Land to the North East of KGV Playing Fields, Cuffley

Geo-Environmental Phase 2 Interpretative

June 2015

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Lands Improvement

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PHASE II GEO-ENVIRONMENTAL ASSESSMENT - INTERPRETATIVE

NORTHAW ROAD EAST
CUFFLEY
POTTERS BAR, HERTSFORDSHIRE
EN6 4HW

JUNE 2015

Prepared for:

Lands Improvement

Brookbanks Consulting

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EXECUTIVE SUMMARY

Current Site Status

The site, which covers an area of approximately 4.5 hectares, is located on the east side of Northaw Road East in Cuffley, Hertfordshire, at the approximate National Grid reference 530486E, 202063N.

The site comprises a single agricultural arable field, the majority of which falls gently south and south-westwards from the north and north-eastern boundary respectively. Overhead electricity lines traverse the south eastern corner of the site.

Geology, Hydrogeology, Hydrology & Landfills

The solid geology underlying the site consists of the London Clay Formation of the Palaeogene Period (Unproductive Strata) overlain by Superficial Deposits of the Dollis Hill Gravel Member (Secondary A Aquifer) in the eastern section of the site.

Flooding

The site lies within Flood Zone 1, and hence has a low probability of flood risk.

Historical Information

By 1882 the site comprised agricultural fields. By 1970 the site was shown as a single agricultural field with an electrical substation indicated approximately 50m to the north west of the site. Overhead power lines are shown crossing the south eastern corner of the site. No further changes were identified.

Intrusive Investigations

The intrusive investigation was undertaken on 17th to 19th September 2014 in accordance with current British Standard guidance and comprised window sample boreholes, machine-excavated trial pits and infiltration testing.

Ground Conditions

No Made Ground was encountered in the exploratory holes. Natural topsoil was encountered to depths of 0.20m to 0.40m across the site comprising soft slightly gravelly CLAY.

The Dollis Hill Gravel Member was encountered in all exploratory holes with the exception of WS09 to depths of 0.60m to 1.50m. It typically comprised firm occasionally stiff CLAY locally with boulder-sized gravel pockets. The strata was locally soft to firm (to a maximum depth of 0.90m). Loose very clayey sandy GRAVEL was also found in TP03 from 0.30m to 0.80m.

The underlying London Clay Formation typically comprised firm and stiff CLAY. The strata typically became very stiff with depth. The clay was soft from 0.90m to 2.00m in WS08 and soft to firm from 0.80m to 2.00m in WS04.

The majority of the exploratory holes were dry during the investigation with the exception of an isolated slow seepage at 2.50m in TP04. Groundwater was encountered at depths of 1.15m to 3.47m during the subsequent groundwater monitoring visits with the exception of WS03 which remained dry.

Proposed Development

The masterplan layout of the site comprises a mixture of detached, semi-detached, terraced and apartment dwellings with associated access road and public open space. A settlement pond is indicated in the south eastern corner of the site.

Geotechnical Conclusions & Recommendations

It is recommended that foundation loads are transferred onto the firm or stiff clays of the Dollis Hill Gravel Member or London Clay Formation utilising traditional strip/trench foundations. An allowable bearing pressure of 100 kN/m2 is recommended on the firm clays, and 150 kN/m² on the stiff clays based on total settlements of less than 25mm for 0.60m wide foundations.

Ground bearing floor slabs are considered generally suitable for the majority of the site founding on the natural strata beneath the topsoil. However, where deepening of foundations is required in accordance with NHBC Standards with respect to trees or due to soft/loose spots, floor slabs will need to be suspended.

ACEC Class AC-3 (Design Class DS-3) conditions are indicated to prevail on site.

A CBR design value of 2-3% is recommended for the cohesive soils (based on plasticity indices) and 10% for granular soils.

It was not possible to calculate soil infiltration rates in the natural strata due to the absence of significant infiltration, which was consistent with the predominantly cohesive strata encountered.

Environmental Risk Assessment & Liabilities

Risks to Site Users

Identified Sources: No significant contamination has been identified in the natural ground for the proposed residential end use scenario with home grown produce.

Potential Risks: End users of the site and construction/maintenance workers are therefore not considered to be at significant risk from the site as no significant contaminant sources have been identified by the chemical analyses undertaken.

Risks to Controlled Waters

Potential Sources: No significant soil sources have been identified.

Potential Risks: Risks to Controlled Waters are unlikely to be significant based on the information available.

Ground Gases

According to the NHBC Traffic Light System and CIRIA C665, the site has been characterised as 'Green'.

No radon protective measures are required for the site.

Remediation

Human Health Remedial Measures

Based on the information available, no remedial measures are considered necessary to protect human health over the majority of the site.

Protection of Controlled Waters

No remedial measures are anticipated to protect Controlled Waters, based on the information available.

Further Investigation Requirements

No further work is recommended at this stage.

This executive summary is intended to provide an outline of the site assessment in relation to ground contamination and geotechnical parameters. It does not provide a definitive analysis of the information obtained.

1. INTRODUCTION

1.1 General

Geo Environmental Group (GEG) were commissioned by Brookbanks Consulting Ltd (Brookbanks) on behalf of their client Lands Improvement to undertake a Phase II Geo-Environmental Assessment of a proposed residential development site known as 'Northaw Road East, Cuffley'. The investigation was undertaken in order to provide relevant geotechnical and environmental information with respect to the proposed residential development of the site. The intrusive investigation was carried out in accordance with Brookbank's specification and exploratory hole location plan.

The purpose of this report was to determine:

- Potential environmental risks and liabilities associated with any potential soil and shallow groundwater contamination in accordance with current UK guidance (CLR 11) for a future residential end use.
- Geotechnical requirements for foundations, buried concrete, excavations, earthworks and slope stability with respect to the proposed residential development of the site.

1.2 Available Information

The following information was supplied by Brookbanks:

- 'Proposed Development,' Brookbanks Consulting, Drawing No. 10316-SI-01, dated 20.08.14.
- 'Illustrative Site Constraints Plan,' Brookbanks Consulting, Drawing No. 10316-CP-01, dated 04.08.14.
- 'Location Plan,' Omega Partnership, Drawing No. 2271/A-1000 Rev. A, dated August 2014.
- 'Illustrative Masterplan,' Omega Partnership, Planning Drawing, dated May 2015.

1.3 Proposed Site Development

It is understood that the site is proposed for residential development. The masterplan of the site comprises a mixture of detached, semi-detached, terraced and apartment dwellings with associated access roads and public open space. A settlement pond is indicated in the south eastern corner of the site.

1.4 Scope

The works performed by GEG in accordance with Brookbanks specification included:

- A Phase II intrusive investigation comprising window sample boreholes, machine-excavated trial pits and infiltration testing.

- Chemical analysis and geotechnical testing of selected soil samples.
- Gas and groundwater monitoring.
- Development of the conceptual model and generic quantitative human health and Controlled Waters environmental risk assessments in accordance with CLR11.
- A quantitative ground gas risk assessment in accordance with NHBC and CIRIA guidance.
- A geotechnical assessment (including foundations, floor slabs, buried concrete, road pavement design etc.) and including recommendations for suitability of the site for soakaway drainage.
- Recommendations for further investigation and/or remedial work (if required).
- Provision of a report documenting the above.

Limitations to the scope of the report are outlined in Section 11.

2. SITE SETTING

2.1 Site Location

The site, which covers an area of approximately 4.5 hectares, is located on the east side of Northaw Road East (B156) to the south of Cuffley in Potters Bar, Hertfordshire, at the approximate National Grid reference 530486E, 202063N.

A section of the 1:25,000 Ordnance Survey (OS) map identifying the site location is shown in Figure 1 of Appendix A. The site layout plan is presented in Figure 2 (Appendix A) and a photographic record is provided in Appendix B.

2.2 Site Description

The site comprises a single agricultural arable field, the majority of which falls gently south-westwards from the north-eastern boundary from a height of 69.0m AOD to 58.5m AOD. The north western third of the site falls from 65.5m AOD in the north-west to approximately 59.0m AOD in the central region and the south eastern area of the site falls south eastwards to 55.5m AOD.

Overhead 275kV electricity lines traverse the south eastern corner of the site.

Access to the site was obtained from fields to the south, although a gate was also present off South Drive to the north of the site.

The site boundaries comprise hedges with deciduous trees particularly along the southern boundary. The Hertfordshire Way runs adjacent to the southern boundary of the site.

2.3 Adjacent Land Uses

A summary of surrounding land-uses in the immediate vicinity of the site including neighbouring properties is provided below.

North	Residential development to the north west and Cuffley Primary School to the north east.
West	Northaw Road East adjacent to the western boundary with residential development and agricultural fields beyond.
East	Railway line adjacent to the eastern boundary with agricultural fields beyond.
South	Northaw and Cuffley Lawn Tennis Club and playing fields to the south west and agricultural fields to the south east.

3. SUMMARY OF AVAILABLE DESK STUDY INFORMATION

Available information relating to the history of the site, geology, hydrogeology and hydrology is summarised in the following sections, although a Phase I Desk study has not been provided.

3.1 Landfills

Environment Agency data indicates there are no landfills within 500m of the site.

3.2 Historical Information

A brief review of available online historic maps indicates that in 1882 the site comprised agricultural fields. By 1970 the site was shown as a single agricultural field with an electrical substation indicated approximately 50m to the north west of the site. Overhead power lines are shown crossing the south eastern corner of the site. No further changes were identified.

3.3 Geology

3.3.1 Published Geology

Reference to the British Geological Survey 1:50 000 scale digital mapping indicates that the site is underlain by the solid geology of the London Clay Formation of the Palaeogene Period. It is described as poorly laminated, blue grey or grey brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand, which commonly increase towards the base and towards the top of the formation.

With respect to Superficial Deposits, a localised pocket of the Dollis Hill Gravel Member is conjectured in the eastern section of the site, described generically as sand and gravel, locally with lenses of silt, clay or peat and organic material, with some laminated silty beds.

No faults are conjectured to intersect the site at the surface.

3.3.2 *Mining and Quarrying*

The site is not in an area reported to be affected by coal mining.

3.4 Hydrogeology

3.4.1 *Groundwater Designation*

Environment Agency data indicates that the solid geology beneath the site is designated as Unproductive Strata.

Unproductive Strata - are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The Superficial Deposits are characterised as a Secondary A Aquifer.

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

3.4.2 *Groundwater Source Protection Zone*

Environment Agency data indicates that the site does not lie within a currently defined Groundwater Source Protection Zone.

3.4.3 *Groundwater Abstractions*

Environmental Agency data indicates that there are no groundwater abstraction zones within 500m of the site.

3.5 Hydrology

3.5.1 *Nearest Watercourse*

The nearest identified surface water watercourses are the Northaw Brook located approximately 250m to the south of the site and the Cuffley Brook 500m to the east.

3.5.1 *Surface Water Abstractions*

Environment Agency data indicates that there are no surface abstraction zones within 500m of the site.

3.5.2 *Flooding*

According to the Environment Agency, the majority of the site lies within Flood Zone 1, being land that lies outside the 1 in 1000 year (0.1%AEP) flood risk area and hence has a low probability of flood risk.

3.6 Radon

The site is not in a Radon Affected Area.

4. ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY

4.1 Regulatory Controls

Contaminated land in England is principally controlled by:

- Part 2A of the Environmental Protection Act (1990) and accompanying Statutory Guidance.
- Planning and Development Controls.

Part 2A relates to contaminated land risks from land in its current condition, whilst the planning and development control essentially is applicable to new developments which fall within the planning regime and applies to the proposed end use of the land.

These two key pieces of legislation are discussed further in the following sections together with other potentially relevant systems.

4.2 Environmental Protection Act - Part 2A

Part 2A of the Environmental Protection Act (1990) [EPA], which was introduced by section 57 of the Environment Act 1995, requires an overall risk-based approach to dealing with contaminated sites, to ensure that they are 'suitable for use'.

DETR Circular 02/2000 'Contaminated Land' which came into force in England on 1st April 2000 provided accompanying regulations and Statutory Guidance. This was superseded by DEFRA Circular 01/2006 'Contaminated Land' which included amendments to address land contaminated by radioactivity.

Definition of Contaminated Land

Contaminated land is defined in section 78A(2) of Part 2A as:

'Any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in on or under the land, that –

- Significant harm is being caused or there is a significant possibility of such harm being caused; or
- Pollution of controlled waters is being, or is likely to be caused.'

The Water Act 2003 s86 modified the definition of contaminated land to:

Any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in on or under the land, that –

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

Recent changes to Part 2A require the local authority to use a four category system in order to decide whether or not land is designated as contaminated land.

Category 1 describes land which is clearly problematic e.g. because similar sites are known to have caused a significant problem in the past.

Categories 2 and 3 cover the less straightforward land where detailed consideration is needed before deciding whether it is contaminated land. The test rests on whether or not the Local Authority believes there is a strong case for regulatory action – and thus whether it should be placed into Category 2 (contaminated land) or Category 3 (not contaminated land). The decision basis is initially related to human health risks, and if this is not conclusive due to uncertainty over risks, wider socio-economic factors (e.g. cost, views of local people etc.).

Category 4 describes land that is clearly not contaminated land. The new Category 4 test is particularly important in terms of reducing uncertainty over when land is clearly not contaminated land in the legal sense. Land at or below SGV/GAC levels derived using the CLEA methodology is likely to be well within Category 4. DEFRA are currently in the process of producing Category 4 screening levels. PT2A states that normal levels of contaminants in soil should not be considered to cause land to qualify as contaminated land, unless there is a particular reason to consider otherwise. DEFRA have commissioned BGS to produce a report determining normal levels of contaminants in UK soils.

Once land has been determined as contaminated land, the enforcing authority must consider how it should be remediated and, where appropriate, it must issue a remediation notice to require such remediation. The enforcing authority for the purposes of remediation may be the local authority which determined the land, or the Environment Agency, which takes on responsibility once land has been determined if the land is deemed to be a "special site". The rules on what land is to be regarded as special sites, and various rules on the issuing of remediation notices, are set out in the Contaminated Land (England) Regulations 2006.

'Special Sites'

In certain cases, the Environment Agency is the regulatory authority for the contaminated land legislation. This arises if the site under investigation has been used for certain processes, or if the site is situated on bedrock classed as a Principal Aquifer (i.e. water-bearing strata). In the legislation, these sites are referred to as "Special Sites".

4.3 Planning and Development Controls

The Part 2A contaminated land regime will not normally apply where land is being managed within the normal cycle of land redevelopment and regeneration, where planning and development control will continue to be the primary means of control.

Land contamination, or the possibility of it, is a material consideration for the purposes of town and country planning. Current planning control on contaminated land is set out in **National Planning Policy Framework (England), which replaced PPS23 in March 2012**.

National Planning Policy Framework (England) is intended to complement the pollution control framework under the Pollution Prevention and Control Act 1999 and the PPC Regulations 2000.

In addition to the planning system, the **Building Regulations 1991** (made under the Building Act 1984) may require measures to be taken to protect the fabric of new buildings, and their future occupants, from the effects of contamination. Approved Document Part C (Site Preparation and Resistance to Contaminates and Moisture) 2004 edition gives guidance on these requirements.

4.4 Environmental Protection Act 1990 Part III – Statutory Nuisance

Statutory nuisance provisions will no longer apply where the nuisance arises in relation to land in a 'contaminated state'. However, nuisance provisions could still apply where land gives rise to a nuisance (such as an odour) that is an offence to human senses but which is not covered under the various categories of harm set out in the Contaminated Land Statutory Guidance.

4.5 Permitted Installations

Part 2A will not apply where the Environment Agency or the Local Authority has powers under Integrated Pollution Prevention and Control (IPPC) provisions of the Environmental Permitting Regulations 2007 to take action to remedy contamination resulting from the breach of an installation permit.

Waste Management Licensing (Part II of EPA 1990)

Part 2A will not normally apply where contamination has resulted from land subject to a waste management licence, although it may apply where adverse effects arise from causes other than a breach of licence conditions or from activities that are permitted under the licence. Licences are regulated and issued by the Environment Agency.

Waste management licensing is currently being incorporated into the Environmental Permitting Regulations (see Permitted Installations).

4.6 Water Resources Act (WRA) 1991

Sections 161 to 161D of the Water Resources Act 1991 give the Environment Agency powers to take action to prevent or remedy the pollution of controlled waters. The Agency can serve a 'works notice' on any person who has 'caused or knowingly permitted' potential pollution to be in a place from which it is likely to enter controlled waters, or to have caused or knowingly permitted a pollutant to enter controlled waters. The works notice specifies what actions have to be taken in what time periods. Where urgent action is required or a works notice is not complied with, the Agency has the power to carry out the works itself and recover costs from the appropriate person.

The Water Resources Act may apply where the Part 2A regime does not, for example where there is historic pollution of groundwater.

The Water Act 2003 includes a provision, not yet commenced, to amend the current Part 2A definition of pollution of controlled waters to introduce a 'significance' test. The Government propose to return to this issue when a

significance test for radioactive and non-radioactive contamination can be considered together.

4.7 Groundwater Regulations (GWR) 2009

The existing Groundwater Directive (80/68/EEC) aims to protect groundwater from pollution by controlling discharges and disposals of certain dangerous substances to groundwater. In the UK, the directive is implemented through the Groundwater Regulations (GWR) 2009.

Groundwater is protected under these regulations by preventing or limiting the inputs of polluting substances into groundwater. Substances controlled under these regulations fall into two categories:

- **Hazardous** substances are the most toxic and must be prevented from entering groundwater. Substances in this list may be disposed of to the ground, under a permit, but must not reach groundwater. They include pesticides, sheep dip, solvents, hydrocarbons, mercury, cadmium and cyanide. Hazardous substances replace the previous List 1 substances which came under the 1998 GWR.
- **Non-hazardous pollutants** are less dangerous, and can be discharged to groundwater under a permit, but must not cause pollution. Examples include sewage, trade effluent and most wastes. Non-hazardous pollutants include any substance capable of causing pollution and the list is much wider than the previous List 2 substances. For example, nitrate is included as a pollutant but it was excluded from List 2 in the 1998 GWR.

The existing Groundwater Directive is to be repealed by the Water Framework Directive 2000/60/EC (WFD) in 2013. The GWR 2009 has recently been made law to enact both the WFD and its Daughter Directive 2006/118/EC on the protection of groundwater. This new Groundwater Directive (2006/118/EC) is commonly referred to as the Groundwater Daughter Directive (GWDD).

4.8 Suitable for Use Approach

In practice, most sites with a previous potentially contaminating history are remediated to a condition 'suitable for use' under the planning regime rather than the Part 2A legislation.

The 'suitable for use' approach outlined in DEFRA Circular 01/2006 consists of the following three elements:

- Ensuring that land is suitable for its current use.
- Ensuring that land is made suitable for any new use, as planning permission is given for that new use.
- Limiting requirements for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to the current use or future use of land for which planning permission is being sought.

Where new development is taking place, it will be the responsibility of the developer to carry out the necessary remediation. In most cases, the enforcement of any remediation requirements will be through planning conditions and building control, rather than through a remediation notice issued under Part 2A.

4.9 Assessment Methodology

The DEFRA and Environment Agency Contaminated Land Report 11 (CLR11) 'Model Procedures for the Management of Land Contamination' provides a technical framework for structured decision making about land contamination.

Definition of Risk

CLR11 defines risk as:

- A combination of probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

The Concept of the 'Pollutant Linkage'

In the context of contaminated land, there are three essential elements to any risk:

- A **contaminant (or source)** – a substance that is in, on or under land and has the potential to cause harm or cause pollution of Controlled Waters.
- A **receptor** - humans, ecological system, water body or property.
- A **pathway** – a route or means by which a receptor can be exposed to, or affected by, a contaminant.

Each of these elements can exist separately; however, they create a risk only where they are linked together forming a **pollutant linkage**.

Conceptual Site Models

A conceptual site model represents the characteristics of the site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors.

The Tiered Risk Assessment Approach

CLR11 presents a tiered approach to risk:

Tier 1 *Preliminary risk assessment (PRA)*

The purpose of the preliminary risk assessment is to develop an initial conceptual model of the site and to establish whether or not there are potentially unacceptable risks. If potential risks are identified the initial conceptual model is developed in subsequent tiers of the risk assessment process.

Tier 2 *Generic quantitative risk assessment (GQRA)*

The purpose of the generic quantitative risk assessment is to establish whether generic assessment criteria and assumptions are appropriate for assessing the risks and, if so, to apply them to establish whether there are actual or potential unacceptable risks. It also determines whether further detailed quantitative risk assessment is required.

Tier 3 *Detailed quantitative risk assessment (DQRA)*

The purpose of the detailed quantitative risk assessment is to establish and use more detailed site specific information and criteria to decide whether there are unacceptable risks. It may be used as the sole method of quantitative assessments of risks, or it may be used to refine earlier assessments using generic assessment criteria.

5. PRELIMINARY RISK ASSESSMENT AND OUTLINE CONCEPTUAL MODEL

5.1 Potential and Identified Contaminants of Concern

Based on the historic and current usage of the site as agricultural land, potential **on-site** contamination sources are likely to be limited to:

- Herbicides / pesticides.
- Any localised spillages or leakages of fuel or oils from farm machinery/vehicles.
- Any historically imported contaminated Made Ground used to raise site levels/infill voids or fly-tipped material.

There are no significant potential **off-site** contamination sources identified at this stage. However, a full Phase I Desk Study of the site is recommended. Based on the anticipated low permeability of the strata, the electrical substation identified approximately 50m north west is considered sufficiently distant as to not represent a significant risk to the site.

The potential contaminants of concern associated with the current and historic land uses outlined above include:

- Herbicides / pesticides (including DDT and dieldrin).
- Petroleum hydrocarbons (TPH) and polyaromatic hydrocarbons (PAHs).
- General contaminants including metals, semi-metals and non-metals, inorganic chemicals and organics.

A diagrammatic illustration of the outline conceptual model is presented in Figure 3 of Appendix A.

5.2 Preliminary Human Health Conceptual Model

Potential Sources: Potential limited contamination associated with the usage of the site and adjacent land as detailed in Section 5.1.

Potential Receptors: Future site users (residents, site workers, visitors, construction/maintenance workers and potential trespassers) and adjacent residents. Also site flora and fauna and future buildings/structures and construction materials (e.g. water supply pipes).

Potential Pathways: Dermal contact with soil and dust, ingestion of home grown produce and attached soil, inhalation of soil and dust, and the inhalation of indoor and outdoor vapours and ground gases. Potential combustion or explosion of ground gases in confined spaces.

5.3 Preliminary Controlled Waters Conceptual Model

Potential Sources: Potential limited localised contamination associated with the usage of the site and adjacent land as detailed in Section 5.1.

Potential Receptors: Underlying groundwater in the Secondary A Aquifer of the Superficial Deposits and the Northaw Brook 250m south and Cuffley Brook 500m east.

Potential Pathways: Infiltration of precipitation through the site's surface and leaching of potential contaminants and subsequent vertical migration to the Secondary A Aquifer or horizontal migration to the watercourses.

5.4 Preliminary Ground Gas Assessment

As previously described, there are no landfills identified within 500m of the site and no other potential sources of ground gas identified (subject to a detailed Phase I Desk Study). Consequently, risks associated with ground gas are considered low at this stage (see Section 9.2).

As previously described, no radon protective measures are required for the site.

6. INTRUSIVE INVESTIGATION

The following section outlines the scope of the intrusive investigation carried out by GEG and details the ground conditions encountered and the chemical testing undertaken.

6.1 Site Works

6.1.1 General

The intrusive investigation was undertaken on 17th to 19th September 2014 in accordance with current British Standard guidance (BS:5930 and BS:10175) and ICE UK Specification for Ground Investigation (2nd Edition 2012) guidelines and comprised window sample boreholes, machine-excavated trial pits and infiltration testing according to the Brookbanks Specification. The positions of the exploratory holes were also determined by Brookbanks.

Prior to commencement of the works, service plans obtained from the client were viewed in order to identify the location of all major services.

The exploratory holes were logged and sampled by an experienced geo-environmental engineer from GEG. The ground conditions encountered were recorded on the exploratory hole logs (Appendix C). Where strengths and relative densities are in brackets on the exploratory hole logs, these are based on visual assessment in accordance with BS:5930, in the absence of in-situ or laboratory tests.

The locations of the exploratory holes are shown on Figure 4 presented in Appendix A.

6.1.1.1 Limitations of the Intrusive Investigation

There were no limitations to access across the site for the duration of the Intrusive Investigation, although the location of all exploratory holes was agreed with cooperation of the client and the vendor.

6.1.2 Window Sample Holes

9 No. window sample boreholes (WS01-WS09) were drilled using a Competitor Dart dynamic sampling rig to a maximum depth of 6.45m.

Continuous sampling was undertaken using a liner system and standard penetration tests (SPTs) were carried in each hole to confirm the strength/relative density.

WS2, WS3, WS5 and WS9 were installed with 50mm diameter standpipes to depths detailed on the exploratory hole logs for subsequent gas and groundwater monitoring.

6.1.3 Trial Pits

9 No. trial pits (TP01-TP09) were excavated using a JCB-3CX to a maximum depth of 3.80m to facilitate investigation of the near surface soils.

6.1.4 Sampling

Samples were taken from the recovered soil for geotechnical and chemical testing as described in Section 6.2 and 6.3 respectively.

6.1.5 *Infiltration Tests*

5 No. infiltration tests were undertaken in 5 No. trial pits (TP01, TP02, TP06, TP08 and TP09) in general accordance with BRE Digest 365.

The trial pits were excavated to depths of 3.30m to 3.70m and infiltration tests undertaken in the most permeable strata. Clean water was dispensed from a bowser at a rapid rate to fill each excavation as quickly as possible to the proposed depth of the invert levels and/or the most permeable strata. The excavations took less than 5 minutes to fill to the maximum capacity.

Measurements were then taken of the fall of water at suitable time increments to allow the infiltration rate to be calculated from the time taken for the water level to drop from 75% to 25% effective depth (where possible).

On completion of the measurements, the infiltration pits were backfilled with arisings.

The water level measurements from the infiltration tests are tabulated and graphically depicted on Figures F1 to F5 in Appendix F. The results are summarised in Table 1.

Table 1. Infiltration Test Results

Location	Test No.	Strata*	Effective Depth Reached	Time (mins)	Infiltration Rate (m/s)
TP01	1	LC	101%	282	NA
TP02	1	LC	100%	240	NA
TP06	1	DHGM	100%	245	NA
TP08	1	DHGM	103%	268	NA
TP09	1	DHGM	100%	309	NA

*DHGM=Dollis Hill Gravel Member; LC=London Clay

As shown in Table 1, the water levels in TP02, TP06 and TP09 remained constant while the level in TP01 and TP08 rose slightly (potentially due to groundwater ingress or instability of sides); consequently, no infiltration rates could be calculated.

Recommendations with respect to potential use of soakaway drainage are presented in Section 8.11.

6.1.6 *Gas and Groundwater Monitoring*

Gas and groundwater monitoring was undertaken on 20th and 31st October and 7th November 2014 targeting periods of falling atmospheric pressure where possible. The standpipes were monitored for methane, carbon dioxide, oxygen, hydrogen sulphide and the borehole gas flow rate using a GA2000 gas analyser. Atmospheric pressure and trend were also recorded.

The results of the ground gas monitoring are presented in Table 2 below.

Table 2. Gas Monitoring Results

Borehole	Date	Atmospheric Pressure (mb)	Atmospheric Pressure Trend	Methane (% Vol.)	Carbon Dioxide (% Vol.)	Oxygen (% Vol.)	Hydrogen Sulphide (ppm)	Borehole Flow (l/hr)
WS02	20/10/14	1008	Falling	0.0	0.8	18.7	0	0.0
	31/10/14	1010	Rising	0.0	0.7	18.3	0	0.0
	07/11/14	982	Falling	0.0	2.3	12.3	0	0.0
WS03	20/10/14	1008	Falling	0.0	2.6	17.3	0	0.0
	31/10/14	1010	Rising	0.0	2.4	17.3	0	0.0
	07/11/14	982	Falling	0.0	2.3	18.0	0	0.0
WS05	20/10/14	1008	Falling	0.0	2.7	16.7	0	0.0
	31/10/14	1010	Rising	0.0	2.5	16.8	0	0.0
	07/11/14	982	Falling	0.0	2.9	15.3	0	0.0
WS09	20/10/14	1008	Falling	0.0	0.2	20.4	0	0.0
	31/10/14	1010	Rising	0.0	0.7	19.0	0	0.2
	07/11/14	982	Falling	0.0	0.5	19.9	0	0.0

A ground gas risk assessment is presented in Section 7.4.

The water levels were monitored using a dip meter; results are presented in Section 6.4.5.

6.2 Geotechnical Laboratory Testing

Selected samples were despatched to Geo Site and Testing Services Limited and scheduled for geotechnical testing. The schedule of testing comprised:

- 8 No. Natural Moisture Contents (BS1377: Part 2: 1990:3.2)
- 8 No. Liquid and Plastic Limits (BS1377: Part 2: 1990:4.2-4.4 & 5.2-5.4)
- 8 No. Particle Size Distribution Wet Sieve Method (BS1377: Part 2: 1990: 9.2)
- 8 No. Dry Density/Moisture Content Relationship, 4.5Kg Rammer Method 1 Litre Mould (BS1377: Part 4: 1990: 3.5).
- 8 No. One-Dimensional Consolidation 75mm or 50mm diameter specimens (5 days) (BS1377: Part 5: 1990: 3).

The results of the geotechnical testing are presented in Appendix E.

4 No. water soluble sulphate, soluble magnesium and pH determinations were also undertaken on the natural soils as part of the chemical testing (Section 6.3).

6.3 Chemical Laboratory Testing

Samples were despatched to Scientific Analysis Laboratories Limited for chemical analysis. A total of 4 No. representative samples of natural ground were scheduled for general chemical analysis. The schedule of analysis was undertaken in accordance with the Brookbanks Specification, as listed below. All soil analysis was

MCerts accredited where possible. The results of the chemical analysis are located in Appendix D.

Soils

Metals:	Antimony, cadmium, chromium, copper, lead, nickel, zinc, mercury.
Semi-Metals and Non-Metals:	Arsenic, boron, selenium.
Inorganic Chemicals:	Cyanide (total and free), sulphate (soluble), sulphide.
Others:	pH, soil organic matter.
Organics:	Total phenols, banded and speciated petroleum hydrocarbons (TPHs), speciated polycyclic aromatic hydrocarbons (PAHs), SVOC pesticide screen.

** Selected samples only*

6.4 Ground Conditions Encountered

The ground conditions encountered are described below and broadly confirmed the published geology. The strength/relative density of the strata is detailed further in the geotechnical assessment in Section 8.1.

6.4.1 Made Ground

No Made Ground was encountered in the exploratory holes.

6.4.2 Topsoil

Natural topsoil was encountered to depths of 0.20m to 0.40m across the site comprising soft slightly gravelly CLAY.

6.4.3 Dollis Hill Gravel Member

The Dollis Hill Gravel Member was encountered in all exploratory holes with the exception of WS09 to depths of 0.60m to 1.50m. It typically comprised firm occasionally stiff orange brown slightly gravelly to gravelly (quartzite and flint) CLAY locally with boulder-sized gravel pockets. The strata was locally soft to firm (to a maximum depth of 0.90m). Loose brown very clayey sandy GRAVEL was also found in TP03 from 0.30m to 0.80m.

6.4.4 London Clay Formation

The London Clay Formation was encountered underling the Dollis Hill Gravel Member and locally beneath the topsoil (in WS09), to the base in all exploratory holes. It typically comprised firm and stiff brown occasionally grey CLAY, locally with gravel-sized mudstone lithorelicts and gypsum crystals, orange brown sandy to very sandy partings, and occasional cobbles of ironstone and sandstone. The

strata typically became very stiff with depth. The clay was soft from 0.90m to 2.00m in WS08 and soft to firm from 0.80m to 2.00m in WS04.

6.4.5 Groundwater

Groundwater was not encountered in the majority of the exploratory holes during the investigation with the exception of an isolated slow seepage at 2.50m in TP04. The ground was also 'wet' from 3.10m to 3.50m and 4.30m to 4.70m in WS09.

Groundwater levels recorded during the monitoring period are presented in Table 3 below.

Table 3. Groundwater Depths recorded during Monitoring Visits

Borehole	Date	Depth of Installation (m)	Groundwater Depth (m)
WS02	20/10/14	5.00	1.22
	31/10/14		1.28
	07/11/14		1.15
WS03	20/10/14	5.00	DRY
	31/10/14		DRY
	07/11/14		DRY
WS05	20/10/14	5.00	3.47
	31/10/14		3.53
	07/11/14		3.38
WS09	20/10/14	5.00	2.15
	31/10/14		2.21
	07/11/14		1.94

It should be noted that groundwater levels may vary due to seasonal and other effects.

6.4.6 Stability of Trial Pits

All of the trial pits remained stable during the short time they remained open.

6.4.7 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of contamination was encountered in any of the exploratory holes undertaken.

7. GENERIC HUMAN HEALTH QUANTITATIVE RISK ASSESSMENT

7.1 Generic Human Health QRA

7.1.1 CLEA Version 1.06

A generic human health quantitative risk assessment has been undertaken primarily using the CLEA software (version 1.06).

Generic assessment criteria (GAC) derived in CLEA v.1.06, assuming a 'sand' soil type of pH 7 and SOM of 1% were used in the assessment of the natural ground.

The 'residential with home grown produce' for a semi-detached property has been used in the assessment as this is the most sensitive generic land use and building type in the CLEA model applicable to the proposed development.

The exposure pathways used in the CLEA model were:

- Ingestion of soil and dust
- Ingestion of home grown produce and attached soil
- Dermal contact with soil and dust
- Inhalation of soil and dust
- Inhalation of vapours outdoors
- Inhalation of vapours indoors

7.1.2 Other Assessment Criteria

In view of the current absence of specific generic parameters required for the CLEA v. 1.06 Model, namely F_{int} (the fraction of the chemical in the root system reaching edible plant parts) for chromium and lead; and δ (the soil-plant availability correction factor) for chromium; it was not possible to derive SSAC for these chemicals using this model. As such, former CLEA soil guideline values (SGVs) have been used in the interim for this site.

The Risk Based Corrective Action (RBCA) Toolkit (Version 2.5) has been used to derive assessment criteria for pesticides not covered by the CLEA v. 1.06 Model.

A GEG in-house GAC for total cyanide (for all end uses) has been derived based on acute toxicity and a one-time soil ingestion event.

The following contaminants were not assessed as they are not generally considered to represent a significant risk to human health: sulphate and sulphide.

7.2 Statistical Analysis of Soil Chemical Data

7.2.1 Methodology

The chemical analysis results from this investigation have been subjected to statistical analysis as detailed in the guidance produced by the Chartered Institute of Environmental Health (CIEH) (CIEH/CL:AIRE, May 2008) where sufficient data is available.

For details of the statistical tests and hypotheses, reference should be made to the aforementioned publication. However, a brief overview is presented below.

In the first instance, a Null Hypothesis (H_o) and Alternative Hypothesis (H_1) are defined as below, in this case based on the Planning Scenario:

H_o $\mu \geq Cc$ i.e. the true mean concentration (μ) is equal to or greater than the critical concentration (Cc)

H_1 $\mu < Cc$ i.e. the true mean concentration (μ) is less than the critical concentration (Cc)

The data is firstly split into averaging areas based on historic site uses etc. For this site the data has been designated as natural ground soil concentrations for the site.

An outlier test (Grubb's Test) is undertaken to determine whether the soil concentrations for each determinand and averaging area belong to the same or are part of a separate population i.e. represent outliers or 'hot spots'.

A normality test is then undertaken to determine if the data is normally distributed, or otherwise.

A significance test (dependent upon the distribution of the data) is then applied to the data to test H_0 and H_1, and determine the associated level of evidence against H_0.

The GAC are used as critical concentrations in the assessment.

The one sample t-test is undertaken for Normal data and the Chebychev test for Non-normal data. The former derives a single value for the level of evidence against H_0, whereas the latter derives upper and lower bound values.

The ESI Ltd Contaminated Land Statistical Calculator has been used to undertake the aforementioned statistical assessments and the output tables are presented in Appendix G and summarised in the following sections.

7.2.2 Natural Ground

Statistical analysis of the chemical data from the 4 No. samples of natural ground from the site did not identify any outliers or 'hotspots' above the relevant critical concentrations. In addition, the upper confidence limits of the true mean were also below the relevant critical concentrations (indicating the absence of widespread contamination) for all determinands including:

- Metals (antimony, arsenic, cadmium, total chromium, chromium VI, copper, lead, mercury, nickel and zinc).
- Semi-metals and non-metals (boron and selenium).
- Inorganic chemicals (total and free cyanide).
- Organics (total phenols, C6-C40 banded and speciated petroleum hydrocarbons, USEPA 16 polycyclic aromatic hydrocarbons [naphthalene, acenaphthylene, acenaphthene, fluorine, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, dibenzo(ah)anthracene and benzo(ghi)perylene].

7.2.3 Pesticides

No pesticides were identified in the 4 No. samples of natural ground screened.

7.2.4 Summary of Soil Contamination

No elevated soil contaminants have been identified.

7.3 Generic Controlled Waters Quantitative Risk Assessment

No significant sources of contamination have been identified by the soil analyses undertaken.

7.4 Ground Gas Risk Assessment

The gas monitoring results recorded methane concentrations of 0.0% and carbon dioxide concentrations of 0.2% to 2.9% with a maximum flow rate of 0.2 l/hr.

The recorded gas monitoring results have been assessed against the NHBC Traffic Light System detailed in the NHBC 'Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present' and CIRIA C665 'Assessing risks posed by hazardous ground gas to buildings' for 'low rise traditional housing'.

Using maximum concentrations of methane and carbon dioxide of 0.2% and 2.9% respectively and the maximum recorded borehole flow rate of 0.2 l/hr, gas screening values (GSV) of 0.000 l/hr and 0.006 l/hr respectively were calculated. Therefore, according to the aforementioned guidance using the GSVs and typical maximum concentrations of carbon dioxide and methane the data indicates that the site should be characterised as 'Green'.

As previously described the site is not in a Radon Affected Area; consequently, no protective radon measures are required for new properties.

8. GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

8.1 Overview

8.1.1 Summary of Strata Encountered

No Made Ground was encountered in the exploratory holes.

Natural topsoil was encountered to depths of 0.20m to 0.40m across the site comprising soft slightly gravelly CLAY.

The Dollis Hill Gravel Member was encountered in all exploratory holes with the exception of WS09 to depths of 0.60m to 1.50m. It typically comprised firm occasionally stiff CLAY locally with boulder-sized gravel pockets. The strata was locally soft to firm (to a maximum depth of 0.90m). Loose very clayey sandy GRAVEL was also found in TP03 from 0.30m to 0.80m.

The underlying London Clay Formation typically comprised firm and stiff CLAY. The strata typically became very stiff with depth. The clay was soft from 0.90m to 2.00m in WS08 and soft to firm from 0.80m to 2.00m in WS04.

8.1.2 *Groundwater*

The majority of the exploratory holes were dry during the investigation with the exception of an isolated slow seepage at 2.50m in TP04. The ground was also 'wet' from 3.10m to 3.50m and 4.30m to 4.70m in WS09.

Groundwater was encountered at depths of 1.15m to 3.47m during the subsequent groundwater monitoring visits with the exception of WS03 which remained dry.

8.1.3 *Trial Pit Stability*

The trial pits remained stable for the short periods they remained opened.

8.1.4 *Undrained Shear Strength*

An in-situ hand shear vane test recorded an undrained shear strength of 62 N/m² at 1.20m in the cohesive strata of the Superficial Deposits.

In-situ hand shear vane tests recorded undrained shear strengths of 56 kN/m² to 110 kN/m² from 1.00m to 3.30m in the cohesive strata of the weathered solid geology as shown on Graph 1 (Appendix E).

A total of 54 No. standard penetration tests (SPTs) were undertaken in the natural cohesive weathered solid geology, which recorded 'N' values of 6 to 24 at depths of 1.00m to 6.00m, which based on the relationship: Cu = f1 x N after Stroud 1974, where f1 is assumed as 5, corresponds to undrained shear strength (Cu) of 30 to 120 kN/m² respectively. The data is shown in Graph 2 of (Appendix E).

8.1.5 *Plasticity Indices (PI)*

The Modified Plasticity Indices and Volume Change Potential of the natural clay are presented in Table 4 below in accordance with NHBC Standards Chapter 4.2.

Table 4. Volume Change Potential

Location / Depth (m)	Strata#	Plasticity Index (%)	Fraction <0.425mm (%)	Modified Plasticity Index* (%)	Volume Change Potential
TP01 1.10	LCF	32	96	31	Medium
TP04 1.20	LCF	29	97	28	Medium
TP05 1.00	LCF	28	98	27	Medium
TP06 1.20	LCF	31	100	31	Medium
TP07 1.10	LCF	28	91	26	Medium
TP08 1.00	LCF	31	93	29	Medium
TP09 1.20	LCF	28	100	28	Medium
WS02 1.00	LCF	32	100	32	Medium

Notes: *Modified Plasticity Index = Plasticity Index x (% <0.425mm/100); #LCF=London Clay Formation

8.1.6 *Initial Desiccation Assessment*

The Atterberg Limit data for the London Clay Formation has been provisionally assessed in Table 5 below based on guidance given in BRE Digest 412 ('Desiccation in clay soils'), to indicate whether the soils tested were potentially significantly desiccated at the time of sampling.

Table 5. Desiccation Parameters

Location / Depth (m)	MC (%)	LL (%)	0.4 x LL	MC < 0.4 x LL (Y/N)	Description
TP01 1.10	29	57	23	N	Not significantly desiccated
TP04 1.20	27	55	22	N	Not significantly desiccated
TP05 1.00	28	55	22	N	Not significantly desiccated
TP06 1.20	29	58	23	N	Not significantly desiccated
TP07 1.10	30	56	22	N	Not significantly desiccated
TP08 1.00	27	56	22	N	Not significantly desiccated
TP09 1.20	28	53	21	N	Not significantly desiccated
WS02 1.00	27	57	23	N	Not significantly desiccated

The above assessment indicates that the cohesive soils tested were typically not significantly desiccated at the time of sampling, although BRE note that the above assessment only provides a crude estimate of the onset of significant desiccation. It should also be noted that desiccation may subsequently occur due to seasonal and other effects and as such foundations in cohesive soils should be deepened as detailed in Section 8.2.5 in accordance with NHBC requirements.

8.1.7 *Proposed Development*

As previously described, the masterplan layout of the site comprises a mixture of detached, semi-detached, terraced and apartment dwellings with associated access road and public open space. A settlement pond is indicated in the south eastern corner of the site.

8.2 Foundations

8.2.1 *Geotechnical Constraints*

Potential geotechnical constraints have been identified which include:

- Localised softening of the cohesive strata to depths of up to 2.00m.
- Potential deepening of foundations in the cohesive strata with respect to existing trees (Section 8.2.5).

- Potentially elevated sulphate associated with naturally occurring gypsum crystals (see Section 8.3).
- Localised shallow groundwater encountered during the groundwater monitoring visits (from 1.15m).

8.2.2 Foundation Types

The following foundation design proposals are recommended based on the information obtained (presuming current site levels).

It is recommended that foundation loads are transferred onto the firm or stiff clays of the Dollis Hill Gravel Member or London Clay Formation utilising traditional strip/trench foundations. An allowable bearing pressure of 100 kN/m2 is recommended on the firm clays, and 150 kN/m² on the stiff clays based on total settlements of less than 25mm for 0.60m wide foundations.

8.2.3 Anticipated Foundation Depths

Based on NHBC Chapter 4.2 and the ground conditions encountered a minimum foundation depth of 0.90m is recommended for the cohesive strata (based on medium volume change potential) deepened below any soft layers/pockets with typical minimum foundation depths ranging from 0.90m to 2.00m.

8.2.4 Reinforcement of Foundations

Reinforcement of foundations is unlikely to be required as the foundation formation is anticipated to be uniform. However, should variation of granular and cohesive strata be identified on the site in the foundation formation, particularly in the Superficial Deposits, it is recommended that foundations are suitably reinforced due to the potential for differential settlement across the foundation.

8.2.5 Deepening of Foundations due to Trees

Deepening of foundations with respect to former, current, and proposed trees is likely to be required in sections of the site where cohesive horizons predominate below the founding depth (in accordance with the aforementioned NHBC guidelines).

8.2.6 Deepening of Foundations due to Made Ground

Deepening of foundations due to Made Ground is unlikely to be required.

8.2.7 Deepening of Foundations due to Structures/Footings

Deepening of foundations due to structures/footings is unlikely to be required.

8.2.8 Deepening of Foundations due to Soft Ground

Foundations should be deepened below any soft strata.

8.2.9 Inspection of Foundation Excavations

It is recommended that the proposed founding formations are inspected by a suitably qualified geotechnical engineer prior to construction.

8.2.10 Floor Slabs

Ground bearing floor slabs are considered generally suitable for the majority of the site founding on the natural strata beneath the topsoil. However, where deepening of foundations is required in accordance with NHBC Standards with respect to trees or due to soft/loose spots, floor slabs will need to be suspended.

8.2.11 Heave Precautions

Heave precautions should be incorporated in accordance with NHBC Ch. 4.2.

8.3 Chemical Attack on Buried Concrete

On the basis of the maximum soil soluble sulphate concentration for the site of 1.9 g/l (1900 mg/l), and most acidic pH of 6.9, ACEC Class AC-3 (Design Class DS-3) conditions are indicated to prevail on site as defined in BRE Special Digest 1 (2005) for foundations, based on mobile groundwater conditions.

8.4 Underground Plastic Services

Special precautions with respect to protection of underground plastic water mains are not considered necessary.

8.5 Slope Stability and Retaining Walls

Slope stability is not considered an issue on this site.

Any proposed retaining walls would need to be designed by a suitably experienced engineer.

8.6 Earthworks

Recorded maximum dry densities, optimum moisture contents and natural moisture contents ranged from 1.71-2.01 Mg/m^3, 9.0-18.2% and 12.0-32.1% respectively (Appendix E). Optimum moisture contents were typically significantly below the natural moisture contents.

Potential earthworks are unknown at this stage. However, subject to further testing, suitable compaction and control of moisture content, the majority of the Superficial Deposits and solid geology soils are potentially suitable as engineering fill.

8.7 Fault Reactivation

No significant faults are indicated on the site.

8.8 Excavations

Dewatering of shallow excavations is unlikely to be required except during periods of heavy precipitation or if excavations are to remain open for prolonged periods.

The majority of shallow excavations are likely to be stable for short periods of time. However, where excavations extend beyond 1.20m deep, and access for personnel is required, and locally through unstable soils, appropriate shoring will be necessary in accordance with current Health and Safety requirements.

8.9 Road Pavement Design

At this stage, prior to in situ CBR testing, a CBR design value of 2-3% is recommended for the cohesive soils (based on plasticity indices) and 10% for granular soils.

8.10 Loose/Soft Spots

The formation (of foundations, floor slabs and roads etc.) should be inspected for soft/loose spots by a suitably experienced geotechnical engineer. Soft spots if encountered should be removed and replaced with suitable well compacted granular material/lean mix concrete as deemed appropriate. Soft spots beneath roads may also require the use of additional geotextiles. Any loose soils at formation level may need to be proof rolled to increase their relative density.

8.11 Soakaways

As previously described, it was not possible to calculate soil infiltration rates in the natural strata due to the absence of significant infiltration, which was consistent with the predominantly cohesive strata encountered.

9. ENVIRONMENTAL CONCLUSIONS & RECOMMENDATIONS

Following the findings of the intrusive investigation and generic quantitative risk assessment, the preliminary conceptual site model has been revised as outlined below in Sections 9.1.1 and 9.1.2 and as illustrated in Figures 6A and 6B of Appendix A.

9.1.1 Revised Human Health Conceptual Model

Identified Sources: No significant contamination has been identified in the natural ground for the proposed residential end use scenario with home grown produce.

Potential Risks: End users of the site and construction/maintenance workers are therefore not considered to be at significant risk from the site as no significant contaminant sources have been identified by the chemical analyses undertaken.

9.1.2 Revised Controlled Waters Conceptual Model

Potential Sources: No significant soil sources have been identified.

Potential Risks: Risks to Controlled Waters are unlikely to be significant based on the information available.

9.2 Ground Gases

According to the NHBC Traffic Light System and CIRIA C665, the site has been characterised as 'Green'.

As previously described, no radon protective measures are required for the site.

9.3 Risks to Adjacent Land and Third Parties

Risks to adjacent land are not considered significant based on the information available.

9.4 Risks from Adjacent Land and Third Parties

Risks from adjacent land are not considered to be significant based on the information available.

9.5 Potential Geo-Environmental Liabilities

Potential geo-environmental liabilities under Pt2A of the Environmental Protection Act (1990) and the Groundwater Regulations (GWR) 2009, relating to the site in its current condition are not considered to be significant based on the information available. Under the recent Part 2A four category system, the site is likely to fall into Category 3 (not contaminated land).

9.6 Waste Classification

The chemical analysis undertaken indicates that any soil arisings from the site are likely to be classified as non-hazardous or inert waste. However, this could only be confirmed by undertaking WAC testing to confirm leachable concentrations.

9.7 Re-Use of Topsoil

The chemical analysis undertaken indicates that the topsoil tested is suitable for re-use.

9.8 Remediation

9.8.1 Human Health Remedial Measures

Based on the information available, no remedial measures are considered necessary to protect human health over the majority of the site.

9.8.2 Protection of Controlled Waters

No remedial measures are anticipated to protect Controlled Waters, based on the information available.

9.8.3 Budget Remedial Costings

No budget remedial costings are required.

9.9 Further Investigation Requirements

No further work is recommended at this stage.

10. REFERENCES

1. British Standard Institute (1990) BS: 1377 Parts 1-9. Methods of Tests for Soils for Civil Engineering Purposes.

2. British Standard Institute (1999) BS: 5930 Code of Practice for Site Investigations. BSI, London.

3. British Standard Institute (2001) BS: 10175 Code of Practice for Investigation of Potentially Contaminated Sites. BSI, London.

4. BRE Report 414 (2001). Protective measures for housing on gas-contaminated land. BRE Press, Berkshire.

5. BRE Digest 412 (February 1996). Desiccation in clay soils.

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11. LIMITATIONS

As with all intrusive site investigations, there is a possibility that localised contamination 'hot spots'/geotechnical features remain undetected on the site. Therefore, as with standard practices, this report does not provide a warranty to cover limited localised contamination 'hot spots'/geotechnical features or any post-investigation importation of contamination.

The conclusions and recommendations stated herein are based on information available at the time of production. These may not necessarily apply if the site is to be utilised for a more or less sensitive purpose in the future, or if operational procedures or management alter over time.

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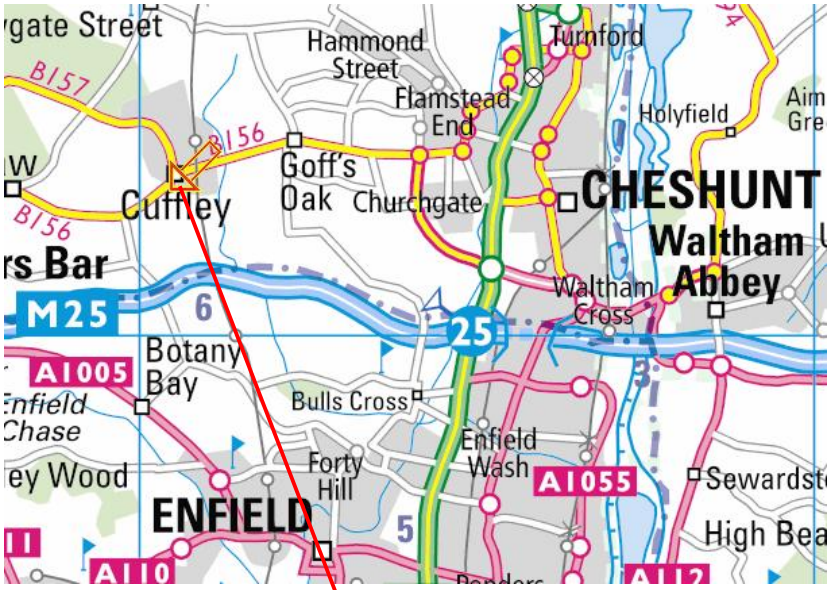
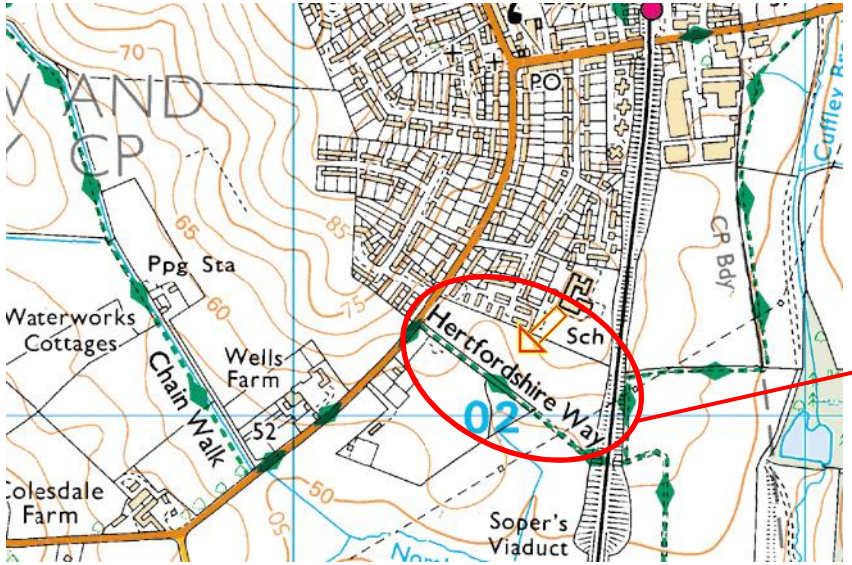
APPENDIX A

FIGURES AND PLANS





SITE LOCATION

TITLE: FIGURE 1 : SITE LOCATION PLAN	
SITE: NORTHAW ROAD EAST, CUFFLEY	
CLIENT: BROOKBANKS CONSULTING/ LANDS IMPROVEMENT	
PROJECT No.: GEG-14-356	**DRAWN/CHECKED:** FT / MR
SCALE: NTS	**DATE:** 10/11/14

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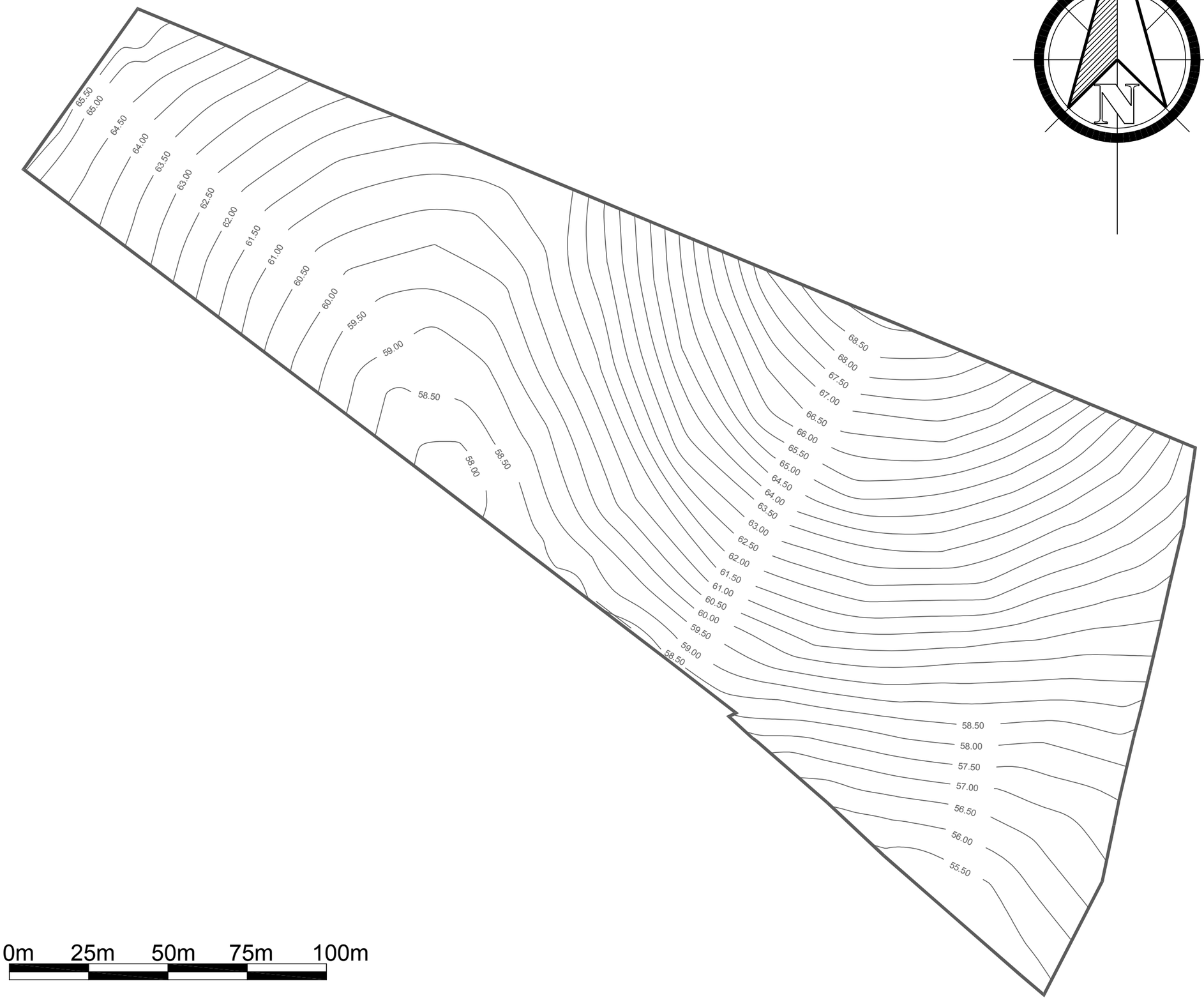
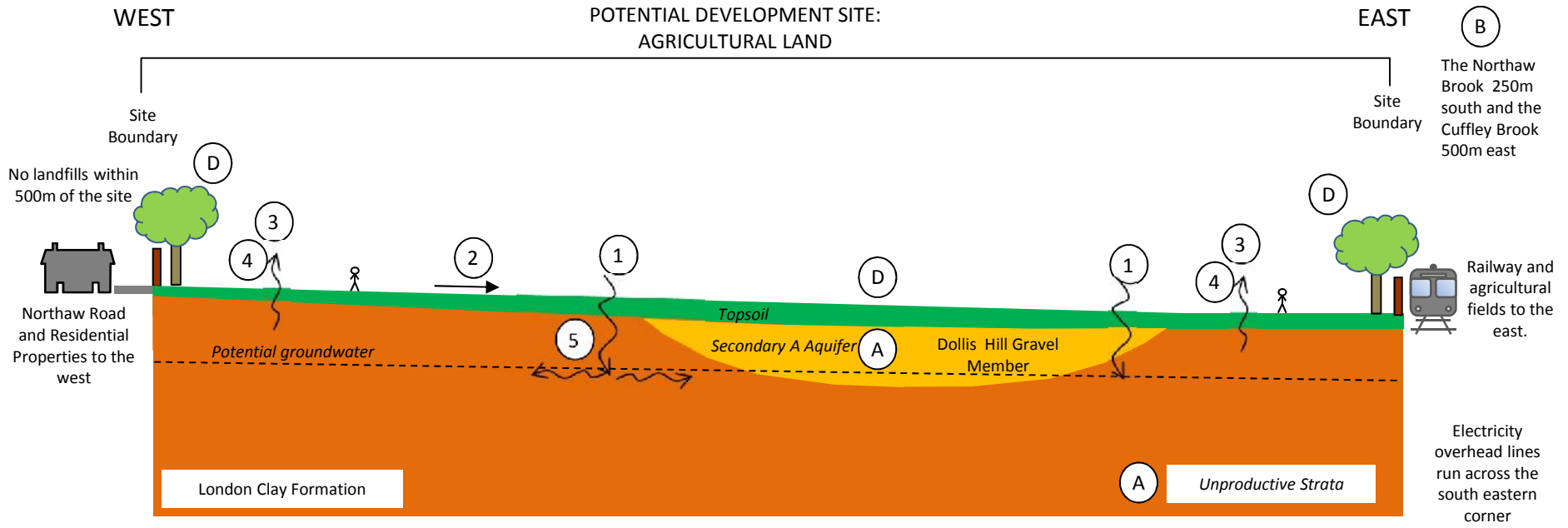


NOTES:

1. BASE IMAGE PROVIDED BY BROOKBANKS CONSULTING.

2. DRAWING TO BE USED IN CONJUCTION WITH GEG REPORT GEG–14–356/PII.

JOB NUMBER: GEG–14–356				Geo Environmental Group
PROJECT TITLE: NORTHAW ROAD, EAST CUFFLEY				
DRAWING TITLE: FIGURE 2: CURRENT LAYOUT PLAN			DRAWING NO.: GEG–14–356_001	
CLIENT: BROOKBANKS CONSULTING	REVISION NO.: A	ORIGINAL SIZE: A3	DIMENSIONS: METRES	SCALE: AS SHOWN
DRAWN BY: FT	CHECKED BY: MP	APPROVED BY: MR	ISSUE: FINAL ISSUE	DATE: 11–10–14



PATHWAYS

1. Infiltration of precipitation
2. Surface water run off
3. Migration of ground gases (methane and carbon dioxide)
4. Potential dermal contact, ingestion of contaminated soil and/or dust and inhalation of gases/vapours
5. Potential leaching/mobilisation of contaminants and lateral and vertical migration

RECEPTORS

- Site users
- A — Aquifer Type
- B — Watercourse
- C — Building Materials (including plastic pipes) (not applicable)
- D — Flora and Fauna

SIGNIFICANT SOURCES

Potential sources of contamination associated with historic/current site usage (see text)

Please refer to the text of the report for further information relating to this diagram.

TITLE: FIGURE 3: PRELIMINARY CONCEPTUAL SITE MODEL	
SITE: NORTHAW ROAD EAST, CUFFLEY	
CLIENT: BROOKBANKS CONSULTING / LANDS IMPROVEMENT	
PROJECT No.: GEG-13-356	**DRAWN/CHECKED:** FT / MR
SCALE: NTS	**DATE:** 10/11/14

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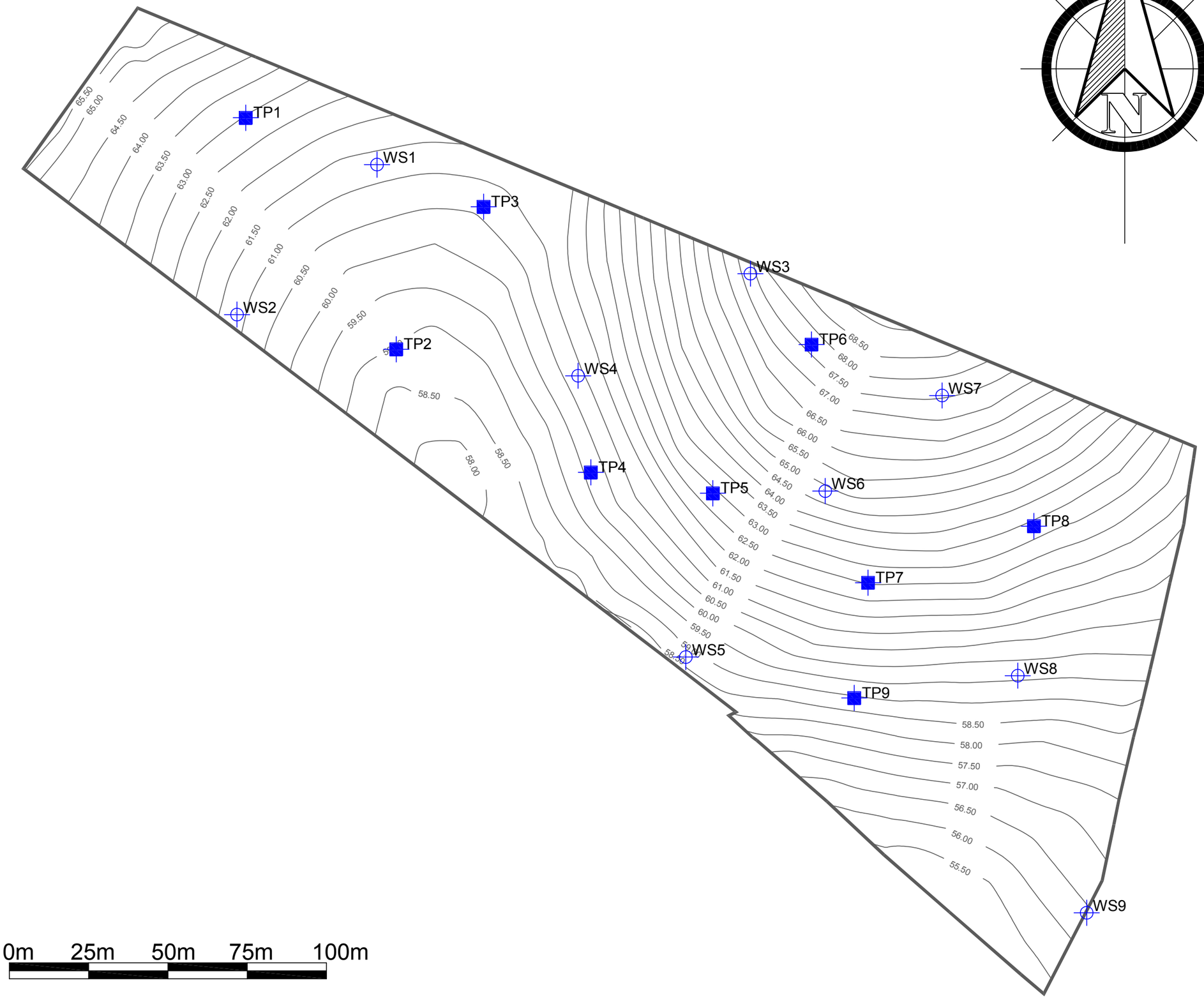


LEGEND

TP1 GEG TRIAL PIT LOCATION

WS1 GEG WINDOW SAMPLE LOCATION

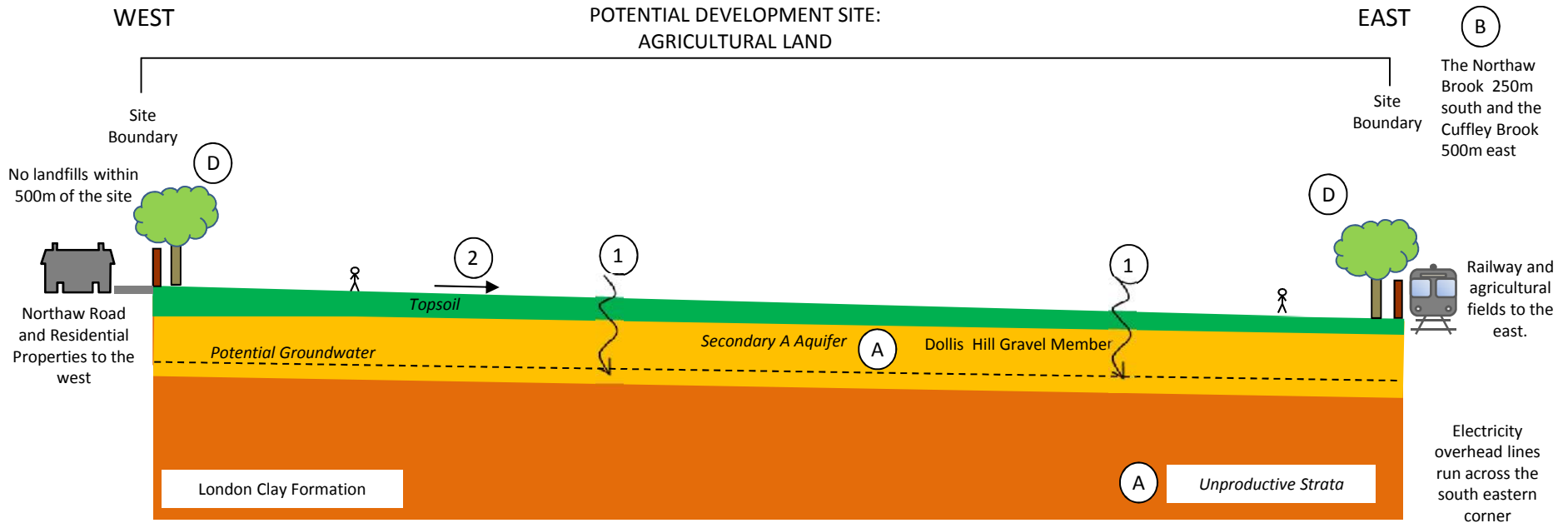
NOTES:

1. BASE IMAGE PROVIDED BY BROOKBANKS CONSULTING.

2. DRAWING TO BE USED IN CONJUCTION WITH GEG REPORT GEG–14–356/PII.

JOB NUMBER: GEG–14–356				Geo Environmental Group
PROJECT TITLE: NORTHAW ROAD, EAST CUFFLEY				
DRAWING TITLE: FIGURE 4: EXPLORATORY HOLE LOCATION PLAN			DRAWING NO.: GEG–14–356_002	
CLIENT: BROOKBANKS CONSULTING	REVISION NO.: A	ORIGINAL SIZE: A3	DIMENSIONS: METRES	SCALE: AS SHOWN
DRAWN BY: FT	CHECKED BY: MP	APPROVED BY: MR	ISSUE: FINAL ISSUE	DATE: 11–10–14

TITLE: FIGURE 5: PROPOSED LAYOUT PLAN	**CLIENT:** BROOKBANKS CONSULTING / LANDS IMPROVEMENT		**DRAWN/CHECKED:** MP / MR		GEG House, 17 Graham Road Malvern, WR14 2HR Tel. 01684 212526 Fax 01684 576917 admin@g-eg.co.uk, www.g-eg.co.uk Geo Environmental Group
SITE: NORTHAW ROAD EAST, CUFFLEY	**PROJECT No.:** GEG-14-356	**SCALE:** As Shown	**DATE:** 11/11/14	**REVISION:** B	



PATHWAYS

1. Infiltration of precipitation
2. Surface water run off
3. Migration of ground gases (methane and carbon dioxide)
4. Potential dermal contact, ingestion of contaminated soil and/or dust and inhalation of gases/vapours (not applicable)
5. Potential leaching/mobilisation of contaminants and lateral and vertical migration (not applicable)

RECEPTORS

- Site users
- A — Aquifer Type
- B — Watercourse
- C — Building Materials (including plastic pipes) (not applicable)
- D — Flora and Fauna

SIGNIFICANT SOURCES

No significant sources of contamination identified (see text)

Please refer to the text of the report for further information relating to this diagram.

TITLE: FIGURE 6A: CONCEPTUAL SITE MODEL (EXISTING)	
SITE: NORTHAW ROAD EAST, CUFFLEY	
CLIENT: BROOKBANKS CONSULTING / LANDS IMPROVEMENT	
PROJECT No.: GEG-13-356	**DRAWN/CHECKED:** FT / MR
SCALE: NTS	**DATE:** 10/11/14

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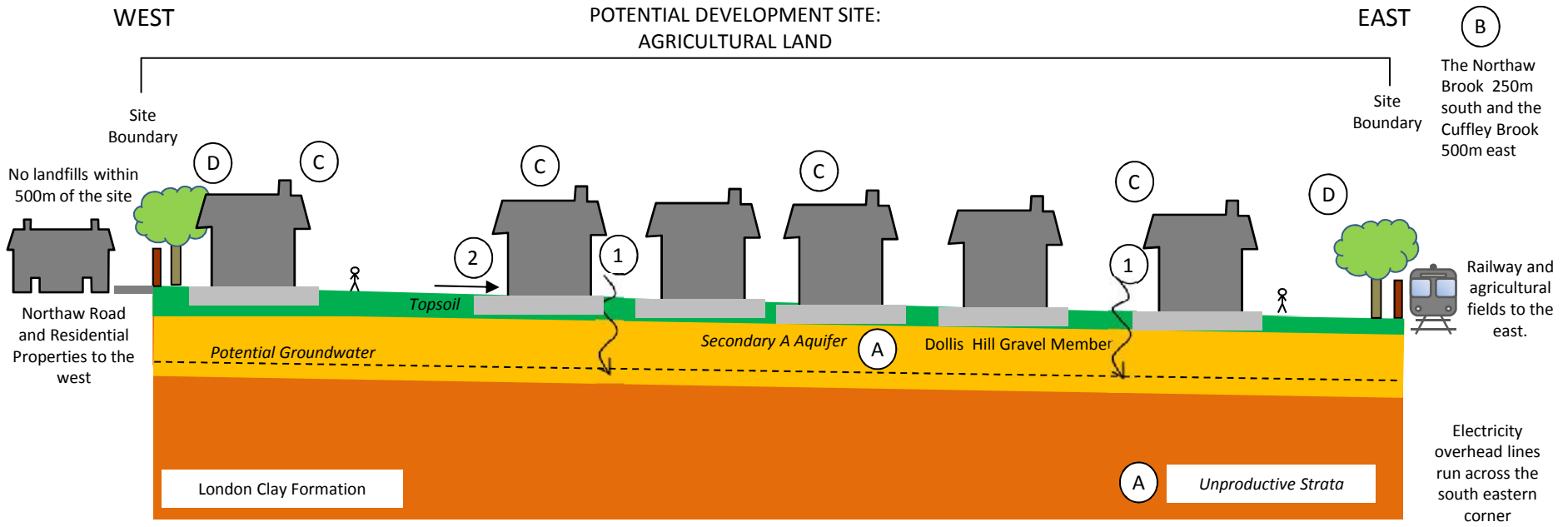

PATHWAYS

1. Infiltration of precipitation
2. Surface water run off
3. Migration of ground gases (methane and carbon dioxide)
4. Potential dermal contact, ingestion of contaminated soil and/or dust and inhalation of gases/vapours (not applicable)
5. Potential leaching/mobilisation of contaminants and lateral and vertical migration (not applicable)

RECEPTORS

- Site users
- A — Aquifer Type
- B — Watercourse
- C — Building Materials (including plastic pipes)
- D — Flora and Fauna

SIGNIFICANT SOURCES

No significant sources of contamination identified (see text)

Please refer to the text of the report for further information relating to this diagram.

TITLE: FIGURE 6B: CONCEPTUAL SITE MODEL (PROPOSED)	
SITE: NORTHAW ROAD EAST, CUFFLEY	
CLIENT: BROOKBANKS CONSULTING / LANDS IMPROVEMENT	
PROJECT No.: GEG-13-356	**DRAWN/CHECKED:** FT / MR
SCALE: NTS	**DATE:** 10/11/14

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