Report No. 30046/1_Rev2
Date: December 2014

GEOENVIRONMENTAL APPRAISAL

of land at

SEFTON MEADOWS, LIVERPOOL

Prepared for

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LAND AT SEFTON MEADOWS, LIVERPOOL (REDROW HOMES LTD)
SUMMARY OF GEOENVIRONMENTAL ISSUES

The site is located off Park Avenue, approximately 3.5km southeast of Liverpool City centre (OS Grid Ref: 338200E 387415N). The site occupies an area of approximately 2.9 hectares (7.15 acres) which is split roughly equally into northern and southern halves by Park Avenue.

The site is currently occupied by public open space, which is surrounded on all sides by mature and semi-mature trees. The site has historically been occupied by a tree/plant nursery during the first half of the 20th Century, whilst the remainder of the site has remained undeveloped.

ALM were commissioned by Redrow Homes Ltd to provide a geoenvironmental appraisal of the site. It is understood that the site is to be redeveloped with domestic dwellings, associated gardens and adoptable roads and sewers. A 'Proposed Site Plan' is shown on the Calderpeel Architects Drawing Reference 14082(Pl)001L, dated 4th December 2014. ALM's investigation included a desk study and a ground investigation comprising 15No. windowless sample boreholes and 3No. hand auger boreholes.

A summary of salient geoenvironmental issues is provided in the Table below.

Issue	Remarks
Made Ground	Topsoil made ground to depths between 0.1m – 0.2m, overlying sandy made ground to depths between 0.35 – 1.0m, has been encountered in the northern half of the site.
Natural Ground	Natural topsoil to depths between 0.3m – 0.6m has been encountered in the southern half of the site. Natural drift strata is variable in strength/density and lateral extent, with soft, firm and stiff clays, and loose, medium dense and dense sands encountered beneath the site. Possible sandstone bedrock was encountered between 3m – 4m in the south of the site.
Contamination	Elevated concentrations of benzo(a)pyrene, above the chosen assessment criteria, have been recorded in topsoil made ground and sandy made ground, and in natural topsoil in the southern half of the site. If Category 4 Screening Levels (C4SL's) are adopted, no significant contamination is present at the site.
Hazardous Gas	Elevated concentrations of carbon dioxide, but no concentrations of methane have been recorded at the site. Based on calculated gas screening values, gas exclusion measures in accordance with a GREEN traffic light classification (CIRIA C665) will be required for new buildings at the site.
Preparatory Works	Stripping of unprotected trees/shrubs and vegetation from the proposed development area. Stripping of topsoil and sandy made ground, and stockpiling for subsequent redistribution on site or export from site. Possible inversion of the soil profile in private gardens and landscaped areas, in order to provide clean soil cover above contaminated made ground and topsoil and minimise the volume of soils that require removal from site or import to site (subject to possible adoption of C4SL's).
Foundations	Due to variable ground conditions across the site, either strip/trench fill foundations, piled foundations or foundations on vibro improved ground are likely to be the most economical foundation solutions for proposed buildings at the site.
Groundwater & Excavations	Groundwater seepage/wet drilling was encountered in natural sands between depths of 1.5m - 3m during the ground investigation, and has typically been encountered at depths between 2m – 2.5m in the west of the site, and deeper (3.8m) in the north, during subsequent monitoring. Perched groundwater in natural clays has been recorded in one monitoring well (WS1) at a typical depth of 1.3m.
Flooding & Drainage	The site does not lie within an Environment Agency Indicative Flood Plain. Surface water drainage should be directed to the existing sewer network.
Highways	Natural firm/stiff clays or medium dense sands should offer a CBR of at least 2%

Significant developer abnormals relating to geo-environmental issues at the site are:

- Stripping and stockpiling of topsoil and made ground for subsequent re-distribution beneath the site or export/disposal from site.
- Possible import of clean soil for use as cover in private garden and landscaped areas (subject to possible adoption of C4SL's).

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

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FOREWORD (Geoenvironmental Investigation Report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of ALM Consult Ltd (ALM); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from ALM prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. ALM cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. laboratory test certificates) is only included within the "electronic", PDF Report on the accompanying CD.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which ALM believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, ALM cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geo-environmental consultants. ALM does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by ALM, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present and that houses will be of two storey construction. If this is not to be the case, then some modification to this report may be required.

ALM cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed Remediation options.

ALM reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL
of land at
SEFTON MEADOWS, LIVERPOOL

1 INTRODUCTION

1.1 The Commission and Brief

1.1.1 ALM Consult Ltd (ALM), were commissioned by Redrow Homes Ltd (Redrow) to carry out a geoenvironmental appraisal of land at Sefton Meadows, Liverpool.

1.1.2 Correspondence regarding ALM's appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- a site walkover and inspection
- an assessment of the land use history
- determination of the site's environmental setting
- an intrusive ground investigation comprising 15No. windowless sample boreholes and 3No. hand auger boreholes
- assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations
- a qualitative assessment of contamination risks, with respect to potential receptors
- the provision of recommendations with respect to site preparatory and Remediation works

1.2 The Proposed Development

1.2.1 It is understood that consideration is being given to redevelopment of the site with residential dwellings, with associated gardens and adoptable roads and sewers. A 'Proposed Site Plan', Calderpeel Architects Drawing No.14082(Pl)001L, has been provided by Redrow, a copy of which is included in Appendix B. The Proposed Site Plan shows 34No. detached houses. Park Avenue is shown to remain as part of the new development.

1.3 Report Format and Limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork (including techniques, in-situ testing and sampling)
- Geotechnical Testing
- Contamination Testing (including current guidance, notes about organics analyses, and WAC)
- Hazardous Gas (including potential sources and notes about current guidance)

1.3.2 General notes and limitations relevant to all ALM geoenvironmental investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

2 SITE DESCRIPTION

2.1 General

2.1.1 The site location is shown on Drawing No.30046/1 presented in Appendix B to this report. Site details are summarised in the Table below.

Detail	Remarks
Location	3.5km southeast of Liverpool City Centre
OS Grid Ref	338200E 387415N
Approximate Area	2.9ha (7.15acres)
Known services	Electricity supply to street lighting along the south of Park Avenue. Low pressure gas main shown to enter the southern half of the site. Intermediate pressure gas main shown to run along the northwest edge of the site.

2.2 Site Features

2.2.1 An ALM Engineer completed a walkover survey of the site, prior to the commencement of fieldwork on Thursday 12th June 2014. Existing salient features presented on Drawing No.30046/2 in Appendix B. Selected photographs of the site at the time of the walkover survey are presented in Appendix D.

2.2.2 The site is currently occupied by two areas of open grass land surrounded by mature and semi-mature trees, and separated by a WNW-ESE trending unadopted road (Park Avenue). The two areas are approximately equal in size, with the northern half of the site being roughly triangular and covering an area of approximately 1.35hectares, and the southern half of the site being roughly rectangular and covering an area of approximately 1.5hectares.

2.2.3 Ground levels in the northern half of the site fall from a high of approximately 32mAOD in the southwest, falling to elevations of approximately 30mAOD in the north and west. Ground levels in the southern half of the site are generally flat, but fall from elevations of approximately 31.40mAOD in the northeast corner to elevations of approximately 29.50mAOD in the southwest.

2.2.4 The section of Park Avenue passing through the site was observed to be in disrepair, with large 'pot holes' being present, particularly in central parts of the road. However, at the time of the investigation, contractors were observed to be providing a temporary fix to the damaged road surface.

2.2.5 Tarmac footpaths were observed to be present along either side of Park Avenue and also along Mossley Hill Drive to the west of the site. A 'trodden path' was observed within the northwest edge of the site.

2.3 Site Operations

2.3.1 The site is in use as an area of public open space. At the time of the investigation, both grassed areas of the site were observed to be occasionally used for dog walking. The section of Park Avenue that passes through the site is used by vehicles accessing the Mossley Hill Drive and Queens Drive to the west, and is also used by pedestrians accessing Sefton Park to the west.

2.3.2 At the time of the investigation, grass in the two fields was long, however, grass in both fields had been mown by the following week.

2.4 Japanese Knotweed

2.4.1 During the site walkover, we did not notice the presence of any Japanese Knotweed. However, it should be noted that we are not qualified ecologists and as such cannot guarantee the absence of Knotweed or other invasive vegetation.

3 SITE HISTORY

3.1.1 In order to investigate the development history and previous land uses at the site and immediate surrounding land, extracts from Ordnance Survey (OS) plans dating back to 1850 were examined. Historical plans were sourced from the Liverpool City Council Environmental Search Report and supplemented with reference to available to view online historical plans. The Liverpool City Council Environmental Search Report (Report Ref: CLS0329) is included in Appendix E to this report.

3.1.2 The Table below provides salient points relating to the history of the site.

Date(s)	Site	Surrounding Land
1850 (online)	The site is shown as open fields.	The site is set amongst open fields with occasional small ponds present in surrounding fields, the nearest of which is located approximately 50m east of the site. An unnamed stream is shown approximately 60m north of the site. A large pond is shown approximately 90m southeast of the site, with woodland, farm buildings, and residential buildings shown beyond 100m to the south of the site. Aigburth Vale (road) passes along the eastern edge of the site. A possible quarry is shown approximately 350m southeast of the site.
1893	The site is shown as open fields with Park Avenue passing approximately from east to west through the centre.	The site is part of larger fields to the north and south of the site. Mossley Hill Drive passes along the southwest boundary of the site, with Sefton Park shown immediately beyond Mossley Hill Drive. A small circular pond is shown in Sefton Park approximately 150m to the southwest. Two elongate buildings are shown off Ibbotson's Lane approximately 100m north of the site, and the un-named stream to the north, which is indicated to be flowing to the west, appears to have been placed in culvert, emerging from culvert approximately 60m north of the site. Most of the land to the north, east, and southeast is now occupied by large residential buildings with associated wooded gardens. Much more dense residential terraced houses, and school building, are shown between 100m to 300m south of the site.
1908	The eastern half of the site is shown to be occupied by a 'Nursery', which is assumed to be a tree/plant nursery (no buildings present). A possible pond is shown in the southeast of the northern parcel of land. Park Avenue and the western boundary of the southern parcel are shown to be tree lined. A continuation of Carnatic Road passes outside the southern boundary of the site and appears to encroach slightly into the southeast boundary.	The 'Palm House' has been constructed in Sefton Park, approximately 250m west of the site. Four additional elongate buildings have been constructed along Ibbotson's Lane approximately 100m north of the site. Further residential terrace housing has been constructed between 150m to 400m southeast of the site, and the former large pond approximately 90m southeast of the site appears to have become infilled.
1925	A pathway extends westward into the site off Aigburth Vale in the northeast, from which four narrow parallel pathways extend southward occupying much of the northern parcel of land. The possible small pond in the north of the site is no longer shown. All boundaries of the site are shown to be tree lined.	Queens Drive has been constructed immediately to the north of the site. A Hospital is now shown immediately to the northeast of the site beyond Aigburth Vale. There is some evidence of disturbed ground / embankments approximately 100m northeast of the site.
1938 (online)	No significant changes.	A school (Liverpool College) is shown 250m northwest of the site.

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1954	By 1954, the whole of the northern parcel of land is noted as a Nursery.	There is some evidence of quarrying/soil abstraction approximately 100m north of the site. Significant alteration to the layout of Hospital buildings has occurred to the east, with most buildings between 20m to 150m east no longer shown. The small pond 50m to the east is no longer shown. A building (old peoples home) has been constructed to the south. Three businesses are shown amongst residential properties to the south. These include a Motor Body Works, an Engineering Works, and a Factory (Glave), all located between 150m - 250m south of the site.
1972	The northern part of the site is no longer shown as a Nursery.	Residential buildings have been constructed beyond Carnatic Road immediately to the south of the site. Carnatic Road has been re-aligned slightly and no longer encroaches into the site.
1982-1989 (online)	No significant changes.	The hospital has expanded with buildings now shown within 30m of the site. The small pond in Sefton Park to the southwest is no longer shown.
Present	No significant changes.	At some time between 1989 and present day, new residential development has taken place on a former sports field immediately to the east of the site, and on the site of a former residential property immediately to the southeast of the site (now apartments). Three large buildings (residential) have also been constructed on the site of former elongate buildings of unknown use, located approximately 100m north of the site.

3.1.3 In summary, the site remained undeveloped until the early 20th Century, with the exception of the construction of Park Avenue through the centre of the site in the late 19th Century. The northern part of the site is understood to have been used as a tree/plant nursery, as is shown on historical plans dating from 1908 until before 1972. The southern part of the site appears to have remained undeveloped, with the exception of a small section of Carnatic Road which is shown to have encroached into the southeast edge of the site on plans dating from 1908, prior to it being re-aligned when land immediately to the south was redeveloped to residential housing by 1972.

3.1.4 Surrounding land remained predominantly undeveloped until the late 19th Century, with the exception of Aigburth Vale (road) along the eastern boundary of the site, leading to the village of Aigburth to the south, which are shown on plans dating from 1850. By the late 19th Century, Sefton Park is shown immediately to the west of the site and land to the north, south and east is shown as being developed with generally large residential buildings with associated gardens and roads. Since the late 19th Century development of the surrounding land has been gradual with Queens Drive being constructed along the northern boundary of the site, a Hospital and school to the east and northeast, and terraced housing to the south and southeast.

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. Environmental search information has been sourced from the Liverpool City Council Environmental Search Report and supplemented with available online information from the Environment Agency and the British Geological Survey (BGS), as well as BGS Geological Plans. The Liverpool City Council Environmental Search Report (Report Ref: CLS0329) is included in Appendix E to this report.

4.2 Geology

4.2.1 British Geological Survey (BGS) 1:50,000 Map (Sheet 96, Liverpool) indicates the site to be underlain by Shirdley Hill Sands, which comprise yellowish grey fine grained Aeolian sands. The Shirdley Hill Sands overlie rocks of the Chester Pebble Beds (Lower Triassic Sherwood Sandstone Group), which comprise red brown sandstone.

4.2.2 The site is not affected by geological faulting.

4.2.3 The site does not lie in an area affected by shallow coal mining activity.

4.2.4 There is no evidence of historical quarrying within the site, however, historical plans suggest that some quarrying has taken place approximately 350m southeast of the site before the mid 19^{th} Century, in an area where BGS plans suggest the absence of drift strata.

4.2.5 BRE Report BR211 indicates that the site is lies in an area where no radon protective measures are required for new houses.

4.2.6 The nearest historical boreholes available to view on the BGS website, are located approximately 400m north of the site, off Greenbank Lane. Five light cable percussion boreholes drilled at this location generally show a veneer of topsoil or made ground up to 1m thick, overlying sands to approximately 2.2m, which overly soft clays to 3.5m beneath which clays become firm/stiff.

4.3 Hydrogeology

4.3.1 The underlying superficial strata are classified as a Secondary A Aquifer. The underlying bedrock is classified as a Principal Aquifer.

4.3.2 The site does not lie within a Groundwater Source Protection Zone.

4.3.3 The EA's Groundwater Vulnerability Map of the area classifies the soil beneath the site as being of High Vulnerability.

4.3.4 There is one active licensed groundwater abstraction within 1km of the site, which is located approximately 800m north northwest of the site. The reason for abstraction is not given on the EA website, however, the borehole is identified as 'Sefton Park ABH' on the BGS website, and is anticipated to be for irrigation in Sefton Park.

4.4 Hydrology

4.4.1 The nearest surface water course to the site is an un-named stream, which is located approximately 60m north of the site, and flows in a westerly direction into Sefton Park. There is no river quality information available for this stream or nearby receiving waters.

4.4.2 The site does not lie within an Environment Agency Indicative Flood Plain. However, the EA website does indicate a low risk of flooding from surface waters along the northern boundary of the site and in small sporadic areas of the south of the site.

4.5 Landfills

4.5.1 There are no recorded landfill sites within 1km of the site. The nearest recorded landfill is a historic landfill named as Fullwood Park, which accepted unknown waste types between 1981 and 1984 and is located approximately 1.15km southwest of the site.

4.5.2 A possible small pond is shown in the northern part of the site on historical plans dating from 1908, but is not shown by 1925, and may have become infilled. Two other ponds are shown within 100m to the east and southeast of the site on historical plans, both of which appear to have become infilled as a consequence of progressive development. Another former pond approximately 150m southwest of the site in Sefton Park is also no longer shown and may have become infilled.

4.5.3 Given the limited extent of the possible former pond in the northern part of the site, it is considered unlikely that any infill to the pond, or organic silts in the base of the pond, would have the potential to generate significant volumes of landfill gas. However, if present, such deposits may give rise to localised elevated concentrations of ground gas.

4.5.4 Similarly, any infill, or organic silts in the base of the former ponds located in the vicinity of the site, are considered unlikely to have the potential to generate significant volumes of landfill gas. However, if present, such deposits may give rise to localised elevated concentrations of ground gas. Given the proximity to these former features and the inferred presence of granular drift strata beneath the site, it is considered that there is some potential for gas generated from these sources to migrate to the study site.

4.6 Other Information

4.6.1 There are no discharge consents relating to the site.

4.6.2 There have been no recorded pollution incidents within 250m of the site.

4.6.3 There are no industrial sites holding Environmental Permits within 500m of the site.

4.6.4 The Liverpool City Council Environmental Search Report indicates that, to the best of their knowledge, there have been no statutory nuisance / pollution incidents, prosecutions or abatement notices served against the site within the last 12 months.

5 GROUND INVESTIGATION DESIGN

5.1 Anticipated Ground Conditions & Potential Issues

5.1.1 Based on the data reviewed in Sections 4 (Environmental Setting) and Section 5 (Previous Investigation Findings), anticipated ground conditions are expected to comprise:-

Anticipated Condition	Remarks
Made Ground	Possibly present as backfill to a former pond in the north of the site, or at/near the surface as former pathways in the tree / plant nursery in the north of the site. Tarmac / kerb stones and sub-grade to Park Avenue.
Natural Soils	Sand (Shirdley Hill Sands) is anticipated to be present at shallow depth beneath topsoil across the site.
Bedrock	Not anticipated to be present near surface beneath the site.
Groundwater	Perched groundwater may be present in localised shallow made ground or within granular strata or bedrock beneath the site.

5.1.2 Based on the data above and that in Sections 2 (Site Description) and Section 3 (Site History), potential ground-related issues associated with this site are likely to include:

Type of Issue	Specific Issue	Remarks
Potential on-site contamination sources	1. Made ground. 2. Pesticides 3. Ground Gas	1. Made ground as tarmac, kerbstones and sub-grade to Park Avenue, and in possible backfilled ponds in the north of the site, and also as former pathways beneath former tree / plant nursery in the north of the site. 2. Pesticides may potentially have been used in the tree / plant nursery in the north of the site. 3. Possibly locally elevated in the vicinity of former backfilled pond.
Potential off-site contamination sources	1. Gas/groundwater migration from off site source.	1. Potential migration from former infilled ponds in the vicinity of the site.
Potential geotechnical hazards	1. Deep MG 2. Soft / loose ground 3. Heave.	1. Associated with former pond. 2. Possibly present locally across the site. 3. Heave may occur due to re-hydration of cohesive soils (if present) following the removal of any trees.
Other potential constraints	1. Underground and/or overhead utilities	1. Electricity supply to street lighting along the south of Park Avenue. Low pressure gas main shown to enter the south of the site. Intermediate pressure gas main along northwest boundary of the site.

5.2 Conceptual Site Model

5.2.1 A conceptual site model, presented as Drawing No.30046/3 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 6.1 inclusive, of this report.

5.2.2 Potential pollutant linkages are shown on the conceptual site model.

5.3 Ground Investigation Design & Strategy

5.3.1 The conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

5.3.2 Proposed exploratory hole locations were selected to provide a good spatial coverage of the site and obtain a representative view of the strata beneath the site, and to target potential areas of interest identified in Section 5.1 above. A nominal 50m grid spacing was proposed. Additional exploratory locations, or adjustment to originally planned locations, were considered by the site engineer in light of the ground conditions actually encountered.

5.3.3 The number of representative samples taken was reflective of the geological complexity actually encountered. However, in general about two or three samples were taken from most trial pits.

5.3.4 Anticipated potential contaminants, within soil and/or groundwater included:

- Toxic metals and polycyclic aromatic hydrocarbons in made ground.
- Asbestos
- Pesticides in near surface soils and groundwater beneath the site.

6 FIELDWORK

6.1 Objectives

6.1.1 The original investigation strategy is outlined in Section 5 above.

6.1.2 The principal objectives of the fieldwork were to sample and characterise near surface soils and groundwater beneath the site, which was done by positioning exploratory holes to give a good spatial coverage of the site and target specific areas of potential contamination that may have been associated with former land uses.

6.2 Exploratory Hole Location Constraints

6.2.1 Mature and semi-mature trees line the edge of the site and Park Avenue. Exploratory holes were positioned away from the tree line in order to avoid both obstruction to drilling and damage to tree roots.

6.2.2 Park Avenue is a used public highway, therefore, no exploratory holes were located within the footprint of Park Avenue.

6.3 Scope of Works

6.3.1 Fieldwork was supervised by ALM between Thursday 12th June and Friday 13th June 2014, with some supplementary hand auger boreholes drilled on Tuesday 24th June 2014, and comprised the exploratory holes listed below.

Scope of Ground Investigation Works

Exploratory Holes	Purpose
WS1 – WS15	To determine the general nature of soils underlying the site, including the: • nature, distribution and thickness of made ground • nature, degree and extent of contamination • proportion of undesirable elements e.g. biodegradable matter, foundations etc • suitability of the ground for founding structures and highways To allow the installation of a gas/groundwater monitoring wells in selected boreholes across the site.
HA1 – HA3	To locate a possible infilled former pond feature in the north of the site.

6.3.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.

6.3.3 Exploratory hole logs are presented in Appendix F to this Report. These logs include details of the:

- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of the in-situ testing
- The monitoring wells installed

6.3.4 Exploratory hole locations are shown on Drawing No.30046/4 in Appendix B.

6.3.5 The exploratory hole locations have been overlain onto historical plans dating from 1908 and 1927 in order to demonstrate that key historical land uses and areas of potentially contaminative use, have been targeted by the investigation. These overlays are presented as Drawing No.30046-4A and 30046-4B in Appendix B.

7 GROUND CONDITIONS

7.1 General

7.1.1 A complete record of strata encountered beneath the proposed development site is given on the various exploratory hole records, presented in Appendix F. However, a summary of the ground conditions is provided below.

7.1.2 Typical ground conditions encountered in each of these areas are described below in Sections 7.2 and 7.3 (made ground & obstructions) and 7.4 (natural ground).

7.2 Made Ground

7.2.1 Topsoil made ground (MG:Topsoil) was encountered in all exploratory holes in the northern part of the site (WS1 – WS7 & HA1 – HA3) and in isolated exploratory holes in the southern part of the site (WS8 & WS11). Topsoil made ground generally comprised sandy silt with some gravel of sandstone and roots, extending to depths between 0.1m to 0.2m in the north of the site and to depths of 0.4m (WS8) and 0.55m (WS11) in the south of the site.

7.2.2 Topsoil made ground was found to be underlain by a sandy made ground comprising dark greyish brown sands (MG:Sand) in all exploratory holes in the north of the site and WS8, and extended to depths of between 0.35m to 1.0m. The sandy made ground also comprised varying quantities of gravel of brick, coal, sandstone and clinker, and occasional rare cobbles of brick and fragments of glass.

7.2.3 Cobbles of sandstone were encountered beneath topsoil made ground in one location (WS11), at a depth of 0.55m to 0.7m.

7.3 Obstructions

7.3.1 No below ground obstructions were encountered during the ground investigation.

7.4 Natural Ground

7.4.1 Natural topsoil was encountered across the majority of the southern parcel of land. The natural topsoil generally comprised dark grey sandy silts and was encountered to depths between 0.3m and 0.6m.

7.4.2 Firm/stiff clays were encountered immediately beneath made ground or topsoil in four exploratory holes (WS1, WS2, WS4 and WS12) along the north-eastern edge of the site, to depths between 3m to 5.45m.

7.4.3 Loose and medium dense sands were encountered immediately beneath topsoil or made ground across the remainder of the site. The sands generally persisted to the base of exploratory holes in the north and west of the site, to depths between 4m to 5.45m, however, sands were underlain by generally soft or firm clays in exploratory holes in the southern part of the site, with clays encountered from depths of 0.9m to 4.3m, but typically 1.5m.

7.4.4 Very dense orange brown sands were encountered beneath clays at depths between 2.6m to 2.8m in central southern parts of the site, and also from a depth of 3.7m in WS9 in the southwest corner of the site. These very dense sands, which caused refusal of the drilling, have been interpreted as possible sandstone bedrock.

7.5 Visual & Olfactory Evidence of Organic Contamination

7.5.1 No visual or olfactory evidence of significant hydrocarbon contamination was encountered during the ground investigation.

7.6 Groundwater

7.6.1 Groundwater seepage was recorded was recorded from depths between 1.5m to 3m in sand and soft clay strata across the site. Groundwater was absent from exploratory holes in the northeast and southeast of the site.

7.6.2 Groundwater has been encountered in monitoring wells across the site after the completion of the ground investigation. Groundwater levels recorded in the monitoring wells are summarised below.

Groundwater Levels

Hole ID	Response Zone (depth range & strata)	Groundwater Body	Typical standing water level (m bgl)
WS1	1.0m – 5.0m	Perched	1.30
WS3	1.0m – 4.6m	Granular Drift Strata	3.80
WS5	1.0m – 4.0m	Granular Drift Strata	2.45
WS8	1.0m – 3.5m	Granular Drift Strata	2.20
WS9	1.0m – 3.1m	Granular Drift Strata	2.20
WS11	1.0m – 3.0m	Granular Drift Strata	DRY

7.6.3 An ALM engineer visited the site on Tuesday 17th June 2014 to obtain representative water samples from the groundwater monitoring wells.

7.7 Stability

7.7.1 The stability of borehole within the made ground and natural cohesive strata was generally good. However, boreholes often collapsed within granular strata.

7.8 Revised Conceptual Ground Model (Ground Conditions)

7.8.1 Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:

- the nature and distribution of made ground, including the presence of significant buried obstructions
- the strength, nature and depth of underlying natural strata
- the nature and distribution of contamination (based on visual/olfactory evidence only)

7.8.2 Further refinement of the Conceptual Site Model is presented in Sections 9.1, where the results of laboratory testing for contaminants have been considered.

8 CONTAMINATION (ANALYSIS)

8.1 General

8.1.1 Notes outlining current guidance with respect to the interpretation of analytical data are included in Appendix A to this report.

8.1.2 The northern part of the site has been historically used as a tree/plant nursery for much of the 20th Century, with a series of parallel pathways and a pond shown on historical plans, being the only discernable feature recorded at the site. The remainder of the site has remained undeveloped with the exception of Park Avenue crossing the central parts of the site.

8.1.3 Made ground beneath the northern part of the site is noted to have contained gravel of brick, coal, sandstone and clinker, as well as rare fragments of glass, plastic and metal.

8.1.4 No evidence of a former infilled pond in the northern part of the site has been encountered during fieldwork.

8.1.5 The site's former usage is considered unlikely to have given rise to significant ground contamination. An assessment of potential contaminants associated with the former uses has been undertaken (see Section 5).

8.2 Testing Scheduled

8.2.1 Based on the above assessment, an ALM Engineer submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory.

Type of Sample	No. of Samples	Determinands
Made Ground	11	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	9	speciated PAH
	4	TOC
	5	water soluble sulphate
	2	pesticides
	2	SVOC
	5	asbestos screen
	2	calorific value
	4	leachable metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
Natural Soil	16	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	11	speciated PAH
	2	TOC
	11	water soluble sulphate
	1	asbestos screen
Groundwater	4	pH and total metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	4	speciated PAH
	4	conductivity, chloride, nitrate, Amm.N, COD & BOD
	2	pesticides

8.2.2 Notes describing the various organics analyses are included in Appendix A to this report.

8.3 Soil Contamination Results

8.3.1 The soil contamination test results are summarised in the Tables 8.1 to 8.3 below. Laboratory test certificates as received from the laboratory are presented in Appendix G to this report.

8.3.2 The samples are classified by comparison of parameter concentrations with the relevant current UK guidance threshold values for an end use including domestic gardens and any area where plants are to be grown (the most sensitive of the proposed end-uses).

8.3.3 At the time of writing, the assessment of the soil contamination test results does not make reference to Category 4 Screening Levels (C4SL's), which were published by DEFRA in March 2014, which were developed in the context of revised Statutory Guidance to support Part 2A of the Environment Protection Act 1990 that was published in April 2012 (see General Notes (4A) in Appendix A). ALM understand that the C4SL's are also intended to be used in risk assessment under planning guidance, and there has been more recent directive from DEFRA to do so. However, it is our understanding that Liverpool City Council have not yet adopted the use of C4SL's under the planning regime.

8.3.4 Drift strata beneath the site is classified as a Secondary A Aquifer, which overlies bedrock classified as a Principal Aquifer. However, the site is not located within a groundwater source protection zone and the nearest groundwater abstraction well is located approximately 800m from the site. Therefore, when considering the potential risks from mobile contaminants (leachate and groundwater), the surface water stream approximately 60m to the north of the site is considered as the principal receptor, and consideration is given to the Environmental Quality Standards (EQS) values for freshwater.

Table 8.1 - Summary of Degree of Ground Contamination (Inorganics) at Land at Sefton Meadows, Liverpool.

Hole ID	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets and assume a **residential with gardens** end-use.													
			pH#	As (32)$	Cd (10)$	Cr (3000)~	Pb (450)$	Hg (170)$	Se (350)$	B (3)*	Cu (200)♣ x	Ni (130)$	Zn (300)♣ x			Sol SO_4 (0.5 g/l) ◊
WS1 S1	0.05	MG:TOPSOIL	6.54	13.1	<1.0	13.4	162.7	<1.0	<1.0	0.7	56.1	16.6	143			
WS3 S1	0.10	MG:TOPSOIL	7.05	16.7	<1.0	17.3	179.5	<1.0	<1.0	0.4	98.9	20.7	251			
WS4 S1	0.10	MG:TOPSOIL	6.54	14.5	<1.0	16.2	155.4	<1.0	<1.0	0.6	57.6	18.1	136			
WS5 S1	0.10	MG:TOPSOIL	6.37	14.1	<1.0	15.0	156.3	<1.0	<1.0	0.4	53.8	16.1	129			
WS8 S1	0.10	MG:TOPSOIL	6.03	10.3	<1.0	12.0	130.2	<1.0	<1.0	0.3	28.2	11.8	93.6			
WS1 S2	0.20	MG: SAND	7.44	15.6	<1.0	31.9	96.9	<1.0	<1.0	0.3	114.8	32.0	90.6			0.03
WS1 S3	0.40	MG: SAND	7.50	8.3	<1.0	13.0	67.5	<1.0	<1.0	0.4	24.4	11.5	44.9			0.01
WS3 S2	0.25	MG: SAND	7.54	17.5	<1.0	16.7	200.6	<1.0	<1.0	0.4	102.8	22.2	176			0.02
WS4 S2	0.30	MG: SAND	7.09	22.6	<1.0	19.4	194.0	<1.0	<1.0	0.4	60.5	25.6	179			
WS5 S2	0.40	MG: SAND	7.24	15.8	<1.0	17.9	126.8	<1.0	<1.0	0.4	53.9	17.2	107			0.01
WS8 S2	0.50	MG: SAND	6.63	2.2	<1.0	4.2	20.0	<1.0	<1.0	0.1	7.1	3.9	17.6			<0.01

Key		**Source of Guidance Trigger Level**	
bold	Parameter found to be in excess of trigger concentration	$	DEFRA and the EA Contaminated Land Exposure Assessment (CLEA)
	Parameter not tested for	~	LQM/CIEH Generic Assessment Criteria for Human Health
#	All pH results listed to confirm which soil guideline values are to be used in CLEA assessment	◊	BRE Special Digest 1, Concrete in aggressive ground (2005)
♣	Tier 1 Value is pH dependent	*	ICRCL Guidance Note 59/83, Second Edition (1987) – (Boron Phytotoxic only)
		x	Based on phytotoxic risks as plants are the more sensitive receptor (Cu and Zn are pH dependent) - BS3882:2007 & BS8601:2013

Table 8.1 (cont.) - Summary of Degree of Ground Contamination (Inorganics) at Land at Sefton Meadows, Liverpool.

Hole ID	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets and assume a **residential with gardens** end-use.													
			pH#	As (32)$	Cd (10)$	Cr (3000)~	Pb (450)$	Hg (170)$	Se (350)$	B (3)*	Cu (200)♣ x	Ni (130)$	Zn (300)♣ x			Sol SO_4 (0.5 g/l) ◊
WS9 S1	0.15	TOPSOIL	6.09	11.3	<1.0	11.3	98.2	<1.0	<1.0	0.3	35.0	11.3	77.5			
WS10 S1	0.25	TOPSOIL	7.70	13.7	<1.0	16.8	**519.0**	<1.0	<1.0	0.4	49.4	16.0	87.3			
WS11 S1	0.20	TOPSOIL	6.38	10.3	<1.0	13.6	**534.9**	<1.0	<1.0	0.4	39.7	12.9	135.1			
WS12 S1	0.10	TOPSOIL	6.40	9.8	<1.0	13.2	102.9	<1.0	<1.0	0.2	30.8	12.1	120.0			
WS13 S1	0.10	TOPSOIL	6.41	12.5	<1.0	15.4	100.3	<1.0	<1.0	0.3	52.1	14.5	89.1			
WS15 S1	0.20	TOPSOIL	6.37	10.1	<1.0	10.9	213.6	<1.0	<1.0	0.3	28.1	11.4	81.5			
WS2 S3	0.50	CLAY	7.80	5.4	<1.0	32.7	16.3	<1.0	<1.0	0.6	13.6	20.5	27.0			<0.01
WS12 S2	0.80	CLAY	7.07	7.8	<1.0	31.0	18.8	<1.0	<1.0	0.4	12.3	19.7	30.2			<0.01
WS9 S2	0.60	SILT	6.35	5.0	<1.0	18.0	15.1	<1.0	<1.0	0.1	5.9	12.5	22.4			<0.01
WS5 S3	0.90	SAND	7.27	4.1	<1.0	16.7	16.7	<1.0	<1.0	0.3	9.5	11.7	28.5			0.01
WS6 S3	1.10	SAND	7.35	6.3	<1.0	19.0	12.8	<1.0	<1.0	0.6	3.5	5.9	9.6			0.02
WS8 S3	0.90	SAND	7.03	6.7	<1.0	18.0	9.6	<1.0	<1.0	0.1	9.2	20.1	23.2			
WS10 S2	1.00	SAND	8.07	3.3	<1.0	20.1	36.4	<1.0	<1.0	0.2	4.7	15.0	19.4			<0.01
WS11 S2	0.80	SAND	7.06	2.1	<1.0	10.3	22.2	<1.0	<1.0	0.1	4.8	6.0	12.2			<0.01
WS13 S2	0.50	SAND	6.63	4.7	<1.0	13.5	9.3	<1.0	<1.0	0.1	5.3	9.0	11.1			
WS15 S2	0.40	SAND	7.28	<2.0	<1.0	<2.0	14.3	<1.0	<1.0	<0.1	3.7	<2.0	5.5			<0.01

Key		**Source of Guidance Trigger Level**	
bold	Parameter found to be in excess of trigger concentration	$	DEFRA and the EA Contaminated Land Exposure Assessment (CLEA)
	Parameter not tested for	~	LQM/CIEH Generic Assessment Criteria for Human Health
#	All pH results listed to confirm which soil guideline values are to be used in CLEA assessment	◊	BRE Special Digest 1, Concrete in aggressive ground (2005)
♣	Tier 1 Value is pH dependent	*	ICRCL Guidance Note 59/83, Second Edition (1987) – (Boron Phytotoxic only)
		x	Based on phytotoxic risks as plants are the more sensitive receptor (Cu and Zn are pH dependent) - BS3882:2007 & BS8601:2013

Table 8.2 - Summary of the Leachability Testing on Samples from Sefton Meadows, Liverpool

Hole ID	Depth (m)	Material	Concentration in μg/litre unless otherwise Shown. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets.										
				As	B	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Se
				(50)~	(2000)~	(5)~	(5-250)~	(1-28)~	(4-250)~	(1)~	(50-200)~	(8-500)~	(10)*
WS1 S2	0.20	MG: SAND		3.24	30.36	<0.05	1.34	**60.35**	17.59	<0.1	2.47	25.0	<1.0
WS4 S2	0.30	MG: SAND		3.66	36.37	<0.05	0.99	25.72	10.75	<0.1	2.29	24.8	<1.0
WS5 S2	0.40	MG: SAND		6.51	25.53	<0.05	0.93	**36.20**	7.35	<0.1	2.06	20.6	<1.0
WS8 S2	0.50	MG: SAND		1.61	23.11	<0.05	1.36	**31.18**	3.55	<0.1	2.07	25.7	<1.0

Key		**Source of Guidance Trigger Level**	
-	Parameter tested for but not found to be in excess of trigger concentration	*	Water Supply (Water Quality) Regulations 1989, as amended in 2000
	Parameter not tested for	~	Environmental Quality Standard (EQS) for Fresh Water
< LoD	Parameter concentration is below limit of detection (which is greater than trigger concentration	#	PAH = sum of benzo(b)fluoranthene + benzo(k)fluoranthene + benzo(ghi)perylene + indeno(1,2,3-cd)pyrene

Table 8.3 - Summary of Degree of Ground Contamination (Organics) at Land at Sefton Meadows, Liverpool.

Hole ID	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume a **residential with gardens and no cover** end use											
			TOC	Benzene	Toluene	Ethyl Benzene	Xylenes	Phenols		PAH		TPH - C_6 to C_{40}		
										Naphthalene	benzo(a) pyrene	GRO C_6 to C_{10}	DRO C_{10} to C_{20}	LRO C_{20} to C_{40}
			%	(0.33) ♣	(610) ♣	(350) ♣	(230) ♣	(420)♣		(1.5)~	(0.83)~	(0.33)~ ◇	(69)~	(890)~
WS1 S1	0.05	MG:TOPSOIL								<0.1	**4.2**			
WS3 S1	0.10	MG:TOPSOIL								<0.1	**2.8**			
WS4 S1	0.10	MG:TOPSOIL	3.09							<0.1	**3.1**			
WS5 S1	0.10	MG:TOPSOIL								<0.1	**4.0**			
WS8 S1	0.10	MG:TOPSOIL	1.93							<0.1	**1.1**			
WS1 S2	0.20	MG: SAND	1.48					<0.1		<0.1	**2.1**			
WS1 S3	0.40	MG: SAND								<0.1	0.5			
WS3 S2	0.25	MG: SAND								<0.1	**3.3**			
WS4 S2	0.30	MG: SAND	1.89					<0.1		<0.1	**2.1**			
WS5 S2	0.40	MG: SAND								<0.1	**5.2**			
WS8 S2	0.50	MG: SAND								<0.1	<0.1			

Key		**Source of Guidance Trigger Level**	
bold	Parameter found to be in excess of trigger concentration	♣	CLEA SGV is dependent on Soil Organic Matter content. The Tier 1 values used here are the most conservative, and in the event of exceedances, reference should be made to TOC analysis.
	Contaminant not tested for	~	LQM/CIEH Generic Assessment Criteria for Human Health (assumes 1% SOM). For TPH C6-C40, the lowest value of aromatic or aliphatic has been adopted as the initial screening value.
		#	ALM risk-derived Tier 1 screening values. (Assumes **no soil cover**, see Generic Notes 04 in Appendix A).
*	Estimated from Speciated TPH Analysis Results	◇	Conservative value – assumes all C_6 to C_{10} is benzene

Table 8.3 (cont.) - Summary of Degree of Ground Contamination (Organics) at Land at Sefton Meadows, Liverpool.

Hole ID	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume a **residential with gardens and no cover** end use											
			TOC	Benzene	Toluene	Ethyl Benzene	Xylenes	Phenols		PAH		TPH - C_6 to C_{40}		
										Naphthalene	benzo(a) pyrene	GRO C_6 to C_{10}	DRO C_{10} to C_{20}	LRO C_{20} to C_{40}
			%	(0.33) ♣	(610) ♣	(350) ♣	(230) ♣	(420)♣		(1.5)~	(0.83)~	(0.33)~ ◇	(69)~	(890)~
WS9 S1	0.15	TOPSOIL	2.37							<0.1	**1.2**			
WS10 S1	0.25	TOPSOIL								0.2	**2.2**			
WS11 S1	0.20	TOPSOIL								<0.1	**1.2**			
WS12 S1	0.10	TOPSOIL								<0.1	**1.8**			
WS13 S1	0.10	TOPSOIL	1.36							<0.1	**1.0**			
WS15 S1	0.20	TOPSOIL								<0.1	0.7			
WS2 S3	0.50	CLAY								<0.1	<0.1			
WS9 S2	0.60	SILT								<0.1	<0.1			
WS5 S3	0.90	SAND								<0.1	<0.1			
WS8 S3	0.90	SAND								<0.1	<0.1			
WS11 S2	0.80	SAND								<0.1	<0.1			

Key		Source of Guidance Trigger Level	
bold	Parameter found to be in excess of trigger concentration	♣	CLEA SGV is dependent on Soil Organic Matter content. The Tier 1 values used here are the most conservative, and in the event of exceedances, reference should be made to TOC analysis.
	Contaminant not tested for	~	LQM/CIEH Generic Assessment Criteria for Human Health (assumes 1% SOM). For TPH C6-C40, the lowest value of aromatic or aliphatic has been adopted as the initial screening value.
		#	ALM risk-derived Tier 1 screening values. (Assumes **no soil cover**, see Generic Notes 04 in Appendix A).
*	Estimated from Speciated TPH Analysis Results	◇	Conservative value – assumes all C_6 to C_{10} is benzene

Table 8.4 - Summary of Groundwater Contamination at Land at Sefton Meadows, Liverpool

Hole ID	Depth (m)	Concentrations in μg/l unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets											
		pH	As	B	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Se		Ammoniacal N
			(50)~	(2000)~	(5)~	(5-250)~	(1-28)~	(4-250)~	(1)~	(50-200)~	(8-500)~	(10)*		(500)*
WS1		6.84	0.75	74	0.08	0.11	7.22	<0.05	<0.1	8.46	10.7	<1.0		**1500**
WS5		6.87	0.41	62	0.07	0.05	3.00	<0.05	<0.1	3.66	8.0	<1.0		**600**
WS8		6.59	0.53	19	<0.05	1.32	7.46	0.07	<0.1	1.51	3.3	<1.0		**1400**
WS9		6.16	0.60	34	0.09	1.30	13.43	0.26	<0.1	1.73	5.7	<1.0		400

Hole ID	Depth (m)	Concentrations in μg/l unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets								
		Phenols	Benzene	Dissolved TPH (Total)	Benzo(a)pyrene	PAH				
		(0.5)*	(1) *	(10)*	(0.01)*	(0.1)*				
WS1					**0.15**	**2.39**				
WS5					**<0.02**	**0.29**				
WS8					**<0.02**	**0.18**				
WS9					**<0.02**	**0.12**				

Key		**Source of Guidance Trigger Level**	
-	Parameter tested for but not found to be in excess of trigger concentration	*	Water Supply (Water Quality) Regulations 1989, as amended in 2000
	Parameter not tested for	~	Environmental Quality Standard (EQS) for Fresh Water
< LoD	Parameter concentration is below limit of detection (which is greater than trigger concentration		

Inorganic Determinands

8.3.5 Slightly elevated concentrations of lead (519.0mg/kg and 534.9mg/kg) have been recorded in two samples (WS10 S1 – 0.25m and WS11 S1 – 0.20m) of topsoil from the southern part of the site.

8.3.6 Statistical analysis of the results has been carried out in general accordance with the methods outlined in "*Guidance on Comparing Soil Contamination Data with a Critical Concentration*" CIEH\CL:AIRE (2008) (see comments in Appendix A, Contamination Testing) and the results are summarised below.

Results of Statistical Analysis of Inorganic Soil Contamination Data

Stratum	US_{95} Values for Contaminants that have yielded one or more Tier 1 exceedances for a given made ground type (mg/kg)
	Lead (450)
Topsoil	434.5

Notes: Values are bolded where the US95 value exceeds the relevant Tier 1 value.
Values in brackets are US95 values inclusive of any outliers.

8.3.7 Statistical analysis of lead concentrations in natural topsoil from the southern part of the site, have yielded a US_{95} concentration of lead below the tier 1 threshold value.

Leachable Metals

8.3.8 Elevated concentrations of leachable copper, above the maximum EQS value, have been recorded in three of four samples of sandy made ground (MG:Sand) beneath the site.

Calorific Value

8.3.9 The calorific value of two samples of sandy made ground (WS1 S2 – 0.4m and WS4 S2 – 0.3m), have yielded calorific values of 4.212MJ/kg and 2.091MJ/kg respectively. Materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn.

Asbestos

8.3.10 No asbestos fibres were identified in any of the 5No. samples of made ground, and 1No. samples of natural topsoil screened for asbestos.

Organic Determinands

8.3.11 Samples have been classified by comparison with published CLEA Soil Guidance Values (SGV's), or where no CLEA SGV is available, samples have been compared to LQM/CIEH Generic Assessment Criteria for Human Health.

Total Petroleum Hydrocarbons (TPH)

8.3.12 No visual or olfactory evidence of hydrocarbon contamination was encountered during the ground investigation, and the identified previous land uses do not suggest that hydrocarbon contamination would be present at the site. Therefore, no samples were submitted for TPH analysis.

Poly Aromatic Hydrocarbons (PAH)

8.3.13 Speciated analysis has confirmed the absence of significant concentrations of naphthalene in the soils beneath this site.

8.3.14 Elevated concentrations of benzo(a)pyrene have been recorded in samples of topsoil made ground, sandy made ground and natural topsoil beneath the site.

8.3.15 Statistical analysis of the results has been carried out in general accordance with the methods outlined in "*Guidance on Comparing Soil Contamination Data with a Critical Concentration*" CIEH\CL:AIRE (2008) (see comments in Appendix A, Contamination Testing) and the results are summarised below.

Results of Statistical Analysis of Inorganic Soil Contamination Data

Stratum		US_{95} Values for Contaminants that have yielded one or more Tier 1 exceedances for a given made ground type (mg/kg)
	Average SOM (%)	Benzo(a)pyrene (0.94*)
MG: Topsoil	4.32	**4.22**
MG: Sand	2.89	**3.76**
Topsoil	3.20	**1.80**

Notes: Values are bolded where the US95 value exceeds the relevant Tier 1 value.
Values in brackets are US95 values inclusive of any outliers.
* Screening Value based on 2.5% SOM.

8.3.16 Average Soil Organic Matter (SOM) contents have been calculated from Total Organic Carbon (TOC) derived from laboratory analysis (SOM=TOC x 1.72), which have determined the use of the CIEH threshold value of 0.94mg/kg based on an SOM of 2.5%.

8.3.17 Elevated concentration of benzo(a)pyrene have been recorded in topsoil made ground, sandy made ground and natural topsoil beneath the site.

8.3.18 Double ratio plots of the benzo(a)pyrene concentrations suggest that for the topsoil made ground and sand made ground they are coal and combustion derived, and for natural topsoil they are coal derived.

Semi-Volatile Organic Compounds (SVOC)

8.3.19 No significantly elevated concentrations of SVOC were encountered in either of the two samples of made ground submitted for SVOC analysis.

Pesticides

8.3.20 No elevated concentrations of organochlorine or organophosphorus pesticides, were recorded in the two samples of made ground submitted for analysis.

8.4 Water Contamination Results

8.4.1 The groundwater test results are summarised in the Table 8.4 above.

8.4.2 With consideration to the environmental setting of the site, the significance of the results has been assessed by comparison with the Environmental Quality Standards (EQS) values for freshwater. Where no EQS value for freshwater is available, reference to the Water Supply (Water Quality) Regulations has been given.

8.4.3 Groundwater encountered beneath the site is considered to be either present in granular drift strata or perched in cohesive drift strata.

8.4.4 In the absence of EQS values for ammoniacal nitrogen, and PAH's, slightly elevated concentrations of ammoniacal nitrogen, and PAH above drinking water standards have been recorded in groundwater beneath the site.

8.4.5 Concentrations of PAH's in groundwater within the granular drift strata are only marginally elevated above Dinking Water Standard, with concentrations of benzo(a)pyrene being below the laboratory threshold, which exceeds the Dinking Water Standard. Elevated concentrations of PAH's were recorded in perched groundwater within low permeability clays in WS1.

8.4.6 No elevated concentrations of pesticides were recorded in the two sample of groundwater form beneath the northern part of the site.

9 CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)

9.1 Assessment of Contamination Test Results

9.1.1 Notes outlining current guidance with respect to the interpretation of analytical data are included in Appendix A to this report.

9.1.2 Topsoil made ground, between 100mm to 200mm thick, is present across the north of the site, and natural topsoil, between 300mm to 600mm thick, is present across the southern half of the site. Laboratory chemical analysis suggests that both the topsoil made ground, and to a lesser extent the natural topsoil, is unsuitable for re-use as topsoil in private gardens and landscaped areas.

9.1.3 Sandy made ground is present beneath topsoil made ground in the north of the site, to depths between 0.35m to 1.0m. These strata are probably the result of re-working of the surface of the site as a consequence of the previous land use as a plant/tree nursery. Elevated concentrations of benzo(a)pyrene identified in the sandy made ground confirm that the sandy made ground is unsuitable for retention at the surface in private garden and landscaped areas of the proposed development.

9.1.4 Slightly elevated concentrations of leachable copper have been identified in sandy made ground beneath the north of the site. There is no obvious source of copper contamination at the site, and the leachable concentrations do not appear to have translated to groundwater beneath the site. Therefore, the concentrations of leachable copper are not considered to present a significant risk to controlled waters beneath or in the vicinity of the site.

9.1.5 Groundwater beneath the site, has been found to exhibit slightly elevated concentrations of Ammoniacal Nitrogen and PAH, with respect to UK Drinking Water Standards, with slightly higher concentrations recorded in one sample of perched groundwater in WS1. Given the generally low concentrations and the environmental setting of the site, it is considered that the identified contamination in the groundwater does not present a significant risk to controlled waters.

9.2 Revised Conceptual Site Model (Contamination)

9.2.1 The Conceptual Site Model has been amended in light of data obtained during the ground investigation, most notably with respect to the distribution of made ground and contaminants.

9.2.2 A Revised Conceptual Site Model is presented as Drawing No.30046/5 in Appendix B. The Model includes the significant contaminant sources described in Section 9.1 above, and potential pollutant linkages to receptors.

9.3 Environmental Setting & End Use

9.3.1 As discussed in Section 9.1 above, some contamination exists in the soil/groundwater beneath this site. In order to assess the significance of this contamination, consideration must be given to the site's environmental setting and the proposed end use.

9.3.2 The underlying drift strata is classified as a Secondary A Aquifer and the underlying bedrock is classified as a Principal Aquifer. However, the site is not located within a groundwater source protection zone, nor are there any groundwater abstractions within 750m of the site. The nearest surface watercourse is an un-named stream approximately 60m north of the site, which flows in a westerly direction toward Sefton Park. Therefore, the site's environmental setting is considered to be low sensitivity.

9.3.3 With respect to human health, the proposed end use (residential) is considered to be sensitive. Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, see Section 13.3.

9.4 Pollutant Linkages

9.4.1 In terms of a proposed redevelopment of this site, plausible pollutant linkages can be summarised as follows.

Sources

9.4.2 Contaminant sources have been summarised in Section 9.1 above.

Pathways

9.4.3 Potential contaminant pathways include:

- ingestion
- dermal contact
- inhalation of contaminated particulates
- surface water run-off

Receptors

9.4.4 Potential contaminant receptors include:

- end users of the site (residents)
- the environment – un-named stream (60m) to the north

9.4.5 It can be concluded that there are plausible pathways between actual contaminant sources and potential receptors. Consequently, based on the above assessment, some Remediation action will be required, either treatment/removal of the source, or "breakage" of the pathway.

9.4.6 It is worth noting at this point that, if the Category 4 Screening Levels were adopted for the assessment of soil analysis for the site, concentrations of benzo(a)pyrene recorded in both topsoil and made ground beneath the site would not exceed the C4SL concentration of 5mg/kg for residential development with home grown produce, and therefore no remediation action would be required with respect to soil contamination.

9.5 Potential Remediation Options

General

9.5.1 Approval of the recommendations given below should be sought from the appropriate regulatory authorities prior to commencement of site redevelopment.

9.5.2 If Category 4 Screening Levels are adopted by the Local Planning Authority (Liverpool City Council), there will be no requirement for ground remediation with regard to soil contamination at the site.

Inorganic Contamination

9.5.3 No significant inorganic contaminants have been encountered beneath the site.

Organic Contamination

9.5.4 As discussed in Section 9.1 above, elevated concentrations of benzo(a)pyrene have been recorded in topsoil made ground, natural topsoil and sandy made ground beneath the site.

9.5.5 Both topsoil made ground and natural topsoil have been determined to be unsuitable for re-use as topsoil in private gardens and public open space.

9.5.6 Where topsoil and made ground remains beneath garden and landscaped areas, it is recommended that a 600mm thick surface cover of "clean" soil, typically comprising 450mm subsoil and 150mm topsoil be placed over the made ground. This cover will break potential pollutant linkages between the contaminated made ground and future end-users.

9.5.7 Given the organic nature of the topsoil and made ground, where these soils are retained beneath the site, they should not be placed at a depth greater than 1m, due to their potential to generate ground gas.

Combustibility

9.5.8 Two samples of sandy made ground at this site have yielded calorific values of 4.212MJ/kg and 2.091MJ/kg. These are at the lower end of the range where the potential for combustion exists and it is not considered a significant hazard.

Waste Classification

9.5.9 Disposal of the made ground off site is not considered appropriate, economically viable, nor in line with current Government philosophy regarding sustainable development. However, some excess arisings may be generated by excavations for foundations, sewers etc. Disposal to landfill may be the most practical solution, if redistribution and retention on site is not feasible.

9.5.10 Notes outlining the interpretation of analytical data with respect to waste classification are included in Appendix A to this report, together with notes about Waste Acceptance Criteria (WAC).

9.5.11 All soil arisings generated by excavations at this site are likely to be classified as either inert or non-hazardous waste.

10 HAZARDOUS GAS

10.1 General

10.1.1 Consideration of the conceptual site model and potential linkages enabled a preliminary qualitative assessment of risks associated with gas;

Source	Receptors	Hazard	Pathway	Initial Risk
On-site made ground	Human Health	Asphyxiation & explosion.	Vertical migration, ingress & accumulation	**Very Low**: made ground essentially inert, with little degradable matter.
	Buildings	Explosion.		
Off-site landfill (Hall Lane Tip)	Human Health	Asphyxiation & explosion.	Lateral migration, ingress & accumulation	**Very Low**: natural strata to at least 5m depth are generally of low permeability.
	Buildings	Explosion.		
	Buildings	Explosion.		

10.1.2 The generation potential of the gas sources both on and off site was initially considered to be VERY LOW, and this has been confirmed by the monitoring results obtained to date. Consequently, in accordance with CIRIA Report C665, given the proposed residential end use, six visits have been scheduled over a three month period, between June and September 2014.

10.1.3 Gas monitoring wells have been installed in selected boreholes across the site. Details of the installations are given on the borehole logs presented in Appendix F to this the report.

10.2 Scope of Works

10.2.1 The wells have been monitored on six occasions for groundwater levels and soils-gases. Gas monitoring results are included in Appendix I.

3.1.1 A standard procedure was followed, in accordance with CIRIA guidance:

- Ambient oxygen concentration
- Atmospheric temperature & pressure
- Methane, oxygen and carbon dioxide concentrations and flow rates using a Gas Data GMF 430 gas analyser
- Standing water level using a dip meter
- Ambient oxygen concentration (check for instrument drift)

10.3 Monitoring Results

10.3.1 The results of the monitoring programme are summarised below.

Summary of Gas Monitoring Results

Hole ID	Range of Methane Concentrations (% v/v)	Range of Carbon Dioxide Concentrations (% v/v)	Range of Positive Flow Rates (litre/hour)	Gas Screening Values (GSV) CH4/CO2 (ltrs/hr)
WS1	0.0 – 0.0	0.6 – 3.2	0.0 – 0.0	0.0001 / 0.0032
WS3	0.0 – 0.0	9.1 – 12.0	0.0 – 0.0	0.0001 / 0.0120
WS5	0.0 – 0.0	0.9 – 5.5	0.0 – 0.0	0.0001 / 0.0055
WS8	0.0 – 0.0	2.5 – 5.5	0.0 – 0.0	0.0001 / 0.0055
WS9	0.0 – 0.0	3.9 – 7.1	0.0 – 0.0	0.0001 / 0.0071
WS11	0.0 – 0.0	3.5 – 8.6	0.0 – 0.0	0.0001 / 0.0086

10.4 Discussion

10.4.1 Concentrations of carbon dioxide, up to a maximum concentration of 12.0%, have been detected in monitoring wells across the site.

10.4.2 Base on the calculated Gas Screening Values (GSV's) and maximum gas concentrations for results obtained, gas exclusion measures in accordance with a GREEN traffic light classification (CIRIA C665) will be required for new properties to be constructed at the site.

Typical Gas Exclusion Measures

Traffic Light Classificn	Gas "score" req'd by BS 8485	Floor Slab (BS8485 "score")	Protective Measures	
			Sub-floor ventilation (BS8485 "score")	Membrane Type (BS8485 "score")
Green & **CS2** (Wilson & Card)	**2***	*For Green\Amber1\Amber2, select one from:* i. Block & Beam – **(0)**. ii. Reinforced ground bearing slab – **(0.5)**. iii. Reinforced, cast in-situ suspended slab (with minimal service penetrations & water bars around all slab penetrations & at joints) – **(1.5)**. iv. Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater that provided by the side ventilation (air bricks) – **(1.5)**.	*For Green\Amber1, select one from:* Passive sub-floor ventilation; venting layer could be: i. A min. 150mm clear void **(2.5)**, or ii. A proprietary void former (expanded polystyrene shuttering) providing an equivalent clear void depth of 33mm **(2.5)**, or iii. Min. 300mm thick blanket of 20mm single size gravel **(1.0)**. Min. ventilation = 1,500 mm^2/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 2m centres or honeycombing of any sub-floor sleeper walls.	Waterproof DPM (2000 gauge polyethylene). Lapped & sealed in accordance with BR 414. **(0.5)**

Footnotes:

* Modified from BS 8485 by ALM. Monitoring data has also been reviewed using Wilson & Card methodology and found to be Characteristic Situation 2; consequently a membrane & ventilation are recommended.

1. The membrane should always be lapped and sealed in accordance with BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*". The membrane should be continuous across cavity walls, and there should be a cavity tray in external walls.
2. In all cases there should be minimum penetration of floor slab by services; any penetrations should be suitably sealed.
3. Integral garages with occupied rooms above, or direct access through a doorway from the garage to the house, should be provided with the same protective measures as the rest of the dwelling. Buildings with basement car parks (with ventilation in accordance with Building Regulations) may not require gas resistant membranes.

11 GEOTECHNICAL TESTING

11.1 General

11.1.1 Selected samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by ALM.

11.1.2 The geotechnical laboratory test results are presented in Appendix H to this report.

11.2 Atterberg Limits

11.2.1 The results of plastic index tests undertaken on five samples of natural clay are summarised below.

Soil type	Range of Plasticity Indices (Average)	Shrinkability
Glacial Drift	11 - 23 (15.8)	Low

Note. The term Shrinkability is equivalent to the term Volume Change Potential used in Chapter 4.2.

11.2.2 For the purposes of foundation design, it is recommended that all natural cohesive soils be regarded as being of low shrinkability.

11.3 Soluble Sulphate and pH

11.3.1 In accordance with BRE Special Digest 1:2005, this site has been classified as brownfield with a mobile groundwater regime.

11.3.2 It is envisaged foundations will extend to depths of generally up to 5.0m, through made ground and natural strata, and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).

11.3.3 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the Table below.

Summary of Sulphate and pH results

Soil type	Lowest pH values	Highest Soluble Sulphate Concentration (g/l)
MG: Sand	6.63	0.03
Clay	7.07	<0.01
Sand	6.63	0.02
Silt *	6.35	<0.01

* one sample recorded.

11.3.4 Therefore, in accordance with Tables C1 and C2 of SD1, sub-surface concrete should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

12 GEOTECHNICAL ISSUES

12.1 Conceptual Site Model

12.1.1 The site is underlain by a veneer of topsoil, which overlies made ground in the north and natural drift strata in the south. Made ground has been recorded to a maximum depth of 1.0m in one location (WS6), but is generally less than 0.75m depth.

12.1.2 Groundwater seepage was recorded from depths between 1.5m to 3m in sand and soft clay strata across the site. Groundwater was absent from exploratory holes in the northeast and southeast of the site. Standing water levels recorded in monitoring wells are generally below a depth of 2m, with the exception of perched groundwater at a typical depth of 1.3m in WS1.

12.2 Site Regrade and/or Ground Improvement

12.2.1 The site is generally flat and exists at similar elevations to surrounding land. Therefore, no significant re-profiling of site levels is envisaged.

12.3 Foundation Recommendations

General

12.3.1 It is understood that consideration is being given to redevelopment of the site with 34No. detached houses, with associated gardens and adoptable roads and sewers, as shown on the Calderpeel Architects 'Proposed Site Plan', Drawing No. 14082(Pl)001L in Appendix B.

12.3.2 Foundation recommendations assume that development will be 2 or 3-storey and that line loads will typically not exceed 60kN/m run. If this is not the case significant alteration to these recommendations may be required.

12.3.3 We have also assumed that final development levels will not differ significantly from ground levels existing at the time of investigation.

12.3.4 Made ground is not considered a suitable foundation material and foundations should therefore be taken through these materials into underlying natural strata of adequate bearing capacity.

12.3.5 Firm/stiff boulder clay or medium dense sand is anticipated to be the competent bearing strata for proposed buildings.

12.3.6 For the purposes of foundation design, it is recommended that all natural cohesive soils be regarded as being of low shrinkability.

12.3.7 A suspended floor construction should be used wherever the depth of made ground or infill beneath a plot exceeds 600mm.

12.3.8 Sub-surface concrete in contact with the made and natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

12.3.9 Redrow Homes or their groundworker should seek further advice from ALM if unexpected ground conditions are encountered in foundation or sewer excavations.

12.3.10 The depths to competent strata and strata type are variable across the site, therefore, it is possible that a number of different foundation solutions may represent the most economical foundation solutions for proposed buildings. It is considered that a traditional strip/trench fill foundation, piled foundations or vibro-ground improvement will be the most economical options for two or three storey residential properties constructed on this site and these are discussed below.

12.3.11 An indicative foundation zoning plan, based on the Proposed Site Plan and ground conditions encountered in boreholes near to proposed buildings, is presented as Drawing No.30046/6_Rev1 in Appendix B.

Strip / Trench Fill Footings

12.3.12 Strip footings/trench fill will likely be the most suitable foundation solution where the made ground or soft loose natural strata is less than about 2.5m thick, and firm clay or medium dense sand is the founding material.

12.3.13 Where the ground is found to comprise varying soil types, reinforcement of footings is recommended as a precaution against differential settlement.

12.3.14 Clay classification tests suggest that natural cohesive soils at the site should be regarded as being of low shrinkabilty. A minimum founding depth of 750mm is therefore recommended for all soils on the site where strip footings are proposed.

12.3.15 Foundations should be deepened near trees in accordance with NHBC Standards Chapter 4.2.

12.3.16 Founding depths are from original or finished ground level, whichever is the lower, to the underside of the footing.

12.3.17 In order to minimise softening and swelling of cohesive soils or loosening of granular soils, it is recommended that as soon as formation level is reached, it should be blinded. The blinding should consist of concrete with as low a water:cement ratio as possible.

Piled Foundations

12.3.18 Piled foundations may be an option for dwellings constructed in areas where loose sands or soft clays are present to depths below 2.5m. The following general comments relating to piling are provided for guidance, and further advice should be sought from a specialist-piling contractor.

12.3.19 Piled foundations should extend into the underlying firm/stiff clays or medium dense sands.

12.3.20 For piled foundations suspended floor slabs should be utilised. A pre-cast ‘Beam and Block’ concrete ground floor construction could be utilised, and suspended across the ring beams.

12.3.21 Ground conditions at this site are considered likely to require provision of a piling mat (working platform) and further advice should be sought from the appointed specialist-piling contractor regarding the proposed plant loadings and resulting pressures. This data, together with a knowledge of the strength and variability of the near-surface ground conditions is required in order that design of a mat can be undertaken in accordance with guidance provided in the 2004 BRE document, “*BR 470: Working platforms for tracked plant*”.

12.3.22 The design of working platforms for tracked plant is a geotechnical design process and should be carried out by a competent person. The following parties should have input into the design:

- Permanent works designer, to consider additional uses for platform material as part of the overall development
- Principal contractor, to define any other purposes for which the platform might be used
- Contractor or subcontractor, to specify requirements for the platform, including gradients, ramps and edges

12.3.23 The number of plots affected by piling will depend on final layout proposals, however, initial consideration of ground conditions suggests approximately 40% of the proposed buildings may require piled foundations.

12.3.24 It may be more practical and economic to pile *all* the plots on this site, since mobilisation charges are likely to be similar regardless of how many plots are piled. A piled solution would also result in less disturbance than strip footings and negate the need to dispose of soil arisings.

12.3.25 Piles can provide an enhanced pathway for the vertical migration of mobile contaminants. The Environment Agency may therefore object to the adoption of piles as a foundation solution. However, objection is considered unlikely given the nature of the contamination encountered.

Vibro Foundations

12.3.26 Vibro is a technique used to improve the geotechnical characteristics of made ground, loose granular soils and some cohesive soils (shear strength >30kPa).

12.3.27 On residential developments, stone columns are typically 500mm to 700mm in diameter at spacings of between 1.5m and 2.0m. After treatment, houses can be founded on either strip footings or rafts.

12.3.28 In accordance with Chapter 4.6 of NHBC Standards, NHBC should be notified of any proposed vibro ground improvement in advance. Furthermore, Redrow Homes should obtain written confirmation from the specialist contractor that the site is suitable for the proposed ground improvement, and submit this confirmation to NHBC.

12.3.29 NHBC require footings placed on vibro improved ground to be suitably reinforced.

12.4 Excavations

12.4.1 Based on the results of the investigation it is unlikely that major groundwater flows will be encountered in shallow excavations.

12.4.2 Excavations in natural ground should remain stable in the short term, however, excavations through made ground or loose/wet sands are likely to be unstable.

12.5 Drainage

12.5.1 Given the variable nature of natural drift strata beneath the site, including low permeability clays and some wet sands, soak-away drainage is not considered to be a feasible option for surface water drainage. Instead, drainage should be directed into the local sewer network.

12.5.2 It is recommended that the developer contact United Utilities with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

12.6 Highways

12.6.1 Based on visual inspection of the natural materials and the recorded plasticity indices at the site, the natural deposits are likely to have a CBR value of at least 2%. These values should be verified prior to or during construction.

12.6.2 Where made ground is present beneath proposed road/pavements, the made ground should be excavated and replacement with suitable aggregate in accordance with Series 600 (Earthworks) of The Highways Agency (HA) "Specification for Highway Works" 1998.

12.6.3 The bulk of made ground encountered beneath the site is considered unsuitable for re-engineering, on account of its generally organic nature.

13 REDEVELOPMENT ISSUES

13.1 General

13.1.1 This report has presented options with respect to foundation solutions, treatment of contamination etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. Copies of this report should be forwarded to the relevant regulatory authorities (NHBC & Local Authority) for their comment/approval.

13.2 Remediation & Site Preparatory Works

13.2.1 Topsoil and sandy made ground have been found to exhibit elevated concentration of benzo(a)pyrene, and are therefore considered unsuitable for retention at the surface in private garden and landscaped areas. Where these soils remain beneath private garden and landscaped areas, they should be retained beneath a minimum 600mm clean soil cover. Given the generally organic nature of these soils they should not be located any deeper than 1m below finished ground level as they may have potential to generate ground gas.

13.2.2 Depending on proposed finished ground levels, consideration should be given to the possibility of 'inverting' the soil profile beneath proposed private garden and landscaped areas, by removing the topsoil and/or made ground, excavating underlying natural clean clays/sands to a depth of 1m below finished levels, replacing topsoil and/or made ground to a depth of 600mm below finished levels and replacing natural clays/sands to a depth of 150mm below finished levels prior to placement of clean imported topsoil. This would greatly reduce the volume of topsoil and subsoil material required to be removed from site and imported to site.

13.2.3 Some site preparatory works will be necessary to facilitate the redevelopment of the site. The scope of anticipated site preparatory works will depend upon finished development levels, but the anticipated scope is summarised below:

- General site clearance
- Removal of unprotected trees and shrubs, and stripping of vegetation.
- Stripping of topsoil and made ground and stockpiling for either re-distribution beneath the site or disposal to a suitably licensed landfill.
- Re-profiling of soils to achieve required development levels.
- Preparation of road footprints.

13.3 Health & Safety Issues - Construction Workers

13.3.1 Much of the topsoil and made ground may be retained on site. Some soils beneath the site locally contain contaminants at concentrations above the guidance threshold values for an end use that includes domestic gardens. Workers involved in excavations for foundations, drainage, utilities etc are likely to come into direct contact with the made ground in localised areas of the site.

13.3.2 Although workers will only be exposed to the contaminated soil for a relatively short time, the contaminants represent a risk, and simple precautionary measures are required, i.e. good personal hygiene and basic personnel protective equipment.

13.3.3 Consequently, during the remediation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land".

13.4 Control of Excavation Arisings

13.4.1 Excavations into made ground are likely to yield contaminated arisings, or arisings containing rare fragments of wood, metal and glass. The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of “clean” natural soils, in order that an excessive volume of unsuitable material is not generated.

13.5 New Utilities

13.5.1 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

13.6 Potential Development Constraints

13.6.1 The site is surrounded by numerous mature and semi-mature trees, some of which may be protected. The determination of which trees are protected and/or are to be retained, may have a significant impact upon the proposed development layout.

14 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

14.1 General

14.1.1 The site is under consideration for redevelopment with residential dwellings, with associated gardens, public open space and adoptable roads and sewers. The 'Proposed Site Plan' shows 34No. detached dwellings, and also shows Park Avenue to be retained as part of the proposed development.

14.1.2 The site is currently used as an area of public open space. The north of the site has been formerly used as a tree/plant nursery for much of the 20th Century, however, the south of the site has remained undeveloped.

14.1.3 The site has been found to be generally underlain by a veneer of topsoil overlying made ground, natural clays or sands. Topsoil in the north of the site is generally 100mm – 200mm thick and overlies sandy made ground, which extends to depths between 0.35m and 1.0m. Topsoil in the south of the site has been recorded to depths between 0.3m to 0.6m. Topsoil and made ground is underlain by either natural clays or natural sands, which are variable in strength/density.

14.2 Contamination

14.2.1 Elevated concentrations of benzo(a)pyrene, above the chosen assessment criteria, have been recorded in topsoil made ground, natural topsoil and sandy made ground across the site. The topsoil across the site is therefore unsuitable for re-use as topsoil in private gardens and landscaped areas. Both the topsoil and sandy made ground are therefore unsuitable to remain at the surface of the site in private garden and landscaped areas, and should be retained beneath a minimum 600mm of clean soil cover. Given the generally organic nature of both the topsoil and made ground, they should not be retained at greater depth than 1m below finished ground levels due to the potential for ground gas generation.

14.2.2 As suggested earlier in this report, if DEFRA Category 4 Screening Levels are adopted by the Local Planning Authority (Liverpool City Council), for the assessment of soil analysis for the site, concentrations of benzo(a)pyrene recorded in both topsoil and made ground would not exceed the C4SL concentration of 5mg/kg, and therefore no remediation action would be required with respect to soil contamination at the site, and topsoil could be re-used as topsoil in private garden and landscaped areas of the proposed development.

14.3 Site Preparatory Works

14.3.1 All unprotected trees and shrubs should be stripped where they conflict with the proposed development. All other vegetation (grass) should be stripped from the surface of the site for disposal off site.

14.3.2 Topsoil and made ground should be stripped and stockpiled separately for either re-distribution at the site and/or disposal off site.

14.3.3 Natural strata should be re-profiled to achieve required development levels.

14.3.4 Unless Category 4 Screening Levels are adopted, consideration should be given to the potential inversion of the soil profile in private garden and landscaped areas, comprising the removal of topsoil and made ground, the excavation of natural strata to a depth of 1m below finished ground levels, the placement of topsoil/made ground to a depth of 600mm below finished ground levels, and the replacement of clean natural strata to a depth of 150mm below finished ground levels to allow for the placement of imported clean topsoil.

14.3.5 The footprints to proposed roads should be prepared in accordance with Series 600 (Earthworks) of The Highways Agency (HA) "Specification for Highway Works" 1998.

14.4 Hazardous Gas

14.4.1 Elevated concentrations of carbon dioxide and no concentrations of methane and have been recorded in monitoring installations at the site.

14.4.2 Based on the calculated gas screening values and maximum concentrations from monitoring results obtained, gas exclusion measures in accordance with a GREEN traffic light classification (CIRIA C665) will be necessary for new buildings within the proposed development.

14.5 Foundations

14.5.1 Given the variability of natural strata across the site, a mixture of traditional strip/trench fill, piled foundations or vibro-ground improvement will likely be the most economical foundation solution for proposed buildings at the site.

14.5.2 It may be prudent to undertake further plot specific ground investigation prior to the construction of proposed buildings in order to confirm the most suitable foundation solution for plots across the site.

14.5.3 Natural clays have been classified as low shrinkability, therefore, a minimum foundation depth of 750mm will be required.

14.5.4 Sub-surface concrete in contact with the made and natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

14.6 Flooding

14.6.1 The EA indicate that the site is/is not located within an indicative floodplain.

14.7 Drainage & Highways

14.7.1 Ground conditions beneath the site are not conducive to soak-away drainage, therefore, surface water drainage should be directed to the existing sewer network.

14.7.2 Natural firm/stiff clays or medium dense sands beneath the site should offer a CBR of at least 2%.

APPENDIX A
GENERAL NOTES

Generic Notes – ALM Geoenvironmental Investigations

01 - Environmental Setting

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the Correspondence Appendix of this Geoenvironmental Report.

Geology, Mining & Quarrying

In order to establish the geological setting of a site, ALM refer to BGS maps for the area, and the relevant geological memoir.

A coal mining report is obtained from the Coal Authority where the study site is located within a Coal Authority Search area. Further information is sourced from the Local Authority and by reference to current and historical OS plans.

Landfills

ALM obtain data from the Landmark Information Group/Emapsite, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move though fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, ALM refer to BRE Report BR211, 2007: "*Radon: guidance on protective measures for new buildings*".

The level of protection needed is site-specific and is determined by reference to the maps contained in Annex A of BR211. These maps are derived from the Radon Atlas of England and Wales (2007), and indicate the highest radon potential within each 1km grid square.

If the site falls within a light grey square on the relevant map in Annex A then basic radon protection should be installed in new buildings; if the site falls within a dark grey square then full radon protection should be installed. **If the site is in an un-shaded square then no radon protection is needed.**

BR211 provides a preliminary indication of the measures required for a particular site, but it is also often beneficial to request a BR211 Radon Report from the BGS. The Annex A maps indicate the highest geological radon potential within each 1km grid square, but in many cases the radon potential varies considerably within the grid square. The BR211 Radon Report gives definitive guidance on the requirement for radon protective measures, and therefore may allow the adoption of a lower level of protection than that indicated in the Annex A maps.

ALM typically obtain a BR211 Radon Report for all sites that fall within a shaded square on the relevant Annex A map.

When requesting a BR211 Radon Report from the BGS ALM select the search radius carefully, since too large a search radius may result in the inclusion of areas of higher geological radon potential, and therefore in the recommendation of too high a level of protection.

Further details of the protective measures required, if appropriate, are provided in the Hazardous Gas section of this Geoenvironmental Report.

Hydrogeology

ALM obtain information from the Environment Agency (EA) and the Landmark Information Group/Emapsite with respect to:

- groundwater quality
- recorded pollution incidents
- licensed groundwater abstractions

Reference is also made to the EA document "*Policy and Practice for the Protection of Groundwater*" (1998) and the relevant Groundwater Vulnerability Map.

Since 1st April 2010 the Environment Agency's *Groundwater Protection Policy* uses aquifer designations that are consistent with the Water Framework Directive and represent a slight modification to those aquifer designations which have been used in the past. These new designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems.

The aquifer designation data is based on geological mapping provided by the British Geological Survey and will be updated to time to time based on the ongoing programme of improvements to these maps.

The Bedrock and any overlying granular Drift deposits are classified and defined by the Environment Agency as follows:

'Principal Aquifers' (formerly known as Major Aquifers):

"Layers of rock or drift deposits that have high intergranular and/or fracture permeability which can usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as a major aquifer"

'Secondary Aquifers' (generally formerly known as Minor Aquifers):

These include wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary Aquifers are sub-divided into two types:

- **Secondary A**: *"Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers".*

- **Secondary B**: *"Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of layers formally classifies as non-aquifers"*

- **Secondary Undifferentiated**: *"Layers of rock or drift where it has not been possible to attribute either Secondary A and Secondary B classification. This means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to variable characteristics of the rock or drift type"*

'Unproductive Strata' (formerly known as Non-aquifers):

"*These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow".* NB: Groundwater flow through Unproductive Strata although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some non-aquifers can yield water in sufficient quantities for domestic use.

Groundwater vulnerability is determined by 4 variables:

1. The presence and nature of overlying soil (the weathered zone affected by living organisms; soil in the UK can extend up to 2m in depth). Physical properties of the soil affect the downward passage of water and it's ability to attenuate pollutants. The EA make reference to a three-fold classification of soil types:-

   - Soils of **low** leaching potential are defined as *"soils in which the pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants".*

   - Soils of **intermediate** leaching potential are defined as *"soils which have a moderate ability to attenuate diffuse source pollutants or in which it is possible that some nonadsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer".*

   - Soils of **high** leaching potential are defined as *"soils with little ability to attenuate diffuse source pollutants and in which non-adsorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater".*

In urban areas and restored mineral workings the soil information is based on fewer observations than elsewhere. A worst-case vulnerability (H) is therefore assumed for these areas and for current mineral workings by the EA. All are given a designation of **HU** unless proved otherwise.

2. The presence and nature of Drift, which often overlies bedrock. Where Drift is of substantial thickness and low permeability, it can provide an effective barrier to surface pollutant migration. Permeable Drift is classified as a Minor Aquifer except where it is in probable hydraulic continuity with a Major Aquifer, where it is regarded as part of the Major Aquifer unless proven otherwise by site investigation.

3. The nature of the geological strata (bedrock). Rocks that contain groundwater in exploitable quantities are called aquifers.

4. The depth of the unsaturated zone; i.e. that part of the aquifer which lies above the water Table The EA have also designated Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted, groundwater flow travel times and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

ALM obtain information from the Environment Agency and the Landmark Information Group with respect to:

- surface water quality
- recorded pollution incidents
- licensed abstractions (groundwater & surface waters)
- licensed discharge consents
- site susceptibility to flooding

The EA have set **water quality** targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are six GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to **flooding** is assessed by reference to a Flood Map on the Environment Agency's website. These maps provide show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.

There are two different kinds of area shown on the Flood Map:

1. Dark blue areas could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year

2. Light blue areas show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year (or 1 in 200 year as appropriate), areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist consultant who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc.

COMAH & Explosive Sites

ALM obtain information from the Landmark Information Group with respect to COMAH or explosive sites within 1km of the proposed development site. ALM's report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise it's emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary Conceptual Ground Model

The site's environmental setting (and proposed end use) is used by ALM to assess the significance of any contamination encountered during the subsequent ground investigation.

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential targets.

Potential pollutant linkages are shown on a preliminary conceptual site model, presented as a Drawing in an Appendix to this Geoenvironmental Report. The preliminary model is revised in light of data arising from the subsequent ground investigation.

Generic Notes – ALM Geoenvironmental Investigations

02 - Ground Investigation Fieldwork

General

ALM Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:1999 "*Code of practice for site investigation*"
- BS10175:2001 "*Code of practice for the identification of potentially contaminated sites*".
- "*Technical Aspects of Site Investigation*" – EA R&D Technical Report P5-065/TR (2000)
- "*Development of appropriate soil sampling strategies for land contamination*" – EA R&D Technical Report P5-066/TR (2001)
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "*Sampling strategies for contaminated land*"
- "*Guidance on the protection of housing on contaminated land*" – NHBC & EA R&D Publication 66 (2000)
- AGS: 1996 "*Guide to the selection of Geotechnical Soil Laboratory Testing*"

Exploratory hole logs are presented in Appendices to this Geoenvironmental Report. These logs include details of the:

- Investigation technique adopted
- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of any in-situ testing
- Any gas\groundwater monitoring well installed

Exploratory Hole Locations

Exploratory hole locations are selected by ALM, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation Techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 1999 and BS1377: 1990. Techniques most commonly used by ALM include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket.
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing.

- Window or Windowless Sampling boreholes. Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tricone rock roller bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas\groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10 mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete.

Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ Testing

Where relative densities of granular materials given on the trial pit and window sample logs are based on visual inspection only, they do not relate to any specific bearing capacities. However, wherever possible ALM employ a Mackintosh probe to assess relative density. Mackintosh probe results can be related to approximate allowable bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPT's are carried out in boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x.

The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Representative soil/fill samples are taken at regular intervals from the exploratory holes to assist in description of the ground and to allow selected laboratory testing to be performed. The type of sample taken is dependent on the nature of the stratum and the purpose of the analysis.

Where the soils encountered contain a significant proportion of coarse grained material, truly representative samples are not typically obtained - only the finer fraction is placed in sample containers. However, a visual estimate of the amount of coarse material is made on site.

NB: Coarse constituents not sampled are defined as: coarse gravel, cobble and boulder. (i.e. any 'particles' with an average diameter greater than 20mm).

Occasionally, unrepresentative 'spot' samples are also taken from some exploratory locations for contaminant analysis, typically where unusual, localised pockets of materials are encountered.

Samples of soil for chemical testing are placed into 1 litre plastic tubs prior to delivery to the selected laboratory. Samples of water are taken in one litre, brown glass bottles and stored in cool boxes, at a temperature of <5ºC, until delivery to the selected laboratory. Soil\fill samples for organic analysis are also stored in cool boxes.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

Description of Strata

The soils encountered during an ALM ground investigation are described (logged) in general accordance with BS 5930. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text.

The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to Exploratory Hole Logs

Keys to logs are presented in the Appendix(ces) containing the logs. There are two Keys – Symbols & Legends and Terms & Definitions.

Generic Notes – ALM Geoenvironmental Investigations

03 - Geotechnical Laboratory Tests

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by ALM. All tests are carried out in accordance with BS 1377:1990.

The test results are presented as received in an Appendix to this Geoenvironmental Report.

The following laboratory testing are routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading.
- Compaction tests
- Particle density.

Atterberg Limits & Moisture Content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. ALM typically only consider a soil to be shrinkable if the proportion finer than 63μm is >35%.

PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'p), defined as:

I'p = Ip * (%< 425μm/100)
i.e. if PI is 30%, but the soil contains 80% < 425μm, then: I'p = 30 * 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425μm sieve is routinely reported by testing labs.

ALM apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- the average values for each particular soil type (i.e. differentiate between residual soil and alluvium),
- the number of results in each class and
- the actual values.

Unless the judgment strongly indicates otherwise, ALM typically adopt a conservative approach and recommend assumption of the higher classification.

Soluble Sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

ALM refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2001). SD 1 provides definitions of:

- the nature of the site (greenfield, brownfield or pyritic)
- the groundwater regime (static, mobile or highly mobile)
- the Design Sulphate Class (DC Class) and
- the Aggressive Chemical Environment for Concrete (ACEC Class)

ALM reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Generic Notes – ALM Geoenvironmental Investigations

4A. Contamination Laboratory Analysis & Interpretation (including WAC)

Waste Classification & Waste Acceptance Criteria (WAC)

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics).
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds).
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds).

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Since 16th July 2005, landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

ALM typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc.

If off-site disposal of soils classified as hazardous waste were undertaken during redevelopment, then WAC analysis should be scheduled at an early stage in the remediation programme.

However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous. These contaminants can often be dealt with by alternative technologies (e.g. by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

Contamination Laboratory Analysis & Interpretation

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to DEFRA/Environment Agency R&D Publication CLR8 "*Potential contaminants for the assessment of land*" (2002) and the relevant DETR/DoE Industry Profile(s).

<u>Common Inorganic Contaminants</u>

These include:

- metals, most notably cadmium, copper, chromium, mercury, lead, nickel, and zinc.
- semi-metals, most notably arsenic, selenium, and (water soluble) boron
- non-metals, most notably sulphur
- inorganic anions, most notably cyanides (free & complex), sulphates, sulphides, and nitrates.

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction.

Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to uv digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO_4), sulphides etc

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common Organic Contaminants

Petroleum hydrocarbons are a mixture of hydrocarbons produced from the distillation of crude oil. They include aliphatics (alkanes, alkenes and cycloalkanes), aromatics (single or multi benzene ringed compounds) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen.

Petroleum hydrocarbons can be grouped based on the carbon number range:-

- GRO – Gasoline Range Organics (typically C_6 to C_{10}). Also commonly referred to as PRO – Petroleum Range Organics
- DRO – Diesel Range Organics (typically C_{10} to C_{28})
- LRO - Lubricating Oil Range Organics (typically C_{28} to C_{40})
- MRO – Mineral Oil Range Organics (typically C_{18} to C_{44})

However, it should be borne in mind that the terms “GRO” and “DRO” analysis are purely descriptive terms, the exact definition of which varies.

Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C_5-C_{40}, whereas other define TPH as C_{10}-C_{30}.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (e.g. petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes, and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons (especially within the C_5 to C_{10} range) that will rapidly evaporate. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX that are relatively volatile and soluble. Small amounts of polyaromatic hydrocarbons (PAHs) such as naphthalene may also be present.

Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% of diesel/light fuel oil is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than diesel. They contain 15 to 40% aromatic hydrocarbons. Polar nitrogen, sulphur and oxygen-containing compounds (NSO) compounds are also present.

Lubricating Oils are relatively viscous and relatively insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although in significantly lower concentrations than in coal tars and heavier oils. Certain PAH compounds are carcinogenic (benzo(a)pyrene) and\or more mobile in the environment (naphthalene).

Volatile (& Semi) Organic Compounds (VOCs/SVOCs) include a variety of compounds which have relatively low boiling points. However, VOC's are much more volatile than SVOC's. Examples of VOC's include benzene, chloroform and trichloroethene (e.g. chlorinated solvents); SVOC's include phenol, fluorine and 'lighter' PAHs. Both groups of chemicals are readily absorbed through skin and some, such as benzene, are believed to be linked to tumour growth.

Phenols are compounds that have a hydroxyl group attached to an aromatic ring (i.e. include a benzene ring and an –OH group). Most are colourless solids. A solution of phenol in water is known as carbolic acid, and is a powerful antiseptic. However, phenol vapour is toxic, and skin contact can result in burns.

Polychlorinated Biphenyls (PCBs) were used in pre-1974 transformers as dielectric fluids. PCB's possess increasing toxicity relative to the degree of chlorination, they do not degrade in the environmental and can bio-accumulate. Acute symptoms of PCB poisoning are irritation of the respiratory tract leading to coughing and shortness of breath. Nausea, vomiting and abdominal pain are caused by ingestion of PCB's.

Dioxins and furans (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) are some of the most toxic chemicals known. In the environment, they tend to bio-accumulate in the food chain. Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8 tetrachlorodibenzo–p-dioxin or TCDD.

Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators and also from uncontrolled burning (e.g. bonfires). Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

Methods of Analysis (Organic Compounds)

TPH by GC-FID is an analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C_{10} to C_{40} (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a breakdown of the TPH results into gasoline range organics (**GRO**), diesel range organics (**DRO**) and heavier lubricating oil range organics (**LRO**).

GRO (PRO) by GC-FID analysis detects the more volatile C_6-C_9 hydrocarbons (aliphatic and aromatic), including those organic compounds present in petrol.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; dichlorobenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated SVOC by (GC-MS) analysis quantifies the concentrations of a variety of organic compounds, including the chlorinated compounds 16 USA-EPA priority PAHs, phenolic compounds, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked-up when testing TPH by GC-FID. Naphthalene (the lightest PAH) is also one of the 58 US EPA VOCs.

Speciated TPH by GC-MS provides a "banded" TPH, initially split into aromatic and aliphatic fractions and then further divided into fraction specific carbon bandings based upon behavioural characteristics and includes speciated BTEX compounds.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

Current UK Guidance

The UK approach to contaminated land is set out in Environment Agency Contaminated Land Report (CLR) No. 11 (2004) "*Model Procedures for the Management of Land Contamination*". The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source, (2) a receptor (eg controlled water or people) and (3) a pathway linking the (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

ALM adopts a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or **'Tier 1'**) is the comparison of site data with appropriate UK guidance levels, ALM risk-derived screening values, or remedial targets.

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Depending upon the specific characteristics and environmental setting of the site the appropriate standard is likely to be one of the following:

- Water Supply (Water Quality) Regulations 1989
- Environmental Quality Standards (for Freshwater)
- The Surface Waters (Abstraction for Drinking Water) Regulations

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents:

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2006) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2007 – Code of Practice for the characterisation & remediation from ground gas in affected developments

Further information with respect to hazardous gas assessments is presented in 'Generic Note No. 5 – Hazardous Gas'.

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to **human health** from land contamination. In March 2004 DEFRA and the Environment Agency published a further four documents (Briefing Notes 1-4) which expanded, or where necessary revised, the original R&D Documents.

Publications CLR 7, 8, 9 and 10 and Briefing Notes 1-4 set out the UK's quantitative modelling approach to contaminated land (the ***Contaminated Land Exposure Assessment*** (CLEA) model). The CLEA model set out exposure frequency and duration assumptions, together with technical algorisms for the modelling of human-health-related risks to contaminated land. The CLEA model lead to the publication of Soil Guidance Values (SGVs) for certain contaminants of concern ('SGV Reports'), based on collated published toxicity data for the contaminant in question ('TOX Reports')

In 2008 R&D Publications CLR 7, 9 and 10 and all corresponding SGV and TOX reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008 [i] (effectively replaced CLR7)
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR [ii]
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2 [iii] (effectively replaced CLR9)
- Updated technical background to the CLEA model - Science Report: SC050021/SR3 [iv] (effectively replaced CLR10)
- CLEA Software (Version 1.05) Handbook Science report: SC050021/SR4 [v] (replaces pre-existing CLEA software models released prior to 2009)
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7[vi] (presents a technical physiochemical reference for contaminants of concern)

The approach set out in the above documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEA version 1.06). The Environment Agency/DEFRA are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs) under Environment Agency Science Report SC050021 for Residential, allotment and commercial end use scenarios.

At the time of writing this report, SGV's were only available for a limited number of contaminants, the development of both the CLEA model and additional SGV's is ongoing. Where published, SGV's have been utilised as 'intervention values' for the purpose of an initial 'Tier 1' assessment.

It should be noted that exceedance of 'Tier 1' does not necessarily mean that remedial action will be required.

With respect to the assessment of potential **phytotoxic effects** of contaminants, ALM refer to BS3882:2007 for copper and zinc [vii]. Nickel is also regarded as a phytotoxin, however, ALM adopts the CLEA SGV for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that:

> "*In general…it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn".*

'Tier 1' Screening Values Derived by ALM

In the absence of UK SGVs for a number of "common" organic compounds, ALM has derived generic screening values for use as "Tier 1" values. These values have been derived using the CLEA v1.06 model, and taking account of UK policy decisions, Health Criteria Values and CLEA defaults.

PAH cannot be assessed as a single "total" value, as each individual PAH compound has different toxicity and mobility in the environment. Speciated analysis is required to determine the concentrations of the various compounds, most notably the key PAHs: benzo(a)Pyrene (considered the most toxic of the PAHs); and naphthalene (the most mobile and volatile of the PAHs).

Similarly, TPH cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "*The UK approach for evaluating human health risks from petroleum hydrocarbons in soils*". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG).

The TPHCWG assessed "TPH" into thirteen representative constituent fractions or "Equivalent Carbon (EC) Bandings". EC Bandings are based around Equivalent Carbon numbers and the TPHCWG have derived a series of physiochemical and toxicological parameters for each of the thirteen EC bandings. This approach is in line with the TPHCWG documents volume 1[viii], 2[ix], 3[x] and 4[xi].

ALM have calculated a screening value for each of the thirteen constituent fractions. These fractions have then been considered in terms of GRO, DRO and LRO to provide simpler, conservative initial Tier 1 screening values.

ALM's derivation of Tier 1 values is based on a number of assumptions, most notably:

a. The site's environmental setting, in terms of proximity to **Controlled Waters**, is not sensitive. It is not possible to derive generic Tier 1 values for waters, because distance and ground permeability are key factors, and both are extremely site-specific. Consequently, additional detailed quantitative risk assessment is required.
b. Contamination identified is located in the top 0.5m of soil on site. The CLEA model assumes that all exposure pathways are relevant within 0.5m of ground level.

c. A conservative **Soil Organic Matter** of 1%.

(Note: TOC = SOM x 0.58; and FOC = TOC/100).

Hydrocarbons tend to be "bind" with SOM, and therefore become less mobile. Consequently, Tier 1 values can be revised if the amount of organic matter within the soil exceeds 1%.

d. Some determinands reach **residual saturation** before a vapour risk is predicted to occur. Prior to residual saturation, as the concentration of a contaminant in soil increases, so does the concentration of the same contaminant in the associated vapour phase. However, once saturation is reached, the concentration of contaminant in the vapour phase remains constant (for any given atmospheric conditions – temperature and pressure).

However, ALM recognise that it is unacceptable to leave free product in the ground and therefore arbitrary Tier 1 values have been ascribed to such contaminants. These values have been selected on the basis that they are below the limit of olfactory detection (i.e. at concentrations below Tier 1, odours are not readily identified).

Table 1 - ALM Tier 1 values (Residential Use With Home-grown Produce)

Contaminant	Tier 1 Value (mg/kg)	Comments/Notes
PCB	1.2	Based on PCB EU Seven
Benzene	0.33	Science Report SC050021 / Benzene SGV
Toluene	610	Science Report SC050021 / Toluene SGV
Ethyl benzene	350	Science Report SC050021 / Ethyl Benzene SGV
Xylene	230	Science Report SC050021 / Xylene SGV
Benzo(a)pyrene	0.83	Based on CIEH/LQM GAC[xii]
Naphthalene	1.5	Based on CIEH/LQM GAC[xii]
total PAH	0.83	The higher toxicity of Benzo(a)pyrene makes it the most problematic PAH in near surface soils. Consequently, ALM have adopted the Tier 1 value for Benzo(a)pyrene (0.83mg/kg) as an initial Tier 1 screening value for total PAH, on the conservative assumption that all the PAH is Benzo(a)pyrene.
TPH <C_{10} Gasoline range organics (GRO)	0.33	Based on conservative assumption that all TPH<C_{10} is benzene. If concentrations >0.33 mg/kg are recorded, but no benzene present, a Tier 1 value of 16mg/kg could be adopted for the gasoline range or reference can be made to Refined Tier 1 Values for speciated TPH (see below).
TPH C_{10} – C_{20} Diesel range organics (DRO)	69	If DRO above tier 1 value and speciated fraction bandings are available, refer to Refined Tier 1 Values for speciated TPH (see below).
TPH C_{21} – C_{40} Lubricating range organics (LRO)	890	Risk at surface driven by direct ingestion/dermal contact/veg uptake pathway of heavy aromatic fractions, if speciated fraction bandings are available, refer to Refined Tier 1 Values for speciated TPH (see below).

If site concentrations of any of the three broad TPH bandings (GRO, DRO or LRO) exceed the Tier 1 values quoted in Table 1 above, further assessment, with reference to speciated TPH results, will be required:

Table 2 - Refined Tier 1 values (TPH Bands)
For Residential Use With Home-Grown Produce)
(After LQM/CIEH[xii])

Contaminant	Refined Tier 1 values (mg/kg)	Comments/notes
Aliphatic C5-C6	30, 55, 110	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aliphatic C6-C8	73, 160, 370	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aliphatic C8-C10	19, 46, 100	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aliphatic C10-C12	93, 230, 540	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aliphatic C12-C16	740, 1000*, 1000*	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aliphatic C16-C21	1000*	See Note
Aliphatic C21-C44	1000*	See Note
Aromatic C5-C7	65, 130, 280	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C7-C8	120, 270, 611	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C8-C10	27, 65, 150	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C10-12	69, 160, 346	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C12-16	140, 310, 593	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C16-C21	250, 480, 770	For 1%, 2.5% and 6% Soil Organic Matter respectively
Aromatic C21-C44	890, 1000*, 1000*	For 1%, 2.5% and 6% Soil Organic Matter respectively

Note:
* Selected value considering visual and olfactory impacts

The significance of speciated TPH results can be assessed by following the 3 steps outlined in Table 3 below.

Note: This 3-step assessment is **not** required if concentrations of GRO, DRO & LRO are all above their respective Tier 1 values (see Table 1).

Table 3 – Assessment of TPH

Step	Result	Action
1 – Consider indicator compounds: Are BTEX, Naphthalene, Benzo(a)pyrene (and the other toxic PAHs) above their respective screening values (refer to Table 1 above)?	Yes	Detailed Quantitative Risk Assessment (DQRA) required
	No	Proceed to Step 2
2 – Consider individual TPH fractions: Are they above respective screening values (refer to Table 2 above)?	Yes	DQRA required
	No	Proceed to Step 3
3 – Assess Cumulative effects (use the equation below): Is the calculated Hazard Index for each source >1	Yes	DQRA required
	No	TPH compounds pose no significant risk.

Equation used to determine Hazard Index (Step 3).

$$HI = \sum_{F_i = 1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\ kg^{-1})}{SGV\ F_i\ (mg\ kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

UK physiochemical properties, environmental properties, receptor and pathway parameters assumed within the assessment are detailed in Table 4 below.

Table 4 - Parameters to Reflect UK Position and Data Source.

Parameter	Data Source
Chemicals of concern	- Individual chemical SGV and Tox reports
	- Environment Agency Science Report – SC050021/SR7 Compilation of Data for Priority Organic Pollutants for the Derivation of Soil Guidelines Values, 2008
	Environment. Technical Report P5-079/TR1
	- TPH Criteria Working Group Vols 1-4
Surface soil and pathways selection	Assumed direct ingestion of soil and dust, dermal contact, vegetable uptake and consumption and inhalation pathways.
Vapour Inhalation and pathways selection	Johnson and Ettinger model used as default in CLEA v1.06 model considering vapours from a contaminated soil. Default model acceptable as is also UK adopted model for inhalation
Indoor Air – Building parameters (small terraced house)	Environment Agency Science Report SC050021/SR3 "Updated Technical Background to the CLEA Model" 2008
Building footprint = 28m2	
Air exchange rate = 0.5hr	
Living space height = 4.8m	
Foundation thickness = 0.15m	
Floor crack area = 423cm2	
Porosity of cracks = 0.25	
Flow rate of soil gas into building = 0	
Pressure difference = 3.1Pa	
Permeability of soils = 3.56e3 cm/sec	
Source data	Environment Agency Science Report SC050021/SR3 "Updated Technical Background to the CLEA Model" 2008
Porosity of source material = 053	
Water filled porosity = 0.33	
Fraction organic carbon = 0.006	
Bulk density = 1.21g/cm3	
Receptor and analysis type	Environment Agency Science Report SC050021/SR3 "Updated Technical Background to the CLEA Model" 2008
Deterministic analysis, one receptor of a female child resident	
Based on a female child of 0-6 years.	
Averaging time/lifetime = 6yrs	
Body weight = 14.5kg	
Exposure Frequency = 365days/yr	
Exposure duration = 6yrs	

Possible Action in Event of Tier 1 Exceedance

Should any of the Tier 1 criteria detailed above be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or hazardous gas).

- Undertake further statistical analysis following the approach set out in CL:AIRE/CIEH 2008[xiii] in order to determine whether contaminant concentrations of contaminants within soil\fill actually present a risk (only applicable to assessing the risk to human health).
- Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.
- Based on a qualitative risk assessment, advocate an appropriate level of remediation to "break" the pollutant linkage - for example the removal of the contaminated materials or the provision of a clean cover.

Prior to undertaking any statistical analysis contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, ALM gather and analyse sample results by fill type, and\or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the statistical data set is associated with the extent of a particular fill type, or an area affected by spillage\leakage.

In terms of brownfield redevelopment, this is considered a more appropriate methodology which provides a more representative sample population for statistical analysis. As such the entire site is considered in terms of the proposed end use, be this residential with, or without gardens.

Analysis by soil\fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil\fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass; i.e. contamination would normally be more pervasive and significant in granular soils than cohesive soils.

Category 4 Screening Levels (C4SLs)

In March 2014, DEFRA published the findings of a research project relating to the development of 'Category 4 Screening Levels' (C4SLs) [xiv]. The project was carried out within the context of the revised Statutory Guidance to support Part 2A of the Environment Protection Act 1990 that was published in April 2012. The revised Statutory Guidance introduced a new four-category system for classifying land under Part 2A for cases of a Significant Possibility of Significant Harm to human health, where 'Category 1' includes land where the level of risk is clearly unacceptable and 'Category 4' includes land where the level of risk is acceptably low.

An impact assessment that accompanied the revised Part 2A Statutory Guidance identified that the current practice of 'generic' ('Tier 1') screening of soil contamination concentrations against published SGVs or other Generic Assessment Criteria (GAC) derived from the CLEA model, (as outlined above within this document), was too conservative and identified a potential new role for C4SLs in providing a simple test for deciding whether land is suitable for use and definitely not contaminated land.

The C4SLs were proposed to be more pragmatic (whilst still strongly precautionary) compared to existing 'generic' ('Tier 1') screening levels, and that the C4SLs will be used as new generic screening criteria, albeit describing a higher level of risk that the currently available SGVs/GACs.

Six substances were selected within the C4SL project because of their ubiquity within contaminated land risk assessments and a draft methodology for the derivation of C4SLs was subjected to peer review.

The final C4SLs derived for the 6 initially modelled contaminants of concern are presented in Table 5 below.

With respect to the applicability of use of the C4SLs, the DEFRA 2014 report states:

> *"The Part 2A Statutory Guidance…(was) developed on the basis that Category 4 Screening Levels could be used under the planning regime… However policy responsibility for the National Planning Policy Framework and associated Planning Practice Guidance falls to the Department for Communities and Local Government"*

"Where a valid SGV exists for a contaminant where a C4SL has been derived, it is anticipated that risk assessors will use the C4SL…In the absence of a suitable C4SL, risk assessors should identify and select appropriate GAC criteria in accordance with established good practice. It is for the Environment Agency to decide whether or not any of the SGVs will be updated in the light of more recent toxicological data or whether any particular SGV should be withdrawn."

Table 5 – Final C4SLs (after DEFRA 2014 [xiv])

Substance	Residential (with home grown produce)	Residential (without home grown produce)	Allotments	Commercial	Public Open Space (Residential)	Public Open Space (Park)
Arsenic	37	40	49	640	79	168
Benzene	0.87	3.3	0.18	98	140	230
Benzo(a)pyrene	5	5.3	5.7	76	10	21
Cadmium	26	149	4.9	410	220	880
Chromium VI	21	21	170	49	23	250
Lead	200	310	80	2330	630	1300

All C4SLs expressed as mg/kg

Until such time as C4SLs are formally adopted by the Department for Communities and Local Government into the National Planning Policy Framework and associated Planning Practice Guidance, ALM will continue to adopt the use of published GSVs/GACs for 'generic' ('Tier 1') screening of soil contamination concentrations, unless otherwise advised by the Local Planning Authority in question. This is with the exception of lead, where ALM will adopt the C4SLs presented in Table 5 above given that no recognised/published criteria are available.

References

i CL:AIRE and CIEH, Guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008

ii Evaluation of models for predicting plant uptake of chemicals from soil Science Report – SC050021/SR, 2008

iii Environment Agency Science Report – SR2 Human health toxicological assessment of contaminants in soil, 2008

iv Environment Agency Science Report - SC050021/SR3 Updated Technical Background to the CLEA Model (as amended 2009)

v Environment Agency Science Report - SC050021/SR4 CLEA Software (Version 1.05) Handbook, 2009

vi Environment Agency Science Report – SR7 Compilation of Data for Priority Organic Pollutants for the Derivation of Soil Guidelines Values, 2008

vii BS3882:2007 – Specification for Topsoil and Requirements for Use. British Standards Institution

viii Total Petroleum Criteria Working Group Series, Volume 1 Analysis of Petroleum Hydrocarbons in Environmental Media, 1998.

ix Total Petroleum Criteria Working Group Series, Volume 2 Composition of Petroleum Mixtures, 1998.

x Total Petroleum Criteria Working Group Series, Volume 3. Selection of Representative TPH Fractions Based on Fate and Transport Considerations, 1997

xi Total Petroleum Criteria Working Group Series, Volume 4. Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH), 1998.

xii The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment. 2nd Edition. Land Quality Management/ Chartered Institute of Environmental Health. 2009

xiii Guidance on Comparing Soil Contamination Data with a Critical Concentration. CL:AIRE/Chartered Institute of Environmental Health, May 2008

xiv DEFRA. SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document. Department for Environment Food and Rural Affairs. March 2014

Generic Notes – ALM Geoenvironmental Investigations

05 - Hazardous Gas

General

Hazardous gas is considered to be any mixture of potentially explosive, toxic or asphyxiating gases, most notably methane, carbon dioxide and oxygen (deficiency).

In addition, radon, a naturally occurring radioactive gas is also considered. Further information about radon is included in Notes 01 – Environmental Setting.

Assessment of potential risks associated with hazardous gas are based on a review of data obtained from the Landmark Information Group, the Environment Agency and the Local Authority and the British Geological Survey.

Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Where landfilling has occurred within 250m of the site boundary, the Local Planning Authority may request a landfill gas investigation in accordance with the Town and Country Planning General Development Order, 1988.

Sources

Potential sources of hazardous gas are:

- Landfill sites
- Made ground, especially where significant depths are present
- Shallow mineworkings associated with coal extraction
- Geological strata, including peat, organic silts, coal-bearing strata and limestone (reaction with acidic waters), granite (radon)
- Groundwater can sometimes act as a "carrier" for hazardous gas.
- Leakages from pipelines or storage tanks
- Sewers, septic tanks and cess pits

Generation

Wherever biodegradable material is deposited, landfill gas (principally a mixture of methane and carbon dioxide) is likely to be generated by microbial activity. Carbon dioxide is an asphyxiant and toxic; methane is flammable and a mixture containing between 5% and 15% methane by volume in air is explosive. Landfill gas in the ground is unlikely in itself to pose a significant risk, though it may damage vegetation. However, infiltration of landfill gas into confined spaces (e.g. cellars, services, etc) may give rise to considerable risk.

There is no typical figure for the length of time that landfill gas will be evolved, but at many sites significant gas generation continues for at least 15 years after the last deposit of waste.

Migration

Gas migration from a landfill site may occur in several ways. It may migrate through adjacent strata; the distance of migration being dependent on the pressure gradients, volume of gas and permeability of the strata. Where there are faults, cavities and fissures within the strata, gas may move considerable distances. Other migration pathways for gas include man-made features such as mine shafts, roadways and underground services.

Gas migration is influenced by a number of climatic factors, such as atmospheric pressure variations, water table level variations and the influence of a covering of snow or ice over the surface of the site and surrounding area.

Gas Monitoring Procedure

ALM adopt a standard gas monitoring procedure, in accordance with CIRIA guidance. This procedure involves the measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration on site immediately prior to and on completion of monitoring.
- Gas emission rate.
- Methane, oxygen and carbon dioxide concentrations using an infra-red gas analyser. Standing water level using a dipmeter.

In addition, ground conditions at each sampling location are recorded together with prevailing weather conditions and any other observations such as any vandalism.

Where samples of gas are required for laboratory analysis, Gresham Tubes are used. Gas concentrations in the well are typically recorded immediately before and after retrieval of a sample.

Current Guidance

CIRIA Report 151 (1995)i identified that there was inadequate guidance on trigger concentrations for ground gases. CIRIA concluded that the most important aspect of a gas regime below or adjacent to a site was the surface emission rate, i.e. how quickly the gas is coming out of the ground. The lower the surface emission rate the lower the risk.

CIRIA Report C665 (2006)ii advocates two methodologies for characterising sites:

A – All developments except low rise housing. The advocated methodology is that proposed by Wilson & Card, 1999iii.

B – Low rise housing. An alternative (traffic light) methodology, derived by Boyle and Witherington, 2006iv for NHBC

Both methodologies refer to Gas Screening Values (GSV); previously referred to as limiting borehole gas volume flow.

A – All developments except low rise housing.

(Wilson & Card, 1999)v revised Table 28 of CIRIA 149v in terms of borehole gas volume flow rate (now GSV) in order to achieve a more consistent design of protection measures. This was done to reflect the importance of recognising the gas surface emission rate.

Wilson & Card then developed a method for classifying gassing sites (Table 1 below), which took into account the combined gas concentration and GSV.

Table 1 – Site Classification (Wilson & Card)

Characteristic Situation (Wilson & Card, 1999)	Gas Screening Value, CH4 or CO2 (l/hr)	Additional limiting factors	Typical source of generation
1	<0.07	Methane not to exceed 1%v/v and carbon dioxide not to exceed 5%v/v	Natural soils with high organic content
2	<0.7	Borehole air flow rate not to exceed >70ltr/hr otherwise increase to Characteristic Situation 3	Natural soils with high peat/organic content
3	<3.5		Old landfill, inert waste, flooded mineworkings
4	<15	Quantitative Risk Assessment required to evaluate scope of protection measures	Mineworkings susceptible to flooding, completed landfill, inert waste (WMP 26B criteria)
5	<70		Mineworkings, unflooded, inactive
6	>70		Recent landfill sites

Notes:
Borehole flow rate = volume of gas (regardless of composition) which is escaping from well (l/hr).
Gas Screening Value (litre/hour) = gas concentration (%) / 100 x borehole flow rate (l/hr).
To facilitate design implementation, the limiting values for both methane and carbon dioxide are identical.

B – Low rise housing.

NHBC have developed a characterisation system similar to that of Wilson & Card above, but specific to low-rise housing development (Boyle and Witherington[xii]) (Table 8.7). This approach compares measured gas emission rates with generic “Traffic Lights”. The Traffic Lights include “Typical Maximum Concentrations” for initial screening, and risk-based Gas Screening Values (GSVs) for consideration of situations where the Typical Maximum Concentrations are exceeded. Calculations are carried out for both methane and carbon dioxide and the worse case adopted in order to establish the appropriate protection measures.

Table 8.7 *NHBC Traffic light system for 150 mm void*

Traffic light	Methane[1]		Carbon dioxide[1]	
	Typical maximum concentration[5] (% v/v)	Gas screening value (GSV)[2,4,6,] (litres per hour	Typical maximum concentration[5] (% v/v)	Gas screening value (GSV)[2,3,4,5] (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				

Notes:

1. The **worst gas-regime** identified at the site, either methane or carbon dioxide, recorded from monitoring in the worst temporal conditions, will be the decider for which Traffic Light and GSV is allocated.
2. Generic GSVs are based on guidance contained within “The Building Regulations: Approved Document C” (2004) and assume a **sub-floor void** of 150 mm thickness.
3. The **small room** is considered to be a downstairs toilet, with dimensions of 1.50 × 1.50 × 2.50 m, with a soil pipe passing into the sub-floor void.
4. The **GSV**, in litres per hour, is as defined in Wilson and Card (1999) as the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered.
5. 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 **judgment** 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.
6. The GSV thresholds should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

i Harries CR, Witherington PJ and McEntee JM (1995). Interpreting measurements of gas in the ground. CIRIA Report 151

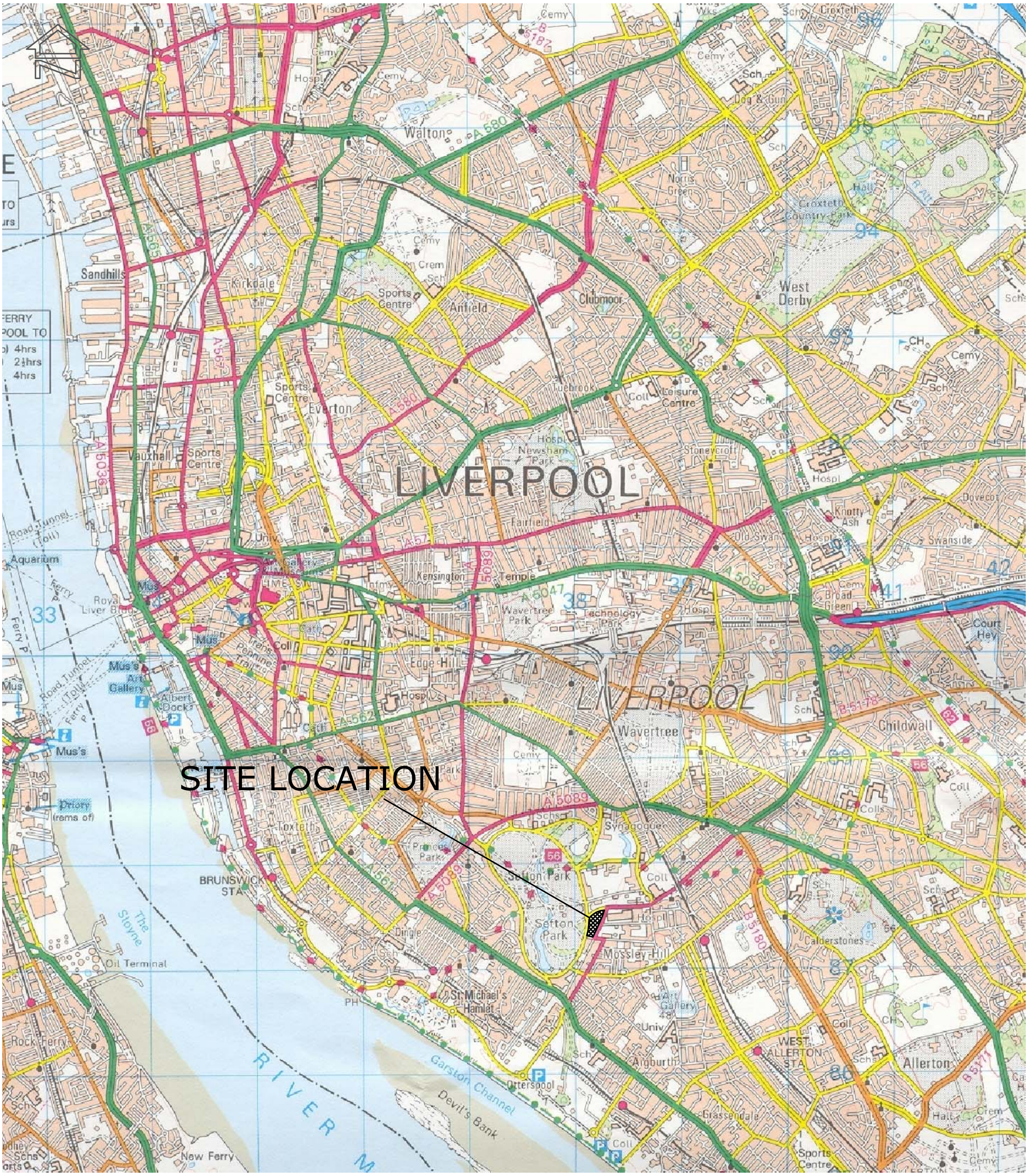
ii CIRIA (2006) – Assessing risks posed by hazardous ground gases to buildings.

iii Wilson SA and Card GB (February 1999). Reliability and Risk in Gas Protection Design. Ground Engineering.

iv Boyle & Witherington (2006) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating “traffic lights”. Report Ref. 10627-R01-(02), for NHBC

v Wilson SA and Card GB (February 1999). Reliability and Risk in Gas Protection Design. Ground Engineering.

APPENDIX B
DRAWINGS



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CLIENT	REDROW HOMES LTD
JOB TITLE	SEFTON MEADOWS, LIVERPOOL
DRAWING TITLE	SITE LOCATION PLAN

DRAWN BY	SIGNATURE	DATE	STATUS	
KL		02-07-2014	FINAL	
APPROVED	**SIGNATURE**	**DATE**	**SCALE**	**DRG No.**
KL		02-07-2014	NTS	30046-1

		area	no.	total area
BA	BA	circa.1813 sqft	2	circa.3626 sqft
BL	BL	circa.2343 sqft	3	circa.7029sqft
D	D	circa.1900 sqft	8	circa.15200 sqft
M	M	circa.1906 sqft	3	circa.5718 sqft
R	R	circa.2098 sqft	4	circa.8392sqft
B	B	circa.3201 sqft	5	circa.16005 sqft
F	F	circa.2978 sqft	4	circa.11912sqft
G	G	circa.2580 sqft	5	circa.12900 sqft
Total			34	circa.80,782 sqft

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Redrow Homes
Park Avenue, Liverpool

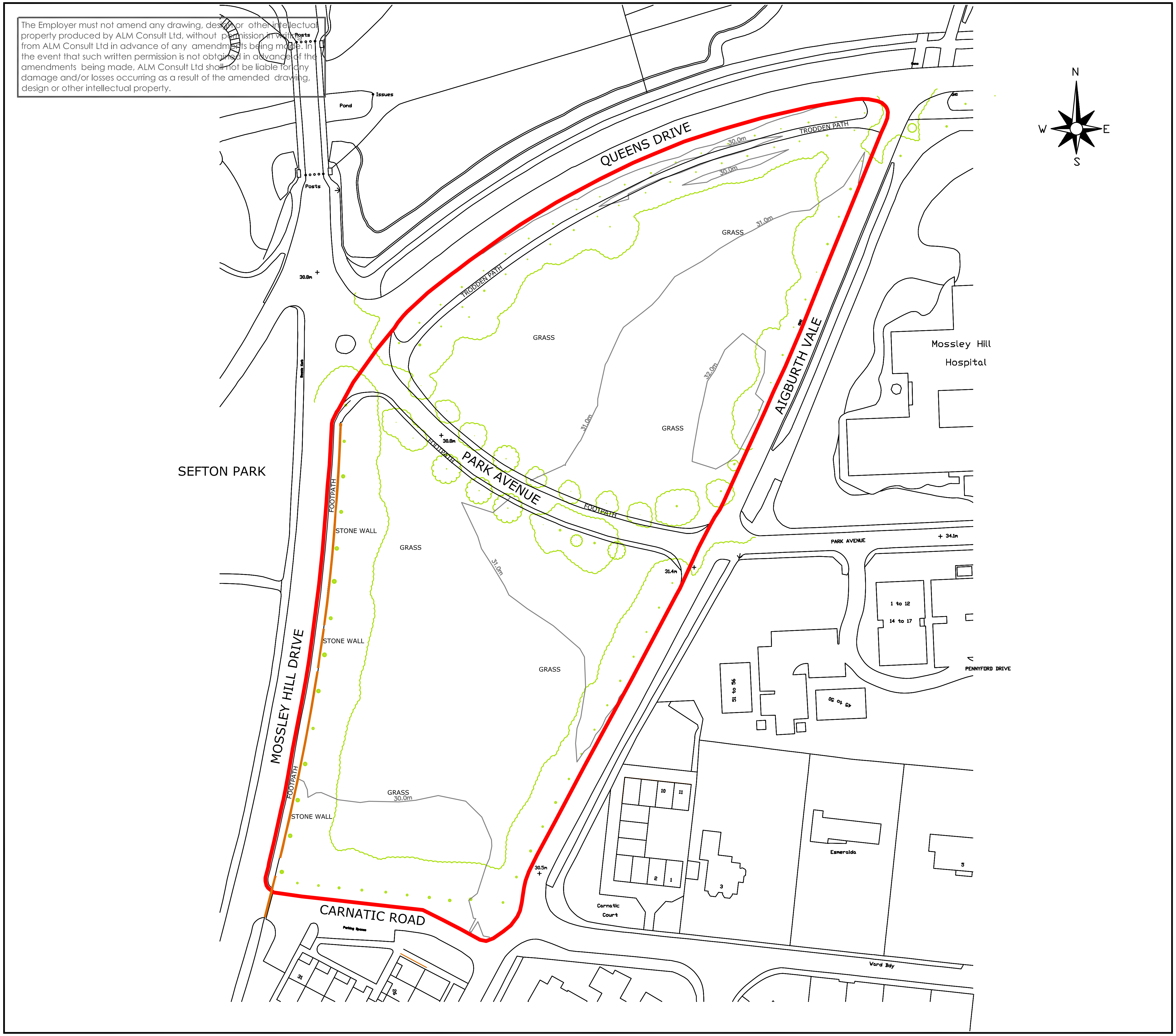
PROPOSED SITE PLAN

04.12.14 AG 1:500 @ A1

14082 (PI) 001 L

revision	date	drawn	description
C	03.11.14	AG	Expanded area schedule breakdown
D	07.11.14	AG	Changes to road layouts and boundaries
E	07.11.14	AG	D Type orientation change, carports and patios added
F	12.11.14	AG	Boundary changes following TEP & Redrow comments
G	12.11.14	AG	OS Data Inserted
H	17.11.14	AG	Plot Numbers Added
J	18.11.14	AG	Plot numbers edited
K	02.12.14	AG	Apartments removed and area redeveloped.
L	04.12.14	AG	Boundary Amendments

www.calderpeel.com



KEY

TREE WITH CANOPY

30.0m GROUND CONTOUR

STONE WALL

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CLIENT

REDROW

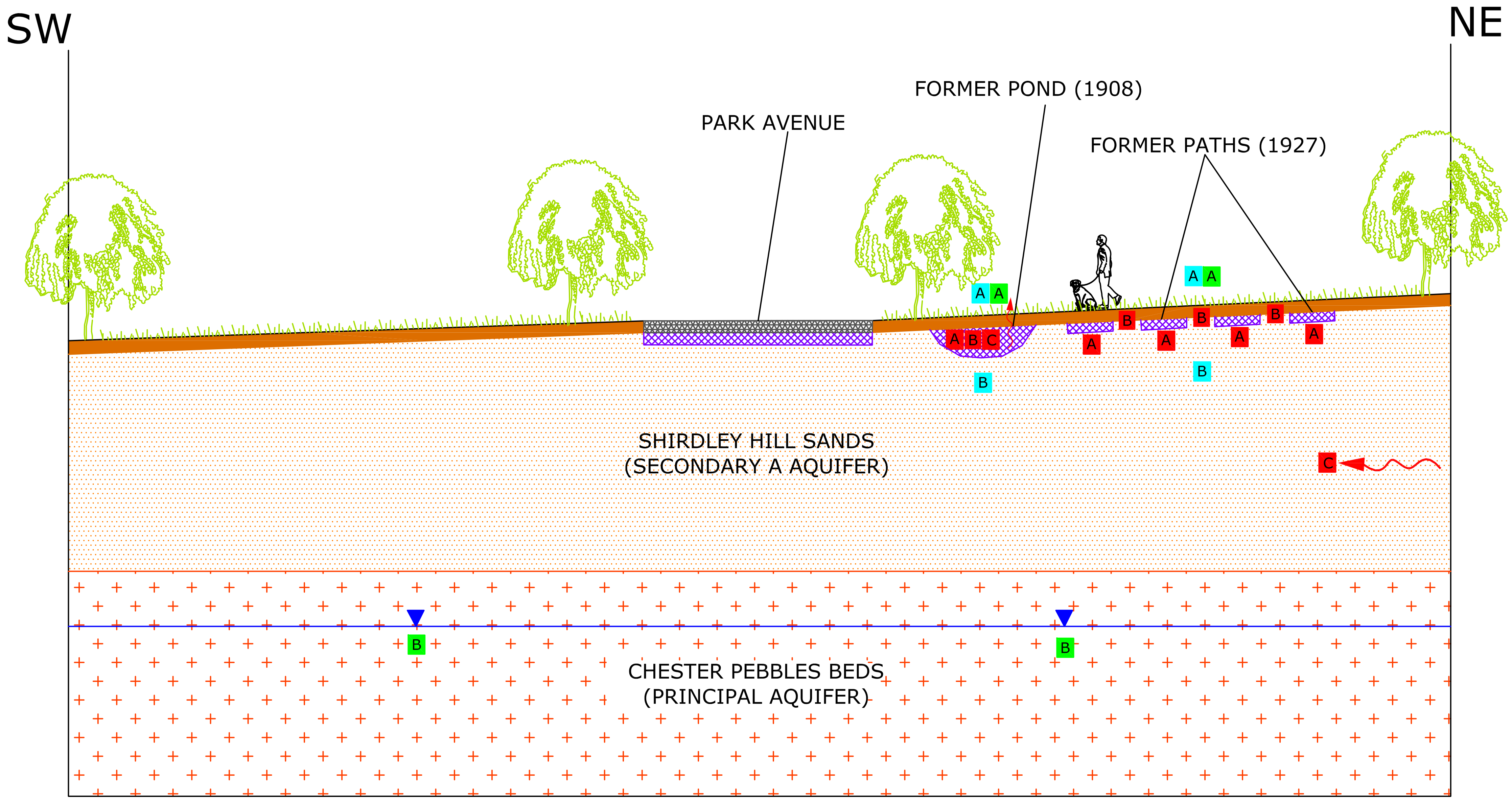
JOB TITLE

SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE

SITE FEATURES PLAN

STATUS		
FINAL		
DRAWN BY: KL	SIGNATURE	DATE: 15/07/2014
APPROVED: KL	SIGNATURE	DATE: 15/07/2014
SCALE: 1:1250@A3	DRG No.: 30046-2	



SOURCES	PATHWAYS	RECEPTORS
A Made ground	A Inhalation, Ingestion & Dermal Contact	A Human health
B Pesticides	B Leaching to groundwater / surface waters	B Controlled Waters
C Ground Gas / Vapour		

KEY

- TARMAC
- TOPSOIL
- MADE GROUND
- SHIRDLEY HILL SANDS (DRIFT)
- BEDROCK (CHESTER PEBBLE BEDS)
- GROUNDWATER

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CLIENT: REDROW

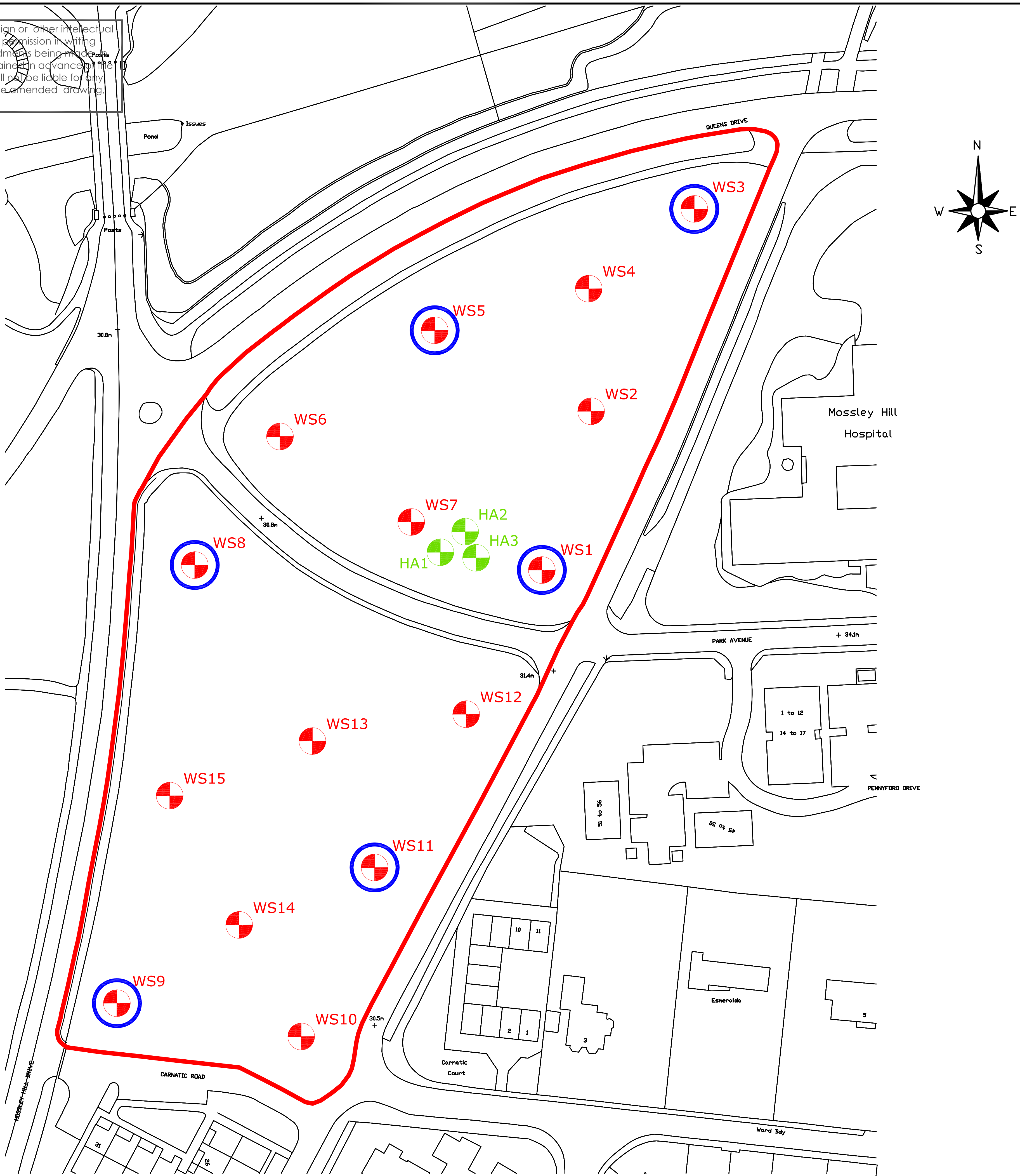
JOB TITLE: SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE: CONCEPTUAL SITE MODEL

STATUS: FINAL

DRAWN BY	SIGNATURE	DATE
KL		17/06/2014
APPROVED	SIGNATURE	DATE
KL		17/06/2014

SCALE	DRG No.
NTS	30046-3



KEY

WS2 — WINDOWLESS SAMPLE BOREHOLE

WS5 — BOREHOLE FITTED WITH MONITORING WELL

HA2 — HAND AUGER BOREHOLE

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CLIENT: REDROW

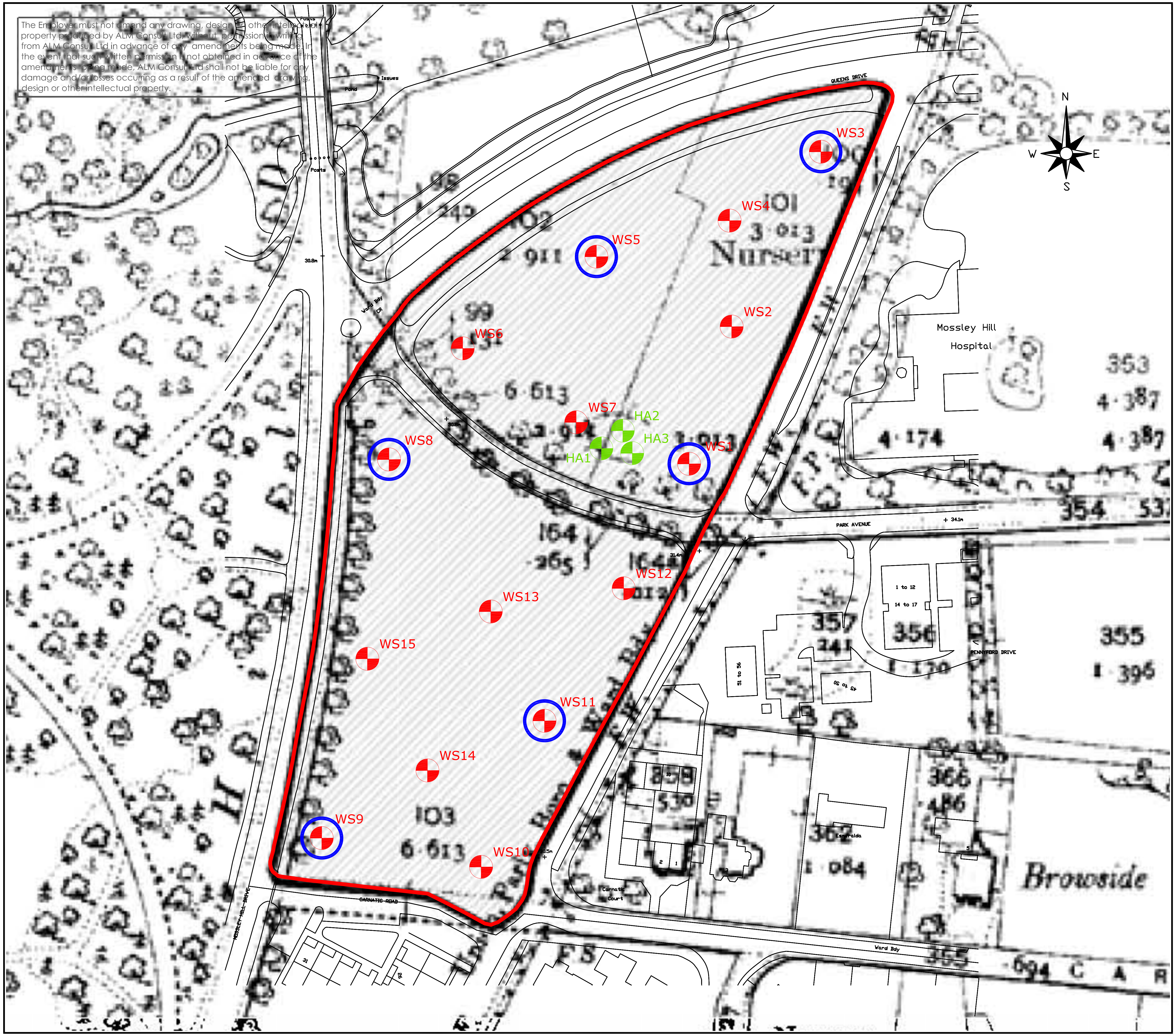
JOB TITLE: SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE: EXPLORATORY HOLE LOCATION PLAN

STATUS: FINAL

DRAWN BY	SIGNATURE	DATE
KL		24/06/2014
APPROVED	**SIGNATURE**	**DATE**
KL		24/06/2014

SCALE	DRG No.
1:1250@A3	30046-4



KEY

WS2	WINDOWLESS SAMPLE BOREHOLE
WS5	BOREHOLE FITTED WITH MONITORING WELL
HA2	HAND AUGER BOREHOLE

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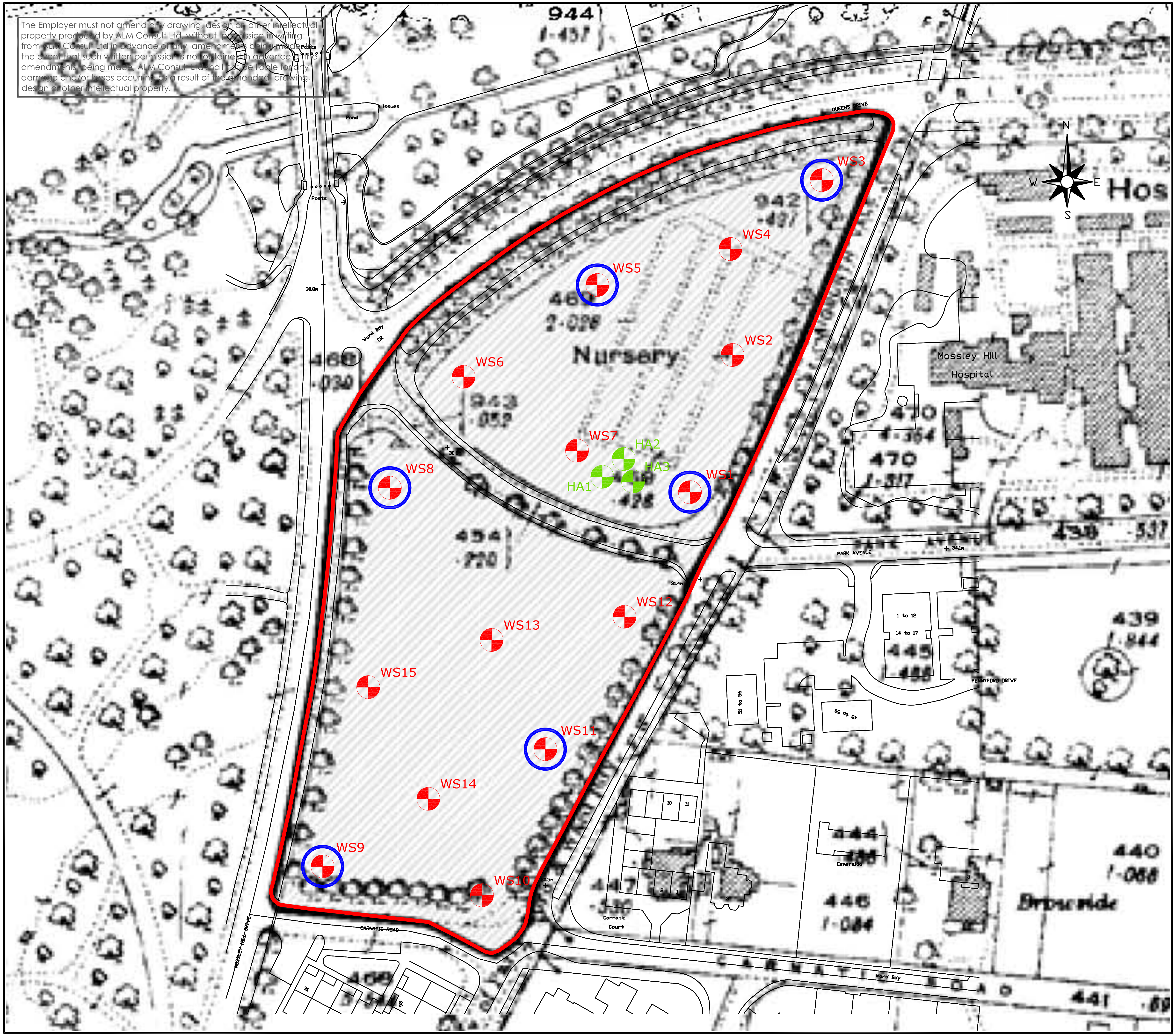
JOB TITLE

SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE

EXPLORATORY HOLE OVERLAY ONTO 1908 MAP

STATUS	FINAL		
DRAWN BY: KL	SIGNATURE	DATE: 24/06/2014	
APPROVED: KL	SIGNATURE	DATE: 24/06/2014	
SCALE: 1:1250@A3	DRG No. 30046-4A		



KEY

WS2	WINDOWLESS SAMPLE BOREHOLE
WS5	BOREHOLE FITTED WITH MONITORING WELL
HA2	HAND AUGER BOREHOLE

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JOB TITLE

SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE

EXPLORATORY HOLE OVERLAY ONTO 1927 MAP

STATUS

FINAL

DRAWN BY	SIGNATURE	DATE
KL		24/06/2014
APPROVED	SIGNATURE	DATE
KL		24/06/2014

SCALE	DRG No.
1:1250@A3	30046-4B

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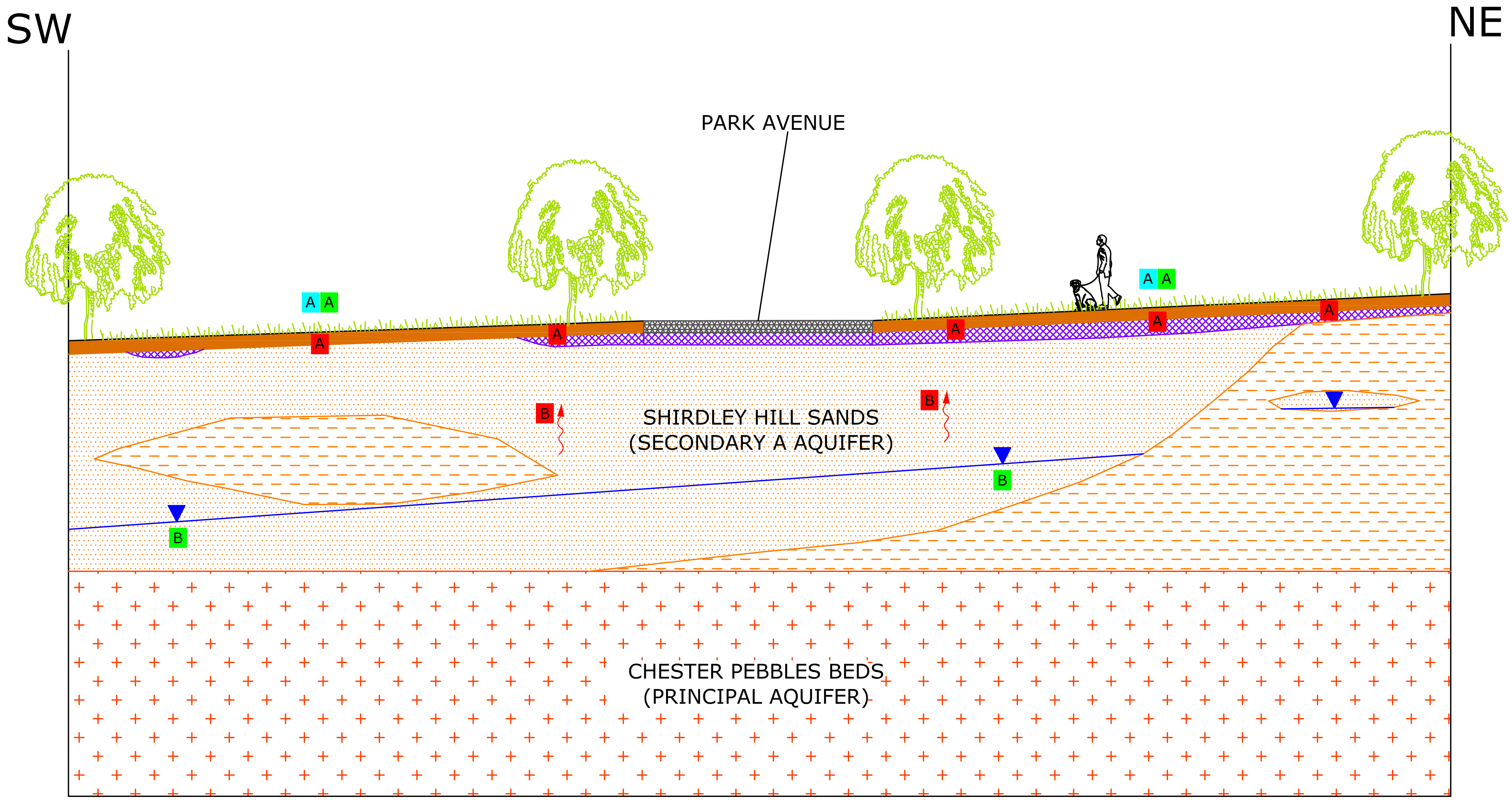

SOURCES	PATHWAYS	RECEPTORS
A Made Ground / Topsoil	A Inhalation, Ingestion & Dermal Contact	A Human Health
B Ground Gas / Vapour		B Controlled Waters

KEY

- TARMAC
- TOPSOIL
- MADE GROUND
- SAND
- CLAY
- BEDROCK (CHESTER PEBBLE BEDS)
- GROUNDWATER

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CLIENT: REDROW

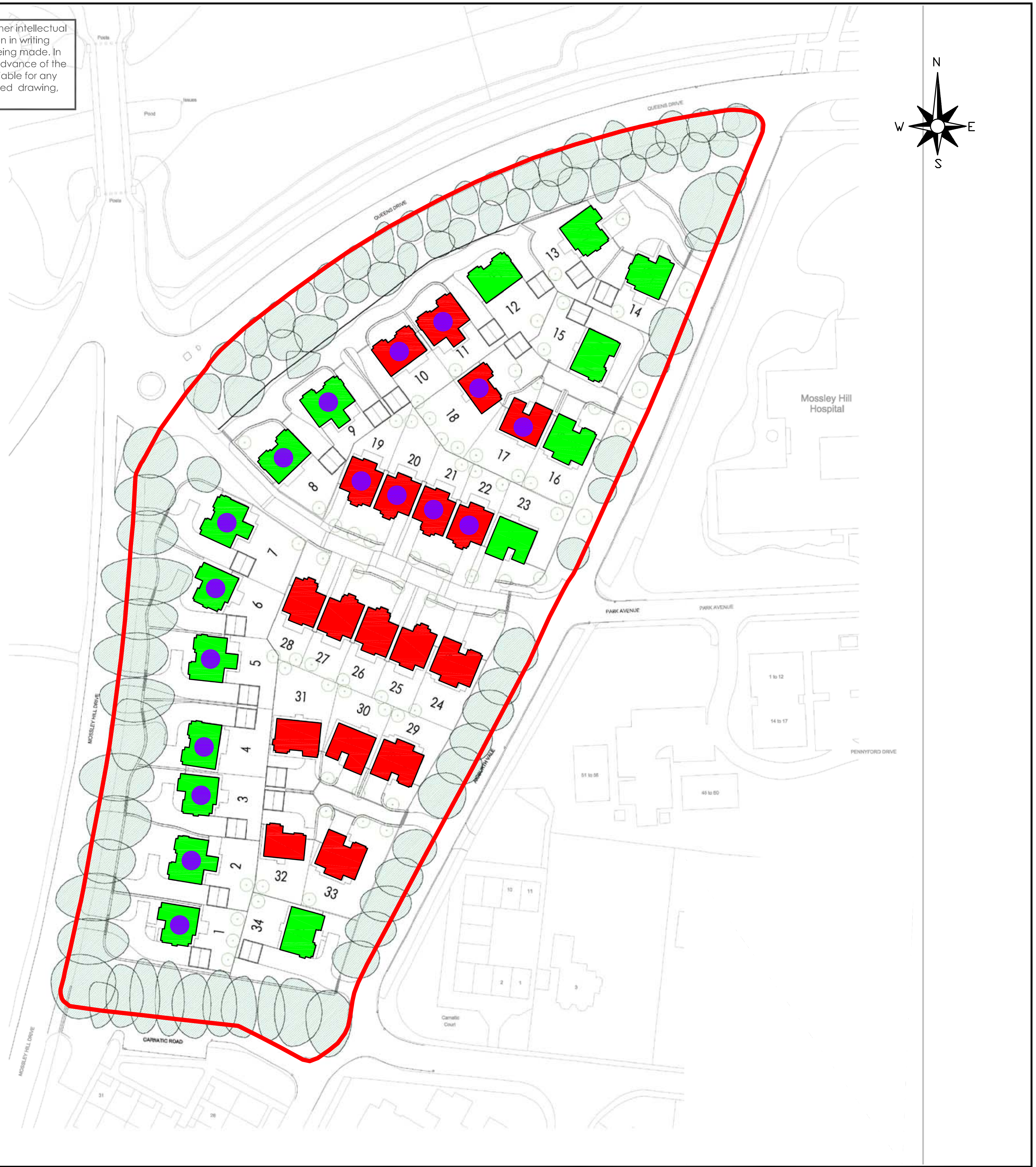
JOB TITLE: SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE: REVISED CONCEPTUAL SITE MODEL

STATUS: FINAL

DRAWN BY	SIGNATURE	DATE
KL		15/07/2014
APPROVED	SIGNATURE	DATE
KL		15/07/2014

SCALE	DRG No.
NTS	30046-5



KEY

- TRADITIONAL STRIP (<1.5m)
- TRENCH FILL (>1.5m<2.5m)
- PILED (>2.5m)
- POSSIBLY SUITABLE FOR VIBRO GROUND IMPROVEMENT

(VALUES IN BRACKETS ARE ESTIMATED DEPTHS TO COMPETANT STRATA FROM EXISTING GROUND LEVELS)

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JOB TITLE
SEFTON MEADOWS, LIVERPOOL

DRAWING TITLE
INDICATIVE FOUNDATION ZONING PLAN

STATUS
FINAL

DRAWN BY	SIGNATURE	DATE
KL		10/12/2014
APPROVED	SIGNATURE	DATE
KL		10/12/2014

SCALE	DRG No.
1:1250@A3	30046-6_REV1

APPENDIX C
COMMISSION

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9th June 2014

30046/001

Mr Paul Sinclair
Technical Director
Redrow Homes Ltd
Redrow House
St Davids Park
Ewloe
Flintshire
CH5 3RX

Dear Paul

Proposed Geoenvironmental Appraisal – Sefton Meadows, Liverpool

Further to your recent invitation, please find our proposal for undertaking a geoenvironmental appraisal of the above site. We understand that the site is under consideration for development with residential dwellings with associated gardens, public open space and adoptable roads and sewers, although no layout is yet available.

Review of the Ordnance Survey base plan supplied with your correspondence dated 8th June 2014, suggests that the site consists of two parcels of land of approximately 1.35 hectares and 1.48 hectares, separated by Park Avenue, in the Mossley Hill area of Liverpool.

The site is occupied by open grassed areas surrounded by mature trees. The site appears to be maintained as an area of open space.

A review of available online historical plans indicates that the southern parcel of land has remained generally undeveloped since plans dating from the late 19th Century. The northern parcel of land is noted as a "Nursery" on plans dating from 1908 to 1953, and a possible small pond is shown in the south of the northern parcel on plans dating from 1908. No buildings are apparent on available historical plans of the site.

The scope of works outlined in this letter should enable us to assess abnormal development issues, associated with ground. However, the nature of site investigation is such that it is not always possible to foresee all the potential issues. Consequently, it is sometimes necessary to recommend additional work, but where this occurs we will inform you immediately, provide costs, and seek your further instruction. We have observed available online imagery, reviewed available geological maps, and available online historical maps, in order to minimise the likelihood of further work.

Brief examination of the relevant geological map suggests the site is underlain by Shirdley Hill Sands, which are a Secondary A Aquifer, overlying rocks of the Chester Pebble Beds (Sherwood Sandstone – Principal Aquifer).

Our site investigation proposal allows for the following works:

Desk Study:

Site centred historical Ordnance Survey plans will be obtained and examined to determine whether any past land uses of both the site and surrounding area, have had any effect on the proposed development. Additionally, published geological plans of the area, and environmental search information will be examined, and enquiries will be made of the Local Authority.

Information obtained as part of the Desk Study will be used to develop a Conceptual Site Model, which will be used to refine our initial ground investigation proposals.

Fieldwork:

At this stage we have allowed for two day's window sample drilling. All boreholes will be supervised and logged by an experienced geoenvironmental engineer.

Representative soil samples of natural and man-made ground, including any contaminated samples, will be taken during the works. In-situ shear strengths of any cohesive soils encountered will be determined by the use of a hand-held shear vane in the shoe of the drilling rods. Standard Penetration Tests (SPT's) will also be undertaken at regular intervals in selected boreholes across the site.

The use of window sample drilling is primarily intended to minimise disruption to the surface of the site whilst retrieving soil samples, but will also enable the installation of gas/groundwater monitoring wells.

This site is predominantly greenfield and therefore unlikely to be underlain by significant thickness of made ground. A possible small pond is noted on historical plans dating from 1908, and may have been infilled with materials of an unknown nature. Other small ponds are noted to the southeast of the site on historical plans dating from the late 19^{th} Century, which may also have become infilled. The site is indicated to be underlain by Shirdley Hill Sands, which may act as a migration pathway for any ground gas from an off site source.

The generation potential of these gas sources is considered likely to be Very Low. Therefore, in accordance with CIRIA Report C665, we have initially allowed for six visits over a three month period. A hazardous gas risk assessment will be issued on completion of monitoring.

Soils Testing:

This will comprise basic geotechnical soils analysis sufficient to establish the plasticity of natural cohesive strata.

Although no allowance has been for in-situ or laboratory CBR testing, CBR values will be estimated from the strata descriptions and classification test results, where appropriate.

Appropriate chemical analyses, based on our review of available online historical plans and geological plans, have been allowed for. In the event that ground contamination is more significant or different to that anticipated, it might be necessary to carry out additional chemical testing.

Reporting & Timescales:

In order to provide you with sufficient information to enable assessment of abnormal costs at the earliest opportunity we will issue a concise **overview** report within three days of fieldwork completion, if requested. A revised overview report can be issued immediately after receipt of laboratory test results about two week later, if requested.

On completion of the desk study, fieldwork and laboratory testing a **comprehensive** bound, factual and interpretative report will be issued. This will contain detailed engineering records, laboratory test results, copies of all relevant correspondence and drawings of the site. The report will include qualitative risk assessment with respect to both controlled waters and human health.

The report will also provide technically feasible options for redevelopment of the site with housing, including consideration of foundation types and treatment\removal of contamination.

Our comprehensive geoenvironmental appraisal report (electronic PDF on CD) will be issued within five weeks of fieldwork completion. This report will comment on issues associated with hazardous gas, but the gas risk assessment will not be issued until monitoring is completed.

Given previous usage of this land, it is considered unlikely that significant contamination will be encountered, consequently a Remediation Strategy and Quantitative Risk Assessment may not be required by the Local Authority.

Copies of the final report(s) will be issued to the relevant regulatory authorities on receipt of written instruction from yourselves.

Invoicing:

The attached proposal provides a breakdown of the costs associated with this project. This breakdown is for information only and the proposal can be regarded as a lump sum price of **£*,*** + VAT**. Variation will only occur in the event that a given item is not undertaken or that substantial additional works are recommended, in which case we will inform you immediately, provide costs for the required works, and seek your prior consent.

Our proposal allows for submission of the report to the Local Authority and NHBC, and for submission of a single piece of subsequent correspondence with each regulator to address any queries they may have. Any further meetings, correspondence etc, would be chargeable.

We will submit our first invoice following completion of the fieldwork, and our final invoice for this project with the final report.

Underground Services:

Utility plans are required in order to protect operatives from the hazards associated with striking buried services and avoid potentially substantial disruption\repair costs. We will make every effort not to damage any services (including review of utility plans and use of a CAT detector).

Copies of any utility plans, relating to underground services within the site will be required prior to the proposed fieldworks.

Terms & Conditions:

This work will be undertaken in accordance with our Standard Terms and Conditions, a copy of which are enclosed.

At the time of writing, we understand that our report is solely for the benefit of Redrow Homes Ltd. If, however, at a later date a third party wishes also to rely on the benefit of our report then we will consider any such request. Whether or not we enter into a warranty with a third party will be at our discretion, and subject to payment of a fee to cover our legal and incidental costs. We will also require approval from our insurers if more than one beneficiary requires a warranty, or if the proposed warranty is not ALM Consult Ltd (ALM) approved standard form.

You will note that in the last two columns of our costed proposal we have included an estimate of the proportion of the total cost of the works that could be eligible for Land Remediation Tax Relief (LRR).

It is hoped the above is sufficient to address your present needs. However, if you require any further information, please contact me.

Yours sincerely

Keith Lyon
For and on behalf of
ALM Consult Ltd

Enc - Cost Breakdown

APPENDIX D
SELECTED PHOTOGRAPHS

PLATE 1: View looking northwest across the northern part of the site.

PLATE 2: View looking north across the northern part of the site.

PLATE 3: View looking west across the northern part of the site.

PLATE 4: View looking south across the southern part of the site.

PLATE 5: View looking southwest across the southern part of the site.

PLATE 6: View looking west across the southern part of the site.

PLATE 7: View west along Park Avenue