

GEO-ENVIRONMENTAL ASSESSMENT
LAND TO THE SOUTH OF WATER LANE
ANGMERING
RYDON HOMES & GLEESON STRATEGIC LAND
GEA-19495-16-306REVB
MAY 2017



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EXECUTIVE SUMMARY

A Geo-Environmental Assessment was requested by Rydon Homes and Gleeson Strategic Land at Water Lane, Angmering. The purpose of the assessment was to identify any contaminative or geotechnical issues associated with former land use at *Land South of Water Lane, Angmering, Littlehampton, West Sussex* which might impact on the site's redevelopment.

SITE DETAILS	
Approximate site area	Approximately 9 ha
Current/previous use	Undeveloped – agricultural/arable.
Proposed use	Residential units with private and adopted highways, soft landscaping and associated roads and parking.

PHASE 1 NON-INTRUSIVE INVESTIGATION	
Expected geology	Superficial deposits comprising Alluvium, Head Deposits and River Terrace Deposits. Solid geology comprises Lambeth Group (clay, silt and sand), Lewes Nodular Chalk Formation (chalk), and Tarrant Chalk Member (chalk).
Groundwater	Not within a SPZ. Where present, the superficial geology is classified as a Secondary Aquifer - Undifferentiated, with drift deposits in the southern section of the site classified as a Secondary (A) Aquifer. The underlying bedrock geology of the London Clay is classified as an Unproductive Stratum, with a Secondary (A) Aquifer (Lambeth Group) and a Principal Aquifer (Chalk) within the central and southern sections of the site. No active groundwater abstraction licences within 1 km.
Surface water	A partially culverted watercourse (referred to elsewhere as Black Ditch) flows alongside Water Lane on the northern section of site. No surface water abstraction licences are located within a 1 km radius of the site. The northern section is located within Flood Zone 3, associated with the watercourse. Flood defences are shown on the southern edge of Flood Zone 3. A flood risk assessment has been undertaken by Idom Merebrook and is reported under separate cover.
Other	The site lies within a Radon Affected Area (between 5% and 10% of houses are above the action level). Basic radon protection measures are required.

PHASE 2 EXPLORATORY INVESTIGATION	
Contamination	No exceedances noted in samples analysed.
Geotechnical issues	Variable depths to competent soil revealed across the site, whilst existing / proposed trees may dictate footing depths locally. Localised areas of deep made ground and vertically persistent weak natural soils.



RECOMMENDATIONS	
Geotechnical	Traditional strip / trench footings are considered acceptable across the majority of the site. Alternative foundation solutions such as ground improvement or piles will be required in areas where deep made ground or vertically persistent weak natural soils are present. Given the local variability in geology, additional site investigation coverage is recommended for detailed design purposes.
Remediation	No specific soil remediation required. Basic radon protection comprising a membrane and ventilated sub-floor void will need to be incorporated into the proposed development.
Waste classification	No waste classification analysis undertaken but materials likely to be designated as inert (subject to WAC) with the exception of topsoil which would be classified separately. Natural as-dug soils (excluding topsoil) could be classed as inert waste without the requirement for WAC testing.



SECTION 1 INTRODUCTION

- 1.1 Rydon Homes and Gleeson Strategic Land propose to develop an area of land located to the South of Water Lane in Angmering for residential development purposes. The proposed development comprises residential units with private and adopted highways, soft landscaping and associated roads and parking. Idom Merebrook Limited (Merebrook) has been commissioned by Rydon Homes and Gleeson Strategic Land to undertake preliminary site investigation works and to advise on the geo-environmental implications of the redevelopment of the site for the proposed end use.
- 1.2 The objectives of the investigation are to:
- i.* Assess surface and sub-surface ground conditions present at the site;
 - ii.* Identify hazards associated with ground contamination which may place constraints on the site and the proposed development;
 - iii.* Evaluate the risks associated with any identified hazards;
 - iv.* Provide preliminary recommendations for the mitigation of any significant risks identified; and
 - v.* Provide preliminary geotechnical recommendations
- 1.3 A Phase 1 (Non-intrusive Investigation) and a Phase 2a (Preliminary Exploratory Investigation) have been undertaken by Merebrook for the subject site.
- 1.4 In addition a soakage investigation was undertaken by Southern Testing / ST Consult for the westernmost section of land, report reference '*Soakage Test Report - Weavers Hill, Angmering*' P0791 dated 4 June 2014 which has been provided to Merebrook for review. Relevant information including ground conditions encountered has been included in this report.
- 1.5 This report presents the findings of the geo-environmental investigation and provides an interpretation of the geo-environmental conditions that exist at the site. The contaminative status of the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment. This report uses a Tier 1 risk assessment to ascribe a conservative qualitative appraisal of the hazards associated with the site.
- 1.6 This report has been prepared for Rydon Homes & Gleeson Strategic Land for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties making reference to the report should consult Rydon Homes & Gleeson Strategic Land and Merebrook as to the extent to which the findings may be appropriate for their use.



SECTION 2 PHASE 1 (NON-INTRUSIVE INVESTIGATION)

2.1 INTRODUCTION

- 2.1.1 The non-intrusive investigation has been conducted with reference to the documents and sources detailed in Table 1 below:

Table 1: Published Data and Information Sources

SOURCE DATA	GROUNDSURE DATA (Aug 2016)
BGS 1:50,000 Series Geological Sheet 317/332 Chichester and Bognor	Ordnance Survey (OS) historical maps scaled at 1:10,560, 1:10,000, 1:2,500 and 1:1,250 dated 1876 - 2014
BGS Geology of Britain 1:50,000 online maps	Water abstraction, discharge and pollution data
Radon: guidance on protection measures for new dwellings	Registered waste management sites
Environment Agency (EA) online data maps	Mining records and natural ground stability data
UK National Air Quality Archive, online	Protected areas of environmentally sensitive land use or conservation
	Other relevant designations and/or authorisations and Trade Directory entries

- 2.1.2 The above sources are all authoritative and it is believed that they are reasonably reliable. However, independent verification of the information supplied has not necessarily been carried out and Merebrook cannot be held liable for inaccuracies or deficiencies in the information.

2.2 SITE LOCATION AND SETTING

- 2.2.1 The site is located to the south of Water Lane in Angmering, Littlehampton, West Sussex.
- 2.2.2 The site occupies an area of approximately 9 hectares located at National Grid Reference 507534,104591 and indicated on drawing 19495-001-002a, presented in Appendix 1 of this report.
- 2.2.3 At the time of the site investigation the subject site comprised agricultural farmland and farmland used for grazing.
- 2.2.4 Surrounding land uses comprise open fields, plant nurseries, and mixed residential and commercial properties.



2.3 SITE HISTORY

- 2.3.1 The site history, based on a review of the historic and current maps, dating from 1876 to 2014 is summarised below. Potentially contaminative land uses are shown in **bold**. Copies of key maps used in this review are provided in Appendix 2. Distances and directions are reported relative to the nearest point on the site boundary.

Table 2: Summary of the key features shown on historic maps

DATA SOURCE	SITE / SURROUNDINGS
1876 – 1877 (1:2,500, 1:10,560)	Site: The site comprises open fields. A watercourse, large pond and smaller pond are present along the northernmost boundary.
	Surroundings: The site is surrounded by farmland and occasional residential dwellings. Avenals Farm with associated buildings is already present to the west of the main site, with an orchard to the south of the farm buildings. A large pond is present to the north of these farm buildings, separated from the pond on site by a track. Several roads are present in their approximate current configuration including Water Lane to the north.
1897-1898 (1:2,500, 1:10,560)	Site: Undeveloped - fields. The large pond to the north is shown as marshy ground.
	Surroundings: A plant nursery is present to the west with large rectangular greenhouses. A gravel pit is labelled approximately 75 m west.
1911-1912 (1:2,500)	Site: Undeveloped - fields.
	Surroundings: The nursery to the west has expanded, with additional greenhouses and a windpump shown. A nursery and windpump are also present to the southwest. Allotment gardens are present beyond the nursery to the west and additional residential properties are present in a row to the northwest. The gravel pit to the west is no longer shown.
1932-1937 (1:2,500, 1:10,560)	Site: Undeveloped - fields.
	Surroundings: Residential properties have been developed along Water Lane to the northwest. A greenhouse is present to the south of the westernmost land parcel. The road to the west is labelled as Weaver's Hill.
1942 (1:2,500)	Site: Undeveloped - fields.
	Surroundings: A gravel pit is present approximately 100 m northwest along Dapper's Lane. A large nursery, Lansdowne Nursery, and water tower are labelled 320 m north northwest. Further residential development has occurred to the west associated with Angmering.
1970	Site: Undeveloped - fields. A slope is noted adjacent to the watercourse near the northernmost boundary.



DATA SOURCE	SITE / SURROUNDINGS
(1:2,500)	Surroundings: The nursery to the west has been replaced by housing. Significant residential development has occurred to the northwest, west and southwest. A builder's yard is present 70 m to the northwest, a further builder's yard is present 90 m north and an embankment / slope is noted 20 m to the north of the western land parcel. Lansdowne Nursery is no longer shown but various other nurseries are present to the north beyond Water Lane and to the south beyond High Street. Additional buildings are shown around Avenals Farm on the former orchard. The gravel pit to the north is no longer shown.
1977	Site: Undeveloped - fields.
(1:2,500)	Surroundings: Further residential development has occurred to the northwest above Water Lane.
1985-1989	Site: Undeveloped - fields.
(1:2,500)	Surroundings: No significant change in land use.
1994	Site: Undeveloped - fields.
(1:2,500)	Surroundings: Builder's yard is no longer shown to the northwest. Several of the buildings associated with Avenals Farm appear to have been reconfigured or demolished. A rectangular building or structure is present alongside the eastern boundary of the westernmost parcel.
2014	Site: Undeveloped - fields.
(1:10,000)	Surroundings: Residential development is present to the west, whilst the east remains largely undeveloped fields.

- 2.3.2 In summary, the historic plans show that the site has always comprised unreferenced open fields.
- 2.3.3 The historic maps show limited evidence of potentially significant land uses on site or within 250 m of the site. These include Avenals Farm and associated buildings with possible fuel storage (although no tanks labelled), backfilled gravel pits (75 m west and 100 m northwest) and builder's yards (70 m northwest and 90 m north). In general the surrounding area has been limited to agricultural uses, with some horticulture (plant nurseries), and residential development to the south and west.
- 2.3.4 Given the nature of the historical mapping process (scale, representation of conditions at discrete time intervals frequency *etc.*), any such maps and plans may not provide a comprehensive account of a site's history. Identification of pertinent land uses and associated potentially contaminative activities, may therefore be absent from mapping records.



2.4 GEOLOGY

- 2.4.1 The published geological map indicates that the underlying strata across the site comprise superficial deposits of Alluvium (a thin strip of clay, silt, sand and gravel associated with the river on the north of the site), Head Deposits (clay, silt, sand and gravel on the northern half of the site), and River Terrace Deposits (sand, silt and clay on the southern half of the site).
- 2.4.2 The underlying strata across the site comprises bedrock geology of London Clay Formation (clay, silt and sand) to the north and Lambeth Group (clay, silt and sand), Lewes Nodular Chalk Formation (chalk), and Tarrant Chalk Member (chalk) to the south.
- 2.4.3 A BGS borehole log for a 47.54 m deep borehole drilled 162 m south west (TQ00SE8 – Angmering Cottage) is provided in Appendix 3. The log indicates drift deposits (Valley Gravel) over Upper Chalk. A fissure is noted 18 inches from the base of the well yielding about 1000 gallons per hour.
- 2.4.4 There are no records of any made ground within 500 m within the Groundsure report.

2.5 HYDROGEOLOGY

- 2.5.1 The site does not lie within an EA designated Source Protection Zone.
- 2.5.2 The superficial geology is classified as a Secondary Aquifer – Undifferentiated Layers, with drift deposits in the southern section of the site and alluvium in the north classified as a Secondary (A) Aquifer. The underlying bedrock geology of the London Clay is classified as an Unproductive Stratum, with a Secondary (A) Aquifer (Lambeth Group) and a Principal Aquifer (Chalk) within the southern section of the site.
- 2.5.3 No groundwater abstraction licences are located within 500 m of the study site.
- 2.5.4 Three groundwater abstraction licences are noted with a 1 km radius of the subject site, all of which are historic. These related to horticultural watering and spray irrigation.

2.6 HYDROLOGY

- 2.6.1 The nearest surface water feature is a tertiary river (unnamed) and associated pond in the north of the site. Further downstream where the river passes through Angmering it is referred to as the Black Ditch. The river is culverted beneath the entrance to Avenals Farm in the north.
- 2.6.2 No surface water abstraction licences are located within a 1 km radius of the site.
- 2.6.3 The northern section of site is located within Flood Zone 3, associated with the watercourse. Flood defences are shown on the southern edge of Flood Zone 3. A



flood risk assessment has been undertaken by Idom Merebrook and is reported under separate cover.

- 2.6.4 The highest susceptibility to groundwater flooding in the search area based on the underlying geological conditions is considered to be potential at surface for Clearwater flooding from the unconfined aquifer, the BGS has assigned a high confidence rating to this result.

2.7 CURRENT SITE ISSUES

- 2.7.1 Potentially significant environmental issues have been investigated within relevant distances of the site, based on the database of records supplied by Groundsure. These relate to the following searches:

- i. Water discharge or pollution incidents within 250 m of the site;
- ii. Waste management sites within 250 m of the site;
- iii. Statutory authorisations within 50 m of the site;
- iv. Trade directory entries of possible contaminative use within 50 m of the site;
- v. Special protection or conservation areas within 50 m of the site; and
- vi. Any other relevant issues.

- 2.7.2 Potentially significant environmental issues identified by the above searches are summarised in Table 3 below.

Table 3: Potentially significant environmental issues

ENVIRONMENTAL CATEGORY	DESCRIPTION
Water discharge or pollution incidents within 250 m	Six licensed Discharge Consents are located within 250 m of the site, which relate to sewerage discharge. Five pollution incidents are recorded within 250 m. These all occurred in 2002 and related to waste materials (January 2002) and petrol (November 2002). They were all classified as minor or no impact to air, water and land. It is considered that these are all unlikely to impact the subject site.
Waste management sites within 250 m	No current or historic Environment Agency landfill sites or other waste sites are listed within 250m of the study site.
Statutory authorisations within 50 m	There are no statutory authorisations listed within 50 m of the site.
Trade directory entries of possible	There are no records of trade directory entries of possible contaminative use within 50 m.



ENVIRONMENTAL CATEGORY	DESCRIPTION
contaminative use within 50 m	
Special protection or conservation areas within 50 m	An area to the northeast of the site (Groom's Copse) is classified as Ancient and Semi-Natural Woodland. South Downs National Park lies 92 m east.
Other relevant issues	The site lies within a radon affected area – see Section 2.9

2.8 INDICATIVE GROUND STABILITY HAZARDS

2.8.1 The following risk ratings have been applied to ground stability hazards;

- i.* Shrink-swell: moderate hazard rating associated with the Lambeth Group Geology, but low or very low hazard rating elsewhere;
- ii.* Landslides: very low hazard rating;
- iii.* Soluble Rocks: low hazard rating associated with the chalk, but very low or negligible elsewhere;
- iv.* Compressible ground: moderate hazard rating associated with the thin strip of alluvium on the north of the site but negligible hazard rating elsewhere;
- v.* Collapsible rocks: low hazard rating associated with the river terrace deposits but very low to negligible hazard rating elsewhere;
- vi.* Running sand – low hazard rating associated with the river terrace deposits and the alluvium but very low hazard rating elsewhere.

2.9 RADON GAS

2.9.1 The site lies within a Radon Affected Area as defined by the Health Protection Agency (between 5% and 10% of houses are above the action level). Guidance issued by the Buildings Research Establishment (BRE-211) indicates that basic protection measures are necessary.

2.10 AIR QUALITY

2.10.1 The site does not lie within a designated Air Quality Management Area (AQMA) for Arun District Council.

2.11 ECOLOGY

2.11.1 Information from environmental and ecological datasets was obtained from a review of the MAGIC (Multi-Agency Geographic Information for the Countryside) website and the Groundsure report. The data assessed indicates that there are no Sites of Special Scientific Interest (SSSI), National Nature Reserves, Special Areas of



Conservation, Special Protection Areas, Local Nature Reserves or Ramsar sites within 1 km of the site. South Downs National Park lies 92 m to the east.

2.12 PREVIOUS INVESTIGATIONS

2.12.1 A soakage investigation was undertaken for the westernmost part of the site by Southern Testing / ST Consult in April and May 2014:

- i.* Soakage Test Report – Weavers Hill, Angmering, 4th June 2014 reference P0791.

2.12.2 In this area the published geology comprises head and river terrace deposits over chalk. The investigation encountered topsoil over gravelly clay becoming chalk and flint gravels in a clayey or silty matrix. Six soakage tests were carried out across the site using the BRE 365 method. No chemical testing was undertaken as part of this investigation. The report concluded good soakage capacity over the majority of this area of site with some variation and better results coming from pits excavated in the east of the site.

2.13 PRELIMINARY CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

2.13.1 From the Phase 1 assessment a preliminary site conceptual model and risk assessment have been produced using the framework established in Part IIA of the *Environmental Protection Act 1990* and detailed in Contaminated Land Report *CLR11 - Model Procedures for the Management of Land Contamination*.

2.13.2 Risk from contamination has been assessed using the source-pathway-receptor and pollutant linkage methodology, whereby a risk can only exist if all elements of: source, pathway and receptor, are present.

2.13.3 Potential Sources

2.13.3.1 Onsite sources:

- i.* None identified.

2.13.3.2 Offsite sources:

- i.* Gravel Pits (< 75m).

2.13.4 Potential Pathways

2.13.4.1 Receptors may be potentially at risk from the identified sources of contamination via the following pathways:

- i.* Ingestion and inhalation of soil and soil-derived dust;
- ii.* Consumption of home-grown produce;
- iii.* Migration of hazardous gases into buildings;



- iv. Migration of vapours into buildings;
- v. Vertical and lateral migration of mobile contaminants.

2.13.5 Potential Receptors

2.13.5.1 The following potential receptors have been identified:

- i. Current and future site users;
- ii. Construction workers;
- iii. Controlled waters - groundwater (Secondary/Principal Aquifers) and surface waters;
- iv. Future planting schemes;
- v. Polymeric services;
- vi. Adjacent land.

2.13.6 From the Phase 1 assessment a preliminary site conceptual model has been produced as Table 4 which identifies the potential pollutant linkages. These have been used to inform the Phase 2 intrusive investigation presented in the subsequent sections.

Table 4: Preliminary Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	Low risk identified Desk study has not identified any previous contaminative uses, site has remained undeveloped and potential for made ground is limited.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (future residents and construction workers)	Low risk identified Desk study has not identified any previous contaminative uses, site has remained undeveloped and potential for made ground is limited.
	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	Low risk identified No evidence of former buildings on site.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	Low risk identified Low risk of contamination identified with potential to affect underlying aquifer.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	Low risk identified Low risk of contamination identified with potential to affect watercourse to the north.



POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Hydrocarbons	Direct contact	Plastic water pipes	Low risk identified Low potential for hydrocarbon contamination – site is greenfield.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	Low to Moderate risk identified Backfilled gravel pits noted in the vicinity but these were small and unlikely to generate significant volumes of hazardous gas. Nonetheless the site lies in an area where basic radon protection is required.
Adjacent Land	Lateral migration	Adjacent land/residents	Low risk identified No evidence of site uses in the vicinity with significant potential for mobile contamination.

SECTION 3 SITE INVESTIGATION RATIONALE

3.1 INTRODUCTION

- 3.1.1 A site investigation rationale has been devised in accordance with the findings of the Phase 1 investigation and the resultant preliminary conceptual site model and risk assessment. No specific priority contaminants were not identified and a broad chemical suite was undertaken on selected samples to confirm the apparent greenfield status.
- 3.1.2 Intrusive sampling locations were chosen on the basis of providing broad spatial coverage of the site as no obvious features suggesting contaminative use were identified which required targeted investigation.

3.2 SITE INVESTIGATION METHODS

- 3.2.1 An intrusive investigation was carried out by Idom Merebrook Ltd from 2 to 4 September and 7 to 8 September 2015, which comprised the following scope of work:
- i. Four shallow windowless sample probe holes (MWS116 to MWS119) to a depth of 3.00 m bgl;
 - ii. Seven machine dug trial holes (MTP118 to MTP124) to a maximum depth of 3.10 m bgl; and,
 - iii. Two soakaway tests (MSA103 to MSA104) at depths between 1.90mbgl and 2.10 m bgl.
- 3.2.2 Exploratory hole locations are indicated on drawing 19495-304-002a in Appendix 1. Logging of exploratory holes was undertaken by a Merebrook Officer. Exploratory hole logs are contained in Appendix 3.
- 3.2.3 A tracked windowless sampling rig was used to advance MWS116 to MWS119. This comprised a rig-mounted drop hammer to drive a hollow steel barrel into the ground.



The barrel is recovered along with a removable plastic sleeve, which lines the barrel and holds a core of soil which is retracted for logging and sampling. SPTs were performed at approximate 1 m intervals in all windowless sample holes.

- 3.2.4 A monitoring standpipe was installed in MWS118 to a maximum depth of 3.00 m bgl for dual purpose gas and groundwater monitoring.
- 3.2.5 Representative soil samples were taken from various depths and strata to assess the contaminative status of the site. Soil samples were submitted to an MCERTS/UKAS accredited laboratory for chemical analysis of a broad suite of potential contaminants. The results are provided in Appendix 4.
- 3.2.6 A programme of geotechnical laboratory testing was performed on selected soil samples obtained from the boreholes comprising classification tests. Chemical testing was also undertaken to assess the aggressiveness of the ground with respect to buried concrete. The results are provided in Appendix 5.

SECTION 4 GROUND CONDITIONS

4.1 SURFACE GROUND CONDITIONS

- 4.1.1 Surface ground conditions comprised grassland actively used for grazing. Hedgerows bounded the site with semi-mature trees noted across the proximity of the site.

4.2 SUB-SURFACE GROUND CONDITIONS

- 4.2.1 The ground conditions were found to be generally consistent with the published geology for the site and included cohesive Head Deposits and granular River Terrace Deposits overlying London Clay or Lambeth Group strata.
- 4.2.2 A summary of the ground conditions encountered is presented in Table 5 including conditions encountered by Southern Testing across the westernmost extent of the site, whilst a more detailed assessment of the strata is contained in the following sections of the report.

Table 5: Summary of Sub-surface Ground Conditions

STRATA	DEPTH TO TOP RANGE (m bgl)	THICKNESS RANGE (m)
Topsoil	0.0	0.15 – 0.55
Made Ground	0.0	0.30 – > 2.90
Head Deposits	0.15 - 0.55	1.40 – 2.25
River Terrace Deposits	0.30 – 1.9	0.60 – > 2.80
London Clay Formation	1.90 – 2.40	> 1.10
Lambeth Group	0.90 – 1.5	> 2.00



4.2.1 Topsoil / Made Ground

- 4.2.1.1 Topsoil was encountered in the majority of the exploratory holes from ground level to depths of between 0.15 and 0.55 m bgl. The strata was fairly consistent in composition, comprising friable brown and dark brown clay with rootlets and variable amounts of flint gravel.
- 4.2.1.2 Made Ground was encountered in a small number of exploratory hole locations. Thicknesses generally ranged between 0.3 and 1.0 m, whilst in trial pit MTP120 a thickness of > 2.9 m was revealed. From a depth of 1.2 m bgl in MTP120 made ground consisted of soft greenish black slightly sandy clay with some flint, brick and concrete gravel and cobbles.
- 4.2.1.3 Visual and olfactory evidence of contamination was noted in MTP120. In MTP120 greenish black clay with an organic odour was noted between 1.2 and 2.9 m bgl.
- 4.2.1.4 Perched groundwater was not observed within the made ground in any exploratory hole locations.

4.2.2 Head Deposits

- 4.2.2.1 Head Deposits were encountered in several locations with thicknesses ranging from 1.4 to 2.25 m. The Head was typically comprised of orange brown, orange mottled grey or light brown sandy clay with variable amounts of flint gravel and cobbles. Locally, limited thicknesses of clayey gravelly sand were revealed.
- 4.2.2.2 Atterberg limit tests carried out on a sample of clay indicate that the soil can be classified as clay of intermediate plasticity. The plasticity index of the soil was found to be between 21 %, and in accordance with NHBC guidelines, this soil is of medium volume change potential. Moisture contents of 30 % were also determined for this samples.
- 4.2.2.3 SPTs carried out in Head Deposits revealed 'N' values in the range 4 to 12, suggesting soft and firm (low and medium strength) ground conditions.
- 4.2.2.4 No visual or olfactory evidence of contamination was noted within the Head Deposits.
- 4.2.2.5 Wet arisings were noted at depths of between 2.25 and 2.4 m bgl in MWS116.

4.2.3 River Terrace Deposits

- 4.2.3.1 These deposits were present at shallow depth across the southern half of the site, and attained proven thicknesses of up to 2.8 m. The stratum typically consisted of orange brown clayey sandy flint gravel and cobbles, however, limited thicknesses of sandy gravelly clay were noted locally.
- 4.2.3.2 Atterberg limit tests carried out on a single sample of clay indicate that the soil can be classified as clay of very high plasticity. The plasticity index of the soil was found



to be 47 %, and in accordance with NHBC guidelines, this soil is of high volume change potential. A moisture content of 29 % was also determined for this sample.

4.2.3.3 SPTs carried out in the granular soils recorded 'N' values in the range 9 to 20, indicative of loose and medium dense ground conditions.

4.2.3.4 No visual or olfactory evidence of contamination was noted within the River Terrace Deposits.

4.2.3.5 No groundwater was encountered in the River Terrace Deposits.

4.2.4 **London Clay**

4.2.4.1 The London Clay Formation was encountered below Head Deposits in several locations. This stratum was revealed at depths ranging from 1.9 to 2.4 m bgl and was not proven in any location. The stratum was relatively consistent in composition typically comprising grey or grey mottled orange sandy clay.

4.2.4.2 Atterberg limit tests carried out on five samples of clay to the north of Water Lane indicate that the soil can be classified as clay of high to very high plasticity. The plasticity index of the soil was found to range from 34 to 51 %, and in accordance with NHBC guidelines, this soil is of medium and high volume change potential. Moisture contents of between 27 and 34 % were also determined for these samples.

4.2.4.3 SPTs performed within London Clay encountered in one location (MWS117) revealed 'N' values of 7 and 15, indicating soft and firm (low and medium strength) ground conditions.

4.2.4.4 No visual or olfactory evidence of contamination was noted within the London Clay.

4.2.4.5 No groundwater was encountered in the London Clay.

4.2.5 **Lambeth Group**

4.2.5.1 Cohesive soils of the Lambeth Group were encountered in the central part of the site at depths ranging from 0.9 to 1.5 m bgl. A maximum thickness of 2.0 m was recorded in trial pit MTP121 (base not proven). The stratum was found to consist of grey or orange brown mottled grey sandy clay.

4.2.5.2 Atterberg limit tests carried out on a single sample of clay indicate that the soil can be classified as clay of very high plasticity. The plasticity index of the soil was found to be 47 %, and in accordance with NHBC guidelines, this soil is of high volume change potential. A moisture content of 36 % was also determined for this sample.

4.2.5.3 SPTs undertaken within the cohesive soils revealed 'N' values ranging from 12 to 26, indicating the presence of firm and stiff (medium and high strength) ground conditions.

4.2.5.4 No visual or olfactory evidence of contamination was noted within the Lambeth Group.



4.2.5.5 No groundwater was encountered in the Lambeth Group.

SECTION 5 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

5.1 FOUNDATIONS

- 5.1.1 At this stage a detailed proposed development layout is not available. However, it is understood that the development will include approximately 175 residential properties with associated soft landscaping areas, roads and the provision for parking.
- 5.1.2 The site investigation undertaken across the site revealed ground conditions generally consisting of topsoil underlain by predominantly cohesive superficial Head Deposits (1.6 – 2.25 m thick), London Clay (> 1.1 m thick) or Lambeth Group (> 2.0 m thick). Locally, thicknesses of made ground between 0.3 and 1.0 m were reported, whilst deeper made ground was revealed in one location (2.9 m thick). SPTs performed within the Head Deposits recorded soft and firm (low and medium strength) ground conditions, whilst the London Clay was found to range from soft to firm (low to medium strength) in nature. SPTs carried out in the River Terrace Deposits revealed loose and medium dense conditions, whilst the Lambeth Group soils were found to be firm and stiff (medium and high strength) in nature.
- 5.1.3 Based on the ground conditions revealed, it is envisaged that traditional strip or trench footings will be feasible across the majority of this area. Strip footings founded at a minimum depth of 1.0 m within firm / stiff (medium / high strength) clays are considered acceptable in the north western portion, whilst trench footings at a minimum depth of 2.0 m (locally 2.5 m) will be required in the central portion. Footing depths could possibly be reduced locally if firm / stiff is encountered at shallow depth. In the southern portion of the site strip footings founded at a minimum depth of 0.75 m within medium dense sand and gravel will be acceptable.
- 5.1.4 In accordance with NHBC guidelines footings may need to be deepened where footprints are located within the zone of influence of existing or proposed trees. Existing trees are present sporadically within the site and around the site boundaries.
- 5.1.5 Allowable bearing pressures (ABPs) of 100 kN/m² will be achievable for footings up to 1 m wide founded within firm / stiff (medium / high strength) clay, whilst ABPs of 125 kN/m² will be achievable for footings up to 1 m wide founded within medium dense sand and gravel.
- 5.1.6 Deep made ground and vertically persistent soft (low strength) clays have been encountered in the northern portion of the site. It is considered unlikely that strip / trench footings will be acceptable in this area, therefore it is recommended that an alternative foundation solution, such as ground improvement (vibro stone columns or concrete columns) or piles, is adopted.
- 5.1.7 Stone columns could be installed along the lines of all load bearing walls and keyed into underlying competent clay to depths of around 5 - 6 m in order to provide a more



suitable founding stratum. This would enable strip footings to be constructed on the improved ground at depths of around 1 m. Allowable bearing pressures of around 100 kN/m² are likely to be achievable for footings up to 1 m wide. Light mesh reinforcement will need to be incorporated into all footings constructed on vibro treated ground. In order to assess the suitability of using ground improvement a specialist contractor should ideally be invited to attend site to view the ground conditions for themselves.

- 5.1.8 Following consultation with a specialist contractor, if stone columns are not deemed to be feasible then consideration could be given to installing vibro concrete columns (VCC).
- 5.1.9 Alternatively, if ground improvement is not considered suitable then a piled foundation solution would need to be adopted.
- 5.1.10 It is envisaged that either driven or bored / Continuous Flight Auger (CFA) piles could be adopted at the site. Driven piles could possibly be utilised as they have the advantage that no arisings are generated, however, the effects of noise / vibrations are likely to be an issue given the proximity of the existing residential development.
- 5.1.11 The advantage of using bored / CFA piles is the low noise / vibration of the system, however, arisings are generated by bored / CFA piles. Piles would need to be taken through the made ground and / or weak natural soils to found within an underlying competent stratum. Pile lengths will depend on the thickness of made ground and / or weak natural soils, but a minimum length of 8 m is likely to be required.
- 5.1.12 The areas of the site discussed above are indicated on a preliminary foundation zoning plan (Drawing 19495-311-002a) which is presented in Appendix 1 of this report.
- 5.1.13 It is recommended that further intrusive investigation is undertaken to provide more comprehensive coverage of the site and to delineate areas of deep made ground and vertically persistent weak natural soils, whilst boreholes will be required in these areas in order to obtain parameters for pile design.

5.2 EXCAVATIONS AND GROUNDWATER

- 5.2.1 Based on the ground conditions observed at the site, any shallow excavations have the potential to become unstable in the short term, therefore, if man-entry is required, excavations should be supported by shoring or otherwise battered back to a safe angle in order to protect the workforce from possible collapse.
- 5.2.2 Obstructions have been encountered in a couple of locations within the motorsports centre. These are possible representative of former building foundations or hardstanding and should ideally be removed and the resulting excavations backfilled with suitable granular fill.



- 5.2.3 Groundwater was generally not encountered during the intrusive investigation. In view of this, it is considered unlikely that groundwater ingress will occur in shallow excavations, however, provision for dewatering during the construction period should still be considered.

5.3 FLOOR SLABS

- 5.3.1 In view of the presence of cohesive soils at shallow depth across the vast majority of the site, it is recommended that suspended floor slabs are adopted for the proposed development. However, in the southernmost part of the site where superficial deposits of sand and gravel were revealed at shallow depth ground bearing floor slabs could be considered. However it is noted that basic radon protection is required and the recommendations in BR414 should be followed in any floor design.

5.4 BURIED CONCRETE

- 5.4.1 Recommendations given in BRE Special Digest 1:2005 "*Concrete in aggressive ground*" have been followed in order to give recommendations with respect to buried concrete.
- 5.4.2 Water soluble sulphate analysis was carried out on 12 soil samples obtained from depths of between 0.2 and 3.0 m bgl with soil pH determination also carried out on these samples. Water soluble sulphate contents ranged between 0.0057 and 0.43 g/l. In accordance with BRE guidelines the characteristic value is calculated by determining the mean of the highest 20 % of results. In this case the characteristic value is 0.4 g/l. On this basis the Design Sulphate Class is DS-1.
- 5.4.3 The pH values in the soil samples varied between 6.0 and 7.8. The mean of the lowest 20 % of values is 6.2 which represents the characteristic value. Mobile groundwater conditions have been assumed and on this basis the Aggressive Chemical Environment for Concrete (ACEC) class for the site is AC-2z.

5.5 ROADS AND PAVED AREAS

- 5.5.1 For preliminary design purposes it is recommended that a California Bearing Ratio (CBR) value of < 2% is assumed for the shallow natural soils and made ground. Once the positions of proposed roads and areas of hardstanding have been finalised, *in situ* testing could be undertaken to determine an appropriate design CBR value.

5.6 SOAKAWAYS

- 5.6.1 Soakage tests were carried out by Merebrook in two machine dug trial pits to a maximum depth of 2.10m bgl using a JCB 3CX. The sides and bases of the pits were squared off prior to filling with water from a 3000 gallon water tanker. Soakage tests were carried out over a maximum period of five hours.



- 5.6.2 The trial pit soakage tests were performed as far as possible in accordance with BRE document 365. The accompanying data sheets in Appendix 9 show how that the water level fell by a maximum of 1.13 m over a period of one hour 50 minutes (MSA104-1).
- 5.6.3 The BRE methodology for calculation of soil infiltration rate requires measurement of the volume outflowing from between 75% and 25% of the effective depth of the trial pit (height of water in the pit), *i.e.* three-quarters of the water should soak away. If due to low levels of infiltration the water level does not fall from between 75% to 25% of the total water height, it may be possible to extrapolate from a curve derived from the plots of the actual depth of water against time elapsed. The soakage test in MSA104 gathered sufficient data to enable extrapolation, whilst the other test did not achieve 75% effective depth, therefore extrapolation was not possible for this test. The table below provides a summary of infiltration rates recorded.

Table 6: Summary of soakage test infiltration rates

Soakage Test Location	Infiltration Rate (m/s)
MSA104 (1)	2.79×10^{-5}
MSA104 (2)	5.89×10^{-6}

- 5.6.4 The trial pit soakage tests demonstrate that the River Terrace Deposits are of relatively high permeability within the southern section of the site. The remainder of the eastern part of the site has low permeability and as such soakaways could not be installed within other areas. Further tests could be undertaken to target specific areas where more granular soils are present at a similar depth, and taking into consideration proposed locations of soakaways.
- 5.6.5 The soakage test assessment undertaken by Southern Testing is included in Appendix 11.

SECTION 6 ENVIRONMENTAL ASSESSMENT

6.1 SOIL QUALITY

- 6.1.1 A total of nine soil samples were submitted to the laboratory for chemical analysis, including four samples from natural ground and five samples from made ground. The laboratory chemical analysis certificates are contained in Appendix 4. The results of the analysis are summarised in Table 6.
- 6.1.2 An initial screening exercise has been undertaken whereby contaminant concentrations recorded in soils have been assessed against *Suitable for Use Levels*



(S4ULs) published in 2015 by LQM/CIEH¹. These precautionary screening levels are designed to be representative of minimal risk to human health in a number of land use scenarios. In this report S4ULs have been selected for a residential land use where the possibility of consumption of homegrown produce exists and assuming a soil organic matter of 2.5 %. For lead the DEFRA Category 4 Screening Level² has been used as this is based on updated toxicological data and a low risk to human health.

- 6.1.3 An additional set of phytotoxin screening levels have been adopted from 'The Code of Agricultural Practice for the Protection of Soil' Ministry of Agriculture, Fisheries and Food (MAFF), 1993, which are protective of healthy plant growth.

Table 6: Summary of Soils Chemical Analysis Results

CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
pH	-	6.0 - 7.8 (range)	6.88	9	5 – 9	0
Arsenic	mg.kg ⁻¹	11	8.1	9	37	0
Cadmium	mg.kg ⁻¹	<0.2	<0.2	9	11	0
Chromium (total)	mg.kg ⁻¹	32	24	9	910	0
Hexavalent Chromium	mg.kg ⁻¹	<4	<4	9	6	0
Lead	mg.kg ⁻¹	70	34	9	200	0
Mercury	mg.kg ⁻¹	<0.3	<0.3	9	40	0
Nickel	mg.kg ⁻¹	37	21	9	130	0
Selenium	mg.kg ⁻¹	2.8	1.51	9	250	0
TPH Aliphatic >EC ₅ - EC ₆	mg.kg ⁻¹	<0.1	<0.1	9	78	0
TPH Aliphatic >EC ₆ - EC ₈	mg.kg ⁻¹	<0.1	<0.1	9	230	0
TPH Aliphatic >EC ₈ - EC ₁₀	mg.kg ⁻¹	<0.1	<0.1	9	65	0
TPH Aliphatic >EC ₁₀ - EC ₁₂	mg.kg ⁻¹	<1.0	<1.0	9	330	0
TPH Aliphatic >EC ₁₂ - EC ₁₆	mg.kg ⁻¹	<2.0	<2.0	9	2400	0
TPH Aliphatic >EC ₁₆ - EC ₂₁	mg.kg ⁻¹	<8.0	<8.0	9	92000	0
TPH Aliphatic >EC ₂₁ - EC ₃₅	mg.kg ⁻¹	<8.0	<8.0	9	92000	0
TPH Aromatic >EC ₅ - EC ₇	mg.kg ⁻¹	<0.1	<0.1	9	140	0
TPH Aromatic >EC ₇ - EC ₈	mg.kg ⁻¹	<0.1	<0.1	9	290	0
TPH Aromatic >EC ₈ - EC ₁₀	mg.kg ⁻¹	<0.1	<0.1	9	83	0
TPH Aromatic >EC ₁₀ - EC ₁₂	mg.kg ⁻¹	<1	<1	9	180	0
TPH Aromatic >EC ₁₂ - EC ₁₆	mg.kg ⁻¹	2.7	2.1	9	330	0
TPH Aromatic >EC ₁₆ - EC ₂₁	mg.kg ⁻¹	14	10	9	540	0
TPH Aromatic >EC ₂₁ - EC ₃₅	mg.kg ⁻¹	59	15	9	1500	0

¹ Nathanail, C. P., McCaffrey, C., Gillett, A. G., Ogden, R. C. and Nathanail, J. F. 2015. *The LQM/CIEH S4ULs for Human Health Risk Assessment*. Land Quality Press, Nottingham. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3100. All rights reserved. Including August 2015 nickel update.

² SP1010 *Development of Category 4 Screening Levels Main Report* (Dec 2013) and *SP1010 Policy Companion Document* (Mar 2014).



CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Benzene	mg.kg ⁻¹	<0.001	<0.001	9	0.17	0
Toluene	mg.kg ⁻¹	<0.001	<0.001	9	290	0
Ethylbenzene	mg.kg ⁻¹	<0.001	<0.001	9	110	0
Xylene	mg.kg ⁻¹	<0.001	<0.001	9	130	0
Acenaphthene	mg.kg ⁻¹	<0.1	<0.1	9	510	0
Acenaphthylene	mg.kg ⁻¹	<0.1	<0.1	9	420	0
Anthracene	mg.kg ⁻¹	0.12	0.1	9	5400	0
Benz(a)anthracene	mg.kg ⁻¹	0.82	0.2	9	11	0
Benzo(a)pyrene	mg.kg ⁻¹	0.76	0.2	9	2.7	0
Benzo(b)fluoranthene	mg.kg ⁻¹	0.97	0.23	9	3.3	0
Benzo(ghi)perylene	mg.kg ⁻¹	0.05	0.05	9	340	0
Benzo(k)fluoranthene	mg.kg ⁻¹	0.73	0.19	9	93	0
Chrysene	mg.kg ⁻¹	1.3	0.24	9	22	0
Dibenz(ah)anthracene	mg.kg ⁻¹	<0.1	<0.1	9	0.28	0
Fluoranthene	mg.kg ⁻¹	2.1	0.39	9	560	0
Fluorene	mg.kg ⁻¹	<0.1	<0.1	9	400	0
Indeno(123-cd)pyrene	mg.kg ⁻¹	<0.1	<0.1	9	36	0
Naphthalene	mg.kg ⁻¹	<0.05	<0.05	9	5.6	0
Phenanthrene	mg.kg ⁻¹	0.54	0.15	9	220	0
Pyrene	mg.kg ⁻¹	2	0.37	9	1200	0
Phenol	mg.kg ⁻¹	<1	<1	9	200	0
PHYTOTOXICITY RISK ASSESSMENT						
	Units	Max	Mean	No of Test	Screening Level (SL)	No > SL
Copper	mg.kg ⁻¹	18	13	9	200	0
Nickel	mg.kg ⁻¹	37	21	9	110	0
Zinc	mg.kg ⁻¹	76	56	9	300	0

Notes: * Number of samples exceeding screening level

nd = not detected

6.1.4 Zootoxic Metals (harmful to human health)

6.1.4.1 No zootoxic metals were recorded in excess of their respective screening levels.

6.1.5 Phytotoxic Metals (harmful to plant health)

6.1.6 Phytotoxic metals were not recorded at concentrations in excess of the screening criteria.

6.1.7 Organic Contaminants

6.1.7.1 All samples analysed recorded concentrations below the screening levels for organic contaminants.



6.1.8 Inorganic Contaminants

6.1.8.1 No inorganic contaminants were recorded in excess of their respective screening levels.

6.1.9 Summary

6.1.9.1 In summary, all samples recorded concentrations below the screening levels.

6.2 GROUNDWATER

6.2.1 Groundwater level monitoring and sampling was undertaken on one occasion. The resting water level in MWS118 was recorded at 1.02 m bgl.

6.2.2 Samples were submitted to the laboratory for analysis of a typical contamination suite. Screening levels for groundwater have been derived from the Maximum Allowable Concentrations (MAC) in the Water Supply (Water Quality) Regulations 2010 where prescribed, or for those determinands not included, the 1989 regulations. The laboratory chemical analysis certificate is contained in Appendix 6 and groundwater level data is contained in Appendix 5. A summary of groundwater contaminant concentrations is contained in Table 8.

Table 8: Summary of Groundwater Chemical Analysis Results

CONTAMINANT	UNITS	CONC	SCREEN LEVEL (SL)	>SL*
pH	-	7.3	6.5**	x
Arsenic	µg.l ⁻¹	9.79	10	X
Cadmium	µg.l ⁻¹	0.03	5	X
Chromium (total)	µg.l ⁻¹	1	50	X
Copper	µg.l ⁻¹	4.3	2000	X
Lead	µg.l ⁻¹	0.5	10	X
Mercury	µg.l ⁻¹	<0.05	1	X
Nickel	µg.l ⁻¹	12	20	X
Selenium	µg.l ⁻¹	7.3	10	X
Zinc	µg.l ⁻¹	13	5000	X
Cyanide	µg.l ⁻¹	<10	50	X
Sulphate	mg.l ⁻¹	108	250	X
TPH	µg.l ⁻¹	<10	10	X
BTEX	µg.l ⁻¹	<1	-	X
PAH (total)	µg.l ⁻¹	<0.02	-	X
PAH****	µg.l ⁻¹	<0.01	0.1	X
Benzo(a)pyrene	µg.l ⁻¹	<0.01	0.01	X
Naphthalene	µg.l ⁻¹	<0.01	-	X
Phenols	µg.l ⁻¹	<10	0.5	X***

Notes: * Sample exceeds screen level

** Minimum value applies (i.e. most acid)

*** Not detected above laboratory limit of detection



*** sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene & indeno(1,2,3-cd)pyrene

6.2.3 No parameters were recorded in excess of their respective screening levels.

6.3 HAZARDOUS GAS

6.3.1 Gas monitoring has been undertaken on three occasions – 10, 17 September and 2 October 2015. Levels of methane, carbon dioxide and oxygen were recorded in each standpipe, together with associated parameters including borehole flow and ambient air pressure. The results of these gas monitoring rounds are contained in Appendix 7.

6.3.2 The monitoring rounds were undertaken at barometric pressures ranging from 981 to 1027 mb. Positive flow was recorded to a maximum of 0.7 l.hr⁻¹, with a negligible steady flow. Over the three monitoring rounds methane (CH₄) was not detected, carbon dioxide (CO₂) was detected to a maximum of 7.0 % by volume (% v/v) (although the response zone was almost entirely submerged), with a corresponding depleted oxygen concentration of 13.6 % v/v. During the second visit when the hole was noted to be dry, carbon dioxide was recorded at 4.0 % v/v.

6.4 WASTE CLASSIFICATION, OFF-SITE DISPOSAL OR RE-USE

6.4.1 Waste Considerations

6.4.1.1 Based on the contaminant concentrations recorded site soils (made ground) can generally be expected to be classified as non-hazardous should they require disposal. WAC testing would be required for made ground soils destined for landfill.

6.4.1.2 Natural as-dug arisings (excluding topsoil) could be classed as inert waste without the requirement for WAC testing.

6.4.1.3 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statutes including the *Environmental Protection Act 1990* as amended, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The Hazardous Waste Regulations 2005* as amended, *The Waste Management Regulations 2006*, *The Environmental Permitting Regulations 2010* as amended and *The Hazardous Waste (Miscellaneous Amendments) Regulations 2015*.

6.4.1.4 It is a requirement of these regulations that waste sent to landfill should have been subject to measures to reduce the amount of waste, reduce harmful or hazardous properties and facilitate recycling. These requirements may be satisfied by measures such as segregation and screening of wastes to recover suitable fill and material for crushing, segregation of inert materials and putrescible wastes.

6.4.2 Re-use Considerations

6.4.2.1 As a sustainable alternative to off-site disposal, it may be possible to re-use site-won soils provided the following criteria are met:



- i.* Use of the material will not create an unacceptable risk of pollution to the environment or harm to human health;
- ii.* The material must be chemically and geotechnically suitable without further treatment;
- iii.* There must be certainty of use within the scheme;
- iv.* Material should only be used in the quantity necessary for that use.

6.4.2.2 Provided these criteria are met, the re-use of site-won materials is unlikely to be deemed a waste activity. Production of a *Materials Management Plan* under the industry *CL:AIRE Code of Practice on the Definition of Waste* represents a robust method of demonstrating that proposed re-use of materials meets the criteria.

SECTION 7 RISK ASSESSMENT

- 7.1 The potential sources of contamination at the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment.
- 7.2 The investigations demonstrate that the former uses of the site have not resulted in any significant chemical contamination which could affect human or environmental receptors.
- 7.3 CIRIA 665 guidance has been followed to assess the recorded soil gas and flow conditions. Calculations are presented in Appendix 8 which suggest that on the basis of the three monitoring rounds undertaken the site would be classified as 'green' and 'characteristic situation 1', however given that carbon dioxide has been recorded above 5% v/v on several occasions, basic gas protection measures are recommended ('Amber 1' for low rise housing with a sub-floor void, and 'characteristic situation 2' for all other development).
- 7.4 The site lies within a Radon Affected Area as defined by the Health Protection Agency (between 5% and 10% of houses are above the action level). Guidance issued by the Buildings Research Establishment (BRE-211) indicates that basic protection measures are necessary.

SECTION 8 UPDATED CONCEPTUAL MODEL

- 8.1 Following completion of phases 1 and 2 of the investigation and a qualitative risk assessment, the conceptual model for the site, with relation to pollutant linkages, has been updated. The revised model is presented in Table 9 below.



Table 9: Revised Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	PATHWAYS	RECEPTORS	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	Low risk identified Concentrations of metals and hydrocarbons detected do not indicate a significant risk to current site users.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (future residents and construction workers)	Low risk identified Concentrations of metals and hydrocarbons detected do not indicate a significant risk to receptors.
	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	Low risk identified No asbestos noted during site investigation.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	Moderate risk identified Concentrations detected do not indicate a significant potential risk.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	Low risk identified Concentrations detected do not indicate a significant potential risk.
Hydrocarbons	Direct contact	Plastic water pipes	Low risk identified No hydrocarbon contamination identified.
Hazardous Gas/Vapours in soil	Ingress into buildings and voids	Human health (future residents and construction workers)	Low to Moderate risk identified Negligible methane and low to moderate levels of carbon dioxide have been recorded to date, with flow generally absent. Nonetheless the site lies in an area where basic radon protection is required.
Adjacent Land	Migration to adjacent site	Adjacent property	No risk identified Levels and flow rates of hazardous gases do not indicate a significant risk to adjacent properties. No evidence of contamination on site.

SECTION 9 PRELIMINARY REMEDIATION STRATEGY

- 9.1 No soil remediation is proposed at this stage.
- 9.2 It is envisaged that site-derived topsoil will be re-used on site. This is considered to be acceptable in terms of contaminant concentrations. Any material imported for the formation of domestic gardens and landscaped areas should be obtained from a validated source. The validation should incorporate an assessment of the provenance of the material and chemical analysis.
- 9.3 Basic radon protection will be required in all properties. This is considered sufficient to mitigate against any risks from other possible hazardous gas ingress (carbon dioxide).



- 9.4 Potential risks to construction workers have not been identified. Provided that dust levels are kept within statutory limits, the levels of contamination in soils do not indicate potential for the existence of respiratory hazards. Operatives should not be allowed to eat, drink or smoke on site except in designated areas and should be required to wash all exposed skin at the end of each shift. Operatives should be informed of the potential hazards at the site and should be required to report any observations of suspect material.
- 9.5 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statutes including the *Environmental Protection Act 1990* as amended, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The Hazardous Waste Regulations 2005* as amended, *The Waste Management Regulations 2006*, *The Environmental Permitting Regulations 2010* as amended and *The Hazardous Waste (Miscellaneous Amendments) Regulations 2015*.
- 9.6 It is recommended that this report is submitted to the regulators (Local Authority EHO and Planners, Environment Agency Planning Liaison and NHBC) for approval prior to commencement of the works.
- 9.7 Any observations of ground conditions atypical of those already described should be reported to Merebrook immediately so that an assessment of appropriate action can be made.

SECTION 10 CONCLUSIONS

- 10.1 Investigations revealed ground conditions generally consisting of topsoil underlain by predominantly cohesive superficial Head Deposits (1.6 – 2.25 m thick), London Clay (> 1.1 m thick) or Lambeth Group (> 2.0 m thick). Locally, thicknesses of made ground between 0.3 and 1.0 m were reported, whilst deeper made ground was revealed in one location (2.9 m thick). SPTs performed within the Head Deposits recorded soft and firm (low and medium strength) ground conditions, whilst the London Clay was found to range from soft to firm (low to medium strength) in nature. SPTs carried out in the River Terrace Deposits revealed loose and medium dense conditions, whilst the Lambeth Group soils were found to be firm and stiff (medium and high strength) in nature.
- 10.2 Traditional strip or trench footings are considered suitable for most of this area, whilst ground improvement or piles will be required in the northern portion where deep made ground and vertically persistent weak natural soils have been encountered. Given the local variability in the geological succession, it is recommended that additional site investigation coverage is achieved for detailed design purposes.
- 10.3 No soil remediation is proposed at this stage. Basic radon protection will be required in all properties.
- 10.4 As the investigation has indicated that large quantities of topsoil are present and that this may in part be displaced by the site construction activities it is recommended



that a pre-start material movement plan is prepared to enable all usable topsoil resources to be reserved for on-site or offsite usage. It is important that such usable resources are not discarded or treated in such a manner as may indicate an intention to discard them.

- 10.5 It may be possible to re-use soil arisings which may otherwise be classed as waste on site, provided that there is a requirement for the material and that it does not represent a potential risk to human health or the environment once it has been placed. Materials to be re-used should be managed through a Materials Management Plan produced under the Contaminated Land: Applications in Real Environments (CL:AIRE) Code of Practice: Definition of Waste.



APPENDIX 1 ▪ Drawings



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Rydon Homes & Gleeson Strategic Land
Water Lane, Angmering
Land to the south of Water Lane

Site Boundary updated		31-10-2016	A
		RH	SJ
Based on OS		03-08-2015	-
		RH	SJ
Issue Details		Dwn	Chd
		App'd	
Job No.	Dwg No.	Revision	
19495	001-002	A	
Scale	Date	Frame Dimensions mm	
N.T.S.	August 2016	(A4) 250x181	
Drawn	Checked	Approved	
RH	SJ	SJ	



Legend

- Southern parcel boundary
- MTPref Merebrook trial pit with location reference
- MWSref Merebrook window sample with location reference
- MSAref Merebrook soakage test pit with location reference

Layout updated to 1911 P 03revC	31-10-2016		A
	RH	SJ	SJ
Based on drawing 19495-304-001	03-08-2016		-
	RH	SJ	SJ
Issue Details	Dwn	Chd	App'd

Client/Project

Rydon Homes & Gleeson Strategic Land

Water Lane, Angmering

Dwg Title

Approximate Site Investigation Locations

Land to the south of Water Lane

Job No.	Dwg No.	Revision
19495	304-002	A
Scale	Date	Frame Dimensions mm
1:2500	August 2016	(A3) 400 x 280
Drawn	Checked	Approved
RH	SJ	SJ

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