first in December 2008 and the second on the 23rd March 2009. Eleven boreholes were undertaken by drive-in window sampler technique, with representative disturbed samples taken and despatched to the laboratory. Falling head permeability testing was undertaken in one borehole and groundwater and gas monitoring visits were undertaken on three occasions.

It is recommended that consideration could be given to the adoption of shallow spread foundations to support the proposed structures. Conventional shallow spread footings should be taken through any Made Ground and placed in the underlying Glacial Till or Glacial Sand and Gravel at a minimum depth of 1.50m. Such foundations may be designed to an allowable bearing pressure of 140kPa. It is recommended that consideration is given to suspending the ground floor slab from the foundations. The results of in-situ permeability tests indicate the glacial deposits to be of poor drainage characteristics and that groundwater was shallow in the majority of the exploratory holes which would have a detrimental effect on the use of soakaways.

None of the contaminants tested exhibited levels above guidance levels. Elevated hydrocarbon levels were encountered near the tanks although levels did not exceed guidance levels. There was no further evidence of hydrocarbons in any of the other locations. Whilst the contamination associated with the tanks is not considered significantly elevated, any existing tanks should be emptied and removed according to current best practice.

The contamination assessment identified that a ‘source – pathway – receptor’ linkage potentially occurs with methane and carbon dioxide impacting upon receptors. It is recommended that tank removal should be undertaken at the earliest possible opportunity in order to enable further gas monitoring before protection measures are finalised.

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1.0 INTRODUCTION

1.1 It is understood that the proposed development comprises a small housing estate, with detached, semi-detached and terraced houses with gardens, and with an access road through the site.

1.2 On the instructions of Savage Hayward Architects, on behalf of Springbourne Homes, a site investigation was undertaken to determine ground conditions to enable foundation and road/hard standing design to be carried out, together with a contamination risk assessment and a review of gas emissions.

1.3 This report should be read in conjunction with the Phase 1 Desk Study which was reported under reference 20384 in May 2008 and our letter report, issued in December 2008 under reference 20469.

1.4 It is recommended that a copy of this report be submitted to the relevant authorities to enable them to carry out their own site assessments and provide any comments.

1.5 This report has been prepared for the sole use of the Client for the purpose described and no extended duty of care to any third party is implied or offered. Third parties using any information contained within this report do so at their own risk.

1.6 The comments given in this report and the opinions expressed herein are based on the information received, the conditions encountered during site works, and on the results of tests made in the field and laboratory. However, there may be conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken into account in the report.

1.7 The comments on groundwater conditions are based on observations made at the time the site work was carried out. It should be noted that groundwater levels vary owing to seasonal or other effects.

2.0 SITE SETTING

2.1 Site Location

2.1.1 The site is situated on Main Street, Carlton, approximately 0.5km to the east of the village centre of Carlton and may be located by National Grid Reference SK399051.

2.2 Site Description

2.2.1 At the time of the investigation, the site was unchanged from that detailed in the desk study and initial investigation phase, comprising a working filling station, and associated residential property and garden.

2.2.2 A site plan is included in Appendix 1, Figure A1.1.

2.3 Geological Setting

2.3.1 Details of the geology underlying the site have been obtained from the British Geological Survey map, Sheet No. 155, 'Coalville', solid and drift edition, 1:50,000 scale, published 1982.

2.3.2 The geological map indicates the site to be underlain by superficial deposits of Glacial Till (Boulder Clay), possible underlain by Glacial Lake Clay. Glacial Sand and Gravel is indicated almost immediately to the south of the site and is shown to overlie the Glacial Till.

2.3.3 The superficial deposits are underlain by the Mercia Mudstone Group. This formation tends to be present in this area as red mudstones, weathering to clays, with occasional sandstone bands or 'skerries'.

2.4 Potential Geological Hazards

2.4.1 The following are brief findings relating to factors highlighted in the Phase 1 report that may have a potential impact upon the engineering of the proposed development.

Potential Hazard	Assessed Risk On Site
Coal mining	None
Compressible ground subsidence	None
Running Sands	Very low
Swelling clay subsidence	Moderate
Landslip subsidence	Very low

3.0 SITE WORK

3.1 The site work was carried out in two phases; the first in December 2008 and the second on the 23rd March 2009. The locations of exploratory holes have been planned, where possible, in general accordance with CLR 4, ref. 9.1 and the site work carried out on the basis of the practices set out in BS 10175:2001, ref. 9.2, BS 5930:1999 ref. 9.3 and ISO 1997:2007, ref 9.4.

3.2 Eleven boreholes in total, designated WS1 to WS11, were undertaken by drive-in window sampler technique at the positions shown on the site plan, Appendix 1, Figure A1.1. The depths of the boreholes, descriptions of strata encountered and comments on groundwater conditions are given in the borehole records, Appendix 2, Figures 20469.WS1 to 20469.WS5 and 20492.WS6 to 20492.WS11.

3.3 Representative disturbed samples were taken at the depths shown on the borehole records and despatched to the laboratory. Standard (split-barrel and cone) penetration tests, ref. 9.5 were carried out in the light cable percussion boreholes in the various strata to assess the relative density or consistency. The values of penetration resistance are given in the borehole records.

3.4 Samples for environmental purposes were collected in amber glass jars and kept in a cool box.

3.5 Monitoring installations, protected by a stopcock cover were installed in boreholes WS01, WS03, WS04, WS08 and WS10, as detailed in the borehole records.

3.6 The ground levels at the borehole locations were not determined.

3.7 Falling head permeability testing was undertaken in borehole WS9, in line with guidelines given in BS 5930: 1999, ref 9.3. The results are included in Figure A2.1.

3.8 Groundwater and gas monitoring visits were undertaken on three occasions between December 08 and May 09 as detailed in Figure A5.1.

4.0 LABORATORY TESTS

4.1 Geotechnical Testing

4.1.1 All soil samples were prepared in accordance with BS1377: Part One: 1990 ref. 9.4 and representative sub-samples were taken for testing. The following tests were carried out:

- 4 No. Moisture contents
- 3 No. Plasticity indices
- 2 No. Particle size distribution by wet sieving
- 3 No. pH and sulphate contents

4.1.2 The results of the testing are given in Appendix 3, Test Report 20492/1.

4.2 Chemical Testing

4.2.1 The suite of chemical analyses has been based upon the findings of the desk study, along with any on-site observations, to investigate the potential sources of contamination identified in the conceptual model. The chemical analyses were carried out on ten samples of soil. The nature of the analyses is detailed below:

4.2.2 **Metals Suite** - arsenic, cadmium, chromium, lead, mercury, selenium, , copper, nickel and zinc

4.2.3 **Organic Suite** - petroleum hydrocarbons (TPH) – CWG speciated analysis and extracable petroleum hydrocarbons (EPH C10-C40), polycyclic aromatic hydrocarbons (PAH) – USEPA 16 suite, phenols, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs)

4.2.4 **Inorganics Suite** - sulphate (water soluble)

4.2.5 **Others** - pH, total organic carbon, asbestos

4.2.6 The results of these tests are shown in Appendix 4, Reports 08-24356 and 09-26647.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Sequence

5.1.1 The sequence of the strata encountered during the investigation generally confirms the anticipated geology as interpreted from the geological map.

5.1.2 Interpolation of strata depths between locations should be undertaken with caution, particularly for depths of Made Ground where structures are still present at the time of the investigation.

5.1.3 The sequence and indicative thicknesses of strata are provided below:

Strata Encountered	Depth Encountered (m)		Strata Thickness (m)
	From	To	
Concrete	0.00	0.16 to 0.20	0.16 to 0.20
Topsoil	0.00	0.20 to 0.30	0.20 to 0.30
Made Ground	0.00 to 0.20	0.30 to 1.40	0.15 to 1.30
Glacial Till / Sand and Gravel	0.20 to 1.40	2.00 to 4.00	>1.70 to >3.80

5.2 Concrete

5.2.1 Concrete was encountered over a substantial part of the site, and will clearly be present beneath the existing buildings at the site. The concrete was present at a thickness of between 0.16m and 0.20m.

5.3 Topsoil

5.3.1 Topsoil was encountered across the western part of the site to a depth of between 0.20m and 0.30m.

5.4 Made Ground

5.4.1 Made Ground encountered across the majority of the site, and was variable both in composition and thickness. The material ranged in composition from soft gravelly clays through to sandy gravels with cobbles.

5.5 Glacial Till / Glacial Sand and Gravel

5.5.1 The superficial deposits underlying either the topsoil or made ground were of glacial origin, and consisted of inconsistent layers of either sandy gravelly clay (Glacial Till) or clayey gravelly sand (Glacial Sand and Gravel). The consistently of the clay varied from soft or firm to begin with, becoming stiff with depth.

5.5.2 The density of the Glacial Sand and Gravel varied between loose and medium dense.

5.6 Groundwater

5.6.1 Groundwater was encountered at depths generally between 1.00m and 2.00m below existing ground level, and tended to be associated with the Glacial Sand and Gravel bands.

6.0 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS IN RELATION TO THE PROPOSED DEVELOPMENT

6.1 Structural Details

6.1.1 It is understood that the proposed development is to consist of a small housing estate, with detached, semi-detached and terraced houses with gardens, and with an access road through the site.

6.1.2 Precise structural details were not available at the time of preparation of this report, but it is envisaged that the structures will be of a maximum two storeys, with line loads in the region of 50kN/m run.

6.2 Assessment of Soil Condition

6.2.1 The Glacial Till encountered on the site was principally cohesive in nature but contained differing proportions of sand and gravel.

6.2.2 In such materials it may be possible to recover undisturbed samples, however, frequently the sampler cannot be driven past the coarse particles. Therefore, quite often the samples recovered may be of limited length and disturbed by coarse particles.

6.2.3 Removing undisturbed samples of over-consolidated fissured clays from boreholes can result in disturbance of the material that is exacerbated during subsequent preparation for laboratory testing. This can result in misleadingly low shear strengths being obtained in the laboratory.

6.2.4 In some cases, in-situ testing is more advantageous when compared with taking undisturbed samples followed by laboratory tests.

6.2.5 Work undertaken by Stroud, ref. 9.6 determined a relationship between SPT 'N' values and the undrained shear strengths of many over-consolidated clays. Further work by Stroud and Butler, ref. 9.7, in which data was analysed from sites covering a wide range of glacial deposits, confirmed there to be a correlation between the 'N' value and undrained shear strength.

6.2.6 The relationship was of the form:

$$Cu = F_1 \times N$$

and

$$mv = \frac{1}{F_2 \times N}$$

where Cu = Undrained shear strength
mv = Coefficient of compressibility
F_1 and F_2 = Factors

6.2.7 It was determined by Stroud that F_1 varied between 4kPa for material of high plasticity and 6kPa for material of low plasticity. Similarly F_2 varied between 400kPa and 600kPa.

6.2.8 It is considered that for the strata encountered on this site a value of F_1 = 5.5kPa would be appropriate.

6.2.9 The Glacial Sand and Gravel encountered at the site has been assessed based on its composition and relative density.

6.3 Foundation Design

6.3.1 Due to the variable nature of the Made Ground encountered at the site, foundations should not be installed in this stratum.

6.3.2 The results of laboratory tests indicate the Glacial Till is of low plasticity and of low volume change potential as defined by the National House Building Council, ref 9.8 and other published data, refs 9.9 and 9.10. Changes in moisture content will result in small changes in volume, seasonal changes being exacerbated by the presence of trees. It is recommended that for design purposes, low volume change potential should be adopted where the foundations are installed in the clay.

6.3.3 The results of laboratory tests indicate the Glacial Sand and Gravel was composed of a very silty sand and gravel. Insitu testing indicates the material to be loose or medium dense, relating to an angle of shearing resistance (ϕ) of 28° to 34°. Due to the variable densities measured, it would be prudent to adopt a design value of 28° where encountered at shallow depth. The relative density increases with depth.

6.3.4 On the basis of observations made on site together with results of in-situ and laboratory tests, it is recommended that consideration could be given to the adoption of shallow spread foundations to support the proposed structures.

6.3.5 Outside the zone of influence of existing and proposed trees, it is recommended that conventional shallow spread footings should be taken through any Made Ground and placed in the underlying Glacial Till or Glacial Sand and Gravel at a minimum depth of 1.50m.

6.3.6 Above this level, the glacial deposits are relatively weak, and poor bearing pressures combined with differential settlement between the cohesive and granular deposits would be an issue.

6.3.7 Within the zone of influence of recently removed, existing or proposed trees, and where foundations are to be placed within the cohesive Glacial Till, the depth should be based on a minimum of 1.50m, or deeper as necessary as recommended by the NHBC for soils of low volume change potential. The

relevant sections of the NHBC Standard are included in Appendix 5, Figures A5.1 and A5.2. Compressible material should be placed on the inside faces of foundations as specified by the NHBC.

6.3.8 Such foundations may be designed to an allowable bearing pressure of 140kPa which would provide an adequate factor of safety against shear failure. Settlements are likely to be of the order of 10mm, however, these should be checked when the final structural loading is known.

6.3.9 It is possible that shallow foundations within the same structure could be supported on different strata, in this instance clay and sand and gravel, resulting in possible differential settlements developing due to the different settlement characteristics of these strata. In these circumstances it is recommended that nominal reinforcement be included within the foundations to minimise differential settlement.

6.4 Ground Floor Slabs

6.4.1 On the basis of observations on site together with the results of laboratory tests it is recommended that consideration is given to suspending the ground floor slab from the foundations.

6.5 Excavations

6.5.1 On the basis of observations on site, together with the results of in-situ and laboratory tests, it is considered that excavations to less than 1.20m may not stand unsupported in the short term, especially where the Made Ground is of a granular nature. Side support for safety purposes should of course be provided to all excavations which appear unstable, and those in excess of 1.20m deep, in accordance with Health and Safety Regulations, ref. 9.12.

6.5.2 Groundwater may be expected in shallow excavations for foundations or services, particularly where the bearing stratum is the sand and gravel overlain by the till. It is also possible that perched groundwater could be present in the Made Ground overlying the till.

6.6 Road and Hard Standing Design

6.6.1 The structural design of a road or hard standing is based on the strength of the subgrade, which is assessed on the California Bearing Ratio, **CBR**, scale. Experience has indicated that the measurement of the in-situ CBR value tends to give unreliable results because of the influence of the moisture content of the materials. In practice, the correlation given by the Highways Agency, ref. 9.13, is usually more appropriate than direct determination of the CBR.

6.6.2 On the basis of laboratory classification tests it is recommended that for formation prepared in the Made Ground, a subgrade CBR value of 2% be adopted for design purposes in order to account for the variability in composition and consistency. The assessment assumes there to be a low water table, average construction conditions and a thin pavement construction. Any

areas of particularly soft or deleterious material in the Made Ground should be excavated and replaced with a properly compacted granular fill.

6.6.3 It would also be prudent to adopt the same CBR value for the natural strata where encountered at formation level at this stage, as it was relatively weak at shallow depths.

6.6.4 It may prove economic to carry out a line of insitu CBR tests along the route of the pavement construction once formation levels are known. This would provide information by which the thickness of pavement could be zoned based on the stiffness of the subgrade encountered.

6.7 Soakaways

6.7.1 The results of in-situ permeability tests gave coefficients of permeability in the Glacial Sand and Gravel at WS9 (the south-east part of the site) of $7x10^{-6}$m/s. These indicate the glacial deposits to be of poor drainage characteristics, ref 9.14.

6.7.2 It should also be noted that groundwater was shallow in the majority of the exploratory holes which would also have a detrimental effect on the use of soakaways.

6.8 Chemical Attack on Buried Concrete

6.8.1 The site has been classified in accordance with BRE Special Digest 1, ref. 9.15, as brownfield without the presence of pyrite/ and laboratory testing undertaken accordingly. It is recommended that the guidelines given in BRE Special Digest 1, ref. 9.15, be adopted. Relevant details of this digest are included in Appendix 5, Figure A5.3.

6.8.2 The results of chemical tests in the non-pyritic soils indicate a sulphate concentration in the soil of 100mg/l as a 2:1 water/soil extract, with pH values in the range of 7.1 to 8.0.

6.8.3 It is recommended that for conventional shallow foundations the groundwater should be regarded as mobile.

6.8.4 On the basis of the laboratory test results it is considered that a Design Sulphate Class for this material may be taken as DS-1. The site conditions would suggest that an ACEC class for the site of AC-1 would be appropriate.

7.0 ENVIRONMENTAL RISK ASSESSMENT IN RELATION TO PROPOSED DEVELOPMENT

7.1 Contaminated Land

7.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.16, which was introduced by the Environment Act 1995, ref 9.17, as;

- '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 there is a significant possibility of such harm being caused; or

- significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.'

7.2 Risk Assessment

7.2.1 The definition of contaminated land is based on the principles of risk assessment. Risk is defined as a combination of:

- The probability, or frequency of exposure to a substance with the potential to cause harm, and:

- The seriousness of the consequence.

7.3 Pollutant Linkage

7.3.1 The basis of an environmental risk assessment involves identifying a 'source' of contamination, a 'pathway' along which the contamination may migrate and a 'receptor' at risk from the contamination.

7.3.2 Current legislation defines the various elements of the pollution linkage as:

- A contaminant is a substance, which is in or under the ground and which has the potential to cause harm or to cause pollution of controlled waters.

- A pathway is one or more routes through which a receptor is being exposed to, or affected by, a contaminant, or could be so affected.

- A receptor is either a living organism, an ecological system, a piece of land or property, or controlled water.

7.3.3 A pollutant linkage indicates that all three elements have been identified. The site can only be defined as 'Contaminated Land' if a pollutant linkage exists and the contamination meets the criteria in Section 7.1 above.

7.3.4 The guidance proposes a four-stage approach for the assessment of contamination and the associated risks. The four stages are listed below:

- Hazard Identification

- Hazard Assessment

- Risk Assessment

- Risk Evaluation

7.3.5 The hazard identification and hazard assessment have been based upon the Phase 1 Desk Study and formed the conceptual site model, detailed in our report, reference 20384, in May 2008.

7.3.6 The risk assessment and evaluation stages are presented in this phase 2 interpretive report, after an intrusive ground investigation has taken place.

7.3.7 A letter was issued to the client on completion of the testing in 2008 advising on site conditions after the initial work, as detailed in section1.3.

7.4 Risk Assessment – Human Health

7.4.1 The proposed development consists of a small housing estate, with detached, semi-detached and terraced houses with gardens, and with an access road through the site. The risk assessment has therefore been based on guidelines for a residential end use with plant uptake. Should the proposed development be changed in the future then further risk assessment may be required.

7.4.2 The results of the soil analyses have been compared to Assessment Criteria (AC) derived in-house using the CLEA Software Version 1.04, ref 9.18, and Environment Agency Science Reports SC050021/SR3, ref 9.19 and SC050021, ref. 9.20. The CLEA AC have been derived by Ian Farmer Associates in accordance with current legislation and guidance, as detailed in Appendix 6.

7.4.3 The guidance values used within this contamination assessment have been tabulated and are detailed within Appendix 6.

7.4.4 The results of chemical analyses have been processed in accordance with recommendations set out in the CIEH and CL:AIRE document ‘Guidance on Comparing Soil Contamination Data with a Critical Concentration’, ref 9.21. Where the concentrations determined on site are at or below the respective Guidance Level, they are considered not to pose a risk and are removed from further consideration, unless otherwise stated.

7.4.5 None of the contaminants tested exhibited levels above guidance levels. Elevated hydrocarbon levels were encountered near the tanks during the original investigation (WS1) although levels did not exceed guidance levels. There was no further evidence of hydrocarbons in any of the other locations, and the minor contamination identified is considered to be due to overtopping during filling, rather than tank leakage.

7.4.6 Whilst the contamination associated with the tanks is not considered significantly elevated, any existing tanks should be emptied and removed according to current best practice. Any visually impacted soil surrounding the tanks should be removed at this stage. In-filling and leaving the tanks in-situ is not considered to be a viable option for both contamination and geotechnical reasons.

7.5 Assessment - Controlled Waters

7.5.1 The site is located on a non aquifer (Mercia Mudstone) and is not situated within a source protection zone. As such, groundwater is considered not to be a significant receptor.

7.5.2 Hydrocarbon odours were evident in the superficial deposits underlying the site in WS1, with some filming where water was present below two metres. Levels of hydrocarbons at the depth of the strongest odour (1.30m) are not considered to be significantly elevated, and due to the generally cohesive nature of the underlying geology, migration is not anticipated. Hydrocarbons were not observed in any of the nearby locations.

7.5.3 Given the ground conditions encountered at the site and the results of this contamination assessment, it is considered unlikely that further assessment of the risks to controlled waters is required.

7.6 Gas Generation

7.6.1 Three gas monitoring visits were undertaken between December 08 and May 09, the results of which are included within Appendix 5, Figure A5.1. Gas monitoring was undertaken due to the presence of a nearby landfill, identified within the Phase 1 Report, as well as the potential for gases created by the degradation of hydrocarbons.

7.6.2 The results of initial gas monitoring determined the presence of methane at a concentration of up to 51.5%v/v and carbon dioxide up to 5.9%v/v with a flow rate of up to 2.6 litres/hour. On the basis of these readings, remedial measures may be required, see section 8.0.

7.7 Protection Of Services

7.7.1 Due to the increasing number of developments being undertaken on potentially contaminated land, the Water Supply Industry has identified the need to protect newly laid water supply pipes. They are likely to impose constraints on the nature of water supply pipes that are to be laid in contaminated land. Guidance on the selection of materials for water pipes is provided by the Water Regulations Advisory Scheme, ref 9.25.

7.8 Risk Evaluation

7.8.1 The conceptual model formed within the Phase 1 Desk Study has been updated to reflect the findings of the contamination risk assessment and the revised conceptual model, detailing the relevant pollutant linkages, is tabulated below:

Source	Potential Pathways	Receptor Group
Methane and carbon dioxide	• Migration • Ingression	Humans and buildings • Gas ingress into building/s • Site occupants
[1] – Assumes no remediation is undertaken [2] – Pathway exists only during the construction period		

7.9 Summary of Risk Evaluation

7.9.1 The above assessment identifies that the 'source – pathway – receptor' linkage potentially occurs with methane and carbon dioxide impacting upon the identified receptors. Therefore, it would be necessary to manage the risk at this location by either eliminating one of the links or by minimising the potential effects.

7.9.2 This assumes that any existing tanks on site are removed prior to development and that no significant unidentified contamination associated to the tanks is discovered during removal.

7.9.3 The presence of significantly elevated methane levels methane levels encountered within WS1, combined with the negative flow, indicate that degradation of the hydrocarbons in the vicinity of the tanks is leading to the production of methane in this area. There is no evidence for methane elsewhere on the site and this is considered a localised event.

7.9.4 The presence of low levels of carbon dioxide elsewhere on the site indicate another process, although the lack of flow, particularly on the low pressure occasion, does not indicate a significant risk to the development.

8.0 MANAGEMENT OF CONTAMINATION

8.1 Remediation and Verification

8.1.1 The risk management framework set out in the Model Procedures for the Management of Land Contamination, CLR 11, ref. 9.26, is applicable to the redevelopment of sites that may be affected by contamination.

8.1.2 The risk management process set out in the Model Procedures has three main components:

- Risk assessment
- Options appraisal
- Implementation

8.1.3 This initial risk assessment has identified the presence of elevated gas concentrations underlying parts of the site. Relevant pollutant linkages have been identified, as demonstrated in the updated conceptual model.

8.1.4 The remediation strategy will need to review methods of reducing or controlling the identified unacceptable risks. This could be done by removing

or treating the source of contamination, removing or modifying the pathways or removing or modifying the behaviour of the receptors, to ensure there is no significant risk of significant harm to either human health or controlled waters from the identified contamination, in relation to the proposed end use.

8.1.5 An important part of the risk management process is identifying and informing all stakeholders with an interest in the outcome of the risk management project. To this end, if the regulators have not yet been contacted with regard to the redevelopment of this site, it is recommended that they be supplied with a copy of both the Phase 1 Desk Study and this Phase 2 Site Investigation report in order to enable liaison to be undertaken with them.

8.1.6 Following liaison with the relevant regulatory bodies, a remediation strategy could be formulated, which should incorporate an options appraisal and summarise in detail the chosen remedial approach, along with the verification proposals. The remediation strategy should then be approved by the relevant regulatory authorities prior to implementation.

8.1.7 Where remediation is required, a verification report will need to be formulated following implementation of the remediation strategy, which should provide a complete record of all remedial activities conducted on site and include all the data obtained to support the remedial objectives and demonstrate that the remediation has been effective. Any unexpected conditions encountered during the remedial works should also be detailed within the verification report.

8.1.8 A number of potential remedial options for dealing with the contamination identified at this site, by removing or treating the contamination sources, are detailed below:

8.1.9 Due to potential volatilisation of the hydrocarbon contamination and its degradation products, where inhalation exposure is a valid pathway, hard cover is unlikely be sufficient to close the exposure pathway. It may be appropriate to include in the building construction, measures to mitigate the entry of soil vapour by impermeable membranes, possibly supplemented by appropriate under floor ventilation.

8.1.10 However, assuming the tanks and impacted soil in their immediate vicinity are removed prior to development, basic gas protection measures only may be necessary. It is recommended that tank removal should be undertaken at the earliest possible opportunity in order to enable further gas monitoring and an environmental watching brief should be considered during removal. Methane levels are expected to show a marked decrease following removal of the hydrocarbon source, and this should be undertaken to finalise protection measures necessary. Clean material used to backfill should be both inert and suitably engineered to be stable underneath the building footprint.

8.1.11 Precautionary measures should be undertaken as follows, assuming the proposed development involve residential buildings with suspended floor slab and ventilated void:

8.1.12 On the basis of the levels of methane/carbon dioxide, gas screening values will give a Traffic Light value according to Table A7.4. Recommended protective measures are given in Appendix 7, section A7.9.

8.1.13 Should the buildings differ to those described above, gas protection measures according to Situation A characteristic situations (Table A7.2) should be used, given in Appendix 7, sections A7.7 and A7.10.

8.1.14 These comments are based on only three sets of readings over a period of five months which does not follow the recommended guidelines given in Appendix 7, Table A7.1.

8.2 Management of Unidentified Sources of Contamination

8.2.1 There is the possibility that other sources of contamination may be present on the site which were not detected during the investigation. Should such contamination be identified or suspected during the site clearance or ground works, these should be dealt with accordingly. A number of options are available for handling this material, which include:

- The removal from site and disposal to a suitably licensed tip of all material suspected of being contaminated. The material would need to be classified prior to disposal.

- Short-term storage of the suspected material while undertaking verification testing for potential contamination. The storage area should be a contained area to ensure that contamination does not migrate and affect other areas of the site. Depending upon the amounts of material under consideration, this could be either a skip or a lined area.

- Having a suitably experienced environmental engineer either on-call or with a watching brief for the visual and olfactory assessment of the material, and sampling for verification purposes.

8.3 Consultation

8.3.1 During the development of a contaminated site, consultation may be required for a number of reasons with a number of regulatory Authorities. The following provides an indication as to the most likely Authorities with which consultation may be required.

- **Local Authority.** There may be a planning condition regarding contamination and consultation will be required with a designated Contaminated Land Officer within the Environmental Health Department. The Local Authority is generally concerned with human health risks. Some Authorities now require ‘Completion Certificates’ to be signed off following remediation works.

- **Environment Agency.** Where a site is within a groundwater protection zone or has been designated as a special site, the Environment Agency is likely to be involved to ensure that controlled waters are protected.

- **National House Building Council, NHBC.** Section 4.1 of the NHBC Standards requires land management to be addressed. For a new housing development to be approved by the NHBC, any remediation will require a validation report.

8.3.2 Based on the results of any consultation, there may be specific remediation requirements imposed by one or more of the Authorities.

8.4 Risk Management During Site Works

8.4.1 During ground works, some simple measures may have to be put in place to mitigate the risk of contamination affecting the site workers and the environs. The majority of the proposed measures represent good practice for the construction industry and include:

- Informing the site workers of the contamination on site and the potential health effects from exposure.

- Where appropriate, the provision of suitable Personal Protective Equipment (PPE) for workers who may be potentially impacted by working in areas of the contamination.

- Ensuring good hygiene is enforced on site and washing facilities are maintained on the site. Workers are discouraged from smoking, eating or drinking without washing their hands first.

- Dust monitoring, and if necessary, suppression measures should be put into practice where contamination is becoming airborne.

8.4.2 Where contaminated materials are being removed from the site they should be disposed of at a suitably licensed landfill, with a 'duty of care' system in place and maintained throughout the disposal operations.

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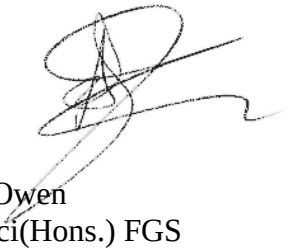
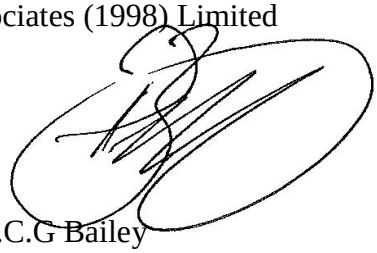
For and on behalf of Ian Farmer Associates (1998) Limited





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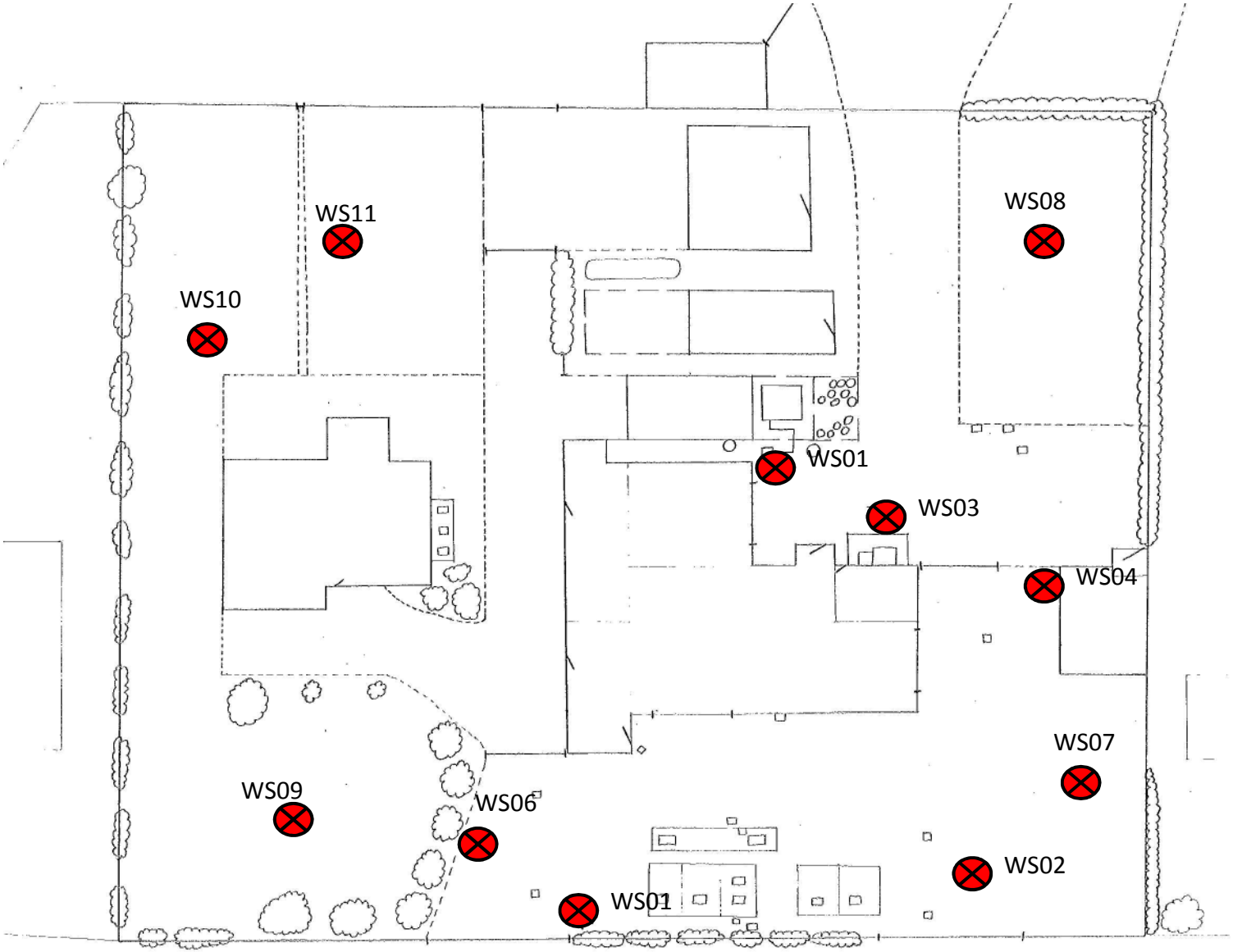
APPENDIX 1

DRAWINGS

20492 Main Street, Carlton



Exploratory Hole Plan

Scale: NTS

Figure A1.1

APPENDIX 2

SITE WORK

APPENDIX 2

GENERAL NOTES ON SITE WORKS

A2.1 SITE WORK

A2.1.1 General

Site work is carried out in general accordance with the guidelines given in ISO 1997, 9.4 and BS 5930, ref 9.3.

A2.1.2 Drive-in Window Sampler

The drive-in window sampler, ref 9.27, consists of a series of cylindrical sample tubes, generally varying in diameter from 80mm to 35mm. A cutting shoe is fitted to the bottom of each tube, while a window, representing about a quarter of the circumference, is cut along the length of the tube.

The largest diameter tube is driven into the ground using a small vibrating breaker. The sample tube is extracted by means of a ratchet or hydraulic extraction system.

The borehole is extended by using progressively smaller diameter tubes.

Soil samples are extracted through the window of the tube.

A2.2 IN-SITU TESTS

A2.2.1 Standard Penetration Test

The Standard Penetration Test is carried out in accordance with the proposals recommended by ISO 1997, ref 9.4, BS 1377, Part 9, 1990 ref 9.5.

The standard penetration test, **SPT**, covers the determination of the resistance of soils to the penetration of a split barrel sampler. A 50mm diameter split barrel sampler is driven 450mm into the soil using a 65kg hammer with a 760mm drop. The penetration resistance is expressed as the number of blows required to obtain 300mm penetration below an initial seating drive of 150mm through any disturbed ground at the bottom of the borehole. The number of blows to achieve the standard penetration of 300mm is reported as the 'N' value.

The test is generally carried out in fine soils, however, it may also be carried out in coarse granular soils, weak rocks and glacial tills using the same procedure as for the SPT but with a 50mm diameter, 60° apex solid cone replacing the split spoon sampler, **CPT.**

When attempting the standard penetration test in very dense material or weathered rocks it may be necessary to terminate the test before completion to prevent damage to the equipment. In these circumstances it is important to distinguish how the blow count relates to the penetration of the sampler. This may be achieved in the following manner:

- Where the seating drive has been completed, the test drive is terminated if 50 blows are reached before the full penetration of 300mm is achieved. The penetration for 50 blows is recorded and an approximate N value obtained by linear extrapolation of the number of blows for the partial test drive.

- If the seating drive of 150mm is not achieved within the first 25 blows, the penetration after 25 blows is recorded and the test drive then commenced.

- For tests in soft rocks, the test drive should be terminated after 100 blows where the penetration of 300mm has not been achieved.

The N-value obtained from the Standard Penetration Test may be used to assess the relative density of sands and gravels as follows:

Term	SPT N-Value : Blows/300mm Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

A2.3 SAMPLES

A2.3.1 General

Samples have been recovered and stored in accordance with the guidelines given in ISO 22475-1:2006, ref 9.27 and BS 5930, ref 9.3.

A represents small disturbed sample recovered in amber glass jar

V represents small disturbed sample recovered in glass amber vial

D represents small disturbed sample recovered in plastic tub

$\underline{\nabla}$ represents water strike

$\underline{\blacktriangledown}$ represents level to which water rose

A2.4 DESCRIPTION OF SOILS

A2.4.1 General

The procedures and principles given in ISO 14688 Parts 1 and 2, ref 9.28, supplemented by section 6 of BS 5930, ref. 9.3 have been used in the soil descriptions contained within this report.

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage	WS01

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes Ltd	20469
	Location	**Dates** 08/12/2008	**Engineer** Savage Hayward Architects	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					(0.18)	CONCRETE			
					0.18				
					(0.22)	MADE GROUND: Brown, soft, sandy, gravelly clay. Gravel is fine to medium, angular brick and weakly cemented black ash. Some angular cobbles of brick and concrete.			
0.30	D1								
0.30	A1				0.40				
0.50	A2				(0.29)	MADE GROUND: Grey, mottled black, firm, sandy, gravelly clay. Gravel is coarse, angular brick, slate and weakly cemented black ash and coarse, rounded quartzite. Slight hydrocarbon odour .			
0.50	D2								
0.50	V1				0.69				
0.80	V2				(0.31)	Brown, mottled grey, firm, sandy, gravelly CLAY. Gravel is fine to medium, rounded quartzite. Strong hydrocarbon odour. (Glacial Till)			
0.80	A3								
0.80	D3				1.00				
1.00-1.45	SPT N=16		2,4/4,5,4,3			Brown, stiff, very sandy, gravelly CLAY. Gravel is fine to medium, rounded quartzite. Very strong hydrocarbon odour. (Glacial Till)			
1.00-1.45	D4				(0.50)				
1.30	D5								
1.30	V3								
1.30	A4		Water strike(1) at 1.50m.		1.50	Brown, mottled grey, stiff, sandy, gravelly CLAY. Gravel is fine to coarse, sub-rounded to rounded quartzite. Slight hydrocarbon odour. (Glacial Till)		▽1	
1.80	D6								
2.00-2.45	SPT N=21		3,4/4,4,6,7		(0.99)	Below 2.00m: Oily film visible			
2.00-2.45	D7								
2.50	D8				2.49	Brown, medium to coarse SAND. Slight hydrocarbon odour. (Glacial Sand and Gravel)			
					(0.20)				
					2.69	Brown, stiff, gravelly, CLAY. Gravel is fine, rounded quartzite. Slight hydrocarbon odour. (Glacial Till)			
2.80	D9								
3.00-3.45	SPT N=24		3,4/5,6,6,7			Below 3.00m: Becoming very sandy			
3.00-3.45	D10								
					(1.31)				
3.50	D11					Below 3.80m: Fine to medium, angular gravels of grey, weak sandstone lithorelicts			
4.00-4.45	SPT N=22		8,6/4,5,6,7		4.00				
						Complete at 4.00m			

Remarks

Scale (approx)	Logged By
1:25	TAC

Figure No. 20469.WS01

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage	WS02

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes Ltd	20469
	Location	**Dates** 08/12/2008	**Engineer** Savage Hayward Architects	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.18)	CONCRETE		
					0.18			
0.25	D1				(0.15)	MADE GROUND: Brown, slightly clayey, gravelly, coarse sand. Gravel is coarse, angular brick and weakly cemented black ash.		
0.25	A1				0.33			
0.50	D2					Grey brown, very soft, sandy, gravelly CLAY. Gravel is coarse, rounded quartzite. Some green/grey, coarse sand pockets. (Glacial Till)		
0.50	A2							
1.00-1.45	SPT N=4		0,0/1,1,1,1					
1.00-1.45	D4				(1.57)			
1.50	D3							
1.50	A3							
					1.90			
2.00-2.45	D6		Water strike(1) at 2.00m.			Brown, clayey, medium dense, medium SAND and GRAVEL. Gravel is medium to coarse, rounded quartzite and coarse, angular to subangular, grey, weak, sandstone lithorelicts. (Glacial Sand and Gravel)		▽1
2.00-2.45	SPT N=26		3,5/7,6,7,6					
2.20	D5				(0.70)			
					2.60			
2.80	D7					Brown, very stiff, sandy, gravelly CLAY. Gravel is fine to coarse, rounded quartzite. (Glacial Till)		
3.00-3.45	SPT N=45		3,4/4,23,10,8					
3.00-3.45	D8							
					(1.40)			
3.50	D9							
					4.00			
						Complete at 4.00m		

Remarks
Borehole backfilled

Scale (approx)	Logged By
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Figure No. 20469.WS02

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage	WS03

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes Ltd	20469
	Location	**Dates** 08/12/2008	**Engineer** Savage Hayward Architects	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.30	D1				(0.68)	MADE GROUND: Brown, dense, sandy gravel. Gravel is fine to coarse, angular brick and concrete. Occasional cobbles of angular brick.			
0.30	A1								
					0.68				
					(0.30)	MADE GROUND: Brown medium dense, clayey, gravelly sand. Gravel is fine to coarse, angular brick, coarse, subrounded to rounded quartzite and coarse, subangular, grey, weak sandstone lithorelicts.			
0.90	D2								
0.90	A2				0.98				
					(0.59)	Brown, soft, sandy, gravelly CLAY. Gravel is fine to coarse, angular quartzite and grey, weak sandstone lithorelicts. (Glacial Till)			
1.50	D3				1.57				
1.50	A3					Brown, dense, clayey, medium SAND and GRAVEL. Gravel is fine to coarse, angular to rounded quartzite and grey, weak sandstone lithorelicts. (Glacial Sand and Gravel)		▽1	
			Water strike(1) at 1.90m.						
2.00	D4				(0.93)				
					2.50				
2.70	D5				(0.50)	Brown, firm, sandy, gravelly CLAY. Gravel is fine to medium, angular quartzite and grey, weak sandstone lithorelicts and coarse, sub-rounded chalk. (Glacial Till)			
					3.00				
						Complete at 3.00m			

Remarks

Scale (approx)	Logged By
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Figure No. 20469.WS03

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage	WS04

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes Ltd	20469
	Location	**Dates** 08/12/2008	**Engineer** Savage Hayward Architects	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					(0.68)	MADE GROUND: Brown, mottled black, soft, very sandy, gravelly clay. Gravel is fine to coarse, angular brick and concrete and coarse, rounded quartzite.			
0.40 0.40	D1 A1				0.68				
0.90 0.90	D2 A2					Brown, soft, sandy, gravelly CLAY. Gravel is fine to coarse, sub-rounded to rounded quartzite and fine, angular chalk. (Glacial Till)			
1.50	D3					Below 1.40m: Becoming firm with some coarse, sandy pockets			
			Water strike(1) at 2.00m.		(2.32)			▽1	
2.50	D4					Below 2.30m: Becoming stiff with coarse, angular, grey, weak sandstone lithorelicts			
					3.00				
						Complete at 3.00m			

Remarks

Scale (approx)	Logged By
1:25	TAC

Figure No. 20469.WS04

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage	WS05

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes Ltd	20469
	Location	**Dates** 08/12/2008	**Engineer** Savage Hayward Architects	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.10) 0.10	MADE GROUND: Grey, coarse, angular gravel over fine, angular brick and concrete		
						MADE GROUND: Black brown, firm, very sandy, very gravelly clay. Gravel is fine to coarse, angular to subrounded slag, brick, concrete and weakly cemented ash		
0.50 0.50	D1 A1				(1.30)			
						Below 1.00: Becoming soft		
					1.40			
1.50 1.50	D2 A2					Yellow brown, dense, very clayey, gravelly, fine to medium SAND. Gravel is fine, angular quartzite, grey, weak sandstone lithorelicts and chalk. (Glacial Sand and Gravel)		
			Water strike(1) at 2.00m.		(0.90)			▽1
					2.30			
						Brown, firm, gravelly CLAY. Gravel is fine, angular quartzite, chalk and charcoal. (Glacial Till)		
2.80	D3				(0.70)			
					3.00			
						Complete at 3.00m		

Remarks
Borehole backfilled

Scale (approx)	Logged By
1:25	TAC

Figure No. 20469.WS05

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS6

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20)	MADE GROUND: Concrete		
					0.20			
0.30	D1					MADE GROUND: Grey brown, gravelly, medium to coarse sand. Gravel is fine to coarse, angular to subrounded including brick, concrete and quartzite		
0.30	A1				(0.50)			
					0.70			
					(0.20)	MADE GROUND: Firm, grey brown, high plasticity, sandy, gravelly clay with black mottling and decayed roots. Gravel is of fine, angular brick		
0.80	D2				0.90			
0.80	A2							
1.00-1.45	SPT(C) N=11		2,2/2,3,3,3			Medium dense, brown, very clayey, gravelly, coarse SAND. Gravel is fine to coarse, subrounded to rounded quartzite, flint and chalk (Glacial Sand and Gravel)		
					(0.60)			
1.40	D3							
					1.50			
1.80	PP 125kPa		125,125,125/Av. 125.00			Stiff, high strength, low plasticity, brown, sandy, gravelly CLAY. Gravel is fine to coarse, angular to rounded charcoal, chalk and grey mudstone. Some grey mottling (Glacial Till)		
1.80	D4							
2.00-2.45	SPT(C) N=28		3,3/5,8,7,8					
					(1.50)			
2.50	PP 125kPa		125/Av. 125.00					
2.50	D5							
2.50	PP 150kPa		150/Av. 150.00					
2.70	PP 200kPa		200/Av. 200.00					
					3.00			
3.00-3.45	SPT(C) N=31		3,4/6,8,8,9			Complete at 3.00m		

Remarks
Borehole backfilled.

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS6

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS7

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.16)	MADE GROUND: Concrete		
					0.16			
0.20	D1				(0.14)	MADE GROUND: Black brown, clayey, gravelly, medium sand. Gravel is coarse, angular brick and ash. Slight hydrocarbon odour		
0.20	A1				0.30			
					(0.60)	Brown, clayey, gravelly, fine to medium SAND. Gravel is fine to coarse, angular to rounded quartzite (Glacial Sand and Gravel)		
0.60	D2							
0.60	A2				0.90			
1.00-1.45	SPT(C) N=6		1,1/1,2,1,2			Soft, low strength, high plasticity, brown mottled grey, sandy CLAY (Glacial Till)		
					(0.70)			
1.30	PP 75kPa		75, 75, 75/Av. 75.00					
1.30	D3				1.60			▽1
			Water strike(1) at 1.60m.			Medium dense, damp, orange brown, very clayey, gravelly, medium SAND. Gravel is fine to coarse, angular to rounded quartzite, flint, chalk and charcoal (Glacial Sand and Gravel)		
1.90	D4							
2.00-2.45	SPT(C) N=14		1,2/2,2,3,7			Below 2.00m: Wet		
					(1.20)			
						Between 2.50 - 2.80m: Red brown clay bands approximately 50mm thick		
2.70	D5							
					2.80			
			200, 225, 237.5/Av.			Stiff, high strength, high plasticity, dark grey brown, gravelly CLAY. Gravel is fine, angular chalk, flint and mudstone (Glacial Till)		
2.90	PP 220.83kPa		220.83		(0.25)			
3.00-3.45	SPT(C) N=23		2,3/4,4,6,9		3.05			
3.00	D6					Medium dense, brown, wet, coarse SAND and fine to coarse, angular to rounded GRAVEL of quartzite and flint (Glacial Sand and Gravel)		
					(0.55)			
3.40	D7							
					3.60			
						Stiff, high strength, low plasticity, dark grey brown, gravelly CLAY. Gravel is fine, angular chalk, flint and mudstone (Glacial Till)		
3.80	D8				(0.40)			
			237.5, 250, 250/Av.					
3.90	PP 245.83kPa		245.83		4.00			
4.00-4.45	SPT(C) N=27		3,4/4,7,7,9			Complete at 4.00m		

Remarks
Borehole backfilled.

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS7

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS8

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					(0.20)	Grass over brown, sandy TOPSOIL with roots and rootlets			
					0.20				
0.50	D1					Brown, very clayey, gravelly, fine SAND. Gravel is fine to coarse, angular to subrounded charcoal, quartzite and flint (Glacial Sand and Gravel)			
0.50	A1				(0.70)				
					0.90				
1.00-1.45	SPT(C) N=8		1,1/1,2,2,3			Soft, low strength, high plasticity, brown, sandy CLAY, with fine to coarse, angular to subrounded gravel of chalk, mudstone, charcoal and flint (Glacial Till)			
1.00	D2								
1.00	A2								
1.20	PP 75kPa		75/Av. 75.00			Below 1.20m: Firm			
1.50	PP 75kPa		75/Av. 75.00						
1.70	PP 100kPa		100/Av. 100.00						
1.70	D3								
2.00-2.45	SPT(C) N=18		3,3/3,4,5,6			Below 2.00m: High strength			
2.20	PP 162.5kPa		162.5/Av. 162.50		(2.70)				
2.50	PP 237.5kPa		237.5/Av. 237.50						
2.50	D4								
2.80	PP 175kPa		175/Av. 175.00						
3.00-3.45	SPT(C) N=31		4,5/6,7,8,10			Below 3.00m: Stiff, very high strength			
3.10	PP 225kPa		225/Av. 225.00						
3.20	PP 225kPa		225/Av. 225.00						
3.50	PP 225kPa		225/Av. 225.00						
					3.60				
3.80	D5				(0.40)	Red brown, coarse SAND (Glacial Sand and Gravel)			
					4.00				
						Complete at 4.00m			

Remarks

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS8

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS9

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 2.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.30)	Grass over brown, sandy TOPSOIL with many roots and rootlets		
					0.30			
0.50 0.50	D1 A1					Damp, orange brown, gravelly, fine to medium SAND. Gravel is medium to coarse, subangular to subrounded of mixed lithologies, predominantly quartzite and flint (Glacial Sand and Gravel)		▽1
			Water strike(1) at 0.88m.					
1.00-1.45 1.00 1.00	SPT(C) N=23 D2 A2		2,4/6,5,6,6		(1.70)	Between 0.40 - 0.60m: Very clayey with many roots and rootlets		
1.60	D3					Below 1.00m: Medium dense		
					2.00			
						Complete at 2.00m		

Remarks
Falling head test carried out at 1.04m
Borehole backfilled.

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS9

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS10

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					(0.20) 0.20	Grass over brown, sandy TOPSOIL with roots			
					(0.20) 0.40	Soft, medium strength, high plasticity, brown CLAY			
0.30	PP 75kPa		75, 75, 75/Av. 75.00						
0.30	D1					Brown mottled black, very clayey, gravelly SAND. Gravel is fine to coarse, angular to rounded chalk and quartzite (Glacial Sand and Gravel)			
0.30	A1								
0.70	D2				(0.60)				
0.70	A2								
1.00-1.45	SPT(C) N=6		0,1/1,1,2,2		1.00	Loose, red brown, clayey, gravelly, medium to coarse SAND. Gravel is coarse, angular flint and quartzite (Glacial Sand and Gravel)			
			Water strike(1) at 1.29m.		(0.60)			▽1	
1.50	D3								
1.60	PP 200kPa		200/Av. 200.00		1.60	Stiff, high strength, high plasticity, brown, gravelly CLAY. Gravel is fine to coarse, angular to rounded chalk, quartzite, charcoal, mudstone and flint. Occasional grey clay laminations (Glacial Till)			
1.70	PP 225kPa		225/Av. 225.00						
1.80	PP 212.5kPa		212.5/Av. 212.50						
1.80	D4								
2.00-2.45	SPT(C) N=22		2,2/3,5,6,8						
2.20	PP 250kPa		250/Av. 250.00		(1.40)				
2.50	PP 250kPa		250/Av. 250.00						
2.60	D5								
2.70	PP 250kPa		250/Av. 250.00			Below 3.00m: Very high strength			
3.00-3.38	SPT(C) 50/225		4,6/7,8,35		3.00				
						Complete at 3.00m			

Remarks

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS10

IAN FARMER ASSOCIATES

Site	Number
Ortons Garage, Carlton	WS11

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler	87mm to 1.00m 77mm to 2.00m 67mm to 3.00m		Springbourne Homes	20492
	Location	**Dates** 23/03/2009	**Engineer** Savage Hayward	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.20)	Grass over brown, sandy TOPSOIL with roots		
					0.20			
					(0.20)	Soft, medium strength, high plasticity, brown, sandy, gravelly CLAY. Gravel is coarse, angular of flint (Glacial Till)		
0.30	PP 37.5kPa		25, 50, 37.5/Av. 37.50		0.40			
0.30	D1					Soft, low strength, high plasticity, brown, very sandy CLAY (Glacial Till)		
0.30	A1							
0.50	PP 25kPa		25/Av. 25.00					
0.70	PP 25kPa		25/Av. 25.00		(0.60)			
0.80	D2							
0.80	A2							
0.90	PP 37.5kPa		37.5/Av. 37.50					
1.00-1.45	SPT(C) N=14		2,3/2,3,5,4		1.00			
						Medium dense, brown, wet, clayey, medium to coarse SAND (Glacial Sand and Gravel)		
1.30	D3							▽1
			Water strike(1) at 1.40m.					
					(1.20)			
						Between 1.70 - 2.00m: Hard clay bands with grey laminations and charcoal		
1.90	D4							
2.00-2.45	SPT(C) N=17		2,3/3,3,4,7					
					2.20			
						Stiff, high strength, low plasticity, brown, gravelly CLAY. Gravel is fine, angular chalk, flint and mudstone (Glacial Till)		
2.30	PP 250kPa		250/Av. 250.00					
2.50	PP 250kPa		250/Av. 250.00					
2.60	D5							
2.70	PP 250kPa		250/Av. 250.00					
3.00-3.45	SPT(C) N=29		3,4/6,6,7,10		(1.80)			
3.30	PP 250kPa		250/Av. 250.00					
3.50	PP 250kPa		250/Av. 250.00					
3.70	PP 250kPa		250/Av. 250.00					
4.00-4.45	SPT(C) N=28		4,5/5,6,8,9		4.00			
						Complete at 4.00m		

Remarks
Borehole backfilled.

Scale (approx)	Logged By
1:25	TAC

Figure No. 20492.WS11

IAN FARMER ASSOCIATES

VARIABLE HEAD PERMEABILITY TEST

20492 Variable Head (Falling) Permeability Test in Borehole WS9

SITE Main Street, Carlton

CONTRACT 20492 WS9 DEPTH : 1.04mBGL

INITIAL CONDITIONS

Base of Response Zone	1.04	mBGL
Top of Reponse Zone	0.00	mBGL
Diameter of casing	101.00	mm
Height of casing	0.00	mAGL
Elevation of Borehole		mAOD
Groundwater Level	0.88	mBGL

Operator	TAC
Date	23/03/2009
Test No.	1
Weather	
Calculated Test Zone	
1.04 m	

TEST CALCULATION

Intake Factor, F

F= 2.16 (i)

Borehole Case d

BS 5930: 1999 Figure 6/7

Permeability, K

$K = \frac{A}{F * (t2 - t1)} .Ln(H1/H2)$ (ii)

or

$K = \frac{A}{F . T}$ (iii)

Where T is the Basic Time Lag Factor corresponding to an H/Ho value of 0.37

L= 1.04 m
D= 0.101 m
L/D= 10.2970297

t1= 0.00 s
t2= 900 s
H1= 1.00 m
H2= 0.159 m

A= 0.00802 m^2
F= 2.1594 From (i)
T= 540 s
K= 7.5814E-06 m/s From (ii)
K= 6.87E-06 m/s From (iii)

Remarks

Elapsed (minutes)	Total seconds	Water Depth (m)	Head (metres)	H/Ho
0.0	0	0.000	0.880	1.000
0.2	10	0.040	0.840	0.955
0.3	20	0.060	0.820	0.932
0.5	30	0.090	0.790	0.898
0.7	40	0.100	0.780	0.886
0.8	50	0.110	0.770	0.875
1.0	60	0.130	0.750	0.852
1.5	90	0.170	0.710	0.807
2.0	120	0.210	0.670	0.761
3.0	180	0.280	0.600	0.682
4.0	240	0.390	0.490	0.557
5.0	300	0.450	0.430	0.489
10.0	600	0.580	0.300	0.341
15.0	900	0.740	0.140	0.159
20.0	1200	0.880	0.000	0.000
30.0	1800	0.880	0.000	0.000
45.0	2700	0.880	0.000	0.000
60.0	3600	0.880	0.000	0.000

APPENDIX 3

LABORATORY TESTS

APPENDIX 3

GENERAL NOTES ON LABORATORY TESTS ON SOILS

A3.1 GENERAL

A3.1.1 Where applicable all tests are carried out in accordance with the relevant British Standard. The laboratory test procedures are as below:

Test Name	Procedures BS1377:1990 Part:Clause
Moisture Content	2:3
Liquid Limit	2:4
Plastic Limit and Plastic Index	2:5
Particle Size Distribution	9.2
Sedimentation	9.4
Mass Loss on Ignition	3.4
Sulphate content	3:5
pH Value	3:9
Compaction Test	4:3
California Bearing Ratio	4:7
Consolidation	5:3
Bulk Density	7:2
Laboratory Vane Tests	7:3
Triaxial Compression	
Total Stress Single-Stage	7:8
Total Stress Multi-Stage	7:9
Desiccation	Note 1

Note 1 - BRE Information paper IP4 issued February 1993

A3.1.2 Where an external laboratory carried out testing, their report, including test methods is included in this Appendix.

A3.1.3 A summary sheet of laboratory test results undertaken by Ian Farmer Laboratories is included, however where copies of the individual test results are required these will be provided on request.

A3.1.4 Any discussion in this report is based on the values and results obtained from the appropriate tests. Due allowance should be made, when considering any result in isolation, of the possible inaccuracy of any such individual result. Details of the accuracy of results are included in this section, where applicable.

A3.2 MOISTURE CONTENT

A3.2.1 Unless stated to the contrary, the moisture content of a soil sample was determined by the standard oven drying method, BS 1377, Part 1, Test 3. The result is reported to an accuracy of ±0.5%

A3.3 ATTERBERG LIMITS

A3.3.1 The Liquid Limit, **LL**, is the moisture content at which the soil passes from the liquid to plastic state. Unless stated to the contrary, the Liquid Limit was determined using the

four point, cone penetrometer method, Test 4. The value is reported to the nearest whole number, to an accuracy of ±0.5%.

A3.3.2 The Plastic Limit, **PL**, is the moisture content at which soil passes from the plastic to solid state and becomes too dry to remain in a plastic condition. The Plastic Limit was determined using the method described in Test 5. The value is reported to the nearest whole number, to an accuracy of ±0.5%.

A3.3.3 The Plasticity Index, **PI**, is the numerical difference between the liquid and plastic limits, corresponding to the range of moisture contents over which a soil is in a plastic state. The determination of the Plasticity Index is covered by Test 5.

A3.4 SOIL CLASSIFICATION

A3.4.1 Classification of soils is usually undertaken by means of the Plasticity Classification Chart, sometimes called the A-Line Chart. This is graphical plot of PI against LL with the A-Line defined as PI = 0.73(LL - 20).

A3.4.2 This line is defined from experimental evidence and does not represent a well defined boundary between soil types, but forms a useful reference datum. When the values of LL and PI for inorganic clays are plotted on the chart they generally lie just above the A-Line in a narrow band parallel to it, while silts and organic clays plot below this line.

A3.4.3 Clays and silts are divided into five zones of plasticity:

Low Plasticity (L)	LL less than 35
Intermediate Plasticity (I)	LL between 35 and 50
High Plasticity (H)	LL between 50 and 70
Very High Plasticity (V)	LL between 70 and 90
Extremely High Plasticity (E)	LL greater than 90

A3.4.4 In general, clays of high plasticity are likely to have a lower permeability, are more compressible and consolidate over a longer period of time under load than clays of low plasticity. Clays of high plasticity are more difficult to compact as fill material.

A3.5 CHEMICAL TESTS

A3.5.1 The water soluble sulphate content of soil was determined using the gravimetric method detailed in BS1377: Part 3: 1990, Test 5. The results are recorded to an accuracy of ±0.1g/l.

A3.5.2 The pH value was determined electrometrically using the procedures given in BS 1377: Part 3: 1990, Test 9. The results are recorded to an accuracy of ±0.1 pH units.

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Building 9, Bilton Ind Est,
Humber Avenue,
Coventry,
CV3 IJL

F.A.O. Roy Smith

TEST REPORT - 20492/1

Site :	Ortons Garage, Carlton
Job Number :	20492
Originating Client :	Springbourne Homes
Originating Reference :	20492
Date Sampled :	Not Given
Date Scheduled :	03/04/09
Date Testing Started :	15/04/09
Date Testing Finished :	22/04/09

Remarks :

- First Report for above Job Number
- Samples will be disposed of 28 days after the report is issue unless otherwise agreed
- This report may contain results from tests which are not included within the scope of the UKAS accreditation. Please see final sheet for details.

Authorised By: C. Lilley Craig Lilley

Position : Laboratory Manager Date : 22/04/09

constructionline

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AGS ASSOCIATION OF GEOTECHNICAL & GEOENVIRONMENTAL SPECIALISTS

UKAS TESTING
1464

IAN FARMER ASSOCIATES

Laboratory Test Report - 20492/1

Site : Ortons Garage, Carlton

Client : Springbourne Homes

Job Number 20492

DETERMINATION OF MOISTURE CONTENT

Borehole/ Trial Pit	Depth (m)	Sample	Moisture Content %	Description
WS10	1.80	D4	18	Brown gravelly CLAY
WS6	1.80	D4	16	Brown slightly gravelly CLAY
WS8	0.40	D1	22	Brown gravelly CLAY
WS8	1.70	D3	17	Brown gravelly CLAY

Method of Preparation : BS 1377:PART 1:1990:7.3.3 Preparation of samples for classification tests

Method of Test : BS 1377:PART 2:1990:3.2 Determination of oven dried moisture content

Remarks :

IAN FARMER ASSOCIATES

Laboratory Test Report - 20492/1

Site : Ortons Garage, Carlton

Client : Springbourne Homes

Job Number 20492

DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX

Borehole/ Trial Pit	Depth (m)	Sample	Natural / Sieved	Natural Moisture Content %	Sample Passing 425µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Class	Description / Remarks
					Percentage %	Moisture Content %						
WS10	1.80	D4	Natural	18	94	18	33	16	17	0.12	CL	Brown gravelly CLAY
WS6	1.80	D4	Natural	16	93	17	32	15	17	0.12	CL	Brown slightly gravelly CLAY
WS8	0.40	D1	Natural	22	72	29	33	21	12	0.67	CL	Brown gravelly CLAY
WS8	1.70	D3	Natural	17								Brown gravelly CLAY

Method of Preparation : BS 1377:PART 1:1990:7.4 Preparation of samples for classification tests BS 1377:PART 2:1990:4.2 & 5.2 Sample preparations

Method of Test : BS 1377:PART 2:1990:3.2 Determination of moisture content 4.3 Determination of the liquid limit 5.3 Determination of the plastic limit and plasticity index

IAN FARMER ASSOCIATES

Laboratory Test Report - 20492/1

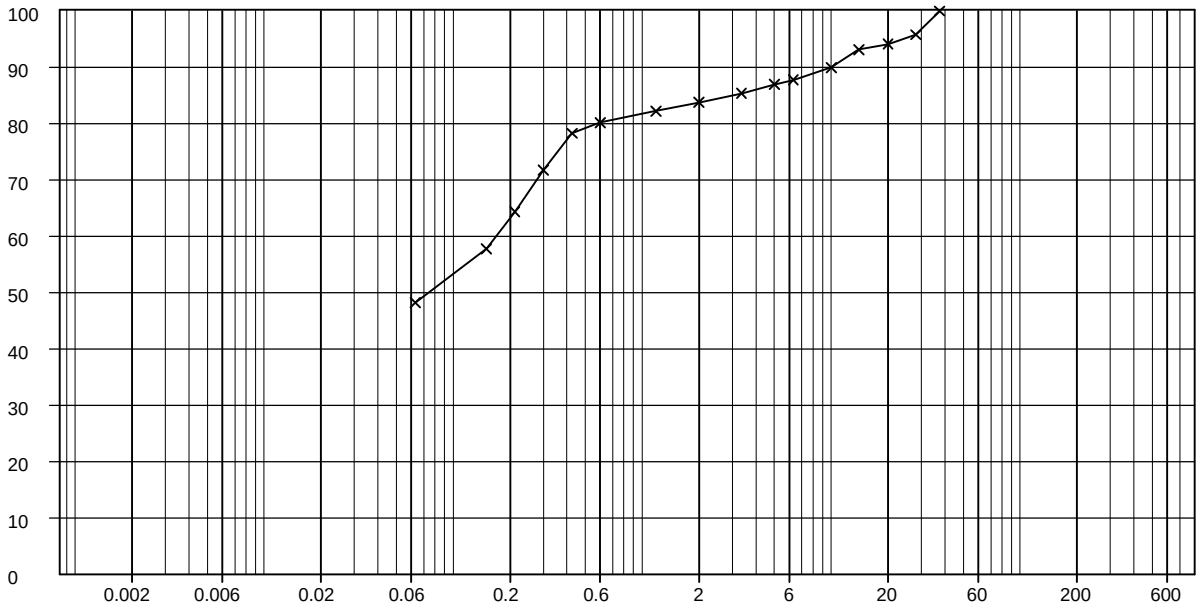
Site : Ortons Garage, Carlton

Client : Springbourne Homes

Job Number 20492

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Pipette/ Hydrometer	Description
WS11	1.30	D3	N/A	Brown slightly gravelly sandy SILT / CLAY



Grading Analysis	
D85	3.0 mm
D60	170.7 µm
D10	-
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	0%
Gravel	16%
Sand	36%
Silt/Clay	48%

Sieve / Particle Size	% Passing
200 mm	100
150 mm	100
125 mm	100
90 mm	100
75 mm	100
63 mm	100
50 mm	100
37.5 mm	100
28 mm	96
20 mm	94
14 mm	93
10 mm	90
6.3 mm	88
5 mm	87
3.35 mm	85
2 mm	84
1.18 mm	82
600 µm	80
425 µm	78
300 µm	72
212 µm	64
150 µm	58
63 µm	48

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 7.4.5 Particle size tests

Preparation Details : Sample washed with no dispersant used, Oven Dried at 105 - 110℃

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

IAN FARMER ASSOCIATES

Laboratory Test Report - 20492/1

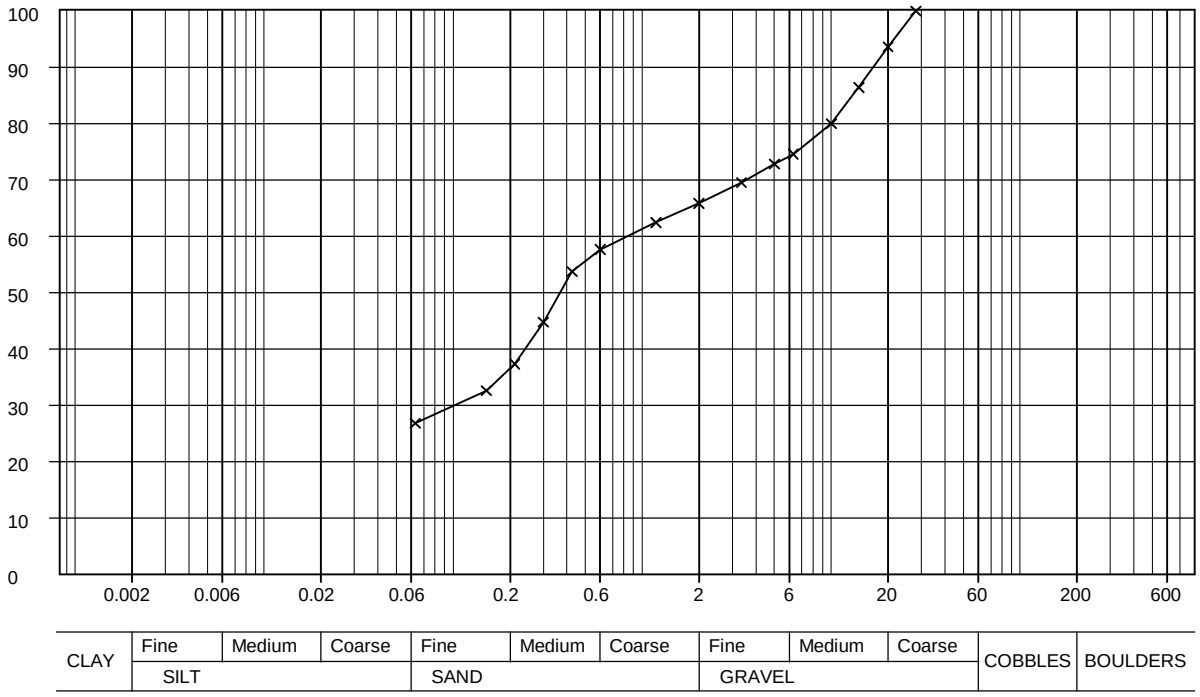
Site : Ortons Garage, Carlton

Client : Springbourne Homes

Job Number 20492

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Pipette/ Hydrometer	Description
WS7	1.90	D4	N/A	Brown slightly silty slightly clayey gravelly SAND



Sieve / Particle Size	% Passing
200 mm	100
150 mm	100
125 mm	100
90 mm	100
75 mm	100
63 mm	100
50 mm	100
37.5 mm	100
28 mm	100
20 mm	94
14 mm	86
10 mm	80
6.3 mm	75
5 mm	73
3.35 mm	70
2 mm	66
1.18 mm	62
600 µm	58
425 µm	54
300 µm	45
212 µm	37
150 µm	33
63 µm	27

Grading Analysis	
D85	13.1 mm
D60	882.8 µm
D10	-
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	0%
Gravel	34%
Sand	39%
Silt/Clay	27%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 7.4.5 Particle size tests

Preparation Details : Sample washed with no dispersant used, Oven Dried at 105 - 110℃

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

IAN FARMER ASSOCIATES

Laboratory Test Report - 20492/1

Site : Ortons Garage, Carlton

Client : Springbourne Homes

Job Number 20492

DETERMINATION OF THE pH VALUE AND THE SULPHATE CONTENT OF SOIL AND GROUNDWATER

Borehole/ Trial Pit	Depth (m)	Sample	Concentration of Soluble Sulphate			Percentage of sample passing 2mm Sieve %	pH	Description / Remarks
			Soil		Groundwater g /l			
			Total S04 %	S04 in 2:1 water:soil g /l				
WS11	0.80	D2		0.1		90	7.1	Brown CLAY
WS6	1.40	D3		0.1		64	8.0	Brown slightly sandy CLAY
WS7	0.60	D2		0.1		73	7.1	Brown sandy CLAY

Method of Preparation : BS 1377:PART 1:1990:7.5 Preparation of soil for chemical tests BS 1377:PART 3:1990:5.2, 5.3, 5.4 & 9.4

Method of Test : BS 1377:PART 3:1990:5 Determination of the sulphate content of soil and ground water BS 1377:PART 3:1990:9 Determination of the pH value

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Test Report : **20492/1**

Site : Ortons Garage, Carlton
Job Number : 20492
Originating Client : Springbourne Homes

All opinions and interpretations contained within this report are outside of our Scope of Accreditation.

The following tests contained within this report are not UKAS Accredited.

Date of Issue : 22/04/09

APPENDIX 4

CHEMICAL TESTS

Derwentside Environmental Testing Services

Certificate of Analysis

2139

Certificate Number: 08-24356

Date: 12/12/2008

Client:	Ian Farmer Associates 2-4 Bilton Industrial Estate, Humber Avenue, Coventry CV3 1JL
Our Reference:	08-24356
Client Reference:	20469
Contract Title:	Ortons Garage
Description:	6 soil samples
Date Received:	10/12/2008
Date Started:	10/12/2008
Date Completed:	12/12/2008
Test Procedures:	Identified by prefix DETSn, details available upon request.
Notes:	Observations and interpretations are outside the scope of UKAS accreditation * denotes test not included in laboratory scope of accreditation # denotes test that holds MCERT accreditation $ denotes tests completed by an approved subcontractor I/S denotes insufficient sample to carry out test N/S denotes that the sample is not suitable for testing DETSM denotes tests carried out by DETS Midlands laboratory Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate Asbestos subsamples will be kept for 6 months
Approved By:	
Authorised Signatories:	Rob Brown Business Manager

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Derwentside Environmental Testing Services Limited
Unit 2, Park Road Industrial Estate South, Consett, Co Durham, DH8 5PY
Tel: 01207 582333 • Fax 01207 582444 • email: info@dets.co.uk • www.dets.co.uk

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

Sample Details

Sample ID	Number	Depth	DETS Ref	Matrix Description	Date Sampled	Time Sampled	Preservation	Analysis Complete
WS1		0.50	168559	Firm brown gravelly sandy CLAY	Not Provided	Not Provided	None	12/12/2008
WS1		0.80	168560	Firm brown gravelly sandy CLAY (made ground includes brick	Not Provided	Not Provided	None	12/12/2008
WS1		1.30	168561	Firm brown sandy gravelly CLAY	Not Provided	Not Provided	None	12/12/2008
WS2		0.25	168562	Firm brown sandy gravelly CLAY	Not Provided	Not Provided	None	12/12/2008
WS3		0.30	168563	Firm brown CLAY	Not Provided	Not Provided	None	12/12/2008
WS5		0.50	168564	Firm brown gravelly sandy CLAY	Not Provided	Not Provided	None	12/12/2008

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

		Lab No.	168559	168560	168561	168562
		Sample Ref	WS1	WS1	WS1	WS2
		Depth	0.50	0.80	1.30	0.25
		Other Ref				
		Sample Type				
Test	**Units**	**DETSxx**				
Arsenic	mg/kg	DETS 042#	6			8
Cadmium	mg/kg	DETS 042#	0.4			0.6
Chromium	mg/kg	DETS 042#	8			11
Copper	mg/kg	DETS 042#	10			42
Lead	mg/kg	DETS 042#	68			40
Mercury	mg/kg	DETS 081#	0.08			0.09
Nickel	mg/kg	DETS 042#	9			12
Selenium	mg/kg	DETS 042#	< 0.5			0.5
Zinc	mg/kg	DETS 042#	40			95
Sulphate Aqueous Extract as SO4	mg/l	DETS 076#	150			120
Total Organic Carbon	%	DETS 002	0.9		0.2	1.4
pH		DETSM-102#	8.3	-	-	10.6
Naphthalene	mg/kg	DETSM-125#	<0.10	0.43	<0.10	<0.10
Acenaphthylene	mg/kg	DETSM-125#	<0.12	<0.12	0.87	<0.12
Acenaphthene	mg/kg	DETSM-125#	<0.10	<0.10	<0.10	<0.10
Fluorene	mg/kg	DETSM-125#	<0.12	<0.12	<0.12	<0.12
Phenanthrene	mg/kg	DETSM-125#	<0.14	<0.14	0.36	0.35
Anthracene	mg/kg	DETSM-125#	<0.10	<0.10	0.29	0.30
Fluoranthene	mg/kg	DETSM-125#	<0.11	<0.11	0.32	0.46
Pyrene	mg/kg	DETSM-125#	<0.12	<0.12	0.31	0.46
Benzo(a)anthracene	mg/kg	DETSM-125#	<0.10	<0.10	<0.10	0.40
Chrysene	mg/kg	DETSM-125#	<0.14	<0.14	<0.14	0.39
Benzo(b)fluoranthene	mg/kg	DETSM-125#	<0.13	<0.13	<0.13	0.44
Benzo(k)fluoranthene	mg/kg	DETSM-125#	<0.13	<0.13	<0.13	0.38
Benzo(a)pyrene	mg/kg	DETSM-125#	<0.14	<0.14	<0.14	0.33
Indeno(123cd)pyrene	mg/kg	DETSM-125#	<0.13	<0.13	<0.13	0.31
Dibenzo(ah)anthracene	mg/kg	DETSM-125#	<0.10	<0.10	<0.10	<0.10
Benzo(ghi)perylene	mg/kg	DETSM-125#	<0.12	<0.12	<0.12	0.18
PAH (total)	mg/kg	DETSM-125#	<0.80	<0.80	2.2	4.0
EPH (C10-C40)	mg/kg	DETS 051#			380	60

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

		Lab No.	168563	168564
		Sample Ref	WS3	WS5
		Depth	0.30	0.50
		Other Ref		
		Sample Type		
Test	**Units**	**DETSxx**		
Arsenic	mg/kg	DETS 042#	6	7
Cadmium	mg/kg	DETS 042#	0.6	0.6
Chromium	mg/kg	DETS 042#	7	20
Copper	mg/kg	DETS 042#	53	16
Lead	mg/kg	DETS 042#	30	20
Mercury	mg/kg	DETS 081#	< 0.05	0.07
Nickel	mg/kg	DETS 042#	7	12
Selenium	mg/kg	DETS 042#	< 0.5	< 0.5
Zinc	mg/kg	DETS 042#	54	63
Sulphate Aqueous Extract as SO4	mg/l	DETS 076#		
Total Organic Carbon	%	DETS 002	0.2	1.1
pH		DETSM-102#	9.4	7.3
Naphthalene	mg/kg	DETSM-125#	<0.10	<0.10
Acenaphthylene	mg/kg	DETSM-125#	<0.12	<0.12
Acenaphthene	mg/kg	DETSM-125#	<0.10	<0.10
Fluorene	mg/kg	DETSM-125#	<0.12	<0.12
Phenanthrene	mg/kg	DETSM-125#	<0.14	<0.14
Anthracene	mg/kg	DETSM-125#	<0.10	<0.10
Fluoranthene	mg/kg	DETSM-125#	<0.11	<0.11
Pyrene	mg/kg	DETSM-125#	<0.12	<0.12
Benzo(a)anthracene	mg/kg	DETSM-125#	<0.10	<0.10
Chrysene	mg/kg	DETSM-125#	<0.14	<0.14
Benzo(b)fluoranthene	mg/kg	DETSM-125#	<0.13	<0.13
Benzo(k)fluoranthene	mg/kg	DETSM-125#	<0.13	<0.13
Benzo(a)pyrene	mg/kg	DETSM-125#	<0.14	<0.14
Indeno(123cd)pyrene	mg/kg	DETSM-125#	<0.13	<0.13
Dibenzo(ah)anthracene	mg/kg	DETSM-125#	<0.10	<0.10
Benzo(ghi)perylene	mg/kg	DETSM-125#	<0.12	<0.12
PAH (total)	mg/kg	DETSM-125#	<0.80	<0.80
EPH (C10-C40)	mg/kg	DETS 051#	43	48

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

		Lab No.	168560
		Sample Ref	WS1
		Depth	0.80
		Other Ref	
		Sample Type	
Test	**Units**	**DETSxx**	
Aliphatic C5-C6	mg/kg	DETS 072*	< 0.01
Aliphatic C6-C8	mg/kg	DETS 072*	0.39
Aliphatic C8-C10	mg/kg	DETS 072*	0.31
Aliphatic C10-C12	mg/kg	DETS 072*	< 0.1
Aliphatic C12-C16	mg/kg	DETS 072*	< 0.1
Aliphatic C16-C21	mg/kg	DETS 072*	< 0.1
Aliphatic C21-C35	mg/kg	DETS 072*	< 0.1
Aromatic C5-C7	mg/kg	DETS 072*	0.12
Aromatic C7-C8	mg/kg	DETS 072*	2.5
Aromatic C8-C10	mg/kg	DETS 072*	3.3
Aromatic C10-C12	mg/kg	DETS 072*	0.1
Aromatic C12-C16	mg/kg	DETS 072*	< 0.1
Aromatic C16-C21	mg/kg	DETS 072*	1.9
Aromatic C21-C35	mg/kg	DETS 072*	< 0.1
Aliphatic C5-C35	mg/kg	DETS 072*	< 1
Aromatic C5-C35	mg/kg	DETS 072*	8
TPH Ali/Aro	mg/kg	DETS 072*	9
Total VOC's	mg/kg	DETS 068*	0.62
Benzene	mg/kg	DETS 068*	< 0.01
1,2-dichloroethane	mg/kg	DETS 068*	< 0.01
Trichloroethylene	mg/kg	DETS 068*	< 0.01
1,2-dichloropropane	mg/kg	DETS 068*	< 0.01
Dibromomethane	mg/kg	DETS 068*	< 0.01
Bromodichloromethane	mg/kg	DETS 068*	< 0.01
cis-1,3-dichloropropene	mg/kg	DETS 068*	< 0.01
Toluene	mg/kg	DETS 068*	< 0.01
trans-1,3-dichloropropene	mg/kg	DETS 068*	< 0.01
1,1,2-trichloroethane	mg/kg	DETS 068*	< 0.01
Tetrachloroethylene	mg/kg	DETS 068*	< 0.01
1,3-dichloropropane	mg/kg	DETS 068*	< 0.01
Dibromochloromethane	mg/kg	DETS 068*	< 0.01
1,2-dibromoethane	mg/kg	DETS 068*	< 0.01
Chlorobenzene	mg/kg	DETS 068*	< 0.01
Ethylbenzene+1,1,1,2-tetrachloroethane	mg/kg	DETS 068*	0.04
m+p-Xylene	mg/kg	DETS 068*	0.28
o-Xylene	mg/kg	DETS 068*	< 0.01
Styrene	mg/kg	DETS 068*	< 0.01
Bromoform	mg/kg	DETS 068*	< 0.01
Isopropylbenzene	mg/kg	DETS 068*	< 0.01
Bromobenzene	mg/kg	DETS 068*	< 0.01
1,2,3-trichloropropane	mg/kg	DETS 068*	< 0.01
n-propylbenzene	mg/kg	DETS 068*	0.01
2-chlorotoluene	mg/kg	DETS 068*	< 0.01
1,3,5-trimethylbenzene	mg/kg	DETS 068*	0.09
4-chlorotoluene	mg/kg	DETS 068*	< 0.01

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

		Lab No.	168560
		Sample Ref	WS1
		Depth	0.80
		Other Ref	
		Sample Type	
Test	**Units**	**DETSxx**	
Tert-butylbenzene	mg/kg	DETS 068*	< 0.01
1,2,4-trimethylbenzene	mg/kg	DETS 068*	0.17
sec-butylbenzene	mg/kg	DETS 068*	< 0.01
1,3-dichlorobenzene+p-isopropyltoluene	mg/kg	DETS 068*	< 0.01
1,4-dichlorobenzene	mg/kg	DETS 068*	< 0.01
n-butylbenzene	mg/kg	DETS 068*	< 0.01
1,2-dichlorobenzene	mg/kg	DETS 068*	< 0.01
1,2-dibromo-3-chloropropane	mg/kg	DETS 068*	< 0.01
1,2,4-trichlorobenzene	mg/kg	DETS 068*	< 0.01
Hexachlorobutadiene	mg/kg	DETS 068*	< 0.01
Naphthalene	mg/kg	DETS 068*	0.03
1,2,3-trichlorobenzene	mg/kg	DETS 068*	< 0.01
Chloroform	mg/kg	DETS 068*	< 0.01
Bromochloromethane	mg/kg	DETS 068*	< 0.01
2,2-dichlororopane+1,2-dichloroethylene	mg/kg	DETS 068*	< 0.01
1,1-dichloroethane	mg/kg	DETS 068*	< 0.01
Trans-1,2-dichloroethylene	mg/kg	DETS 068*	< 0.01
Methylene Chloride	mg/kg	DETS 068*	< 0.01
1,1 Dichloroethylene	mg/kg	DETS 068*	< 0.01
Carbon tetrachloride + 1,1-dichloropropene	mg/kg	DETS 068*	< 0.01
1,1,1-trichloroethane	mg/kg	DETS 068*	< 0.01

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-83163
Client Ref: 08-24356
Contract Title: Ortons Garage

		Lab No.	2
		Sample Ref	
		Depth	0.80
		Other Ref	ws1
		Sample Type	Soil
Test	**Units**	**DETSxx**	
Aniline	mg/kg	DETSM-134*	<0.10
Bis(2-chloroethyl)ether	mg/kg	DETSM-134*	<0.10
Phenol	mg/kg	DETSM-134*	<0.10
2-Chlorophenol	mg/kg	DETSM-134*	<0.10
Benzyl Alcohol	mg/kg	DETSM-134*	<0.10
2-Methylphenol	mg/kg	DETSM-134*	<0.10
3& 4-Methylphenol	mg/kg	DETSM-134*	<0.10
2,4-dimethylphenol	mg/kg	DETSM-134*	<0.10
Bis-(dichloroethoxy)methane	mg/kg	DETSM-134*	<0.10
2,4-Dichlorophenol	mg/kg	DETSM-134*	<0.10
1,2,4-Trichlorobenzene	mg/kg	DETSM-134*	<0.10
Napthalene	mg/kg	DETSM-134*	0.41
4-Chloro-3-methylphenol	mg/kg	DETSM-134*	<0.10
2-Methylnapthalene	mg/kg	DETSM-134*	0.18
Hexachlorocyclpentadiene	mg/kg	DETSM-134*	<0.10
2,4,6 Trichlorophenol	mg/kg	DETSM-134*	<0.10
2,4,5 Trichlorophenol	mg/kg	DETSM-134*	<0.10
2-Chloronapthalene	mg/kg	DETSM-134*	<0.10
2-Nitroaniline	mg/kg	DETSM-134*	<0.10
1,4-dinitrobenzene	mg/kg	DETSM-134*	<0.10
Dimethyl phthalate	mg/kg	DETSM-134*	<0.10
1,3-dintrobenzene	mg/kg	DETSM-134*	<0.10
Acenapthylene	mg/kg	DETSM-134*	<0.10
2,6-Dinitrotoluene	mg/kg	DETSM-134*	<0.10
1,2-Dinitrobenzene	mg/kg	DETSM-134*	<0.10
3-Nitroaniline	mg/kg	DETSM-134*	<0.10
Acenapthene	mg/kg	DETSM-134*	<0.10
Dibenzofuran	mg/kg	DETSM-134*	<0.10
2,4-Dinitrotoluene	mg/kg	DETSM-134*	<0.10
4-Nitrophenol	mg/kg	DETSM-134*	<0.10
2,3,4,6-Tetrachlorophenol	mg/kg	DETSM-134*	<0.10
2,3,5,6-Tetrachlorophenol	mg/kg	DETSM-134*	<0.10
Diethylphthalate	mg/kg	DETSM-134*	<0.10
Fluorene	mg/kg	DETSM-134*	<0.10
4-Chlorophenyl phenyl ether	mg/kg	DETSM-134*	<0.10
4-Nitroaniline	mg/kg	DETSM-134*	<0.10
Diphenylamine/4,6-Dinitro-2-methylphenol	mg/kg	DETSM-134*	<0.10
Azobenzene	mg/kg	DETSM-134*	<0.10
4-Bromophenyl phenyl ether	mg/kg	DETSM-134*	<0.10
Hexachlorobenzene	mg/kg	DETSM-134*	<0.10
Pentachlorophenol	mg/kg	DETSM-134*	<0.10
Phenanthrene	mg/kg	DETSM-134*	<0.10
Anthracene	mg/kg	DETSM-134*	<0.10
Carbazole	mg/kg	DETSM-134*	<0.10
Di-n-butylphthalate	mg/kg	DETSM-134*	<0.10
Benzyl butyl phthalate	mg/kg	DETSM-134*	<0.10
Bis(2-ethylhexyl)ester	mg/kg	DETSM-134*	<0.10
Fluoranthene	mg/kg	DETSM-134*	<0.10
Pyrene	mg/kg	DETSM-134*	<0.10
Benzo(a)anthracene	mg/kg	DETSM-134*	<0.10
Chrysene	mg/kg	DETSM-134*	<0.10
Di-n-octyl phthalate	mg/kg	DETSM-134*	<0.10

Summary of Chemical Analysis
Soil Samples

Our Ref: 08-83163
Client Ref: 08-24356
Contract Title: Ortons Garage

		Lab No.	2
		Sample Ref	
		Depth	0.80
		Other Ref	ws1
		Sample Type	Soil
Test	**Units**	**DETSxx**	
Benzo(b)fluoranthene	mg/kg	DETSM-134*	<0.10
Benzo(k)fluoranthene	mg/kg	DETSM-134*	<0.10
Benzo(a)pyrene	mg/kg	DETSM-134*	<0.10
Indeno(1,2,3-cd)pyrene	mg/kg	DETSM-134*	<0.10
Dibenz(a,h)anthracene	mg/kg	DETSM-134*	<0.10
Benzo(ghi)perylene	mg/kg	DETSM-134*	<0.10

Summary of Asbestos Analysis
Soil Samples

Our Ref: 08-24356
Client Ref: 20469
Contract Title: Ortons Garage

Laboratory Number	Sample Ref	Depth	Other Ref	Material	Result
168559	WS1	0.50		Soil	NAD
168562	WS2	0.25		Soil	NAD
168563	WS3	0.30		Soil	NAD
168564	WS5	0.50		Soil	NAD

Crocidolite = Blue Asbestos, Amosite = Brown Asbestos, Chrysotile = White Asbestos
NAD = No Asbestos Detected. Anthophyllite, Actinolite and Tremolite are other forms of Asbestos

Samples are analysed using polarised light microscopy in accordance with HSG248 and documented in-house methods. Where a sample is NAD, the result is based on analysis of at least 2 sub-samples and should be taken to mean 'no asbestos detected in sample'.

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 002	Organic Matter	%	0.01	Air Dried	No	Yes	Yes
DETS 003	Loss on Ignition	%	0.01	Air Dried	No	Yes	Yes
DETS 004	Total Sulphate	%	0.01	Air Dried	No	Yes	Yes
DETS 075	Total Sulphate	%	0.01	Air Dried	No	Yes	Yes
DETS 004	Water Soluble Sulphate	g/l	0.01	Air Dried	No	Yes	Yes
DETS 076	Water Soluble Sulphate	g/l	0.01	Air Dried	No	Yes	Yes
DETS 006	Chloride	mg/kg	0.01	Air Dried	No	Yes	Yes
DETS 008	pH	pH Units	0.10	Air Dried	No	Yes	Yes
DETS 042	Selenium	mg/kg	0.50	Air Dried	No	Yes	Yes
DETS 019	Ammonia	mg/kg	0.02	Air Dried	No	No	No
DETS 020	Boron (Water Soluble)	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 024	Sulphide	mg/kg	10.00	Air Dried	No	Yes	Yes
DETS 042	Antimony	mg/kg	1.00	Air Dried	No	No	No
DETS 042	Arsenic	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Barium	mg/kg	1.50	Air Dried	No	Yes	Yes
DET S 042	Beryllium	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Cadmium	mg/kg	0.10	Air Dried	No	Yes	Yes

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 042	Cobalt	mg/kg	0.70	Air Dried	No	Yes	Yes
DETS 042	Copper	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Chromium	mg/kg	0.15	Air Dried	No	Yes	Yes
DETS 042	Iron	mg/kg	1.00	Air Dried	No	Yes	No
DETS 042	Lead	mg/kg	0.30	Air Dried	No	Yes	Yes
DETS 042	Manganese	mg/kg	20.00	Air Dried	No	Yes	Yes
DETS 081	Mercury	mg/kg	0.05	Air Dried	No	Yes	Yes
DETS 042	Molybdenum	mg/kg	0.40	Air Dried	No	Yes	Yes
DETS 042	Nickel	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Thallium	mg/kg	1.00	Air Dried	No	No	No
DETS 042	Vanadium	mg/kg	0.80	Air Dried	No	Yes	Yes
DETS 042	Zinc	mg/kg	1.00	Air Dried	No	Yes	Yes
DETS 049	Sulphur (Free)	mg/kg	0.50	As Received	No	Yes	Yes
DETS 050	PAH	mg/kg	0.10	As Received	No	Yes	No
DETS 051	TPH (C10 - C40)	mg/kg	20.00	As Received	No	Yes	Yes
DETS 052	PCB	mg/kg	0.01	As Received	No	Yes	Yes

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 062	Benzene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Toluene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Ethylbenzne	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Xylene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 067	Phenol - Monohydric	mg/kg	0.3	Air Dried	No	Yes	Yes
DETS 067	Easily Liberatable Cyanide	mg/kg	0.1	Air Dried	No	Yes	Yes
DETS 067	Complex Cyanide	mg/kg	0.30	Air Dried	No	Yes	No
DETS 067	Total Cyanide	mg/kg	0.40	Air Dried	No	Yes	Yes
DETS 067	Thiocyanate	mg/kg	0.6	Air Dried	No	Yes	Yes
DETS 068	VOC	mg/kg	0.01	As Received	No	No	No

Certificate of Analysis

2139

Certificate Number: 09-26647

Date: 09/04/2009

Client:	Ian Farmer Associates 2-4 Bilton Industrial Estate, Humber Avenue, Coventry CV3 1JL
Our Reference:	09-26647
Client Reference:	20492
Contract Title:	Ortons Garage
Description:	4 soil samples
Date Received:	01/04/2009
Date Started:	02/04/2009
Date Completed:	09/04/2009
Test Procedures:	Identified by prefix DETSn, details available upon request.
Notes:	Observations and interpretations are outside the scope of UKAS accreditation * denotes test not included in laboratory scope of accreditation # denotes test that holds MCERT accreditation $ denotes tests completed by an approved subcontractor I/S denotes insufficient sample to carry out test N/S denotes that the sample is not suitable for testing DETSM denotes tests carried out by DETS Midlands laboratory Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate Asbestos subsamples will be kept for 6 months
Approved By:	
Authorised Signatories:	Rob Brown Business Manager

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Our Ref: 09-26647
Client Ref: 20492
Contract Title: Ortons Garage

Sample Details

Sample ID	Depth	DETS Ref	Matrix Description	Date Sampled	Time Sampled	Preservation	Analysis Complete
WS6	0.30	185197	brown very gravelly SAND made ground with brick	Not Provided	Not Provided	None	09/04/2009
WS7	0.20	185198	brown gravelly SAND made ground with brick	Not Provided	Not Provided	None	09/04/2009
WS8	0.50	185199	brown sandy CLAY with odd rootlets	Not Provided	Not Provided	None	09/04/2009
WS9	0.50	185200	brown gravelly sandy CLAY	Not Provided	Not Provided	None	09/04/2009

Summary of Chemical Analysis
Soil Samples

Our Ref: 09-26647
Client Ref: 20492
Contract Title: Ortons Garage

		Lab No.	185197	185198	185199	185200
		Sample Ref	WS6	WS7	WS8	WS9
		Depth	0.30	0.20	0.50	0.50
		Other Ref				
		Sample Type				
Test	**Units**	**DETSxx**				
Arsenic	mg/kg	DETS 042#	5	8	8	15
Cadmium	mg/kg	DETS 042#	0.5	0.5	0.6	0.9
Chromium	mg/kg	DETS 042#	11	14	14	24
Copper	mg/kg	DETS 042#	19	19	20	22
Lead	mg/kg	DETS 042#	47	53	33	17
Mercury	mg/kg	DETS 081#	0.06	0.06	0.07	0.07
Nickel	mg/kg	DETS 042#	9	13	12	31
Selenium	mg/kg	DETS 042#	< 0.5	< 0.5	< 0.5	< 0.5
Zinc	mg/kg	DETS 042#	140	120	110	83
Total Organic Carbon	%	DETS 002	0.3	2.1		0.3
pH	pH units	DETSM-102#	9.4	8.0	6.7	7.0
Aliphatic C5-C6	mg/kg	DETS 072*	0.01	0.04		
Aliphatic C6-C8	mg/kg	DETS 072*	0.01	0.01		
Aliphatic C8-C10	mg/kg	DETS 072*	0.06	< 0.01		
Aliphatic C10-C12	mg/kg	DETS 072*	< 0.1	< 0.1		
Aliphatic C12-C16	mg/kg	DETS 072*	0.2	< 0.1		
Aliphatic C16-C21	mg/kg	DETS 072*	2.1	2.0		
Aliphatic C21-C35	mg/kg	DETS 072*	18	20		
Aromatic C5-C7	mg/kg	DETS 072*	< 0.01	< 0.01		
Aromatic C7-C8	mg/kg	DETS 072*	< 0.01	< 0.01		
Aromatic C8-C10	mg/kg	DETS 072*	< 0.01	< 0.01		
Aromatic C10-C12	mg/kg	DETS 072*	< 0.1	< 0.1		
Aromatic C12-C16	mg/kg	DETS 072*	< 0.1	0.3		
Aromatic C16-C21	mg/kg	DETS 072*	2.5	2.5		
Aromatic C21-C35	mg/kg	DETS 072*	12	22		
Aliphatic C5-C35	mg/kg	DETS 072*	20	23		
Aromatic C5-C35	mg/kg	DETS 072*	15	25		
TPH Ali/Aro	mg/kg	DETS 072*	35	47		
Naphthalene	mg/kg	DETSM-125#	<0.10	<0.10		<0.10
Acenaphthylene	mg/kg	DETSM-125#	<0.12	<0.12		<0.12
Acenaphthene	mg/kg	DETSM-125#	<0.10	<0.10		<0.10
Fluorene	mg/kg	DETSM-125#	<0.12	<0.12		<0.12
Phenanthrene	mg/kg	DETSM-125#	0.17	<0.14		<0.14
Anthracene	mg/kg	DETSM-125#	0.11	<0.10		<0.10
Fluoranthene	mg/kg	DETSM-125#	0.44	0.15		<0.11
Pyrene	mg/kg	DETSM-125#	0.40	0.14		<0.12
Benzo(a)anthracene	mg/kg	DETSM-125#	0.20	0.19		<0.10
Chrysene	mg/kg	DETSM-125#	0.18	0.16		<0.14
Benzo(b)fluoranthene	mg/kg	DETSM-125#	0.29	0.39		<0.13
Benzo(k)fluoranthene	mg/kg	DETSM-125#	<0.13	<0.13		<0.13
Benzo(a)pyrene	mg/kg	DETSM-125#	<0.14	<0.14		<0.14
Indeno(123cd)pyrene	mg/kg	DETSM-125#	<0.13	0.19		<0.13
Dibenzo(ah)anthracene	mg/kg	DETSM-125#	<0.10	<0.10		<0.10
Benzo(ghi)perylene	mg/kg	DETSM-125#	0.19	0.27		<0.12
PAH (total)	mg/kg	DETSM-125#	2.2	1.7		<0.80

Summary of Chemical Analysis
Soil Samples

Our Ref: 09-26647
Client Ref: 20492
Contract Title: Ortons Garage

		Lab No.	185197	185198	185199	185200
		Sample Ref	WS6	WS7	WS8	WS9
		Depth	0.30	0.20	0.50	0.50
		Other Ref				
		Sample Type				
Test	**Units**	**DETSxx**				
Moisture Content	%	DETSM-101*	15.2	19.8	16.9	14.8
Stones Content	%	DETSM-101*	14.7	4.25	4.20	2.51

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 002	Organic Matter	%	0.01	Air Dried	No	Yes	Yes
DETS 003	Loss on Ignition	%	0.01	Air Dried	No	Yes	Yes
DETS 004	Total Sulphate	%	0.01	Air Dried	No	Yes	Yes
DETS 075	Total Sulphate	%	0.01	Air Dried	No	Yes	Yes
DETS 004	Water Soluble Sulphate	mg/l	10.00	Air Dried	No	Yes	Yes
DETS 076	Water Soluble Sulphate	mg/l	10.00	Air Dried	No	Yes	Yes
DETS 006	Chloride	mg/kg	0.01	Air Dried	No	Yes	Yes
DETS 008	pH	pH Units	0.10	Air Dried	No	Yes	Yes
DETS 042	Selenium	mg/kg	0.50	Air Dried	No	Yes	Yes
DETS 019	Ammonia	mg/kg	0.02	Air Dried	No	Yes	Yes
DETS 020	Boron (Water Soluble)	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 024	Sulphide	mg/kg	10.00	Air Dried	No	Yes	Yes
DETS 042	Antimony	mg/kg	1.00	Air Dried	No	No	No
DETS 042	Arsenic	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Barium	mg/kg	1.50	Air Dried	No	Yes	Yes
DET S 042	Beryllium	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Cadmium	mg/kg	0.10	Air Dried	No	Yes	Yes

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 042	Cobalt	mg/kg	0.70	Air Dried	No	Yes	Yes
DETS 042	Copper	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Chromium	mg/kg	0.15	Air Dried	No	Yes	Yes
DETS 042	Iron	mg/kg	1.00	Air Dried	No	Yes	No
DETS 042	Lead	mg/kg	0.30	Air Dried	No	Yes	Yes
DETS 042	Manganese	mg/kg	20.00	Air Dried	No	Yes	Yes
DETS 081	Mercury	mg/kg	0.05	Air Dried	No	Yes	Yes
DETS 042	Molybdenum	mg/kg	0.40	Air Dried	No	Yes	Yes
DETS 042	Nickel	mg/kg	0.20	Air Dried	No	Yes	Yes
DETS 042	Thallium	mg/kg	1.00	Air Dried	No	No	No
DETS 042	Vanadium	mg/kg	0.80	Air Dried	No	Yes	Yes
DETS 042	Zinc	mg/kg	1.00	Air Dried	No	Yes	Yes
DETS 049	Sulphur (Free)	mg/kg	0.50	As Received	No	Yes	Yes
DETS 050	PAH	mg/kg	0.10	As Received	No	Yes	No
DETS 051	TPH (C10 - C40)	mg/kg	20.00	As Received	No	Yes	Yes
DETS 052	PCB	mg/kg	0.01	As Received	No	Yes	Yes

Appendix A - Details of Analysis

Method details are shown only for those determinants listed in Annex A of the MCERTS standard. Anything not included on this list falls outside the scope of MCERTS.
No Recovery Factors are used in the determination of results. Results reported assume 100% recovery
Full method statements are available on request.

Method	Name of Parameter	Units	Limit of Detection	Sample Preparation	Sub-Contracted	UKAS	MCERTS
DETS 062	Benzene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Toluene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Ethylbenzne	mg/kg	0.01	As Received	No	Yes	Yes
DETS 062	Xylene	mg/kg	0.01	As Received	No	Yes	Yes
DETS 067	Phenol - Monohydric	mg/kg	0.3	Air Dried	No	Yes	Yes
DETS 067	Easily Liberatable Cyanide	mg/kg	0.1	Air Dried	No	Yes	Yes
DETS 067	Complex Cyanide	mg/kg	0.30	Air Dried	No	Yes	No
DETS 067	Total Cyanide	mg/kg	0.40	Air Dried	No	Yes	Yes
DETS 067	Thiocyanate	mg/kg	0.6	Air Dried	No	Yes	Yes
DETS 068	VOC	mg/kg	0.01	As Received	No	No	No

APPENDIX 5

DESIGN CONSIDERATIONS

Broad leafed trees		
Water demand	Species	Mature height (m)
High	Elm	
	English	24
	Wheatley	22
	Wych	18
	Eucalyptus	18
	Hawthorn	10
	Oak	
	English	20
	Holm	16
	Red	24
	Turkey	24
	Poplar	
	Hybrid black	28
	Lombardy	25
	White	15
	Willow	
	Crack	24
	Weeping	16
	White	24
Moderate	Acacia False	18
	Alder	18
	Apple	10
	Ash	23
	Bay Laurel	10
	Beech	20
	Blackthorn	8
	Cherry	
	Japanese	9
	Laurel	8
	Orchard	12
	Wild	17
	Chestnut	
	Horse	20
	Sweet	24
	Lime	22
	Maple	
	Japanese	8
	Norway	18
	Mountain ash	11
	Pear	12
	Plane	26
	Plum	10
	Sycamore	22
	Tree of Heaven	20
	Walnut	18
	Whitebeam	12
Low	Birch	14
	Elder	10
	Fig	8
	Hazel	8
	Holly	12
	Honey Locust	14
	Hornbeam	17
	Laburnum	12
	Magnolia	9
	Mulberry	9
	Tulip tree	20

Coniferous trees		
Water demand	Species	Mature height (m)
High	Cypress	
	Lawson's	18
	Leyland	20
	Monterey	20
Moderate	Cedar	20
	Douglas fir	20
	Larch	20
	Monkey Puzzle	18
	Pine	20
	Spruce	18
	Wellingtonia	30
	Yew	12

Note

1. Where hedgerows contain trees, their effects should be assessed separately. In hedgerows, the height of species likely to have the greatest effect should be used

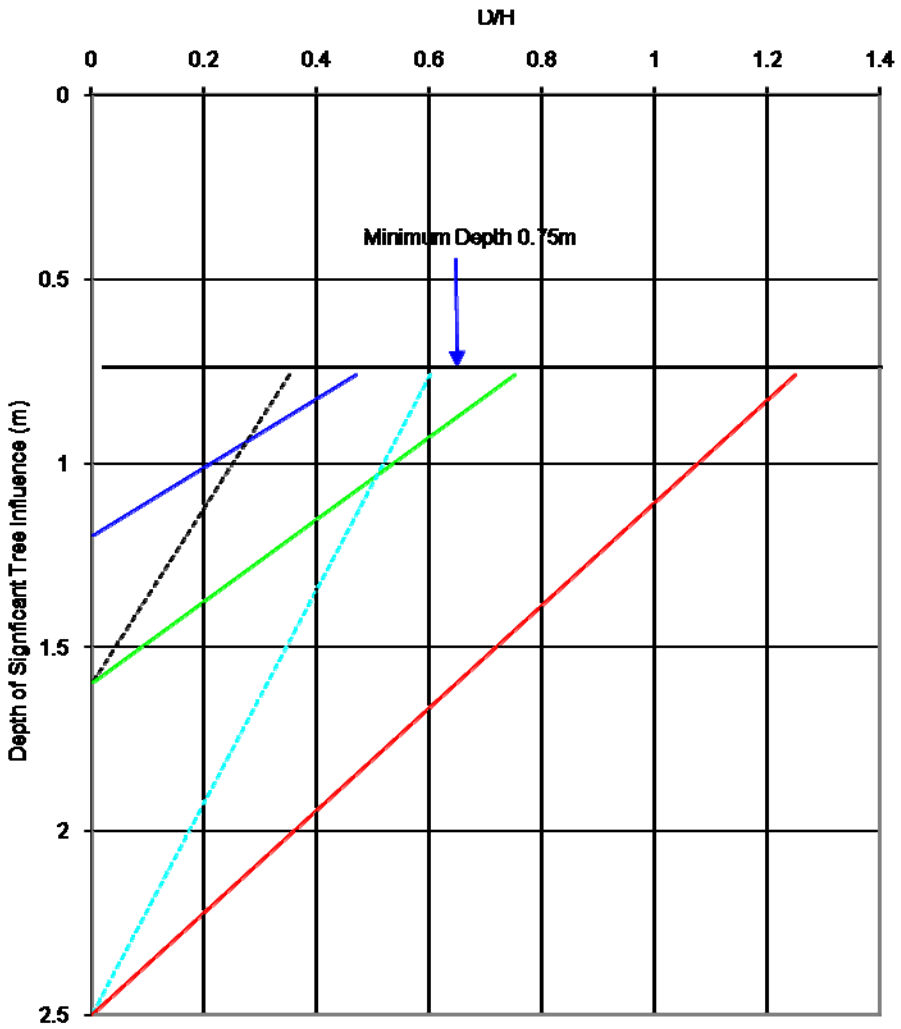
2. Within the classes of water demand, species are listed alphabetically; the order does not signify any graduation in water demand

3. When the species is known but the sub-species is not, the greatest height listed for the species should be assumed

4. Further information regarding trees may be obtained from the Arboricultural Association or the Arboricultural Advisory and Information Service

Reproduced from National House Building Council, Standards, 2003, Chapter 4.2, 'Building Near Trees'

	WATER DEMAND AND MATURE HEIGHT OF TREES	Job no. 20492
	Main Street, Carlton	Fig. A5.1



Reproduced from National House Building Council, Standards 2003, Chapter 4.2, 'Building Near Trees'

	Determination of Foundation Depth - Low Shrinkage Soils	Job no. 20492
	Main Street, Carlton	Fig. A5.2

Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations[a]

Sulphate and magnesium					Groundwater			ACEC Class for location
Design Sulphate Class for Location	2:1 water/soil extract [b]		Groundwater		Total potential sulphate	Static water	Mobile water	
	(SO_4 mg/l)	(Mg mg/l)	(SO_4 mg/l)	(Mg mg/l)	(SO_4%)	(pH)[d]	(pH)[d]	
DS-1	<500		<400		<0.24	≥2.5		AC-1s
							>6.5[d]	AC-1
							5.5-6.5	AC-2z
							4.5-5.5	AC-3z
							2.5-4.5	AC-4z
DS-2	500-1500		400-1400		0.24-0.6	>5.5		AC-1s
							>6.5	AC-2
						2.5-5.5		AC-2s
							5.5-6.5	AC-3z
							4.5-5.5	AC-4z
							2.5-5.5	AC-5z
DS-3	1600-3000		1500-3000		0.7-1.2	>5.5		AC-2s
							>6.5	AC-3
						2.5-5.5		AC-3s
							5.5-6.5	AC-4
							2.5-5.5	AC-5
DS-4	3100-6000	≤1200	3100-6000	≤1000	1.3-2.4	>5.5		AC-3s
							>6.5	AC-4
						2.5-5.5		AC-4s
							2.5-6.5	AC-5
DS-4m	3100-6000	>1200[e]	3100-6000	>1000[e]	1.3-2.4	>5.5		AC-3s
							>6.5	AC-4m
						2.5-5.5		AC-4ms
							2.5-6.5	AC-5m
DS-5	>6000	≤1200	>6000	≤1000	>2.4	>5.5		AC-4s
						2.5-5.5	≥2.5	AC-5
DS-5m	>6000	>1200[e]	>6000	>1000[e]	>2.4	>5.5		Ac-4ms
						2.5-5.5	≥2.5	AC-5m

Notes

a Brownfield locations are those sites, or parts of sites, that might contain chemical residues produced or associated with industrial production
b The limits of Design Sulphate Classes based on 2:1 water/soil extracts have been lowered from previous Digests
c Applies only to locations where concrete will be exposed to sulphate ions (SO_4), which may result from the oxidation of sulphides such as pyrite, following ground disturbance
d An additional account is taken of hydrochloric and nitric acids by adjustment to sulphate content
e The limit on water-soluble magnesium does not apply to brackish groundwater (chloride content between 12000mg/l and 17000mg/l). This allows 'm' to be omitted from the relevant ACEC classification. Seawater (chloride content about 18000mg/l) and stronger brines are not covered by this table.

Explanation of suffix symbols to ACEC class

- Suffix 's' indicates that the water has been classified as static
- Concrete placed in ACEC Classes that include the suffix 'z' have primarily to resist acid conditions and may be made with any of the cements in Digest
- Suffix 'm' relates to the higher levels of magnesium in Design Sulphate Classes 4 and 5

APPENDIX 6

CONTAMINATION ASSESSMENT

APPENDIX 6

GENERAL NOTES ON CONTAMINATION ASSESSMENT

A6.1 STATUTORY FRAMEWORK AND DEFINITIONS

A6.1.1 The statutory definition of contaminated land is defined in the Environmental Protection Act 1990, ref 9.16, which was introduced by the Environment Act 1995, ref 9.17;

'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 –

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) pollution of controlled waters is being, or is likely to be, caused.'

A6.1.2 The UK guidance on the assessment of contaminated has developed as a direct result of the introduction of these two Acts. The technical guidance supporting the new legislation has been summarised in a number of key documents collectively known as the Contaminated Land Reports (CLRs), a proposed series of twelve documents. Seven were originally published in March 1994, four more were published in April 2002, while the last remaining guidance document, CLR 11, ref 9.26 was published in 2004. In 2008 CLR reports 7 to 10 were withdrawn by DEFRA and the Environment Agency and updated version of CLR 9 and 10 were produced in the form of Science Reports SR2, ref 9.23 and SR3, ref 9.19.

A6.1.3 In establishing whether a site fulfils the statutory definition of 'contaminated land' it is necessary to identify, whether a pollutant linkage exists in respect of the land in question and whether the pollutant linkage:

- is resulting in significant harm being caused to the receptor in the pollutant linkage,
- presents a significant possibility of significant harm being caused to that receptor,
- is resulting in the pollution of the controlled waters which constitute the receptor, or
- is likely to result in such pollution.

A6.1.4 A *'pollutant linkage'* may be defined as the link between a contaminant *'source'* and a *'receptor'* by means of a *'pathway'*.

A6.2 ASSESSMENT METHODOLOGY

A6.2.1 The guidance proposes a four-stage assessment process for identifying potential pollutant linkages on a site. These stages are set out in the table below:

No.	Process	Description
1	Hazard Identification	Establishing contaminant sources, pathways and receptors (the conceptual model).
2	Hazard Assessment	Analysing the potential for unacceptable risks (what linkages could be present, what could be the effects).
3	Risk Estimation	Trying to establish the magnitude and probability of the possible consequences (what degree of harm might result and to what receptors, and how likely is it).
4	Risk Evaluation	Deciding whether the risk is unacceptable.

A6.2.2 Stages 1 and 2 develop a *'conceptual model'* based upon information collated from desk based studies, and frequently a walkover of the site. The walkover survey should be conducted in general accordance with CLR 2, ref 9.29. The formation of a conceptual model is an iterative process and as such, it should be updated and refined throughout each stage of the project to reflect any additional information obtained.

A6.2.3 The extent of the desk studies and enquiries to be conducted should be in general accordance with CLR 3, ref 9.30. The information from these enquiries is presented in a desk study report with recommendations, if necessary, for further work based upon the conceptual model. CLR 8, ref. 9.31, together with specific DoE 'Industry Profiles' provides guidance on the nature of contaminants relating to specific industrial processes. Although CLR 8 has been withdrawn, no replacement guidance has been published that lists the contaminants likely to be present on contaminated sites and as such the guidance relating to this issue of CLR 8 is considered to still be relevant.

A6.2.4 If potential pollutant linkages are identified within the conceptual model, a Phase 2 site investigation and report will be recommended. The investigation should be planned in general accordance with CLR 4, ref 9.1. The number of exploratory holes and samples collected for analysis should be consistent with the size of the site and the level of risk envisaged. This will enable a contamination risk assessment to be conducted, at which point the conceptual model can be updated and relevant pollutant linkages can be identified.

A6.2.5 A two-stage investigation may be more appropriate where time constraints are less of an issue. The first stage investigation being conducted as an initial assessment for the presence of potential sources, a second being a more refined investigation to delineate wherever possible the extent of the identified contamination.

A6.2.6 All site works should be in general accordance with the British Standards, BS 5930:1999, ref. 9.3, ISO 1997, ref 9.4 and BS 10175:2001, ref 9.2.

A6.2.7 The generic contamination risk assessment screens the results of the chemical analysis against generic guidance values. Soils will be compared to Assessment Criteria (AC) generated using the Contaminated Land Exposure Assessment (CLEA) Software Version 1.04, ref 9.18. Toxicological and physico-chemical/fate and transport data used to generate the AC has been derived from a hierarchy of data sources as follows:

1. Environment Agency or Department of Environment Food and Rural Affairs

   (DEFRA) documents;

2. Other documents produced by UK Government or state organisations;

3. European institution documents;

4. International organisation documents;

5. Foreign government institutions.

A6.2.8 In the case of the majority of contaminants considered, the toxicological data has been drawn from the relevant CLR 9 TOX report, or updated toxicological data published by the Environment Agency (2009), ref. 9.20, where available. Where no TOX report is available reference has been made to the health criteria values, derived for use in Land Quality Press (2006), ref 9.24, as this is considered to represent a peer reviewed data source. Similarly, fate and transport data has been derived in the first instance from Environment Agency (2003), ref 9.32 and for contaminants not considered in this document the fate and transport data used in previous versions of the CLEA model has been used.

A6.2.9 Recommendations for tolerable intakes of lead are based on evaluation of the relationship between exposure and blood lead levels. Consequently the Tox report for lead considers a health criteria value based on an uptake dose, whereas the CLEA model estimates exposure in terms of an intake dose, therefore, the CLEA model is not considered appropriate for determining an assessment criteria for lead. In the absence of a current published assessment criterion, the SGVs for lead reported in R&D Publication CLR 10 ref 9.33 have been used in this assessment.

A6.2.10 Chemical laboratory test results are processed as follows. A statistical analysis of the results is conducted, as detailed in CIEH and CL:AIRE 'Guidance on Comparing Soil Contamination Data with a Critical Concentration', ref 9.21. Individual concentrations are compared to the selected guideline values to identify concentrations of contaminants that are above the selected screening criteria.

A6.2.11 Initially the distribution of the data set is tested using the Shapiro-Wilk normality test, ref 9.22 to determine if the data set is, or is not, normally distributed. Where the distribution of the data is shown to be normal, the mean value test is applied to determine whether the mean characteristics of the selected soil unit present a significant possibility of significant harm to human health. Where the data is not normally distributed a method based on the Chebychev Theorem can be applied to test the same hypothesis. The significance of the data is further tested using the maximum value test. This determines whether the highest recorded contaminant concentrations are from the same statistical distribution or whether they may represent a 'hot spot'.

A6.2.12 Where the risk estimation identifies significant concentrations of one or more contaminants, a further risk evaluation needs to be undertaken.

A6.2.13 The risk evaluation will address the potential pollutant linkages between an identified source of contamination and the likely receptors both on and off site.

A6.2.14 The potential receptors include:

1) Humans – current site occupants, construction workers, future site users and neighbouring site users.

2) Controlled Waters – surface water and groundwater resources

3) Plants – current and future site vegetation

4) Building materials

A6.2.15 The potential hazards to be considered in relation to contamination are:

a) Ingestion and inhalation.

b) Uptake of contaminants via cultivated vegetables.

c) Dermal contact

d) Phytotoxicity (the prevention or inhibition of plant growth)

e) Contamination of water resources

f) Chemical attack on building materials and services

g) Fire and explosion

A6.2.16 Dependent on the outcome of the initial, generic contamination risk assessment, further detailed assessment of the identified risks may be required.

A6.3 Generic Guidance Values Used Within Contamination Risk Assessment

	Determinant	Guidance Value (mg/kg)	Primary Data Source of Toxicological and Fate and Transport Data
		Residential with plant uptake	
PAH	Benzo(a)pyrene		
	1% SOM[1]	0.80	LQM CIEH GAC
	3% SOM[1]	1.00	LQM CIEH GAC
	6% SOM[1]	1.00	LQM CIEH GAC
	Dibenzo(a,h)anthracene		
	1% SOM[1]	0.90	LQM CIEH GAC
	3% SOM[1]	1.00	LQM CIEH GAC
	6% SOM[1]	1.00	LQM CIEH GAC
	Naphthalene		
	1% SOM[1]	1.5	CLEA SGV 19 (DRAFT)
	3% SOM[1]	4.4	CLEA SGV 19 (DRAFT)
	6% SOM[1]	9	CLEA SGV 19 (DRAFT)
Other Organics	Phenol		
	1% SOM[1]	433	CLEA SGV 8
	3% SOM[1]	1050	CLEA SGV 8
	6% SOM[1]	1920	CLEA SGV 8
Metals	Arsenic	32	EA_SGV 09
	Cadmium	29	CLEA SGV 3
	Chromium	38	CLEA SGV 4
	Inorganic Mercury	170	EA_SGV 09
	Nickel	110	EA_SGV 09
	Selenium	350	EA_SGV 09
	Lead	450	CLEA SGV 10
	Beryllium	25	LQM CIEH GAC
	Copper	432	LQM CIEH GAC
	Vanadium	33	LQM CIEH GAC
	Zinc	282	LQM CIEH GAC

[1] SOM – Soil Organic Matter

A6.3.1 Generic Assessment Criteria for Petroleum Hydrocarbons

Residential with Plant Uptake	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Guidance Value (mg/kg)	Primary Data Source of Toxicological and Fate and Transport Data
	1% SOM	3% SOM	6% SOM	
Aliphatic				
EC 5-6	3.0	6.3	11.2	LQM CIEH GAC
EC >6-8	7.6	20	39	LQM CIEH GAC
EC >8-10	2.0	5.8	11.6	LQM CIEH GAC
EC >10-12	11	34	67	LQM CIEH GAC
EC >12-16	22.1	66.3	133	LQM CIEH GAC
EC >16-35	8840	8840	8840	LQM CIEH GAC
EC >35-44	8840	8840	8840	LQM CIEH GAC
Aromatic				
EC 5-7 (benzene)	1.3	2.7	4.9	LQM CIEH GAC
EC >7-8 (toluene)	3.0	7.8	14.9	LQM CIEH GAC
EC >8-10	6.1	18	35	LQM CIEH GAC
EC >10-12	29.4	85	164	LQM CIEH GAC
EC >12-16	97	263	461	LQM CIEH GAC
EC >16-21	272	579	805	LQM CIEH GAC
EC >21-35	889	1140	1230	LQM CIEH GAC
EC >35-44	889	1140	1230	LQM CIEH GAC
Aliphatic and Aromatic				
EC >44-70	1180	1270	1300	LQM CIEH GAC

Notes: pH = 7; sandy soil

APPENDIX 7

GAS GENERATION

APPENDIX 7

GENERAL NOTES ON GAS GENERATION

A7.1 GENERAL

A7.1.1 In the past, a series of guidance documents were published by CIRIA, ref. 9.34, providing advice on hazards associated with methane. This earlier guidance was consolidated in CIRIA Document C659 to provide a risk based approach to gas contaminated land. This was subsequently re-issued as CIRIA Document C665, ref 9.35. In 2007, British Standard, BS8485, ref 9.36, dealing with ground gas was published. It is recommended that guidance in C665 and BS8485 is adopted to provide a consistent approach in dealing with ground gas contamination, the principal details being as follows.

A7.1.2 This guidance is based on a similar approach to that for dealing with contaminated soil. The presence of hazardous gases could be deemed to be the 'source' in a 'pollutant linkage' that could lead to the conclusion that significant harm is or could be caused to people, buildings or the environment. In such circumstances the land could be deemed 'contaminated', ref. 9.16.

A7.1.3 Should a potential source of gas be identified in the conceptual model, a gas risk assessment should be carried out, sufficient to demonstrate to the local authority that the proposals mitigate any hazards associated with ground gas. The authority enforces compliance with Approved Document Part C of the Building Regulations, ref. 9.37.

A7.2 APPROACH

A7.2.1 A flow chart detailing the approach to assessing a site is given in CIRIA document C665, Figure 1.1. This may be summarised as follows.

- Carry out Phase 1 desk study, including initial conceptual model
- Assess site, potential presence of gas / potential unacceptable risk / identify further action, if necessary
- Monitor gas concentrations
- Assessment of Risk
- Recommendations / remediation
- Validation

A7.3 POLLUTANT LINKAGE ASSESSMENT

A7.3.1 A pollutant linkage assessment is presented in Appendix 3 of the Phase 1 Desk Study Report.

A7.3.2 Using the risk model in the desk study, the pollutant linkage can be identified and a preliminary estimate of risk undertaken. If there is no relevant pollutant linkage identified there is no risk. If there is a very low risk, it is likely that no further assessment is required. If further assessment is necessary, then gas monitoring is required.

A7.4 SITE MONITORING

A7.4.1 For sites with low generation potential, giving consistently low concentrations of soil gas under the worst-case conditions, a limited programme of monitoring would be appropriate. Where high or variable concentrations are anticipated or recorded, an extended programme of monitoring would be appropriate. The following guideline has been proposed, ref. 9.39.

Table A7.1

		Generation potential of source				
Sensitivity of development		**Very low**	**Low**	**Moderate**	**High**	**Very high**
	Low (Commercial)	4/1	6/2	6/3	12/6	12/12
	Moderate (Flats)	6/2	6/3	9/6	12/12	24/24
	High (Residential with gardens)	6/3*	9/6	12/6	24/12	24/24

Notes

1. First number is minimum number of readings and second number is minimum period in months, for example 4/1 – Four sets of readings over 1 month.

2. At least two sets of readings must be at low and falling atmospheric pressure (but not restricted to periods below <1000mb) known as worst case conditions (see Boyle and Witherington, 2006).

3. The frequency and period stated are considered to represent typical minimum requirements. Depending on specific circumstances fewer or additional readings may be required (e.g. any such variation subject to site specific justification). * The NHBC guidance is also recommending these periods/frequency of monitoring (Boyle and Witherington, 2006)

4. Historical data can be used as part of the data set.

5. Not all sites will require gas monitoring however, this would need to be confirmed with demonstrable evidence.

6. Placing high sensitivity end use on a high hazard site is not normally acceptable unless the source is removed or treated to reduce its gassing potential. Under such circumstances long-term monitoring may not be appropriate or required.

A7.4.2 Before taking any readings, zero the instrument, record atmospheric pressure and temperature.

A7.4.3 Gas flow should be recorded, giving the range of pressures, ensuring positive or negative flow is recorded.

A7.4.4 Record gas levels, recording peak and steady. Where steady state not obtained within 3 minutes, record change in concentration, where concentrations are decreasing, always record peak value. For very high concentrations, record for longer period of up to 10 minutes.

A7.5 ASSESSMENT OF RISK AND RECOMMENDATIONS

A7.5.1 The main method of characterising a site is the method described by Wilson and Card, ref. 9.40 and is termed Situation A. This can be used for all types of development except conventional low-rise housing with suspended ground floor and ventilated underfloor void.

A7.5.2 Low rise housing, Situation B, was developed by Boyle and Witherington, ref. 9.41 and was developed for the NHBC for classifying gassing sites for houses with suspended ground floor slab with ventilated void.

A7.5.3 Although the Code of Practice, ref 9.36, assesses the characteristic gas situation as CIRIA recommend for Situation A, see Table A7.2 below, their solution for gas protection systems is different, see section A7.10.

A7.6 SITUATION A - ASSESSMENT

A7.6.1 This system proposed by Wilson and Card, ref. 9.40 was originally developed in CIRIA Report 149, ref. 9.33.

A7.6.2 The method uses both gas concentrations and borehole flow rate for methane and carbon dioxide to define a Characteristic Situation for a site.

A7.6.3 Gas Screening Value (litre/hr) = borehole flow rate (litre/hr) x gas concentration (%). The GSV is determined for methane and carbon dioxide and the worst case adopted. The Characteristic Situation can then be determined from the table below. The GSV can be exceeded if the conceptual model indicates it is safe to do so, and other factors may lead to a change in the Characteristic Situation.

Table A7.2

Characteristic Situation	Risk Classification	Gas screening value (CH_4 or CO_2(1/hr)[1]	Additional factors	Typical source of generation
1	Very low risk	<0.07	Typically methane ≤1% and/or carbon dioxide ≤5%. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" Made Ground
2	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to Characteristic Situation 3	Natural soil, high peat/organic content. "Typical" Made Ground
3	Moderate risk	<3.5		Old landfill, inert waste, mineworking flooded
4	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures	Mineworking – susceptible to flooding, completed landfill (WMP 26B criteria)
5	High risk	<70		Mineworking unflooded inactive with shallow workings near surface
6	Very high risk	>70		Recent landfill site

1. Site characterisation should be based on gas monitoring of concentrations and borehole flow rates for the minimum periods defined in Table A7.1
2. Source of gas and generation potential/performance must be identified.
3. If there is no detectable flow use the limit of detection of the instrument.

A7.7 SITUATION A – SOLUTION

A7.7.1 The Characteristic Situation can be used to define the scope of gas protective measures required.

A7.7.2 The CIRIA approach uses the characteristic situation to define the level of gas protection as follows:

Table A7.3

Characteristic situation	**Residential building (Not low-rise traditional housing)**		**Office/commercial/industrial development**	
	Number of levels of protection	**Typical scope of protective measures**	**Number of levels of protection**	**Typical scope of protective measures**
1	None	No special precautions	None	No special precautions
2	2	a) Reinforced concrete cast in situ floor slab (suspended non-suspended or raft) with at least 1200g DPM and underfloor venting b) Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting All joints and penetrations sealed	1 to 2	a) Reinforced concrete cast in-situ floor slab (suspended non-suspended or raft) with at least 1200g DPM b) Beam and block or pre cast concrete slab and minimum 2000g DPM/reinforced gas membrane c) Possibly underfloor venting or pressurisation in combination with a) and b) depending on use All joints and penetrations sealed
3	2	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space	1 to 2	All types of floor slab as above. All joints and penetrations sealed. Minimum 2000g/reinforced gas proof membrane and passively ventilated underfloor sub-space or positively pressurised underfloor sub-space
4	3	All types of floor slab as above.	2 to 3	All types of floor slab as above.

Characteristic situation	Residential building (Not low-rise traditional housing)		Office/commercial/industrial development	
		All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated underfloor subspace or positively pressurised underfloor sub-space, oversite capping or blinding and in ground venting layer		All joints and penetration sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility
5	4	Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised underfloor sub-space, oversite capping and in ground venting wells or barriers	3 to 4	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised underfloor sub-space with monitoring facility. In ground venting wells or barriers
6	5	Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design	4 to 5	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and actively ventilated or positively pressurised underfloor sub-space with monitoring facility, with monitoring. In ground venting wells and reduction of gas regime.

1. Typical scope of protective measures may be rationalised for specific developments on the basis of quantitative risk assessments.

2. Note the type of protection is given for illustration purposes only. Information on the detailing and construction of passive protection measures is given in BR414, ref. 9.38.

3. In all cases there should be minimum penetration of ground slabs by services and minimum number of confined spaces such as cupboards above the ground slab. Any confined spaces should be ventilated.

4. Foundation design must minimise differential settlement particularly between structural elements and ground-bearing slabs.

5. Commercial buildings with basement car parks, provided with ventilation in accordance with the Building Regulations, may not require gas protection for characteristic situations 3 and 4.

6. Floor slabs should provide an acceptable formation on which to lay the gas membrane. If a block and beam floor is used it should be well detailed so it has no voids in it that membranes have to span, and all holes for service penetrations should be filled. The minimum density of the blocks should be 600kg/m^3 and the top surface should have a 4:1 sand cement grout brushed into all joints before placing any membrane (this is also good practice to stabilise the floor and should be carried out regardless of the need for gas membrane).

7. The gas-resistant membrane can also act as the damp-proof membrane.

A7.8 SITUATION B -ASSESSMENT

A7.8.1 The NHBC has developed a characterisation system that is similar to Situation A but is specific to low-rise housing development with a clear ventilated underfloor void. The gas emission rates are compared to generic 'Traffic Lights'.

A7.8.2 The Traffic Lights include a Typical Maximum Concentration that is used for initial screening purposes. Where the Typical Maximum Concentration is exceeded the risk-based Gas Screening Value, GSV, should be adopted. The GSVs are determined for the 'model' low rise development and where they differ from this model, the GSV should be reassessed, ref. 9.35.

A7.8.3 The calculations should be made for both methane and carbon dioxide, and the worst case adopted. The GSV is only a guideline.

Table A7.4

Traffic light	Methane		Carbon dioxide	
	Typical maximum concentration[2] (% v/v)	**Gas screening value (GSV)[3] (litres per hour)**	**Typical maximum concentration[2] (% v/v)**	**Gas screening value (GSV)[1,2] (litres per hour)**
Green				
	1	**0.16**	5	**0.78**
Amber 1				
	5	**0.63**	10	**1.56**
Amber 2				
	20	**1.56**	30	**3.13**
Red				

1. Generic GSVs are based on guidance contained within latest revision of Department of the Environment and the Welsh Office (2004 edition) "The Building Regulations: Approved Document C" and used a sub-floor void of 150mm thickness.

2. The Typical Maximum Concentrations can be exceeded in certain circumstances should the conceptual site model indicate it is safe to do so. This is where professional judgement will be required, based on a thorough understanding of the gas-regime identified at the site where monitoring in the worst temporal conditions has occurred.

3. The GSV thresholds should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

A7.9 SITUATION B – SOLUTION

A7.9.1 On the basis of this Traffic Light classification the following protection should be applied to low-rise housing.

Table A7.5

Traffic Light Classification	Protection measures required
Green	Negligible gas regime identified and gas protection measures are not considered necessary.
Amber 1	Low to intermediate gas regime identified, which requires low-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. Ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours.
Amber 2	Intermediate to high gas regime identified, which requires high-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to prevent the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. A specialist contractor should always fit membranes. As with Amber 1, ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours. Certification that these passive protection measures have been installed correctly should be provided.
Red	High gas regime identified. It is considered that standard residential housing would not normally be acceptable without a further Gas Risk Assessment and/or possible remedial mitigation measures to reduce and/or remove the source of gas.

A7.10 CODE OF PRACTICE – SOLUTIONS

A7.10.1 The Characteristic Gas Situation is determine in a similar manner to that recommended by CIRIA, see Table A7.2 above.

A7.10.2 Having selected the Characteristic Gas Situation, the appropriate gas protection could be selected for the building. The tables below give a guide as to the relative performance of the various designs and systems.

A7.10.3 A guidance value for the required gas protection, in the range 0 to 7 should be obtained from Table A7.6 below. Then, a combination of ventilation and/or barrier system should be chosen from Table A7.7 to meet that requirement.

Table A7.6

Characteristic gas situation, CS	NHBC *traffic light*	Required gas protection			
		Non-managed property, e.g. private housing	**Public building [A)]**	**Commercial buildings**	**Industrial buildings [B)]**
1	*Green*	0	0	0	0
2	*Amber 1*	3	3	2	1[C)]
3	*Amber 2*	4	3	2	2
4	*Red*	6[D)]	5[D)]	4	3
			6[E)]	5	4
				7	6

NOTE: Traffic light indications are taken from NHBC Report no.: 10627-R01 (04) [3] and are mainly applicable to low-rise residential housing. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.

A) Public buildings include, for example, managed apartments, schools and hospitals.
B) Industrial buildings are generally open and well ventilated. However, areas such as office pods might require a separate assessment and may be classified as commercial buildings and require a different scope of gas protection to the main building.
C) Maximum methane concentration 20% otherwise consider an increase to CS3.
D) Residential building on higher traffic light/CS sites is not recommended unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.
E) Consideration of issues such as ease of evacuation and how false alarms will be handled are needed when completing the design specification of any protection scheme.

A7.10.4 Having determined the appropriate guidance value from Table A7.6, an element or combination of elements from a), b), c) or d) in Table A7.7, should be chosen to achieve the required level of protection .

Table A7.7

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Venting/dilution			
Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.)[A)]	Very good performance	2.5	*Ventilation performance in accordance with Annex A, ref. 9.36*
	Good performance	1	*If passive ventilation is poor this is generally unacceptable and some form of active system will be required*

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.)[A)]		2.5	*There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.* *Active ventilation can always be designed to meet good performance.* *Mechanically assisted systems come in two main forms: extraction and positive pressurization.*
Ventilated car park (basement or undercroft)		4	*Assumes car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F and IstructE guidance*
b) Barriers			
Floor slabs			
Block and beam floor slab		0	*It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum.* *Breached in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances*
Reinforced concrete ground bearing floor slab		0.5	
Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab		1.5	
Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints		1.5	
Fully tanked basement		2	
c) Membranes			
Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation[B), C)]		0.5	*The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints*
Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA)[B), C)]		1	
Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation		2	
d) Monitoring and detection (not applicable to non-managed property, or in isolation)			
Intermittent monitoring using hand held equipment		0.5	
Permanent monitoring and alarm system[A)]	Installed in the underfloor venting/ dilution system	2	*Where fitted, permanent monitoring systems ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.*
	Installed in the building	1	

PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
e) Pathway intervention		
Pathway intervention	-	*This can consist of site protection measures for off-site or on-site sources (see Annex A, ref. 9.36)*

NOTE: In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection

A) It is possible to test ventilation systems by installing monitoring probes for post installation validation.

B) If a 1200 g DPM material is to function as a gas barrier it should be installed according to BRE 414, ref. 9.38 being taped and sealed to all penetrations.

C) Polymeric Materials >1200g can be used to improve confidence in the barrier. Remember that their gas resistance is little more than the standard 1200g (proportional to thickness) but their physical properties mean that they are more robust and resistant to site damage.

Gas and Groundwater Monitoring

Date	17/12/2008	09/04/2009	07/05/2009
WS1			
Atmospheric Pressure (mb)	1002	992	1010
Depth to Water (m)	0.86	1.13	0.92
O_2	20.8%	11.2%	15.2%
CO_2	0.4%	3.6%	1.4%
CH_4	3.2%	51.5%	12.4%
H_2S (ppm)	0	0	0
CO (ppm)	0	0	0
Flow l/hr	0.2	-3.0	0.4
WS3			
Atmospheric Pressure (mb)	1002	992	1010
Depth to Water (m)	0.83	1.25	0.98
O_2	20.5%	14.9%	17.4%
CO_2	0.9%	5.9%	3.2%
CH_4	0.2%	0.0%	0.0%
H_2S (ppm)	0	0	0
CO (ppm)	0	0	0
Flow l/hr	0.2	-0.2	0.1
WS4			
Atmospheric Pressure (mb)	1003	992	1010
Depth to Water (m)	0.62	1.33	1.02
O_2	20.1%	18.1%	20.4%
CO_2	0.3%	0.7%	0.3%
CH_4	0.2%	0.0%	0.0%
H_2S (ppm)	0	0	0
CO (ppm)	0	0	0
Flow l/hr	2.6	0.0	0.1
WS8			
Atmospheric Pressure (mb)		992	1010
Depth to Water (m)		DRY	3.95
O_2		19.2%	19.8%
CO_2		1.2%	0.2%
CH_4		0.0%	0.0%
H_2S (ppm)		0	0
CO (ppm)		0	0
Flow l/hr		0.2	-0.1
WS10			
Atmospheric Pressure (mb)		992	1010
Depth to Water (m)		0.94	0.82
O_2		20.6%	20.9%
CO_2		0.0%	0.0%
CH_4		0.0%	0.0%
H_2S (ppm)		0	0
CO (ppm)		0	0
Flow l/hr		0.0	0.0

Figure A5.1