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environmental and geotechnical consultants

Proposed Redevelopment
95 Hillway, Highgate
London

Ground Investigation Report

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GROUND INVESTIGATION REPORT

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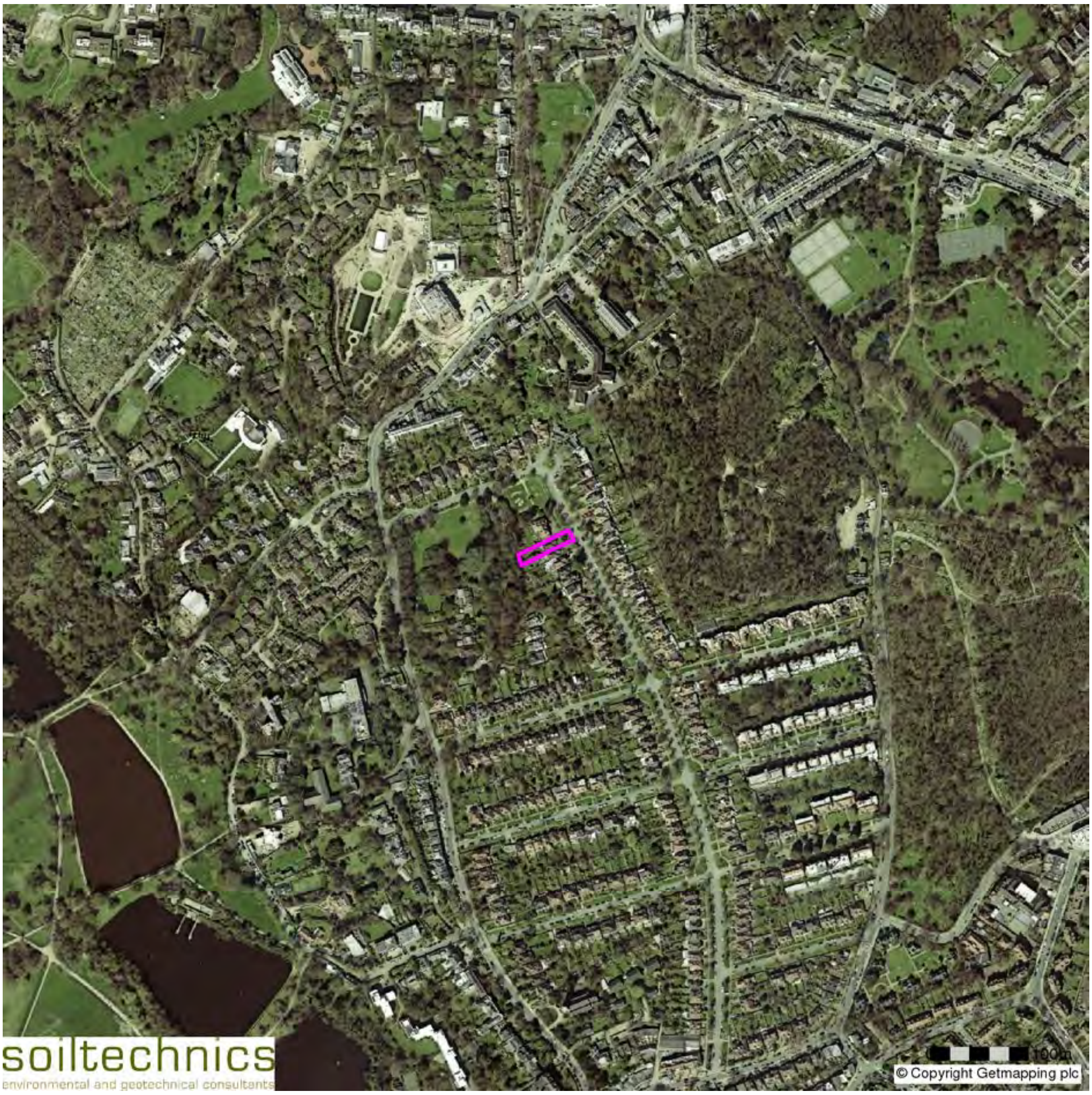
Aerial photograph of site



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Report status and format

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		Revision	Comments
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2	Introduction	01	
3	Desk study information and site observations	01	
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		Revision	Comments
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P	Copy of desk study information produced by Envirocheck

1 Executive summary

General

We recommend the following executive summary is not read in isolation to the main report which follows.

Site description, history and development proposals

The site is located birth of central London in the borough of Camden. The surrounding land use is predominantly residential. The site is currently occupied with one semi-detached house with adjoining garage and bomb shelter to the rear.

The site remained undeveloped prior to construction of the existing property circa 1935. The bomb shelter was a later addition, probably during WW2.

We understand the project comprises the redevelopment of 95 Hillway, including refurbishment of house, construction of a new single storey extension to the front and construction of a single storey basement with ground floor extension to the rear.

Ground conditions encountered

Each exploratory excavation encountered a similar profile of soils considered to be Topsoil or Made Ground overlying Claygate Member. Claygate Member extended beyond 5m depth – the maximum extent of excavations. This is discussed in detail in Section 5.

Foundation solution

The front extension can be formed on strip foundations. A bearing capacity of $150kN/m^2$ is recommended for a 0.6m wide strip at 0.9m depth. To the rear, we understand it is proposed to underpin existing buildings around the perimeter of the proposed basement allowing basement excavations to be carried out with temporary propping providing lateral restraint to the underpinning whilst a permanent concrete box to form the basement is installed. Design parameters are provided in Section 7.

A CBR of 2.2% is recommended for cohesive soils. Granular soils provide higher CBR values. The near surface soils are considered to be frost susceptible which is likely to be the overriding criteria for pavement design.

The Claygate Member soils are considered permeable. Infiltration testing has been undertaken in three boreholes on site with rates calculated between $3.15x10^{-4}m/s$ and $8.41 \times 10^{-6}m/s$.

Chemical and gaseous contamination

Made Ground on site which contains a substantial quantity of clinker and ash presents a potential risk to human end users of the site and water receptors. Laboratory testing confirms that elevated concentration of PAH and heavy metals are present within the Made Ground.

Further testing is recommended in the front garden to determine the extent of PAH contamination and enable production of a detailed remedial strategy.

The risk of the site being impacted by landfill gasses is considered low. Radon protection measures are not considered necessary for the proposed building.

This is discussed in detail in Sections 8 and 9.

Landfill classification

Laboratory testing and our assessment indicate that Made Ground soils are classified as inert waste for off-site disposal. Natural Claygate Member, unaffected by artificial contamination, can also be classified as inert waste for off-site disposal. This is discussed in detail in Section 11.

2 Introduction

2.1 Objectives

2.1.1 This report describes a ground investigation carried out for the proposed redevelopment of 95 Hillway, Highgate, London N6 6AB.

2.1.2 The principal objective of the ground investigation was to establish ground conditions at the site, sufficient to identify possible foundation solutions for the development and provide parameters necessary for the design and construction of foundations.

2.1.3 The investigation included an evaluation of potential chemical and gaseous contamination of the site leading to the production of a risk assessment in relation to contamination.

2.1.4 The investigation has also been produced to support a planning application for the site by satisfying National Planning Policies Framework sections 120 and 121.

2.1.5 Our brief also included investigations and testing to allow classification of soils at the site to be disposed of to landfill.

2.2 Client instructions and confidentiality

2.2.1 The investigation was carried out and reported in November 2014 acting on instructions received from C J O'Shea & Co Ltd.

2.2.2 This report has been prepared for the sole benefit of our above named instructing client, but this report, and its contents, remains the property of Soiltechnics Limited until payment in full of our invoices in connection with production of this report.

2.2.3 Our original investigation proposals were outlined in our letter to Form Structural Design on 29th September 2014. The investigation generally followed our original investigation proposals. The investigation process was also determined to maintain as far as possible the original investigation budget costs.

2.3 Site location and scheme proposals

2.3.1 The National Grid reference for the site is 528229, 186947. A plan showing the location of the site is presented on Drawing 01.

2.3.2 We understand the project comprises the redevelopment of 95 Hillway, including refurbishment of the existing semi-detached property, construction of a new single storey extension to the front and construction of a single storey basement with ground floor extension to the rear.

2.4 Report format and investigation standards

2.4.1 Sections 2 to 6 of this report describe the factual aspects of the investigation with Section 7 presenting an engineering assessment of the investigatory data. Section 8 provides a risk assessment of chemical contamination based on readily available historic records, inspection of the soils and laboratory testing. Section 9 provides a similar risk assessment in relation to gaseous contamination with Section 10, a risk assessment relating to construction materials likely to be in contact with the ground. Section 11 discusses issues related to landfill.

2.4.2 This investigation integrates both contamination and geotechnical aspects. The investigation was carried out generally, and where practical following the recommendations of BS EN 1997:2 2007 '*Eurocode 7 – Geotechnical Design – Part 2: Ground Investigation and Testing*'. The investigation process also followed the principles of BS10175: 2011 '*Investigation of potentially Contaminated Sites – Code of Practice*'. In view of the client's requirement for rapid implementation of the investigation, the following elements, defined in BS10175, have been completed and incorporated in this report.

a) Phase I Preliminary investigation (desk study and site reconnaissance)
b) Phase II Exploratory and main (intrusive) investigations

2.4.3 The extent and result of the preliminary investigation (desk study) is reported in Section 3. Fieldwork combined the exploratory investigation and main investigation stages into one phase with the extent of these works described in Sections 4 and 6 of this report. Any supplementary investigations deemed necessary as a result of deficient information obtained by investigations, completed to date, are identified in Section 12.

2.4.4 Our investigations included testing to allow classification of soils at the site for potential disposal to landfill which is detailed in Section 11.

2.5 Status of this report

2.5.1 This report is final based on our current instructions.

2.5.2 This investigation has been carried out and reported based on our understanding of best practice. Improved practices, technology, new information and changes in legislation may necessitate an alteration to the report in whole or part after publication. Hence, should the development commence after expiry of one year from the publication date of this report then we would recommend the report be referred back to Soiltechnics for reassessment. Equally, if the nature of the development changes, Soiltechnics should be advised and a reassessment carried out if considered appropriate.

2.6 Report distribution

2.6.1 This report has been prepared to assist in the design and planning process of the development and normally will require distribution to the following parties, although this list may not be exhaustive:

Table summarising parties likely to require information contained in this report

Party	Reason
Client	For information / reference and cost planning
Developer / Contractor / project manager	To ensure procedures are implemented, programmed and costed
Planning department	Potentially to discharge planning conditions
Environment Agency	If ground controlled waters are affected and obtain approvals to any remediation strategies
Independent inspectors such as NHBC / Building Control	To ensure procedures are implemented and compliance with building regulations
Project design team	To progress the design
CDM Coordinator	To advise in construction risk identification and management under the Construction (design and management) regulations

Table 2.6

3 Desk study information and site observations

3.1 General

3.1.1 We have carried out a desk study which was limited to a review of readily available information including:

a) Review of published Ordnance Survey maps dating back to 1870 at various published scales

b) Inspection of geological maps produced by the British Geological Survey together with relevant geological memoirs

c) Consultation with Statutory Undertakers

d) Site reconnaissance

e) Other relevant published documents

3.1.2 We have obtained old Ordnance Survey maps using the Envirocheck database system. In addition to retrieval of historical and current Ordnance Survey data, Envirocheck provide information compiled from outside agencies including: -

- Ordnance Survey
- Environment Agency
- Scottish Environment Protection Agency
- The Coal Authority
- British Geological Survey
- Centre for Ecology and Hydrology
- Countryside Council for Wales
- Scottish Natural Heritage
- Natural England
- Health Protection Agency

3.1.3 The study did not extend to research of meteorological information or consultation with other interested parties such as English Heritage (ancient monuments), Ordnance Survey (survey control points), Planning Authorities or Archaeological Units.

3.2 Description of the site

3.2.1 The site is located in Highgate, north of central London in the borough of Camden. Highgate is positioned on relatively high ground, with local topography falling steeply toward the south. The nearest watercourse is located 450m to the west and forms part of the upper reaches of the Fleet which follows a southerly path, ultimately outfalling into the Thames, 6.5km to the south. The Fleet, close to the property has been dammed to form a chain of ponds known as Highgate Ponds. The ponds are located 470m to the south west. The site is located approximately 200m west of the Highgate Chain catchment area. A small pond is located toward the back of the properties rear garden measuring approximately 1.5m by 6.5m. The site is located within the Holly Lodge Estate Conservation Area.

3.2.2 The site is occupied by a semi-detached, two storey residential property together with attached garage to the north and air raid shelter to the rear. There is an access drive and grassed garden to the front of the house, with terraced patio at ground floor level to the rear with steps leading down to a lower level grassed garden. Front garden levels are reasonably uniform but there is a shallow retaining wall along the southern boundary down to the neighbouring gardens. The rear garden is approximately 1.3m lower than ground levels to the front of the property, though the rear grassed garden area is also reasonably uniform.

3.2.3 A number of trees are located around the perimeter of the site. The trees on site ranged in height from 7-12m. There was a large tree measuring approximately 20m in height located in a neighbouring property approximately 7m from the north western boundary.

3.2.4 Site boundaries are well defined, and marked by a combination of concrete walls, timber fencing and vegetation.

3.2.5 Observed site drainage runs east from the property toward Hillway, parallel with the northern site boundary.

3.2.6 The site is surrounded by residential properties and private, estate managed gardens.

3.2.7 A plan showing observed site features and location of exploratory points together with scheme proposals is presented on Drawing 02.

3.3 Injurious and invasive weeds and asbestos

3.3.1 Injurious and invasive weeds

3.3.1.1 Under the Weeds Act 1959, the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent the spread of injurious weeds. The Weeds Act specifies five Injurious weeds: Common Ragwort, Spear Thistle, Creeping or Field Thistle, Broad leaved Dock and Curled Dock. The Wildlife and Countryside act 1981 provides the primary controls on the release of non-native species into the wild in Great Britain. It is an offence under section 14(2) of the act to *'plant or otherwise cause to grow in the wild'* any plants listed in schedule 9, part II. The full list of proscribed species is reviewed regularly by the Environment Agency. Guidance notes are published on their website at www.environment-agency.gov.uk, and also by DEFRA in their publication "*Guidance on section 14 of the Wildlife and Countryside Act, 1981*" available to download at www.defra.gov.uk . The presence of such weeds on site may have considerable effects on the cost / timescale in developing the site.

3.3.1.2 Our investigations exclude surveys to identify the presence of injurious and invasive weeds. Although it should be noted that during our site reconnaissance we did not observe any obvious evidence the above species, we recommend specialists in the identification and procedures to deal with injurious and invasive weeds are appointed prior to commencement of any works on site or if appropriate purchase of the site.

3.3.2 Asbestos

3.3.2.1 Our investigations exclude surveys to identify the presence or indeed absence of asbestos on site. It should be noted that we did observe potential asbestos containing cement bound sheeting to the rear of the garage measuring approximately 10m^2. We took precautions to avoid disturbance of these materials during our on-site activities and recommend a specialist be appointed to confirm or otherwise the presence of asbestos.

3.3.2.2 The presence of asbestos on site may have considerable effects on the cost / timescale in developing the site. There is good guidance in relation to Asbestos available on the Health and Safety Executive (HSE) web site.

3.4 History of the site

3.4.1 An attempt to trace the history of the site has been carried out by obtaining copies of old Ordnance Survey maps provided by Envirocheck. The recent history of the site based on published Ordnance Survey maps is summarised on the following table: -

Summary description of site history from Ordnance Survey maps		
Date	**Historical Usage**	**Comment**
1852	The site is recorded as open space.	Surrounding area is undeveloped
1870-1896	The site is recorded as an orchard	Surrounding area is also recorded as an orchard. Highgate cemetery recorded 100m north east of the site.
1915-1920	Site recorded as open space	Increased development to the surrounding area.
1935	One building located centrally on site.	Further, suspected residential development in the surrounding area and adjacent to the site.
1952	Building extended toward the rear and concurrent with existing layout (including bomb shelter)	No significant change.
Table 3.4.1		

3.5 Geology and geohydrology of the area

3.5.1 Geology of the area

3.5.1.1 Envirocheck reproduce geological map extracts taken from the British Geological Survey (BGS) digital geological map of Great Britain at 1:50,000 scale (ref Appendix P). A summary of the recorded geological information for the site is presented in Table 3.5.1 below:-

Summary of Geology and likely aquifer containing strata					
Strata	**Bedrock or drift**	**Approximate thickness**	**Typical soil type**	**Likely permeability**	**Likely aquifer designation**
Claygate member	Bedrock	5m	Clay	Low	Secondary Aquifer
London Clay Formation	Bedrock	100m	Clay	Low	Unproductive
Thanet Sands	Bedrock	17m	Fine sand	Moderate	Secondary Aquifer
Chalk	Bedrock	>100m	Chalk	High	Principal
Table 3.5.1					

3.5.1.2 It should be noted strata names in accordance with the BGS Lexicon of Named Rock Units have superseded commonly used local names for specific strata. Bedrock deposits are soils or rocks deposited prior to the glaciation, with drift deposited during or post glaciation. Soil types and assessments of permeability are based on geological memoirs, in combination with our experience of investigations in these soil types.

3.5.2 Geohydrology – aquifer designation and groundwater vulnerability

3.5.2.1 Envirocheck reports the Claygate, London Clay and Thanet Sand Formation deposits (bedrock) are designated Unproductive Strata with Chalk deposits at substantial depth designated a Principal Aquifer.

3.5.2.2 Unproductive strata are defined as deposits exhibiting low permeability with negligible significance for water supply or river base flow. Unproductive Strata are generally regarded as not containing groundwater in exploitable quantities.

3.5.2.3 Principal aquifers are defined as deposits exhibiting high permeability capable of high levels of groundwater storage. Such deposits are able to support water supply and river base flows on a strategic scale.

3.5.3 Geohydrology – water abstractions

3.5.3.1 Envirocheck report that there are no abstraction points within 2000m of the site.

3.5.4 Geohydrology – source protection zone

3.5.4.1 Envirocheck does not record the site is located within a zone protecting a potable water supply abstracting from a principal aquifer (i.e. a source protection zone).

3.6 Environmental database

3.6.1 A copy of records produced by Envirocheck is presented in Appendix P. Envirocheck produce a wealth of factual database information. Although we can provide a discussion on each of the database topics, this would produce a very lengthy document, but some of these discussions would not be relevant to the aims of this report. As a consequence we have extracted some of the relevant geotechnical topics (including flood risk) and discussed them in this section of the report. Key environmental issues from the Envirocheck database are discussed in Section 8. Similarly landfilling is discussed in detail in Section 9.

3.7 Landfill sites

3.7.1 Envirocheck reports there are no recorded landfill sites and no BGS recorded mineral sites (which may have been restored) within 2000m of the subject site.

3.8 Coal mining records

3.8.1 We have reviewed the Coal Authority web site, to determine if the site is located within an area which has been affected by coal mining or brine extraction. The web site address is:

http://coal.decc.gov.uk/en/coal/cms/services/reports/en_cy/en_cy.aspx.

The web site advises the site is not located within an area affected by past or present coal mining, or minerals worked in association with coal or indeed brine extraction.

3.9 Radon

3.9.1 With reference to the Building Research Establishment (BRE) publication "*Radon: guidance on protective measures for new buildings*" (2007), the site is located where **no protection** is considered necessary. In addition, Envirocheck use the British Geological Survey database to review reported radon levels in the area in which the site is located to establish recommended radon protection levels for new dwellings. The database confirms the BRE recommendations.

3.9.2 The Building Research Establishment publication applies to all new buildings, conversions and refurbishments whether they are for domestic or non-domestic use.

3.9.3 It is noteworthy that the BRE and BGS / HPA information is based on statistical analysis of measurements made in dwellings in combination with geological units, which are known to emit radon. Therefore there is a risk for actual radon levels at the site to exceed the levels assessed by the BGS / HPA / BRE. Currently, the only true method of checking actual radon levels is by measurement within a building on the site over a period of several months. It should be noted that it is not currently a requirement of the Building Regulations to test new buildings for radon, however the BRE recommends testing on completion or occupation of all new buildings (domestic and non-domestic), extensions and conversions. Should you wish to undertake radon monitoring following completion of the development, we can provide proposals.

3.10 Flood risk

3.10.1 The Envirocheck report indicates the site is not located within a fluvial or tidal flood plain. It should be noted that this information does not constitute a site specific Flood Risk Assessment (FRA), and a full FRA may be required for the development to support a planning application or satisfy planning conditions.

3.11 Shallow mining and natural subsidence hazards

3.11.1 Envirocheck use the British Geological Survey database to establish hazard ratings for shallow mining and natural subsidence hazards. The database indicates the following ratings for the site.

Table summarising Envirocheck mining and subsidence hazards

Hazard	Envirocheck rating
Shallow mining hazard rating	No hazard
Potential for collapsible ground stability hazard	Very low
Potential for compressible ground stability hazard	No hazard
Potential for ground dissolution stability hazard	No hazard
Potential for landslide ground stability hazard	Low
Potential for running sand ground stability hazard	Low
Potential for shrinking or swelling clay ground stability hazard	Moderate

Table 3.11

3.12 Borehole records

3.12.1 The British Geological Survey (BGS) retain records of boreholes formed from ground investigations carried out on a nationwide basis. The location of boreholes with records held by the BGS is recorded on the borehole map contained in Appendix P. We do not normally obtain copies of these records but can do on further instructions. There is normally a charge made by the BGS for retrieving and copying these records.

3.13 Mining and dissolution hazards

3.13.1 Envirocheck's database indicates the subject site is **not** within a zone of conclusive rock mining based upon the findings of a report completed by Ove Arup and Partners in December 1991, commissioned by the Department of the Environment (DoE). It forms part of the ''Geology and Mining Planning Research Programme'' of the DoE, aimed at assessing the significance of environmental hazards and their influence on planning and control of development.

3.14 Enquiries with statutory undertakers

3.14.1 We have contacted the following Statutory Undertakers (SUs) to obtain copies of their records in order to avoid damaging their apparatus during our fieldwork activities: -

a) BT Openreach Ltd
b) Transco
c) UK Power Network
d) National Grid Gas Plc
e) London Underground Ltd

Copies of responses received prior to publication of this report are presented in Appendix M. These records have been obtained solely for the purposes described above. Some of these records have been obtained from the Internet and from our database without contacting the statutory undertaker direct. Occasionally, SU information is recorded on drawings larger than A3, and thus cannot be easily presented in this report. In such cases we will copy the correspondence but not incorporate the drawing in this report, and maintain the records on our office file.

3.14.2 In addition, we have visited the linesearch web site (www.linesearch.org) which provides a report on national grid networks (National Gas and Electricity Transmission Networks). Again a copy of their report is presented in Appendix M.

3.14.3 Normally Statutory Undertakers drawings record the approximate location of their services. We recommend further on site investigations be undertaken to confirm the position of the apparatus and thus establish the effect on the proposed development and the necessity or otherwise for the permanent or temporary diversion of the service to allow the construction of the development to safely and successfully proceed.

3.15 Enquiries with local authority building control and environmental health officers

3.15.1 We have contacted the local building control authority who do not maintain comprehensive records of ground conditions in the borough. Their response is presented in appendix N.

3.15.2 We have contacted the local authority environmental health officers and are currently awaiting their responses. Should their response provide us with information of any concern/relevance we will update the report on receipt.

4 Fieldwork

4.1 General

4.1.1 Fieldwork comprised the excavation of five boreholes, two dynamic cone penetration tests and four trial pits. Fieldwork was carried between October and November 2014.

4.1.2 A plan of the site showing observed/existing site features and position of exploratory points is presented on Drawing 02. The position of exploratory points relative to site development proposals is presented on Drawing 02. The position of exploratory points shown on these plans is approximate only and confirmation of these positions is subject to dimensional surveys, which is considered outside our brief.

4.1.3 The extent of fieldwork activities and position of exploratory points were defined by the Client's Engineer.

4.1.4 Exploratory points were positioned to avoid known locations of underground services, to avoid possible location of proposed foundations but were also positioned to provide a reasonable coverage of the site. Prior to commencement of exploratory excavations an electronic cable locating tool was used to scan the area of the excavation. If we received a response to this equipment then the excavation would be relocated.

4.1.5 All soils exposed in excavations were described in accordance with BS EN ISO 14688 *'Identification and Classification of soil'* and BS EN ISO 14689 *'Identification and classification of rock'.*

4.2 Site restrictions

4.2.1 Due to limited access, boreholes to the rear of the property and trial pits were carried out using hand held tools/equipment. Dynamic Cone Penetration testing was thus restricted to the front of property.

4.3 Exploratory trial pits

4.3.1 Trial pits TP01-TP04 were excavated using hand tools to a maximum depth of 1.93 metres.

4.3.2 Trial pits exposed foundation arrangements to existing buildings within and along the site boundaries. The trial pit excavations were backfilled with excavated material, which was compacted using hand held ramming tools. The surface was reinstated to match the original surroundings. A Geotechnical Engineer supervised the excavations.

4.3.3 Surface concrete/bituminous bound materials were broken out prior to our arrival on site.

4.3.4 Sampling and logging was carried out as trial pit excavations proceeded. The density of granular soils encountered in excavations was gauged by the ease of excavation.

4.3.5 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from the sides of trial pits. If as a consequence of visual or olfactory evidence, a sample was suspected to be contaminated by organic material, the sample was stored in an amber glass jar with a PTFE sealing washer.

4.3.6 Soil samples for classification laboratory testing were taken from the side of trial pits or from bulk samples taken from the excavator bucket. The sample was placed in a plastic bag and subsequently sealed and labelled.

4.3.7 Soil samples were obtained to meet quality class 3 to 5 as described in BS EN I997-2:2007. Sample sizes were appropriate for the laboratory test being considered.

4.3.8 Trial pit records are presented in Appendix C.

4.4 Driven tube sampling

4.4.1 Boreholes BH01 to BH05 were formed using driven tube sampling equipment. Driven tube sampling comprises driving 1m long steel sample tubes, which are screw coupled together or coupled to extension rods and fitted with a screw on cutting edge. The sample tubes are of various diameters, generally commencing with 100mm and reducing, with depth, to 50mm, and include a disposable plastic liner which is changed between sampling locations in order to limit the risk of cross contamination. On completion of excavation the liner containing the sample is cut open and the soil sample logged by a geo-environmental engineer. Borehole records are presented in Appendix D.

4.4.2 Samples for determination concentration of chemical contaminants are taken from samples obtained in the disposable tubes as sub-samples, using stainless steel sampling equipment, which is cleaned with de-ionised water.

4.4.3 The driven tube sampler obtains samples under category A allowing laboratory test quality classes 3 to 5 as described in BS EN ISO 22475-1:2006.

4.4.4 A pocket penetrometer was used in the cohesive soils retrieved from the borehole. This tool is deemed to measure the apparent ultimate bearing capacity of the soil under test. The pocket penetrometer is calibrated in kg/cm2. The reading can be approximately converted to an equivalent undrained shear strength by multiplying the results by a factor of 50. The results are reported on borehole records. The pocket penetrometer is not covered by British Standards.

4.4.5 A summary of pocket penetrometer results obtained from the cohesive soils retrieved from the boreholes are presented in graphical format on Drawing 04.

4.4.6 Groundwater monitoring standpipes were installed in boreholes DTS01, DTS03 and DTS05. The standpipes were installed following the recommendations of BS EN ISO 22475-1:2006 '*Geotechnical Investigation and Testing – Sampling methods and groundwater measurements – Part 1: Technical Principles for execution*'. Details of the standpipe installations are recorded on Drawing 05.

4.4.7 Water levels in the standpipes have been measured during a return visit to the site. The water level was measured using a measuring tape calibrated in 1mm intervals with an electronic end piece, which emits an alarm sound in contact with water. Water levels are measured from ground levels at the borehole position.

4.4.8 Soil infiltration testing was carried out in boreholes DTS01, DTS03 and DTS05 at depths of between 0.9m and 4.3m. The infiltration testing was carried out following the procedure described in Building Research Establishment (BRE) Digest 365 (2007) "Soakaway Design". Records of the test results and calculations to determine the soil infiltration rate are presented in Appendix I. It should be noted that the testing has not been strictly carried out in accordance with the BRE publication, as the minimum size of the test hole (described in the BRE document) could not be achieved in the borehole, however the test provides an indication of the likely permeability of the soils under test. A standpipe was installed in the boreholes to retain stability during infiltration testing. Details of the standpipe installation are recorded on Drawing 06.

4.5 Dynamic cone penetration testing

4.5.1 Dynamic Cone Penetration (DCP) testing was carried out in two locations. Dynamic Cone Penetration testing consists of driving a 50mm diameter, 90^{o} cone into the ground, via an anvil and extension rods with successive blows of a freefall hammer. The number of blows required to drive the cone each successive 100mm (N100) is recorded.

4.5.2 Dynamic Cone Penetration testing was carried out following BS EN ISO 22476-2:2005 and the apparatus used was categorised as 'Super heavy' (DPSH-B) in accordance with the standard.

4.5.3 Dynamic cone penetration test data is presented in graphical format on Drawing 03.

4.6 Sampling strategies

4.6.1 Geotechnical

4.6.1.1 In general we adopted a judgemental sampling strategy in relation to geotechnical aspects of the investigation. The location and frequency of sampling was carried out in consideration of the following:-

i) Topography
ii) Geology (including Made Ground)
iii) Nature of development proposals

4.6.2 Environmental

4.6.2.1 Details of sampling with respect to contamination issues are described in Section 8.

4.6.3 Sample retention

4.6.3.1 Samples are stored for a period of one month following issue of this report unless otherwise required.

5 Ground conditions encountered

5.1 Soils

5.1.1 Each exploratory excavation encountered a similar profile of soils considered to be Made Ground or Topsoil overlying Claygate Member deposits.

5.1.2 **Topsoil** was encountered within the rear garden, extending to approximately 0.2-0.3m depth. It comprised orange brown clay with occasional gravels of flint.

5.1.3 **Made Ground** encountered within external areas to the front of the property generally comprised generally comprised low to medium strength dark brown and orange brown sandy slightly gravelly clay with gravels of ash, brick, flint, concrete and clinker. Such Made Ground extended to depths of 1.8m beneath the driveway and 0.5m within the front garden.

5.1.4 Within the footprint of the building, Made Ground generally comprised medium dense dark brown slightly clayey gravelly sand and brown to dark brown sandy gravel. Gravels predominantly consisted of ash, clinker, concrete, brick and flint.

5.1.5 **Claygate Member** generally consisted of loose to medium dense orange, orange brown and grey silty fine SAND with varying quantities of clay bands throughout the predominantly granular soils. Gravels consisted of flint.

5.1.6 Geological records indicate Claygate Deposits are located at crop on site with Claygate Member recorded at surface approximately 50m to the north. The composition of near surface deposits on site however were consistent with Claygate Member soils.

5.2 Topsoil

5.2.1 As a practice we have adopted the following policy for description of topsoil. If surface soils exhibit a visually significant organic content and darker colour than the soils it overlies (which are considered to be naturally deposited) then we will describe the soil as topsoil. In some cases it is difficult to visually distinguish the interface between topsoil and subsoils below, which may also exhibit an organic content, and in such cases we will adopt an estimate of the interface but may also use the terms ‘grading into’ with some defining depths.

5.2.2 If ‘topsoil’ deposits include materials such as ash, brick and other man made materials, or the topsoil overlies Made Ground deposits we will term the material ‘Made Ground’, even though it may still be able to support vegetable growth, and potentially reused as topsoil.

5.2.3 Topsoil can be classified following a number of test procedures as described in BS3882: 2007 *'Specification for Topsoil and Requirements for use'*, to allow its uses to be determined. We do not carry out such testing unless specifically instructed to do so.

5.3 Existing foundation arrangements

5.3.1 Trial pit **TP01** was excavated within the garage, on the northern wall of the kitchen to a depth of 1.71m and exposed two rows of brick corbels onto dense, clinker aggregate, concrete, extending to a depth of 1.7m below existing surface level. The concrete was located on Claygate Member soils consisting of medium dense orange brown slightly gravelly, fine sand. Gravel consists of rounded flint.

5.3.2 Trial pit **TP02** was excavated on the south western corner of the property, targeting the existing corner of the property and the adjacent property boundary wall. Trial pit TP02 was excavated to a depth of 2.5m exposing two rows of brick corbels onto concrete with clinker aggregate beneath the property on site. Further concrete was observed to the southwest of the excavation and beneath the adjacent property to a depth of 2.35m. The foundations were located on natural Claygate Member soils consisting of medium dense light brown very silty fine sand.

5.3.3 Trial pit **TP03** was excavated toward the north west corner of the garage wall. Trial pit TP03 was excavated to a depth of 1.93m exposing two rows of brick corbels onto a clinker aggregate concrete. The foundations were located on Claygate Member consisting of medium strength orange brown sandy slightly gravelly CLAY. Gravels consist of brick.

5.3.4 Trial pit **TP04** was excavated on the southern boundary of the property, to the west of the property to establish the foundation arrangement to the adjacent conservatory. Trial pit TP04 was excavated to a depth of 1.1m exposing a concrete strip footing to a depth of 0.7m for the neighbouring property.

5.4 Groundwater

5.4.1 Minor water seepages were observed in one of the exploratory excavations during fieldwork. Subsequent groundwater monitoring has indicated slight accumulation of water within DTS03 and DTS05. A summary of our observations is tabulated below:

Table summarising groundwater observations

Exploratory point	Depth (m) below ground levels	Observations
DTS01	Fieldwork:4.7m	Minor water seepages observed at 4.7m during fieldwork
	Monitoring:4.48-4.6m	Groundwater levels recorded during monitoring.
DTS03	Fieldwork: Dry	No groundwater encountered during fieldwork.
	Monitoring: Dry-1.96m	Slight accumulation of water encountered during monitoring.
DTS05	Fieldwork: Dry Monitoring: Dry	No groundwater encountered during fieldwork or subsequent monitoring.

Table 5.3.1

5.3.2 It should be noted that water levels will vary depending generally on recent weather conditions and only long term monitoring of levels in standpipes will provide a measure of seasonal variations in groundwater levels.

6 Laboratory testing

6.1 Classification testing

6.1.1 Laboratory testing was carried out in accordance with BS1377: 1990 *"Methods of Test for Soils for Civil Engineering Purposes"* and limited to the following: -

i) Determination of the liquid limit – one point cone penetrometer method (method 4.4)
ii) Determination of the plastic limit and plasticity index (method 5)
iii) Determination of particle size distribution – wet sieving (method 9.2)

6.1.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme. Copies of laboratory test result certificates are presented in Appendix E.

6.2 Chemical testing

6.2.1 Laboratory testing was carried out as deemed necessary and carried out using the following techniques:

- Using inductively coupled plasma mass spectrometry (ICP-MS), determination of concentration of metals, semi-metals and soluble sulphate

- Using gas chromatography flame ionisation detection methods (GC–FID), determination of concentration of polycyclic aromatic hydrocarbons (PAH)

- Using electromagnetic measurement, determination of pH

- Following methods described in the Environment Agency publication *'Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures'* (April 2005) – suite of testing in accordance with Table 2.1.

6.2.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme. Copies of laboratory test result certificates are presented in Appendix F.

7 Engineering assessment

7.1 General description of the development

7.1.1 The following assessments are made on the investigatory data presented in the preceding sections of this report and are made with reference to specific nature of the development. Should the development proposals change then it may be necessary to review the investigation and report.

7.1.2 Proposals are to construct a single storey deep basement to the rear part of the building of together with a single storey ground floor extension to the rear and a single storey extension to the front of the existing garage. As ground levels to the rear of the existing building are about 1.3m below ground floor levels excavations to formation levels of the new basement will extend around 1.9m below ground levels and around 0.8m below air raid shelter floor levels. Excavations to basement floor formation level below the existing house / garage could extend to depths of around 3.2m.

7.1.3 Plans outlining development proposals are provided on Drawing 03.

7.2 Building foundation, design and construction

7.2.1 Definitions of geotechnical terms used in the following paragraphs are provided in Appendix A.

7.2.2 Single storey extension to the northeast

7.2.2.1 In our opinion naturally deposited Claygate Member will adequately support the proposed single storey extension to the northeast on concrete strip/trench fill foundations. Based on laboratory determination of plasticity and following National House Building Council (NHBC) Standards Chapter 4.2, we recommend foundations extend to a minimum depth of 0.9m below existing or proposed ground levels whichever gives the deeper founding level. In all cases we recommend foundation excavations fully penetrate any Made Ground deposits and extend into the naturally deposited Claygate Member by a minimum of 0.3m. The majority of the near surface soils comprised granular soils however locally, clay lenses were recorded. It should thus be noted that there are a number of trees and major vegetation on the site which will require foundation depths exceeding the minimum depth defined above. Further guidance on this is provided in the following report paragraphs.

7.2.2.2 The near surface Claygate Member deposits exhibit a degree of plasticity and potentially adopting a conservative approach, our assessment of bearing values is based on the assumption that the soils exhibit cohesion. Calculations based on conservative undrained shear strength of say 60kN/m^2 (medium strength category) below proposed founding levels indicate that the ultimate bearing capacity for a 0.6m wide strip/trench fill foundation supporting structural loads on naturally deposited Claygate Member at 0.9m depth would be about 430kN/m^2. Adopting a factor of safety of 3 on this value the presumed bearing value would be about 160kN/m^2. We recommend this value be limited further to an allowable bearing pressure of 150kN/m^2 with a view to producing acceptable levels of total and differential settlement.

7.2.2.3 Based on observations in trial pit excavations, it is likely that excavations to founding levels will encounter both cohesive and granular soils. Whilst these soils will ultimately generate similar amounts of total settlement under applied foundation loads, the rate at which settlement will be achieved will differ. Granular soils will produce settlements almost immediately loads are applied with cohesive soils generating settlement some years after completion of construction. Thus foundations (particularly strip / trench fill concrete foundations) traversing differing soil types will be subject to some differential settlements due to differing rates at which total settlement will be achieved. To minimise the effects of such differing rates of settlement we recommend foundations are reinforced to stiffen concrete and thus resist the effects of differential movement where foundations traverse cohesive and granular soils. In the event that a soft area is located in the course of foundation excavations then we recommend excavations continue to locate stiffer/denser soils.

7.2.3 Basement construction

7.2.3.1 Our client's Structural Engineer proposes to underpin existing buildings around the perimeter of the proposed basement allowing basement excavations to be carried out with temporary propping providing lateral restraint to the underpinning whilst a permanent concrete box to form the basement is installed.

7.2.3.2 With reference to development proposals (see 7.1.2) and for the purposes of our assessment we have considered a worst case scenario of the excavation to formation level of the basement floor extending to around 3.2m.

7.2.3.2 Mass concrete underpinning

7.2.3.2.1 Mass concrete underpinning, would be undertaken in stages beneath the existing elevations. The concrete would act as a retaining structure in the temporary and permanent conditions. Following underpinning, the basement excavation will commence.

7.2.3.2.2 Once the basement excavations are complete, a waterproof, concrete, structural box will be constructed, lining the excavation, with the basement slab installed to provide permanent support to perimeter retaining walls, essentially acting as a raft foundation. We anticipate the raft will also provide support to new columns supporting openings below walls to the original building within the basement.

7.2.3.2.3 The design of the raft foundation will be governed by the net load of the new structure, taking consideration of the effects of the basement excavation. The raft could be constructed so that it forms a rigid box with the retaining walls so that differential movements are minimised. A movement (settlement/heave) analysis should be carried out once the proposed loads have been determined which will assist in the detailed design of the raft.

7.2.3.2.4 Underpinning bays, both in the short and long term will act as a gravity retaining structure to remaining walls around the perimeter of the building. We recommend the underpinning concrete is designed to resist lateral pressures derived using K_0 (active earth pressure at rest) which, following guidance in Tomlinson, 2001, can be determined by $K_0 = (1 – \sin \Phi)$ for the Claygate Member which are considered over consolidated.

7.2.3.3 Settlement around and inward yielding of basement excavations

7.2.3.3.1 The following analysis is based on observations of ground movements around basement excavations in clays as reported in Tomlinson '*Foundation design and construction*' (seventh Edition).

7.2.3.3.2 It is recognised that some inward yielding of supported sides of strutted excavations and accompanying settlement of the retained ground surface adjacent to the excavation will occur even if structurally very stiff props / strutting is employed. The amount of yielding for any given depth of excavation is a function of the characteristics of the supported soils and not the stiffness of the supports. Based on observations of other excavations in granular sands (which will be the case at this site) the average maximum yield / excavation depth (%) was 0.19 with a range of 0.04 to 0.46. Assuming a maximum excavation depth of 3.25m then the likely inward yield will be in the order of 3.2 x 0.19/100 x1000 = 6mm. Taking a worst case upper bound factor (0.3%) then the inward yield would be about 14mm

7.2.3.3.3 Coincidental with the inward yield of perimeter walls, some settlement of the retained soils around the excavation will occur. Again, based on published observations, the ratio of surface settlement to excavation depth in sands is about 0.1% (range 0.1 to 0.2). Adopting the average of 0.1, and a maximum 3.2m deep excavation, then surface settlement in the order of 3.2 x 0.1/100 x 1000 = 3.2mm will occur. Again taking an upper bound factor of 0.2% then the surface settlement will be 6mm. Importantly, whilst some surface settlement will occur around the excavation, this settlement profile will extend for a distance of about 3 times the depth of excavation i.e. about 10m in a reasonably linear fashion. For a settlement of 3.2mm immediately adjacent to the excavation, diminishing over 10m this amounts to an angle of distortion of about 1 in 3000 (again a worst case of 1 in 666). Such an angle of distortion would not cause damage to any nearby buildings or indeed below ground services. Published values indicate angles of distortions up to 1 in 500 could cause crack damage in buildings and with structural damage around 1 in 150.

7.2.4 Foundation excavation stability

7.2.4.1 Based on our observations of the stability of the sides of trial pit excavations we consider there is a possibility of some overbreak/instability in the sides of foundation excavations producing a wider than planned trench widths resulting in an increase in the quantity of foundation concrete to fill voids produced by instability of trench sides. On the whole however, pit sides remained stable in the short term.

7.2.4.2 Based on groundwater observations in exploratory excavations, it is considered unlikely that significant groundwater will be encountered in foundation excavations. Localised perched water lenses may be encountered, resulting in minor groundwater seepages and potentially promoting collapse of trench sides during construction. We anticipate any water inflows will be controlled with nominal pumping techniques.

7.2.4.3 The silty nature of the near surface Claygate Member deposits will render them moisture susceptible with small increases in moisture content promoting rapid deterioration. We recommend, therefore, that as soon as foundation excavations are opened foundation concrete be poured as quickly as practically possible.

7.2.5 Basement heave

7.2.5.1 The proposed construction of a 1-3m deep basement on site will result in an approximate unloading of around 20-60kN/m^2, which will result in an elastic heave and long term swelling of the cohesive soils on site, which we estimate to be in the order of 15mm. The effects of longer term swelling movement will be mitigated by the load applied by the new structure.

7.2.6 Piled basement retaining walls

7.2.6.1 Should it be decided that a piled foundation solution be utilised/partially utilised, piles should penetrate the basement depth and potentially the Claygate Member to extend into the Claygate Member soils at depth. The depth of piling would be dependent upon the height to be retained, and vertical load carrying requirements and indeed geotechnical parameters. General guidance on construction of basements is provide in *'Design and construction of deep basements including cut and cover structures'* published by the Institution of Structural Engineers (March 2004).

7.2.6.2 The design of the basement support in the temporary and permanent condition needs to take into account the need to maintain the stability of the excavation and surrounding structures. The choice of wall may be governed by access restrictions but it is understood that a contiguous bored piled wall is the favoured option. A contiguous bored pile wall can be incorporated into the permanent works as is can also provide support for the permanent lateral loads.

7.2.6.3 The ground movements associated with the basement excavation will depend on the method of excavation and support as well as the overall stiffness of the basement structure in the temporary condition. Suitable propping will therefore be required to provide the necessary rigidity.

7.2.6.4 Should a piled foundation solution be considered, an additional deep borehole, extending through the Claygate Member and into the London Clay at depth would be required in order to obtain design parameters for piles.

7.2.6.5 Space and access constraints may limit the use of piles.

7.3 Influence of Trees and other major vegetation

7.3.1 Soil classification and new foundation design

7.3.1.1 The results of plastic and liquid limit determinations performed on two samples of the cohesive Claygate Member soils, taking a conservative approach, indicate the deposits are soils of medium volume change potential when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2. Foundations taken down onto a depth of 0.9m will penetrate the zone of shrinkage and swelling caused by seasonal wetting and drying. Trees and other major vegetation extend this zone and will require deeper foundations. A good guide to this subject is provided in NHBC Standards, Chapter 4.2.

7.3.2 New planting

7.3.2.1 Any planting schemes should also take into account the effect that new trees could have on foundations when they reach maturity. Again a good guide to this subject is provided in NHBC Standards, Chapter 4.2.

7.3.3 Tree species identification

7.3.3.1 There are a number of trees and other major vegetation at the site. We recommend a qualified Arboriculturist (listed in the Arboricultural Association Directory of Consultants – www.trees.org.uk) be appointed to determine the location, height (and mature height) and water demand of all trees/major hedgerows at the site, information, which will be necessary to design foundations in accordance with NHBC Standards, Chapter 4.2.

7.3.4 Influence of trees on existing buildings

Some existing trees may be within influencing distance of existing foundations as the trees grow towards maturity, which could result in future crack and movement damage. We recommend an assessment is carried out to determine which trees are within influencing distance with removal likely to be a solution to avoid future risks to existing and remaining buildings.

7.3.5 Existing foundations

7.3.5.1 Exploratory excavations exposed existing foundations comprising concrete strips extending to depths in the range of 1.7-2.35m below ground level and constructed on soils which are considered naturally deposited Claygate Member soils. As these foundations are greater than the 0.9m depth they penetrate soils which will be subject to variations in water content and thus volume due to influences of seasonal weather conditions, thus reducing the risk of seasonal movement of foundations, and superstructural damage. We recommend a survey is carried out using NHBC guidelines to establish the risk of trees affecting existing buildings, and thus action required to mitigate risks of future damage. We will be pleased to implement this on further instructions.

7.4 Ground Floor Construction

7.4.1 We anticipate the basement slab will act as a ground bearing floor slab for the extension to the rear. Toward the front of the property, exploratory excavations indicate the Made Ground ranges from approximately 0.5m in DTS01 to 1.2m in TP01. On this basis, we recommend the use of a suspended ground floor with a sub floor void determined following NHBC Standards, Chapter 4.2 is adopted for the front extension.

7.5 Service Trench Excavations

7.5.1 Generally, we anticipate the sides of trench excavations will remain stable in the short term. Locally, excavations will encounter more granular soils, which may include some water. In such cases we are of the opinion that water seepages / inflows could promote progressive instability in trench sides requiring continuous trench sheet shoring to maintain an open excavation. We anticipate water will be controlled with nominal pumping techniques.

7.5.2 We recommend any trench excavation requiring human entry is shored as necessary to conform with current best practice, and accepted by the Health and safety Executive (HSE) and in particular, following guidance provided in the HSE publication 'Health and safety in construction (HSG 150)' (www.hse.gov.uk)

7.6 Infiltration Potential

7.6.1 Requirements for use of infiltration systems

7.6.1.1 It is a requirement under H3 (3) of the current building regulations to discharge stormwater collected by a development to soakaways as a priority (as opposed to water courses and sewers).

7.6.2 Infiltration measurements

7.6.2.1 The Claygate Member deposits are permeable. The permeability of these soils was measured in three boreholes, generally following the procedures described in Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*" and BS 5930: 1999, (Section 25.4) and CIRIA special publication 25 '*site investigation manual'* (where groundwater was recorded in the base of the borehole) Records of testing and calculations are presented in Appendix I.

7.6.2.2 Tests were carried out at depths of between 0.9 and 4.3mbgl. Infiltrations rates in the range of 3.1×10^{-4} m/s and 8.4×10^{-6} m/s have been recorded. Faster infiltration rates were recorded within the predominantly granular deposits to the rear of the property, in comparison to rates recorded in DTS01 to the front of the property wherein substantial clay lenses were also recorded. It should be noted that testing has not been strictly carried out in accordance with the BRE publication, as the minimum size of the test hole (BRE 365 states that the trial pit should be 0.3 to 1 m wide and 1 to 3 m long and should have vertical sides trimmed square) could not be achieved in the borehole, however the test provides an indication of the likely permeability of the soils under test.

7.6.2.3 Details of the standpipe installations (in which the tests were carried out) are recorded on Drawing 06.

7.6.3 Design of infiltration systems

7.6.3.1 As described above it is likely the Claygate Member will exhibit some variation in permeability. On this basis the use of trench type soakaways will increase the likelihood of locating more permeable soils along its length and by evenly distributing stormwater along their length minimise the risk of promoting formation of solution cavities.

7.6.3.2 If infiltration systems are adopted as a means of stormwater disposal (including permeable pavement construction), we recommend approval for the use of soakaways is sought from the Environment Agency. It should be noted that the Groundwater Regulations 1998 require that list 1 substances (e.g. Hydrocarbons) are to be prevented from entering groundwater receptors and list 2 substances (e.g. metals) are also restricted. Typically, the Environment Agency will require details of the proposed soakaway systems, showing pollution prevention measures. They will also require geological and geo-hydrological information, (contained in this report) as well as the risks of chemical contaminants in the ground affecting water resources. It is also typical requirement that there is an 'unsaturated zone' between the base of the soakaway system and the groundwater table (saturated zone) providing attenuation capacity.

7.7 Pavement Foundations

7.7.1 It is anticipated that the proposed access road and associated hardstanding areas will be located at or about existing ground levels with formation located on Made Ground and/or Claygate Member soils.

7.7.2 Equilibrium CBR (California Bearing Ratio) values (with reference to Transport and Road Research Laboratory (TRRL) Report LR1132 '*Structural design of Bituminous Roads'*) are derived from knowledge of soil classification data (plasticity index for soils exhibiting cohesion (clay type) and particle size distribution for granular soils), the location of the water table pavement thickness, and weather conditions at the time of construction. It is anticipated that excavations to formation levels will encounter a mixture of both granular and cohesive soils. Granular soils will provide numerically high CBR values, but cohesive soils will typically provide significantly lower values. Assuming an average plasticity index of say 20 for cohesive soils, a low water table, a 'thin' pavement the following equilibrium CBR values are derived for varying construction conditions

Equilibrium CBR values for differing construction conditions

Poor	Average	Good
CBR = 3%	CBR = 5%	CBR = 6%

Table 7.7.2

7.7.3 It is possible to derive the 'insitu' CBR value at formation from undrained shear strength data by applying a conversion factor of 23 (refer TRRL laboratory report LR889). Thus adopting pessimistic undrained shear strength of say 50kN/m^2 at formation level (based on insitu shear strength measurements) then an equivalent CBR value can be obtained i.e.

$$\text{Insitu CBR = undrained shear strength } {C}/{23} = \quad 2.2\%$$

The 'insitu' CBR derived above, is susceptible to change dependent upon weather conditions during construction. The equilibrium CBR value derived in paragraph 7.7.2 above is an estimate of the CBR value, which will predominate during the life of the pavement. We recommend the insitu CBR of 2.2% derived from shear strength data be utilised for design purposes and reassessed during construction. The fact that the clay subgrade soils are likely to be deemed frost susceptible will probably be the overriding criteria for pavement foundation design purposes. It should also be noted that the thickness of the pavement foundation also relates to the amount and loading from construction traffic, which is discussed in detail in the Transport and Road Research Laboratory (TRRL) Report LR1132 '*Structural design of Bituminous Roads'*.

7.7.4 Made Ground deposits at the site exhibit a degree of variation in compactness. Some long term settlement of hardstandings will occur due to consolidation of the Made Ground deposits and from applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as potentially applied loading patterns are not known. Assuming a constantly applied uniformly distributed load of say 10kN/m^2, settlement in the order of 10mm could occur within 5 to 10 years of construction. Equally, some differential settlement could occur in the long term, if hardstandings are not uniformly loaded. We suggest that pavements under transient (vehicular) loads are unlikely to generate significant levels of settlement.

7.7.5 Once formation levels have been established it is recommended that the formation be trimmed and rolled following current requirements of the Highways Agency Specification for Highways Works (clause 616) (refer www.dft.gov.uk/ha/standards/mchw/vol1) Such a process will identify any soft areas, which we recommend be either excavated out and backfilled with a suitable well compacted material similar to those exposed in the sides of the resulting excavation, or large cobbles of a good quality stone rolled into the formation to stabilise the 'soft' area.

7.7.6 The silty nature of the Made Ground and Claygate Member will render them moisture susceptible with small increases in moisture content giving rise to a rapid loss of support to construction plant. We therefore recommend, as soon as formation is trimmed and rolled, that sub-base is laid in order to avoid deterioration of the subgrade in wet or frosty conditions.

8 Chemical contamination

8.1 Contaminated land, regulation and liabilities

8.1.1 Statute

8.1.1.1 Part IIA of the Environment Protection Act 1990 became statute in April 2000. The principal feature of this legislation is that the hazards associated with contaminated land should be evaluated in the context of a site-specific risk based framework. More specifically contaminated land is defined as:

"any land which appears to the local authority in whose area it is situated to be in such a condition, by reasons of substances in, on or under the land, that:

a) Significant harm is being caused or there is a significant possibility of such harm being caused; or
b) Pollution of controlled waters is being or is likely to be caused".

8.1.1.2 Central to the investigation of contaminated land and the assessment of risks posed by this land is that:

i) There must be contaminants(s) at concentrations capable of causing health effects (*Sources).*
ii) There must be a human or environmental receptor present, or one which makes use of the site periodically *(Receptor)*; and
iii) There must be an exposure pathway by which the receptor comes into contact with the environmental contaminant *(Pathway).*

8.1.1.3 In most cases the Act is regulated by Borough or District Councils and their role is as follows:

i) Inspect their area to identify contaminated land
ii) Establish responsibilities for remediation of the land

iii) See that appropriate remediation takes place through agreement with those responsible, or if not possible:
   - by serving a remediation notice, or
   - in certain cases carrying out the works themselves, or
   - in certain cases by other powers

iv) keep a public register detailing the regulatory action which they have taken

8.1.1.4 For "special" sites the Environment Agency will take over from the Council as regulator. Special sites typically include:-

- Contaminated land which affects controlled water and their quality
- Oil refineries
- Nuclear sites
- Waste management sites

8.1.2 Liabilities under the Act

8.1.2.1 Liability for remediation of contaminated land would be assigned to persons, organisations or businesses if they caused, or knowingly permitted contamination, or if they own or occupy contaminated land in a case where no polluter can be found.

8.1.3 Relevance to predevelopment conditions

8.1.3.1 For current use, Part IIA of the Environmental Protection Act 1990 provides the regulatory regime. The presence of harmful chemicals could provide a 'source' in a 'pollutant linkage' allowing the regulator (local authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

8.1.4 Relevance to planned development

8.1.4.1 The developer is responsible for determining whether land is suitable for a particular development or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

a) Whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model

b) Whether the development proposed will create new linkages e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors, and

c) What action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable safe development and future occupancy of the site and neighbouring land?

8.1.4.2 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, 'Site preparation and resistance to contaminants and moisture' which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from chemical contaminants.

8.1.5 Pollution of controlled waters

8.1.5.1 Part IIA of the Environment Protection Act 1990, defines pollution of controlled waters as

'The entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter'

8.1.5.2 Paragraphs A36 and A39 of statutory guidance (DETR 2000) further define the basis on which land may be determined to be contaminated land on the basis of pollution of controlled waters.

'Before determining that pollution of controlled waters is being, or likely to be, caused, the Local Authority should be satisfied that a substance is continuing to enter controlled waters, or is likely to enter controlled waters. For this purpose, the local authority should regard something as being likely when they judge it more likely than not to occur'

'Land should not be designated as contaminated land where:

a) A substance is already present in controlled waters:
b) Entry into controlled waters of that substance from the land has ceased, and
c) It is not likely that further entry will take place.

Substances should be regarded as having entered controlled waters where:

a) They are dissolved or suspended in those waters; or
b) If they are immiscible with water, they have direct contact with those waters, or beneath the surface of the waters'

8.1.5.3 Controlled waters are defined in statute to be:

'territorial waters which extend seawards for 3 miles, coastal waters, inland freshwaters, that is to say, the waters in any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit, and groundwaters, that is to say, any waters contained in underground strata.'

8.1.6 Further information

8.1.6.1 The above provides a brief outline as regards current statute and planning controls. Further information can be obtained from the Department for the Environment, Food and Rural Affairs (DEFRA) and their Web site www.defra.gov.uk.

8.2 Objectives and procedures

8.2.1 Objectives

8.2.1.1 This report section discusses investigations carried out with respect to chemical contamination issues relating to the site. The investigations were carried out to determine if there are any liabilities with respect to Part IIA of the Environment Protection Act. As stated in Section 2.4.2, the investigation process followed the principles of BS10175: 2011 *'Investigation of potentially contaminated sites – Code of Practice'*, with the investigation combining a desk study (preliminary investigation) together with the exploratory and main investigations (refer BS10175: 2011 for an explanation).

8.2.1.2 This section of the report produces *'Conceptual models'* based on investigatory data obtained to date. The conceptual model is constructed by identification of *contaminants* and establishment of feasible *pathways* and *receptors.* The conceptual model allows a *risk assessment* to be derived. Depending upon the outcome of the risk assessment it may be necessary to carry out remediation and/or further investigations with a view to eliminating, reducing or refining the risk of harm being caused to identified receptors. If appropriate, our report will provide recommendations in this respect.

8.2.1.3 Definition of terms used in the preceding paragraph and subsequent parts of this section of the report are presented in Appendix B.

8.2.2 Procedure to assess risks of chemical contamination

8.2.2.1 For the purposes of presenting this section of this report, we have adopted the following sequence in assessing risks associated with chemical contamination.

Table outlining sequence to assess risk associated with chemical contamination

Conceptual model element	Contributory information	Outcome
Receptor	Development categorisation	Identification of receptors at risk of being harmed Method of analysing test data Criteria for risk assessment modelling
Pathways	Geology and ground conditions Development proposals	Identification of critical pathways from source to receptor
Source	Previous site history Desk study information Site reconnaissance Fieldwork observations	Testing regime Identification of a chemical source Analysis of test data and other evidence

Table 8.2.2

8.2.2.2 We have adopted, in general, the procedures described in CIRIA C552 'Contaminated land risk assessment - a guide to good practice' in deriving a risk assessment. Initially we have carried out a 'phase 1 assessment' based on desk study information and site reconnaissance, to produce an initial conceptual model and thus a preliminary risk assessment. This model / assessment is then used to target fieldwork activities and laboratory testing, with the results of this part of the investigation used to allow a phase 2 assessment to be produced by updating the conceptual model and refining the risk assessment.

8.3 Development characterisation and identified receptors

8.3.1 Site characterisation

8.3.1.1 The nature of the site has a significant influence the likely exposure pathways between potentially contaminated soils and potential receptors. The following table summarises elements which characterise the site based on site observations and desk study information.

Summary of site characteristics

Element	Source / criteria	Characteristic
Current land use	Observations	Residential house with domestic garden
Future land use	Advice	Maintained residential use.
Site history	Desk study	Undeveloped prior to construction of property in 1930s.
Geology	Desk study and site investigation	Made Ground over Claygate Member and London Clay at depth.
Ground water	Aquifer potential	Secondary A within Claygate Member
	Abstractions	No active groundwater abstraction points within 2km
	Source protection zone	Site not within source protection zone
Surface waters	Location	Small fish pond located in the rear garden (proposed for infilling). The Fleet river is located 450m to the west.
	Abstractions	None within 2km of the site

Table 8.3.1

8.3.2 Identified receptors

8.3.2.1 The principal receptors subject to harm caused by any contamination of the proposed development site are as follows.

a) Users of the current site (Humans)
b) End users of the developed site (Humans)
c) Construction operatives and other site investigators (Humans)
d) Plants, both before and after development (Vegetation)
e) Controlled waters (Water)

This section of the report assesses those receptors listed above. Section 10 provides a risk assessment in relation to building materials.

8.3.3 Human receptors

8.3.3.1 The Contaminated Land Exposure Assessment (CLEA) model can be used to derive guideline values, against which land quality data can be compared to allow an assessment of the likely impacts of soil contamination on humans. The parameters used within the model can be chosen to allow guideline values to be derived for a variety of land uses and exposure pathways. For example, a construction worker is likely to be exposed in different ways and for different durations than an adult in a residential setting.

8.3.3.2 The site is currently an unoccupied residential property and therefore current site users are not considered as potential receptors. Following completion of the proposed development the site will be a residential property with a domestic garden and basement. On this basis the critical site user (receptor) is considered to be a child under the age of 6 years. This criterion has been used in the conceptual model for the proposed site use. Our assessment also considers construction operatives as adult receptors.

8.3.4 Vegetation receptors

8.3.4.1 Soil contaminants can have an adverse effect on plants if they are present at sufficient concentrations. The effects of phytotoxic contaminations include growth inhibition, interference with natural processes within the plant and nutrient deficiencies.

8.3.4.2 Vegetation is currently present on site and will remain following completion of the development. On this basis vegetation is considered to be a viable receptor.

8.3.5 Water receptors

8.3.5.1 The site lies in an area designated as a Secondary A aquifer probably contained in the Claygate Member. There is a small fish pond located to the rear of the property though we understand this is likely to be infilled as part of the redevelopment. On this basis the critical water receptor following redevelopment is considered to be ground water.

8.4 Identification of pathways

8.4.1 Pathways to human receptors

8.4.1.1 Guidance published by the Environment Agency in Science Report SC050021/SR3 *'Updated technical background to the CLEA model'* provides a detailed assessment of pathways and assessment and human exposure rates to source contaminants. In summary, there are three principal pathway groups for a human receptor:

Table summarising likely pathways	
Principal pathways	**Detail**
Ingestion through the mouth	Ingestion of air-borne dusts
	Ingestion of soil
	Ingestion of soil attached to vegetables
	Ingestion of home grown vegetables
Inhalation through the nose and mouth.	Inhalation of air-borne dusts
	Inhalation of vapours
Absorption through the skin.	Dermal contact with dust
	Dermal contact with soil

Table 8.4

8.4.1.2 Based on the proposed land use, we consider that all of the above exposure pathways will be present. All of the above pathways will also be considered for construction operatives with the exception of those associated with home grown produce. A summary of our pathway assessment is presented in Section 8.4.4.

8.4.1.4 A summary of our pathway assessment is presented in Section 8.4.4.

8.4.2 Pathways to vegetation

8.4.2.1 Guidance published by the Environment Agency in Science Report SC050021/SR (Evaluation of models for predicting plant uptake of chemicals from soil) provides a detailed assessment of plant uptake pathways. In summary, plants are exposed to contaminants in soils by the following pathways:

- Passive and active uptake by roots.
- Gaseous and particulate deposition to above ground shoots.
- Direct contact between soils and plant tissue.

8.4.2.2 All of the above routes of exposure are considered to be present for vegetation.

8.4.3 Pathways to controlled waters

8.4.3.1 A number of pathways exist for the transport of soil contamination to controlled waters. A summary of these pathways is presented below:

- Percolation of water through contaminated soils.
- Near-surface water run-off through contaminated soils.
- Saturation of contaminated soils by flood waters.

8.4.3.2 Near surface soils are generally granular in nature and therefore would provide little resistance to migration of water to groundwater. Percolation of water through contaminated soils is therefore considered to be the most viable pathway. Conversely, near surface soils are unlikely to be amenable to substantial run-off.

8.4.3.3 The site does not lie in a flood plain and therefore saturation by flood-waters is not considered to be a viable pathway.

8.4.4 Summary of identified likely pathways

8.4.4.1 Based on the above assessments, the following table summarises likely pathways of potential chemical contaminants at the site to identified receptors.

Table of likely pathways

Receptor group	Critical receptor	Pathway
Proposed site users	Child	Ingestion air-borne dusts
		Ingestion of soil
		Ingestion of soil attached to vegetables
		Ingestion of home grown vegetables
		Inhalation air-borne dusts
		Inhalation of vapours
		Dermal contact with dust
		Dermal contact with soil
Construction operatives	Adult	Ingestion of air-borne dusts
		Ingestion of soil
		Inhalation of air-borne dusts
		Inhalation of vapours
		Dermal contact with dust
		Dermal contact with soil
Vegetation		Root uptake, deposition to shoots and foliage contact.
Controlled waters	Groundwater	Percolation of water through contaminated soils
	Surface water	Near-surface water run-off through contaminated soils

Table 8.4.4

8.5 Assessment of sources of chemical contamination

8.5.1 Introduction

8.5.1.1 Initially, potential sources of contamination are assessed using the following elements of the investigation process.

- History of the site
- Desk study information
- Site reconnaissance
- Geology
- Fieldwork

These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative sources which may harm identified receptors.

8.5.2 Source assessment – History of the site

8.5.2.1 The history of the site and its immediate surroundings based on published Ordnance Survey maps is described in Section 3.

8.5.2.2 Based on published historical maps, there is no evidence to indicate the site, or its immediate surroundings, has been subject to activities, which could produce a significant source of chemical contamination.

8.5.3 Source assessment – Desk study information

8.5.3.1 Envirocheck presents a detailed database of environmental information in relation to the site including;

- Pollution incidents
- Landfill sites
- Trading activities

8.5.3.2 Based on the Envirocheck data (refer Appendix P) the site has no recorded history of any pollution events, trading activities or landfill sites close to the site which could generate a source of contamination.

8.5.4 Source assessment – Site reconnaissance

8.5.4.1 A full description of the site and observed adjacent land uses is provided in Section 3 of this report. A plan summarising observations made on site during our site reconnaissance visit is presented on Drawing 02.

8.5.4.2 During our site reconnaissance, we did not observe any potential contaminative sources on site which could affect near surface soils and pose a significant risk to human receptors.

8.5.5 Source assessment – Geology

8.5.5.1 Ground investigations indicate the topography local to the site is formed in deposits of Claygate Member. Typically, and in our experience, the Claygate Member does not exhibit any abnormal concentrations of naturally occurring chemical contaminants.

8.5.5.2 With reference to the British Geological Survey (BGS) urban soil chemistry data presented by Envirocheck in Appendix P, background levels of lead are recorded above guideline values. Lead which is prevalent is urban areas, is recorded at concentrations in excess of guideline values within 500m of the site. Spot samples are recorded in the range of 149mg/kg to 382mg/kg. With one spot sample recorded at 762mg/kg located approximately 800m north of the site.

8.5.6 Source assessment - Fieldwork observations

8.5.6.1 Exploratory excavations exposed Made Ground which contained anthropogenic fragments including brick, ash and substantial clinker beneath the footprint of the building. Such fragments potentially present a source of heavy metal and PAH contamination on site which could pose a risk to identified receptors. No ACM was observed within fieldwork excavations.

8.5.7 Source assessment - summary

8.5.7.1 Based on the paragraphs above, we have identified the following potential sources of contamination:

Table summarising results of source assessment

Source	Origin of information	Possible contaminant	Probability of risk occurring	Likely extent of contamination
On site				
Made Ground	Field work	Metals and PAHs	Likely	Site wide

Table reference 8.5.7

8.6 Initial Conceptual Model

8.6.2 Based on our assessment of potential contaminative sources, identified receptors and viable pathways to receptors described in preceding paragraphs, we have produced an initial conceptual model in the form of a table which is presented in Appendix H.

8.6.3 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable, and require further investigation by laboratory testing of soil / water samples to refine the risk assessment.

8.7 Laboratory testing

8.7.1 Testing regime – Human receptors

8.7.1.1 A potential risk has been identified by virtue of Made Ground soils. Thus, in order to carry out a quantitative assessment, we have scheduled testing to measure the concentration of commonly occurring inorganic and organic contaminants.

8.7.1.2 Five samples were submitted for measurement of metals, semi-metals and PAH contaminants. The results of laboratory determination of concentration of chemical contaminants are presented in Appendix G.

8.7.1.3 The following table summarises the scheduled testing, in relation to soil types and identified receptors under consideration of the conceptual model.

Table summarising scheduled testing (human receptors)

Sample origin	Sample type	Strata	Targeted sampling	Non targeted sampling	Scheduled testing	Critical receptor
TP01 @ 0.3-0.4m	Soil	Made Ground		✓	Inorganic & organics*	All human receptors
TP04 @ 0.2-0.3m	Soil	Made Ground		✓	Inorganic & organics*	All human receptors
TP02 @ 0.3-0.4m	Soil	Made Ground		✓	Inorganic & organics*	All human receptors
DTS01 @ 0.2-0.3m	Soil	Made Ground		✓	Inorganic & organics*	All human receptors
DTS04 @ 0.2-0.3m	Soil	Made Ground		✓	Inorganic & organics*	All human receptors

Table 8.7.1.6

8.7.1.7 The results of laboratory determination of concentration of chemical contaminants are presented in Appendix G.

8.7.2 Testing regime – Water receptors

8.7.2.1 Potentially contaminative Made Ground soils were predominantly situated beneath the building footprint and thus not considered to present a risk to water receptors identified on site and thus specific leachate/water samples have not been scheduled for testing at this time. Should elevated concentrations of contaminants be identified as the result of soil sampling/testing then this assessment may be revised.

8.7.3 Criteria for assessment of test data – Human receptors

8.7.3.1 Assessment of laboratory test data has been carried out with reference to current nationally recognised documents listed in the final page of Appendix F. Due to changes in guidance on contaminated land, items 6-8 and item 10 in the document listing above have been withdrawn. In the absence of alternative guidance however we have used these documents. Where new guidance is available, this has been followed in preference to superseded guidance.

8.7.3.2 Soil guideline values (SGVs) are used as a screening tool to assess the risks posed to health of humans from exposure to soil contamination in relation to land uses. Where published SGVs are not available, we have adopted Generic Assessment Criteria (GAC) and Soil Screening Values (SSV) derived by Soiltechnics and by Atkins (SSV^{ATK}). GACs have been derived by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) and presented in *'Generic Assessment Criteria for Human Health Risk Assessment'*. GACs have been prepared for a number of metals and polycyclic aromatic hydrocarbons (PAH) and are used in preference to values produced by Soiltechnics and Atkins. The CLEA model has been used with toxicology data presented by the EA, LQM/CIEH and Atkins (in that order of preference) to derive SSVs by Soiltechnics. SSVs produced by Atkins are presented on their $ATRISK^{SOIL}$ website.

8.7.3.3 SGVs, GACs, SSVs and SSV^{ATK}s represent 'intervention values'; indications to an assessor that soil concentrations above these levels might present an unacceptable risk to the health of site users. These soil guideline values have been produced using conceptual exposure models, which use assumptions and are applied to differing end uses of land. If the values are exceeded, it does not necessarily imply there is an actual risk to health and site-specific circumstances should be taken into account. Conversely, where a critical pathway or chemical form of the contaminant has not been evaluated, a risk may be present even if the SGV/GAC has not been exceeded.

8.7.3.4 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH) contamination, we have compared measured concentrations with corresponding GACs. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest GAC as an initial screening value.

8.7.3.5 We have followed procedures outlined by the CIEH to compare measured concentrations of metals and PAH contaminants against guideline values.

8.7.3.6 We have adopted a residential with plant uptake land use for proposed end users of the site.

8.7.4 Criteria for assessment of test data – Construction operatives

8.7.4.1 In the absence of guidelines we have adopted industrial guideline values for assessment of construction operatives.

8.7.5 Criteria for assessment of test data – Vegetation

8.7.5.1 Guidance published by Forest Research in "*BPG Note 5 - Best Practice Guidance for Land Regeneration*" suggests that a residential without plant uptake or industrial/commercial CLEA model should be adopted for this receptor although specific guideline values are provided for copper and zinc at 130mg/kg and 300mg/kg respectively. As a practice we have adopted the industrial / commercial CLEA model for assessment of test data for vegetation.

8.7.6 Evaluation of test data – Human receptors

8.7.6.1 Tables summarising and analysing test data are presented in Appendix G. The following table summarises the outcome of the analyses.

Table Summarising assessment of test data for Human receptors

Analysis tables	Receptor group	Critical receptor	CLEA model	Inorganic contaminants	Organic contaminants
1 and 4	Construction operatives	Adult	Construction operatives	No exceedances	No exceedances
2 and 5	Proposed site users	Child	Residential with plant uptake	Refer paragraphs 8.7.7.2	Refer paragraph 8.7.7.3

Table 8.7.7.1

8.7.6.2 Proposed site users - inorganic contaminants

8.7.6.2.1 With reference to table 2 in Appendix G, analysis of chemical test data with respect to critical (child) receptors for future site uses, indicates all measured concentrations of selected contaminants are below relevant guideline values with the exception of lead, mercury and vanadium.

8.7.6.2.2 Elevated concentrations of lead were recorded in two of the five samples taken from the site: TP04 and TP02, wherein concentrations of 460mg/kg and 540mg/kg were recorded within the near surface Made Ground, compared to a GAC of 276mg/kg. The mean concentration of the five samples was slightly above the GAC at 293mg/kg. TP04 and TP02 are located beneath the proposed building footprint.

8.7.6.2.3 One concentration of mercury was recorded above the SGV of 1.0mg/kg. The elevated concentration of 2.0mg/kg was taken from a Made Ground sample at TP04 location (beneath the proposed building footprint). The mean concentration for the site was recorded at 0.8mg/kg.

8.7.6.2.4 Concentrations of vanadium were recorded in the range of 52-80mg/kg compared to the GAC of 75mg/kg. The mean concentration for the site is 64mg/kg. One sample produced a concentration above the GAC: A Topsoil sample taken from the rear garden at DTS04 location.

8.7.7.3 Proposed site users - organic contaminants

8.7.7.3.1 With reference to table 4 in Appendix H, all samples indicate concentrations of PAH contaminants well below the relevant guideline values with the exception of the sample taken from the near surface Made Ground within DTS01. Here, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene and dibenzo(a,h)anthracene were all recorded to be above the relevant GAC guideline values.

8.7.8 Evaluation of test data – Vegetation

8.7.8.1 Comparison of test data with guideline values is presented on Tables 4 and 6 in Appendix G. None of the measured concentrations exceed the adopted guideline values with the exception of one concentration of zinc recorded in TP04 location. Here, zinc concentrations were recorded at 760mg/kg compared to an adopted guideline value of 300mg/kg. Notably, in the area of TP04, vegetation appeared to be in good health.

8.7.9 Summary and analysis

8.7.9.1 Elevated concentrations of lead and mercury recorded on site are likely to be associated with ask and clinker fragments within the Made Ground. Such deposits were generally restricted to beneath or close to the existing building and associated with the formation of the concrete footings on site. The position of the elevated concentrations (beneath the proposed building footprint), limits the risk to end users as the pathway will be severed by the existing/new building.

8.7.9.2 One elevated concentration of vanadium was recorded within a topsoil sample from DTS04. All other concentrations of contaminants within the sample were well below guideline values and often below detectable limits (for inorganic contaminants). The marginal exceedance of the GAC (recorded value of 80mg/kg compared to GAC of 75mg/kg) and location within a topsoil sample, as well as the limited concentrations within Made Ground elsewhere suggest the vanadium is a naturally occurring concentration. The mean value for the site (64mg/kg) is below the GAC guideline value. In consideration of the above, the concentrations of vanadium recorded on site are not considered to present a risk of harm to end users.

8.7.9.3 Elevated concentrations of PAH compounds were recorded in the near surface Made Ground soils within the front garden area of the property (DTS01 location). The front garden area is unlikely to be used to grow produce however the recorded concentrations in this area are also above guideline values associated with a ‘residential no uptake’ end use and thus are considered to present a risk to end users and considered worthy of further investigation and/or remediation.

8.7.9.4 One elevated concentration of zinc was recorded within the rear garden (TP04). In this area vegetation seemed in good health though notably, TP04 is located beneath the proposed building footprint and thus vegetation will be removed in this area.

8.7.9.5 With respect to water receptors, elevated concentrations of contaminants were generally restricted to areas beneath the proposed building footprint and following development, the building will limit the infiltration pathway through Made Ground and thus limit potential leachate generation. A substantial amount of Made Ground will, in any case, be removed to enable construction of the basement. Elevated concentrations of PAH have however been recorded within the front garden area and further testing and/or remediation would be required in order to limit the risk to water receptors.

8.8 Updated conceptual model

8.8.1 Having now completed analysis of laboratory testing, we can now update our conceptual model which is presented in Appendix H.

8.8.2 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable, and require further investigation and/or remedial action which is discussed below.

8.9 Remedial action

8.9.1 Based on the above, action is required to limit potential risks to proposed users of the site, water and vegetation.

8.9.2 Where hardstanding and buildings are proposed, the risk to end users is significantly reduced as the hardstanding effectively creates a barrier between contaminants and human users. Similarly, the hardstanding will limit infiltration and thus leachate generation of contaminants.

8.9.3 Outside the proposed building footprint, elevated concentrations of PAH have been recorded within the front garden area which are considered to present a risk of harm to end users and water receptors. The following remedial/further investigation options are recommended:

- Either; removal of the Made Ground within the front garden and replacement with a clean, imported fill. Based on the depth of Made Ground in the area of DTS01 (1.8m), this is likely to prove uneconomical at this stage.

- Or; additional testing to confirm the extent of PAH contamination and its leachable properties to enable production of a more specific remedial strategy such as localised removal of a PAH hotspot or introduction of a capping layer within the front garden.

- Or; introduction of a positively drained hardstanding within the front garden area.

8.10 Risk assessment in relation to use of infiltration systems

8.10.1 With reference to Environment Agency publication '*Groundwater protection: Policy and practice (GP3)* 2012, outside of SPZ1, the EA will support sustainable drainage systems for new discharges to ground. This is subject to an appropriate risk assessment to demonstrate that ground conditions are suitable and infiltration systems do not present an unacceptable risk of promoting mobilisation of contaminants or creating new pathways for contaminant migration.

8.10.2 The permeability of the near surface Claygate Member in combination with the site located over a Secondary A aquifer suggests the site is sensitive to migration of contaminants. To limit the mobilisation of contaminants from the Made Ground, any soakaways should be sited within the natural Claygate Member soils. On this basis, the risk of infiltration systems promoting mobilisation of contaminants at the site is considered low. All discharges to groundwater are subject to compliance with the Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC).

8.11 Risk assessment summary and recommendations

8.11.1 Based on our assessments described above, we can provide the following summary and recommendations for each identified receptor.

8.11.2 Current site users

8.11.2.1 The site is currently unoccupied and thus current site users have not been considered as part of this investigation.

8.11.2 End users

8.12.2.1 Further investigations and remedial measures are recommended in order to limit the risk of harm to end users. Following completion of such investigations/remedial measures, we are of the opinion that the site will represent a low risk of causing harm to the health of future end users of the developed site.

8.11.3 Construction operatives and other site investigators

8.11.3.1 The risk of damage to health of construction operatives and other site investigators from ground conditions is, in our opinion, low. As a precautionary approach, however, we recommend adequate hygiene precautions are adopted on site. Such precautions would be:-

- Wearing protective clothing particularly gloves to minimise ingestion from soil contaminated hands.
- Avoiding dust by dampening the soils during the works.
- Wearing masks if processing produce dust.

8.11.3.2 Guidance on safe working practices can be obtained from the following documents

- The Health and Safety Executive Publication *"Protection of Workers and the General Public during the Development of Contaminated Land"* (HMSO) and

- *"A Guide to Safer Working on Contaminated Sites"* (CIRIA Report 132).

8.11.3.3 In addition, reference should be made to the Health and Safety Executive. In all cases work shall be undertaken following the requirements of the Health and Safety at Work Act 1974 and regulations made under the Act including the COSHH regulations.

8.11.3.4 Notably, potential asbestos containing cement sheeting was observed within the garage super-structure and we recommend specialists in the identification and removal of such materials are appointed prior to any demolition/redevelopment works on site

8.11.4 Controlled waters

8.11.4.1 Elevated concentrations of PAH have been identified within the front garden of the property which present a potential risk to water receptors. Following additional testing and introduction of remedial measures (if considered necessary following testing) we are of the opinion that the site will present a low risk of causing harm to water receptors.

8.12.5 Vegetation

8.12.5.1 Based on testing obtained to date the site is considered to present a low risk of harm to vegetation. However, it is difficult to quantify the phytotoxity of a contaminant as large variations exist between plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Due to the complexities of the effects of soil contamination on different plant species, we recommend that the test results presented in this report are passed to a landscape architect for the selection of suitable planting.

8.13 Statement with respect to National Planning Policy Framework

8.13.1 Providing the recommendations described above are satisfactorily completed, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of the National Planning Policy Framework section 121, and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture'.*

8.14 On Site Monitoring

8.14.1 We have attempted to identify the potential for chemical contamination on the site, however, areas, which have not been investigated at this stage, may exhibit higher levels of contamination. If such areas are exposed at any time during construction we will be pleased to re-attend site to assess what action is required to allow the development of safely proceed.

9 Gaseous contamination

9.1 Legislative framework

9.1.1 There is currently a complex mix of documentation relating to legislative and regulatory procedures on the issue of contamination, and it is not considered a purpose of this report to discuss the detail of these regulations. Essentially, Government Policy is based on *'suitable for use approach',* which is relevant to both the current and proposed future use of land. For current use Part IIA of the Environmental Protection Act 1990 provides the regulatory regime (see Section 8.1 above). The presence of harmful soil gasses could provide a 'source' in a 'pollutant linkage' allowing the regulator (Local Authority) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented with the Environment Agency responsible for enforcement.

9.1.2 The Town and Country Planning (General Development Procedure) Order 1995, requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250 metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision.

9.1.3 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture'* which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from soil gas.

9.2 General

9.2.1 The following assessment relates to the potential for, and the effects of, gasses generated by biodegradable matter. A separate, but related class of problem involves migration of vapour phase of hydrocarbons resulting from spillages of petroleum and solvents, but this is addressed under organic contamination in Section 8. The potential for the development to be affected by Radon Gas is considered in Section 3 above. The principal ground gasses are carbon dioxide (CO_2) and methane (CH_4). The following table provides a summary of the effects of these gases when mixed with air.

Significant gas concentrations in air		
Gas	**Concentration by volume**	**Consequence**
Methane	0.25% 5% 30%	Ventilation required in confined spaces Potentially explosive when mixed with air Asphyxiation
Carbon Dioxide	0.5% 1.5% >3% >5%	8 hour long term exposure limit (LTEL) (HSE workplace limit) 15 min short term exposure limit (STEL) (HSE workplace limit) Breathing difficulties Death can occur
Table 9.2.1		

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 '*Resistance to Contaminates*' (2004 incorporating 2010 and 2013 amendments) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases (permanent gases) and if appropriate the identification of mitigation measures.

- BS10175:2011 *'Investigation of potentially contaminated sites- Code of Practice'.*
- BS8576: 2013 '*Guidance on investigations for ground gas –Permanent gases and Volatile Organic Compounds (VOCs)*'
- BS8485: 2007 '*British Standard Code of practice for the characterisation and remediation from ground gas in affected developments*'
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).
- NHBC report No 10627-R01(04) '*Guidance on development proposals on sites where methane and carbon dioxide are present*' (January 2007)

Whilst we have followed the guidance and recommendations of BS8576, we have used BS8485 to derive recommendations for protective works where considered necessary supplemented by NHBC report No 10627-R01(04).

9.2.3 An assessment of the risk of the site being affected by ground gases is based on the following aspects.

a) Source of the gas
b) Investigation information
c) Migration feasibility
d) Sensitivity of the development and its location relative to the source

9.3 Assessment of source of gases

9.3.1 General sources

9.3.1.1 The following table summarises the source of gasses and parameters for producing gasses

Source and control of gasses

Type	Parameters affecting the rate of gassing
Landfills	Portion of biodegradable material, rate reduces with time.
Mine workings	Flooding reduces rate of gassing
Dock silt	Portion of organic matter
Carbonate deposits	Ground / rainwater (acidic) reacts with some carbonates to produce carbon dioxide.
Soils / rocks	Portion of organic matter

Table 9.3.1

The rate of decomposition in gas production is also related to atmospheric conditions, pH, temperature, and water content / infiltration.

9.3.1.2 As the site is not within a dockland environment or an area affected by mineworkings, and near surface soils do not exhibit high carbonate content, then potential gas sources are limited to landfills and /or soils with a high proportion of organic matter.

9.3.2 Landfill sources

9.3.2.1 Waste Management Paper 27 (1991) produced by the Department of the Environment '*Control of Landfill Gases*' contains the recommendation to avoid building within 50m of a landfill site actively producing large quantities of landfill type gases and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependant, of course, upon the type of landfill and potential for migration of landfill gasses.

9.3.2.2 Envirocheck reports there are no recorded landfill sites within 2000m of the subject site. In addition, we have reviewed old Ordnance Survey maps and there is no obvious evidence of any quarrying in the area or BGS recorded mineral sites which may have been restored with materials which could generate landfill gases. On the above basis there is no recorded evidence to suggest a source of landfill gases from such past activities.

9.3.3 Soil conditions

9.3.3.1 None of the soils observed in exploratory excavations, in our opinion, exhibit significant concentrations of organic matter which are likely to produce elevated quantities of carbon dioxide and / or methane gas.

9.3.3.2 Based on an assessment of 'deep' geological conditions we are of the opinion that it is unlikely that the subject site would be affected by significant quantities of carbon dioxide and methane generated by soils/rocks at depth.

9.3.4 Source assessment summary

9.3.4.1 The following table summarises the possibility of a source of landfill type gasses.

Source assessment summary		
Potential source origin	**Viability of source**	**Evidence**
Landfills	Unlikely	Desk study information
Mineworkings	Unlikely	Desk Study information Geological conditions not amenable
Dock silt	Unlikely	Site remote from dockland environment
Carbonate deposits	Unlikely	Recorded and observed soil conditions do not indicate high concentrations of carbonates
Soils / rocks	Unlikely	Soils exposed in exploratory excavations do not exhibit high concentrations of organic matter

Table 9.3.4

9.4 Conclusion

9.4.1 Based on the above there is no evidence to demonstrate that there is a potential source rendering the site at a significant risk of being affected by ground gasses (carbon dioxide / methane) sufficient to cause significant harm to human end users of the site, construction operatives or indeed buildings. On this basis, it is not considered necessary to consider possible pathways for migration of ground gasses, and indeed implementation of further investigations to measure concentrations of ground gasses. Again on the basis of evidence provided above, mitigation measures against ingress of ground gasses into the proposed development are not considered necessary.

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9.5 Statement with respect to National Planning Policy Framework

9.5.1 Based on investigations completed to date with respect to gaseous contamination, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended (without the need for any remedial action) thus meeting the requirements of the National Planning Policy Framework section 121, and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'

10 Effects of ground conditions on building materials

10.1 General

10.1.1 Building materials are often subjected to aggressive environments which cause them to undergo chemical or physical changes. These changes may result in loss of strength or other properties that may put at risk their structure integrity or ability to perform to design requirements. Aggressive conditions include:-

- Severe climates
- Coastal conditions
- Polluted atmospheres
- Aggressive ground conditions

This report section only considers aggressive ground conditions, with other items considered outside our brief and scope of investigations.

10.1.2 In aggressive ground conditions, the potential for contaminant attack depends on the following:-

- The presence of water as a carrier of chemical contaminants, (except free phase organic contamination)
- The availability of the contaminant in terms of solubility, concentration and replenishment rate
- Contact between the contaminant and the building material
- The nature of the building materials and its capability of being attacked by contaminants

In general the thicker the building material the less likelihood there is for contaminant attack to cause damage to the integrity of the structure.

10.2 Reference documents

10.2.1 Following the Environment Agency publication *'Model Procedures for the Management of Land Contamination'* (Contaminated Land Report 11) the following documents have been referred to in production of the following report paragraphs.

- *'Performance of Building Materials in Contaminated Land'* report BR255 (Building Research Establishment 1994).
- *'Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review'* - Technical Report P331 (Environment Agency 2000).
- *'Guidance on assessing and managing risks to buildings from land contamination'* - Technical Report P5 035/TR/01).
- Building Regulations Approved document C - site preparation and resistance to contaminants and moisture (Office of the Deputy Prime Minister, 2004).
- *'Concrete in aggressive ground'* Special Digest 1: 2005 (Building Research Establishment).

10.3 Hazard identification and assessment

10.3.1 The identification of hazards is based on the findings of this investigation primarily relating to former land uses (potential for chemical contamination, and likely type of contamination) and laboratory determination of concentration of chemical contaminants. Clearly, the scope of laboratory testing is determined with respect to former land uses, contaminants which may cause harm to human health and water resources.

10.3.2 Based on the above, the scope of our testing regime is described in Sections 8. We have utilised this test data in production of the following risk assessments in relation to building materials, in conjunction with test data targeting the effects of chemical attack on concrete in contact with the ground, as described in BRE Special Digest 1.

10.3.3 The identification of hazards from contamination and subsequent assessment of risks is based on the following:-

- The contaminants present on site.
- The nature of the contaminant (i.e. calcium sulphate is much less soluble than sodium or magnesium sulphate and is, therefore, less of a concern with regards sulphate attack).
- The concentration of contaminants - in general the higher the concentration the greater the hazard.
- The solubility of the contaminants - contaminants which are not soluble will not generally react with materials.
- The permeability of the soils - i.e. case by which fluids can transport contaminants to the building.

10.3.4 The process of risk assessment for building materials is concerned with identification of the hazard (contaminants at the site - a source) and subsequently how the contaminants can reach the building (pathway) and how they can react with the building (receptor). Thus the risk assessment is produced based on the source - pathway - receptor model.

10.4 Provision of test data to specifiers/manufacturer/installer

10.4.1 The following risk assessments are based on current published data. We strongly recommend, however, that information gained from this investigation are provided to specifiers/manufacturers/installers of building materials/service ducts/apparatus who may have more up to date research to confirm the ability of the product to resist the effects of chemical contaminants at the site for the desired lifespan of the product.

10.5 Risks assessments for individual building materials

10.5.1 The following/typical sections contain risk assessments for various building materials likely to be incorporated in developments. Other materials which we are not aware of may also be used in developments and in contact with the ground and, therefore, recommend the suppliers are consulted with respect to ground conditions at this site and their opinion sought as to the ability of the product to resist chemical conditions determined at the site.

10.6 Concrete - General mechanisms of attack

10.6.1 There are a number of mechanisms by which contaminants attack concrete including the following:-

- Hydrolysis of the hardened concrete.
- Degradation as a result of exchange reactions between calcium in calcium hydroxide (free lime hydrate) and ions in aggressive solutions.
- Expansive reactions as a result of chemical reaction or salt crystallisation.

10.7 Concrete - Sulphate attack

10.7.1 Hazard

10.7.1.1 Sulphate attack on concrete is characterised by expansion, leading to loss of strength, cracking, spalling and eventual disintegration. There are three principal forms of sulphate attack, as follows:-

- Formation of gypsum through reaction of calcium hydroxide and sulphate ions.
- Ettringite formation through reaction of tricalcium alluminate and sulphite irons.
- Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.7.2 Assessment

10.7.2.1 The hazard of sulphide attack is addressed by reference to procedures described in Building Research Establishment (BRE) Special Digest 1: 2005 '*Concrete in Aggressive Ground*' to establish a design sulphate class (DS) and the '*aggressive Chemical Environment for Concrete*' (ACEC). These procedures have been followed during our investigation and are described in the following paragraphs.

10.7.3 Desk Study Information

10.7.3.1 The first step in the procedure is to consider specific elements of the desk study. These are tabulated below.

Summary of desk study information

Element	Interrogation	Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites	Likely	Box C6
Past industrial uses	Brownfield site?	No	C2.1.2

Table 10.7

10.7.3.2 A brownfield site is defined in SD1: 2005 as a site, or part of a site which has been subject to industrial development, storage of chemicals (including for agricultural use) or deposition of waste, and which may contain aggressive chemicals in residual surface materials, or in ground penetrated by leachates. The site has been recorded as residential use since circa 1935 and recorded as open space prior to development. The site is unlikely to have been used for industrial uses therefor it should be treated as natural.

10.7.3.3 Based on the above it is necessary to follow the procedures described in figure C5 ('*sites or locations where disturbance of pyrite bearing natural ground could result in additional sulphate*').

10.7.4 Assessment of Design Sulphate Class

10.7.4.1 The sulphate concentration in a 2:1 water/soil extract was measured in two samples of *Made Ground* and two samples of Claygate Member. The highest test result has been used as the characteristic value (refer to table 10.7.4).

10.7.4.2 Again following the recommendations of SD1: 2005, we have scheduled additional testing on the same soil samples to include:-

- Determination of total sulphate content (% SO_4)
- Determination of total sulphate present (% S)

Using this test data we have calculated the Total Potential Sulphate content (TPS, % SO_4) and the amount of Oxidisable Sulfides (OS % SO_4), again following the procedures described in SD1: 2005. As the amount of oxidisable sulfides does not exceed 0.3% SO_4, on a significant number of samples, pyrite is probably not present.

10.7.4.3 The characteristic total potential sulphate content has been based on the highest TPS value (rounded to 0.1% SO_4, refer to table 10.7.4). With reference to table C1 of SD1: 2005, the design sulphate class has been based on considering both the initial characteristic value, and characteristic total potential sulphate content, and adopting the more onerous of these two values.

10.7.5 Assessment of groundwater mobility

10.7.5.1 With reference to SD1: 2005, Section C3.2, we are of the opinion that ground and site characteristics suggest 'mobile groundwater' conditions.

10.7.6 Assessment of pH

10.7.5.1 Following SD1: 2005, Section C5.1.1 (step 4) only a 'small number' of samples have been tested and thus the characteristic value for pH within Made Ground and Claygate Member equates to the lowest measured values of 5.0 and 5.1.

10.7.7 Assessment of aggressive chemical environment for concrete (ACEC)

10.7.7.1 Based on the design sulphate class, characteristic value of pH and assessment of groundwater mobility, and with reference to table C1 of SDI: 2005, the ACEC class for each soil type is presented in Table 10.7.2 below.

Summary of concrete classification

Soil type	No. of samples	Characteristic pH	Groundwater mobility	Characteristic TPS	Characteristic sulphate (mg/l)	DS class	ACEC class
Made Ground	2	5.1	Mobile	N/A	370	DS-1	AC-2_Z
Claygate Member	2	5	Mobile	N/A	170	DS-1	AC-2_Z

Table reference 10.7.7

10.8 Concrete - Chloride attack

10.8.1 Hazards

10.8.1.1 There are a number of ways in which chlorides can react with hydrated cement compounds in concrete. These are as follows:-

- Chlorides react with calcium hydroxide in the cement binder to form soluble calcium chloride. This reaction increases the permeability of the concrete reducing its durability.

- Calcium and magnesium chlorides can react with calcium aluminate hydrates to form chloroaluminates which result in low to medium expansion of the concrete.

- If concrete is subject to wetting and drying cycles caused by groundwater fluctuations, salt crystallisation can form in concrete pores. If pressure produced by crystal growth is greater than the tensile strength of the concrete, the concrete will crack and eventually disintegrate.

10.8.2 Risk assessment

10.8.2.1 Chlorides of sodium, potassium, and calcium are generally regarded as being non-aggressive towards mass concrete; indeed brine containers used in salt mines have been known to be serviceable after 20 years service. Depending upon the type of concrete, and the cement used up to 0.4% chloride is allowed in BS8110: Part 1.

10.8.2.2 In view of the past use of the site we consider the likelihood of elevated concentrations of chlorides in the ground is not likely to occur and on this basis have not specifically measured concentrations of chlorides and, in our opinion, the risk of buried concrete being affected by chlorides is considered low.

10.9 Concrete - Acid attack

10.9.1 Hazards

10.9.1.1 Concrete being an alkaline material is vulnerable to attack by acids. Prolonged exposure of concrete structures to acidic solutions can result in complete disintegration.

10.9.2 Risk assessment

10.9.2.1 The rate of acid attack on concrete depends upon the following:-

- The type of acid
- The acid concentration (pH)
- The composition of the concrete (cement/aggregate)
- The soil permeability
- Groundwater movement

British Standard BS8110: Part 1 classifies extreme environment as one where concrete is exposed to flowing groundwater that has a pH<4.5. The standard also warns that Portland Cement is not suitable for acidic conditions with a pH of 5.5 or lower.

10.9.2.2 The pH of the soil was measured below 5.5 and on this basis we recommend advice is sought from the manufacturer with regards to acid attack on concrete. The pH of the soils has been considered in the ACEC class described above.

10.10 Concrete - Magnesium attack

10.10.1 Hazards

10.10.1.1 Magnesium salts (excepting magnesium hydrogen carbonate) are destructive to concrete. Corrosion of concrete occurs from cation exchange reactions where calcium in the cement paste hydrates and is replaced with magnesium. The cement looses binding power and eventually the concrete disintegrates.

10.10.2 Risk assessment

10.10.2.1 In practise 'high' concentrations of magnesium will be found in the UK only in ground having industrial residues. Following BRE Special Digest 1:2005, measurement of the concentration of magnesium is recommended if sulphate concentrations in water extract or groundwater exceed 3000mg/l. Once measured the concentration of magnesium is considered further in BRE Special Digest in establishing the concrete mix to resist chemical attack.

10.10.2.2 We are not aware the site has been subject to any manufacturing processes which would have included magnesium containing compounds, and in addition sulphate concentrations did not exceed 3000mg/l, on this basis we have not measured the concentration of magnesium in soils at the site, and would consider the risk of soils at the site promoting attack on concrete is considered low.

10.10.2.3 BS EN 206-1:2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water, with varying concentrations of magnesium for the design/specification for concrete mixes. As water levels have been measured on five occasions at between 1.35 and 1.47m below formation level it is unlikely that the building may be in contact with groundwater.

10.11 Concrete - Ammonium attack

10.11.1 Hazards

10.11.1.1 Ammonium salts, like magnesium salts act as weak acids and attack hardened concrete paste resulting in softening and gradual decrease in strength of the concrete.

10.11.2 Risk assessment

10.11.2.1 UK guidance is not available on the concentration of ammonium which may affect concrete. BS EN 206-1: 2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water with varying concentrations of ammonia for the design/specification for concrete mixes.

10.11.2.2 The site has no history which provides evidence of the uses of ammonia on site, and in overall conclusion the risk of concrete being affected by ammonia is considered low.

10.12 Concrete blocks

10.12.1 Hazards

10.12.1.1 Precast aggregate concrete blocks and autoclaved aerated concrete blocks are commonly used in the construction of shallow foundations. Concrete blocks are potentially attacked by the same contaminants and ground conditions which affect dense concrete.

10.12.2 Risk Assessment

10.12.2.1 In general, the mechanism of attack on concrete blocks is the same for hardened concrete. We recommend parameters for ground conditions for concrete described in the preceding paragraphs for concrete blockwork in contact with the ground/groundwater and the blockwork manufacturers confirmation sought for applicability of their product.

10.13 Clay Bricks/Pipes

10.13.1 Clay Bricks are highly durable materials which have been used in buildings for many centuries. Fire clay pipe material can also be considered similarly resistant to contaminants.

10.13.2 Hazards

10.13.2.1 Dissolution of clay brick in a potentially serious cause of deterioration. The extent of dissolution depends upon the solubility of the glassy material (produced by firing of the clay) contained in the brick. The acidic nature of the glass phase will produce low solubility in a neutral and acidic environment, but can be soluble in a basic environment.

10.13.2.2 A potentially more serious hazard for brickwork is the crystallisation of soluble salts within the brick pore structure. Salts are transported by water to the interior of the brick originating from the external environment or by rehydration, however, are only likely to occur when there is a gradient from a wet interior to a drying surface. The potential, therefore, for salt crystallisation in the ground is, therefore, low.

10.13.3 Risk Assessment

10.13.3.1 There seems to be little published information as regards the resistance to clay bricks/pipes in aggressive ground conditions, however, clay bricks are generally considered very durable. We recommend manufacturers' advices are sought with respect to their resistance to ground conditions encountered at this site.

10.13.3.2 Some basic guidance is provided in BS5628-3: 2005 '*Code of Practice for the Use of Masonry - Part 3: Materials and components, design and workmanship*' with regards to resistance of masonry to resist the effects of sulphate attack.

10.14 Mortar

10.14.1 Mortars are based on building sands mixed with cement and/or lime as a binder. In the UK Portland cements and masonry cement are commonly used. Masonry cements are a mixture of Portland Cements and fine mineral filler (i.e. Limestone) with an air entraining agent.

10.14.2 Hazards

10.14.2.1 Mortar is subject to the same agents for deterioration as concrete with the major cause of deterioration being sulphate attack.

10.14.3 Risk assessment

10.14.3.1 Sulphates can originate from soils/groundwater or from the bricks themselves. Calcium, magnesium, sodium and potassium sulphates are present in almost all fired-clay bricks. Water can dissolve a fraction of these sulphates and transport them to the mortar.

10.14.3.2 Currently, we are not aware of any guidance on the resistance of mortars to sulphate attack. The Building Research Establishment report that the sulphate resistance of mortar was improved by the use of sulphate resisting Portland cements and lime. Some guidance is also provided in BS5628-3: 2005 '*Code of Practice for the use of Masonry - Part 3: Materials and components, design and workmanship*'.

10.14.3.2 Based on ground conditions determined at the site the risk of significant sulphate attack on mortars (Based on testing/analysis of sulphates in relation to concrete - refer Section 10.7) is considered low.

10.15 Metals - general

10.15.1 There are a number of metals which are used in buildings either as piles, services, non structural and, indeed, structural components. The most common metals used in buildings are steel, stainless steel, copper, lead, zinc, aluminium and cast iron. All these metals can deteriorate through corrosion process. Corrosion can affect metals in a variety of ways depending upon the nature of the metal and the environment to which it is subjected. In most common forms of corrosion are:-

- Electrochemical - the most common form of corrosion in an aqueous solution
- Chemical corrosion - occurs when there is a direct charge transfer between the metal and the attacking medium (examples are oxidation, attack by acids, alkalis and organic solvents)
- Microbial induced corrosion

10.16 Metals - Cast iron

10.16.1 Cast iron is a term to describe ferrous metals containing more than 1.7% carbon and is used extensively in the manufacture of pipes.

10.16.2 Hazards

10.16.2.1 Generally, cast iron has a good resistance to corrosion by soils, however, corrosion can occur due to the following mechanisms:-

1) Generation of large scale galvanic cells caused by differences in salt concentrations, oxygen availability or presence of stray electrical currents.

2) Hydrochloric acid will cause corrosion at any concentration and temperature. Dilute sulphuric, nitric and phosphoric acids are also aggressive as also are well aerated organic acids.

10.16.3 Risk assessment

10.16.3.1 Testing can be carried out on site to measure the resistivity and redox potential of soils which can assist in deriving recommendations for protection of cast iron components using coatings, burial trenches, or isolation techniques. Currently, however, there is no specific guidance and we recommend advice is sought from manufacturers.

10.16.3.2 Guidelines produced by the Water Research Centre (WRc) on the use of ductile iron pipes, state that highly acidic soils (pH <5) are corrosive to cast iron pipe even when protected by a zinc coating or polythene sleeving. WRc also indicate that groundwater containing >300ppm chloride may corrode even protected cast iron pipes.

10.16.3.3 On the basis that the pH of soils at the site are not less than 5, and groundwater is unlikely to be in contact with cast iron elements, then the risk of ductile cast iron pipes being affected by acid/chloride attack is considered low. We have not carried out any redox/resistivity testing (considered outside our brief) and thus we cannot comment further with regards to the risks of galvanic action.

10.17 Metals - Steel piles

10.17.1 Hazards

10.17.1.1 The corrosion of steel requires the presence of both oxygen and water. In undisturbed natural soils the amount of corrosion of driven steel piles is generally small. In disturbed soils (made ground) however, corrosion rates can be high and normally twice as high as those for undisturbed natural soils.

10.17.2 Risk Assessment

10.17.2.1 Guidance on the use of steel piles in different environments is provided in British Steel's piling handbook which includes calculating the effective life of steel piles. There is no specific guidance, however, for contaminated soils in this publication. Coatings can be provided to the pile surface but experience has shown that some coatings can be damaged during driving, particularly in ground which can contain hard materials such as brick/concrete/stone.

10.18 Metals - Stainless steel

10.18.1 Hazards

10.18.1.1 Stainless steel is used in a number of building components including services, pipework, reinforcement bars and wall ties. There is little knowledge, however, of the performance of stainless steel in aggressive environments.

10.18.2 Risk assessment

10.18.2.1 Stainless steel can withstand pH of 6.5 to 8.5, but the chlorine content of a soil increases the risk of corrosion. At concentrations of 200mg/l type 304 stainless steel can be used, but for concentrations of 200 to 1000mg/l type 316 should be used in preference to type 304, but for concentrations greater than 1000mg/l type 316 should always be used.

10.18.2.2 It is considered unlikely that groundwater will be in contact with stainless steel components (unless we are advised otherwise) however pH conditions are low on site and thus we recommend the manufacturers advice is sought with regards to the use of this product.

10.19 Metals - Galvanised steel

10.19.1 Hazards

10.19.1.1 Galvanising steel is a means of protecting steel from aggressive environments; however, zinc galvanising can be corroded by salts and acids.

10.19.2 Risk assessment/remedial action

10.19.2.1 There is no current specific guidance on the effects of aggressive ground conditions on galvanised steel, however, some research indicates zinc alloys are generally more resistant than pure zinc coatings in aggressive conditions.

10.20 Metals - Copper

10.20.1 Hazards

10.20.1.1 Copper is commonly used for gas and water supplies. Copper is generally resistant to corrosion in most natural environments, but in contaminated ground copper can be subject to corrosion by acids, sulphates, chlorides and ground containing cinders/ash. Wet peat (pH 4.6) and acid clays (pH 4.2) are considered aggressive conditions to promote corrosion to copper.

10.20.2 Risk assessment

10.20.2.1 There is no specific published guidance on what constitutes aggressive conditions to copper except very acid/peaty conditions.

10.20.2.2 There are no significantly acidic (not less than 5) or peaty conditions in near surface soils at the site or, indeed, significant concentrations of ash/cinders. On this basis the risk of significant corrosion to copper in contact with the ground is considered low.

10.21 Metals - Lead

10.21.1 Hazards

10.21.1.1 Lead is used in tanking, flashings, damp proof courses, etc. Lead is a durable material which is resistant to corrosion in most environments. Lead damp proof courses can be subject to attach from the lime released by Portland Cement based mortar and concrete. In the presence of moisture, a slow corrosive attack is initiated on lead sheet. In such cases a thick coat of bitumen should be used to protect the lead damp proof course.

10.21.2 Risk assessment

10.21.2.1 There is no current guidance on the performance of lead in contact with contaminated soils, however, acids and alkalis (lime) could be aggressive towards lead.

10.21.2.2 At the site pH conditions in the order of 5 have been recorded and thus we recommend manufacturers advice is sought with regards to the use of lead on site.

10.22 Plastics - General

10.22.1 The range of plastics in construction is wide and increasing. The deterioration of plastics varies with the individual material and the environment to which it is exposed. In general, plastics deteriorate through degradation of their polymer constituent, but loss of plasticizer and other additives can render plastics ultimately unserviceable.

10.23 Plastic membranes and geotextiles

10.23.1 Plastic membranes and textiles are used in the construction industry as damp proof courses, gas resistant membranes, cover systems and liners. They are typically used to restrict the movement of gas or water into buildings, building materials or components or to separate differing soil types. Typically materials used for membranes are polyethylene (PE) and poly vinyl chloride (PVC).

10.23.2 Hazards

10.23.2.1 Membranes of PE and PVC are attacked by a variety of acids and solvents. PE has a poor corrosion resistance to oxidising acids (nitric and sulphuric) at high concentrations. Hydrochloric acid (HCl) does not chemically attack PE but can have a detrimental effect on its mechanical properties. Alkalis, basic salts, ammonia solutions and bleaching chemicals such as chlorine will cause deterioration of PE. PE is resistant to non oxidising salt solutions.

10.23.2.2 PVC is degraded by the action of oxidising acids. Nitric acid is particularly aggressive towards PVC. PVC does not deteriorate under the action of neutral or alkaline solutions.

10.23.3 Risk assessment

10.23.3.1 There is no published guidance on quantitative assessment of the risks to PE or PVC although there is a lot of advice on how contaminants react with these plastics. In general, the more concentrated the contamination the greater the risk to plastic membranes/geotextiles.

10.23.3.2 Based on the investigatory data obtained to date, and in consideration of the hazards described above, acidic conditions have been recorded on site and thus we recommend manufacturers advice is sought with regards to the use of plastics and geotextiles on site

10.24 Plastic Pipes

10.24.1 Hazards

10.24.1.1 Plastic pipes are predominantly manufactured from PVC and PE but other materials can be used. In general they perform well but it is known that chemical attack and permeation of contaminants through the pipes can result from use in contaminated land. A published review on plastic pipes reports the following:-

- Polyethylene (PE) - good resistance to solvents, acids and alkalis
- Poly vinyl chloride (PVC) - most common form of pipe. Good general resistance to chemical attack but can be attacked by solvents such as ketones, chlorinated hydrocarbons and aromatic polypropylene (PP) - chemically resistant to acids, alkalis and organic solvents but not recommended for use with storing oxidising acids, chlorinated hydrocarbons and aromatics.
- Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromide and other halogens
- Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis

A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.24.2 Assessment

10.24.2.1 A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

The UK Water Industry research (UKWIR) have published a document entitled *'Guidance for the selection of Water supply pipes to be used in Brownfield sites'*. The publication defines brownfield sites as

'Land or premises that have been used or developed. They may also be vacant, or derelict. However they are not necessarily contaminated'

The subject site has previously been developed and on this basis could potentially be considered brownfield in accordance with the UKWIR document. Following the preliminary risk assessment procedures described in the UKWIR document however, (paragraph 2.4.2) there is no evidence to indicate that chemicals have ever been used or stored on site.

10.24.2.2 Whilst we have not carried out a full investigation set out in guidance in the UKWIR document, the subject site does exhibit a degree of localised hydrocarbon (PAH) contamination. The UKWIR document advises a trigger concentration of 0.125mg/kg for their 'extended VOC (Volatile Organic Carbons) suite' which includes the PAH suite which we have results for. The measured concentration of individual contaminates forming part of the PAH suite exceeds the trigger value of 0.125mg/kg, however, we have recommended that the area is remediated and on this basis it is considered likely that barrier pipes will have to be installed at this site. We recommend Thames Water however is consulted on this to gain their opinion and requirements.

10.25 Electrical cables

10.25.1 Hazards

10.25.1.1 Electrical cables are generally protected by plastic sleeves. These sleeves are potentially subject to chemical and permeation in similar modes as plastic pipes. Medium and low voltage cables are often laid directly into the ground and are thus at risk of attack by contaminants. High voltage cables tend to be laid in trenches backfilled with 'clean' materials.

10.25.2 Risk assessment/remedial action

10.25.2.1 The selection of appropriate sheathing material is important to provide resistance to ground conditions at the site and recommend manufacturers' advices are sought.

10.26 Rubbers

10.26.1 Hazards

10.26.1.1 Rubbers are crosslinked polymeric materials containing a number of additives such as carbon black, fillers, antioxidant and vulcanising agents. The corrosion resistance of rubber is dependant upon the polymeric constituent. The mechanisms by which rubbers deteriorate when placed in aggressive chemical environments are similar to those described for plastics. Oxidation is the principal form of degradation. Whilst rubbers are resistant to strong acids and alkalis, they are rapidly attacked by oxidising agents such as nitric acid and oxidising salts such as copper, manganese and iron.

10.26.1.2 Rubber is also susceptible to attack by certain hydrocarbons and oils. The absorption of these liquids causes the rubber to smell.

10.26.2 Risk assessment/remedial action

10.26.2.1 Information on the effect of a range of chemicals on the physical properties of various rubbers has been produced by the Rubber and Plastics Research Association. This was based on observations carried out following immersion tests using undiluted chemicals, but this has limitations such as the effects of combined chemicals and the effects of dilution.

10.26.2.2 We recommend manufacturers of the rubber materials likely to be in contact with the ground at the site are consulted to confirm, or otherwise, the applicability of their product.

11 Classification of waste soils under the Waste Acceptance Criteria

11.1 The Landfill Directive

11.1.1 The Landfill Directive represents an important change in the way we dispose of waste. It encourages waste minimisation by promoting increased levels of recycling and recovery. The Landfill Directive became law in 1999 and transcribed into the Landfill (England and Wales) Regulations which came into force in 2002. These Regulations were amended in 2005 by introducing criteria to classify soils for disposal to landfill. It is the duty of the waste producer (the client) to classify the soils for this purpose.

11.2 Classification of soil types

11.2.1 Our investigations consider two soil types which may be generated as wastes as part of construction operations, potentially contaminated soil and uncontaminated soil. A full hazard assessment and subsequent testing for waste acceptance criteria is undertaken on soils which are not considered to be naturally deposited or are likely to be affected by artificial contamination. For soils that are unlikely to be affected by artificial contamination (such as natural soils), specific testing in relation to the classification process is not necessary.

11.3 Waste acceptance criteria (WAC)

11.3.1 The Environment Agency publication, *'Framework for the classification of contaminated soils as hazardous wastes'* (July 2004), provides an appropriate procedure for establishing if the soils are hazardous or non-hazardous and applies to soils that are identified as potentially contaminated. Uncontaminated, natural soils are considered separately (see Section 11.6).

11.3.2 Primary classification

11.3.2.1 The first stage is classifying a potentially 'contaminated' soil for disposal to landfill is to establish its chemical status by first identifying potential sources/types of chemical contamination (desk study) followed by intrusive site investigations to obtain samples for undefined testing of soil samples to measure concentrations of chemical contaminants. Such data provides information to partly complete the basic characteristic checklist.

11.3.2.2 Laboratory test data is then compared with the Environment Agency publication '*hazardous waste – Interpretation of the definition and classification of hazardous waste (second edition, version 2.1)'*. Where the waste is suspected to contain oil, we have referred to the Environment Agency draft consultation paper *'How to Find Out if Waste Oil and Wastes that Contain Oil are Hazardous'* (Draft Version 2.5 – October 2006). With reference to these documents a hazard assessment has been carried out to enable categorisation of the material as hazardous or non-hazardous and to subsequently establish the European Waste Catalogue (EWC) code (ref Section 11.3.4 below).

11.3.3 Secondary classification

11.3.3.1 If the soil is deemed hazardous then measurement of organic contaminants and leachable inorganic contaminants is necessary for comparison with values listed in the Environment Agency publication '*Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures'* (April 2005) Table 5.1. Similarly should the soil be deemed as non-hazardous then such testing may also be undertaken to determine if it is potentially inert. This document also provides guidance on sampling materials and frequency as well as test procedures and quality assurance of testing.

11.3.3.2 The above procedures are described with respect to the subject site in the following sections Section 11.4 (primary) and 11.5 (secondary), leading to basic characterisation of soils for disposal. Subject to the results of the categorisation and anticipated development methodology, consideration should be given by the developer to reduce volumes of disposal or treatment to allow reclassification.

11.3.4 European waste catalogue (EWC) coding

11.3.4.1 The EWC 2002 is a catalogue of all wastes, grouped according to generic industry, process or waste type. It is divided into twenty main chapters, each with a two digit code between 01 and 20. Following the EWC, in our opinion, soils considered as part of this investigation would be categorised within 'Group 17' of the EWC catalogue, which comprises 'Construction and Demolition Wastes (including excavated soils from contaminated sites)'.

11.3.4.2 The Catalogue further categorises the waste, such that soils considered as part of this investigation would be classified as either 17 05 04 defined as *'soil and stones (other than those mentioned in 17 05 03)';* or 17 05 03* defined as soil or stones containing dangerous substances (where hazardous wastes are described by entries followed by an asterisk).

11.4 Primary classification

11.4.1 Soil types

11.4.1.1 Based on soils exposed in exploratory excavations, in combination with anticipated construction works, we assume soils requiring off-site disposal will comprise Made Ground and Claygate Member generated as the result of general site clearance, foundation and basement excavations and remediation.

11.4.2 Classification as hazardous or non-hazardous waste

11.4.2.1 The Environment Agency publication *'Framework for the classification of contaminated soils as hazardous wastes'* (July 2004) provides the following procedure for establishing if the soils are hazardous or non-hazardous. The first stage in classifying a potentially 'contaminated' soil for disposal is to establish its chemical status by first identifying potential sources/types of chemical contamination (desk study) followed by intrusive site investigations to obtain samples for laboratory testing of soil samples to measure concentrations of chemical contaminants.

11.4.2.2 An assessment of potential source of contamination is presented in Section 8 of this report. Laboratory testing has been set as deemed appropriate to our source assessment.

11.4.2.3 We have carried out an analysis of test data for each chemical contaminant considered in this investigation. A conservative approach has been adopted for the analysis whereby the maximum test value for each contaminant has been adopted as a preliminary screening process to determine if the soils are hazardous or non-hazardous. Should the analysis indicate potentially hazardous properties then a process of zoning by further analysing the site history, geological conditions and analytical data may be undertaken.

11.4.2.4 Laboratory test data measures the concentration of anions, which are unlikely to exist in the pure metallic form in the soil, but probably exist as a compound. Following guidance provided in the Environment Agency Technical Guidance WM2 *'Interpretation of the definition and classification of hazardous waste,* we have reviewed a variety of compounds for each of the metallic and semi metallic elements we have tested.

11.4.2.5 To determine the hazardous waste properties for each element, we have reviewed chemical compounds listed in Table 3.2 of Annex VI of the European Regulation (1272/2008) for Classification, Labelling and Packaging (CLP) of chemicals which has now superseded the Approved Supply List (Published by the Health and Safety Executive) for the classification of hazardous chemicals in the UK. In order to provide a 'worst case' scenario, initially we adopt the most severe hazardous properties (risk phrases) associated with the various compounds for each element under review. If measured concentrations produce a hazardous outcome then the element or elements are reassessed on a site specific basis. For review of organic contamination, we have directly adopted the threshold concentrations for the appropriate organic compounds listed in Table 3.2.

11.4.2.6 The compound or compounds adopted for each element is used to convert the measured metallic concentration to the substance concentration using their respective molecular weights. This derived conversion factor is then used in the threshold concentration spreadsheet (refer paragraph 11.3.2.8 below).

11.4.2.7 Our assessment of each of the chemical substances is maintained on our files and is available for confidential review/audit by the Environment Agency.

11.4.2.8 A spreadsheet detailing the hazard assessment following the procedures described in *'framework for the classification of contaminated soils as hazardous wastes'* is presented in Appendix J.

11.4.2.9 The spreadsheet indicates the soils are **inert**.

11.5 Secondary assessment

11.5.1 Following '*Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures*' produced by the Environment Agency (Version 1, April 2005) we have scheduled testing of **one** sample to measure the parameters listed in table 5.1 (landfill waste acceptance criteria) included in the above publication. A copy of the test result certificate is presented in Appendix K. The source of the composite sample(s) is detailed below:

Composition of soil samples for classification testing		
Strata	**Source (m)**	**Soil Type**
DTS01	0.2-0.3, 0.5-0.6, 1.2-1.3, 1.5-1.6	Made Ground comprising low to medium strength dark brown and orange brown sandy slightly gravelly clay, loose to medium dense dark brown slightly clayey gravelly sand, brown to dark brown sandy gravel. Gravels consisted of ash, clinker, concrete, brick and flint**.**
DTS02	0.2-0.3	
TP01	0.2-0.3, 0.4-0.4	
TP02	0.3-0.4	
TP03	0.2-0.3, 0.3-0.4	
TP04	0.2-0.4	

Table 11.5.1

11.5.2 The sample was deemed representative of Made Ground soils as described in Section 5. The sample was formed by combining individual samples taken from exploratory excavations within the Made Ground. The combined sample was then quartered in the laboratory to produce a representative sample for subsequent testing.

11.5.3 Laboratory test data has been compared with the landfill waste acceptable criteria (table 5.1) to allow the secondary assessment to be completed. A copy of table 5.1 is presented in Appendix F with test result data added for ease of comparison.

11.5.4 Comparison of test data with landfill waste acceptance criteria indicates that Made Ground soils are suitable for disposal as **inert waste**.

11.6 Naturally deposited soils not affected by artificial contaminants

11.6.1 With reference to the European Waste Catalogue and table 5.1 of the Environment Agency publication '*a better place – guidance for waste destined for disposal in landfills – version 2 June 2006*', naturally occurring soils not likely to be affected by contamination can be classified as inert waste, with a EWC code of 17 05 04. Should any of the naturally deposited soils be suspected to contain contamination (by virtue of visual of olfactory evidence) upon excavation, then such soils should be stockpiled appropriately and additional testing carried out as considered necessary. Based on evidence obtained during our investigations, we are of the opinion that the Claygate Member at the site are not likely to be affected by chemical contamination and thus can be classified as **inert waste.**

11.7 Basic categorisation

11.7.1 Based on the preceding assessment, we have produced two basic categorisation schedules relating to the Made Ground and Claygate Member, which is presented in Appendix L. This schedule should be provided together with a copy of this report to an appropriately licensed landfill facility to demonstrate the material can be deposited at this facility.

11.7.2 We understand that some landfill sites have licences which have restrictions on concentrations of chemical contaminants and thus we recommend this report is provided to the selected landfill facility to confirm (or otherwise) it can accept the waste. Please be aware that landfill sites are obligated to undertake in house quality assurance tests and thus may require further WAC testing for any soils encountered as part of this investigation. There is no obligation on any landfill operator to accept waste if they choose not to and waste operators may require additional testing of untested waste soils prior to acceptance at landfill in accordance with the landfill regulations.

11.8 Treatment of waste

11.8.1 Treatment of wastes is now a requirement of the landfill directive applied by the Landfill (England and Wales) Regulations 2002. Landfill cannot accept untreated waste (be it hazardous or non-hazardous), thus waste producers have the choice of treating it themselves on site or treating it elsewhere prior to disposal to landfill. The regulations require:

’10 – (1) The operator of a landfill shall ensure that the landfill is only used for landfilling waste which is subject to prior treatment unless:

a) It is inert waste for which treatment is not technically feasible; or

b) It is waste other than inert waste and treatment would not reduce its quantity or the hazards which it poses to human health or the environment.’

11.8.2 Regulation 2 defines treatment as: *‘physical, thermal, chemical or biological processes (including sorting) that change the characteristics of waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery.’*

11.8.3 A treatment option must comply with the definition of treatment. This involves a 'three point test' against which treatment is assessed i.e.

1. It must be a physical, thermal, chemical or biological process including sorting
2. It must change the characteristics of the waste: and
3. It must do so in order to:

    a) Reduce its volume: or
    b) Reduce its hazardous nature: or
    c) Facilitate its handling: or
    d) Enhance its recovery.

11.8.4 Treatment of inert wastes

11.8.4.1 Inert waste does not need to be treated if it is not technically feasible however treatment should reduce the amount of waste which goes to landfill and enhance its recovery (by re-use or recycling). Inert wastes are often suitable for recycling, for example as an aggregate or an engineering fill material. A fact sheet on treatment of inert wastes is available on the following website www.environment-agency.gov.uk

11.8.4.2 Clearly, excavations in the naturally deposited Claygate Member will generate inert wastes which could be reused on site or off site for bulk filling, subject of course to maintenance of an acceptable water content and provided that it is fit for its intended purpose.

11.8.5 Treatment of non-hazardous waste

11.8.5.1 Guidance and indeed examples of treatment is provided in the Environment Agency publication '*Treatment of non-hazardous wastes for landfill - your waste – your responsibility,'* again available on the EA website.

11.8.6 Landfill operators

11.8.6.1 It is a requirement of the landfill operator to check if the waste soils taken to the facility have been treated.

11.9 Reuse of Soils - Materials Management Plans

11.9.1 Where soils are to be moved and reused onsite, or are to be imported to the site, a Waste Exemption or an Environmental Permit is required.

11.9.2 An alternative is the use of a Materials Management Plan (MMP) to determine where soils are and are not considered to be a waste. By following *'The Definition of Waste: Development Industry Code of Practice'* published by CL:AIRE (produced in 2008 and revised in March 2011), soils that are suitable for reuse without the need for remediation (either chemical or geotechnical) and have a certainty of use, are not considered to be waste and therefore do not fall under waste regulations. In addition, following this guidance may present an opportunity to transfer suitable material between sites, without the need for Waste Exemptions or Environmental Permits.

11.9.3 MMPs offering numerous benefits, including maximising the use of soils onsite, minimising soils going to landfill and reducing costs and time involved in liaising with waste regulators.

11.9.4 We can provide further advice on this and provide fees for producing a Materials Management Plan on further instructions.

12 Further investigations

12.1	Further investigations

12.1 Although we have endeavoured to provide a comprehensive investigation for the proposed development within budgetary constraints there are areas which will require further investigations in order to determine a suitable, economical remedial solution for the site. Options for the further investigations and/or remediation are outlined in Section 8.3.

12.2 Following determination of the preferred remedial solution, it is likely that the Local Authority will require a detailed Remediation Strategy and subsequent validation report to confirm that measures have been installed. We would be please to assist with any of these aspects upon further instruction.

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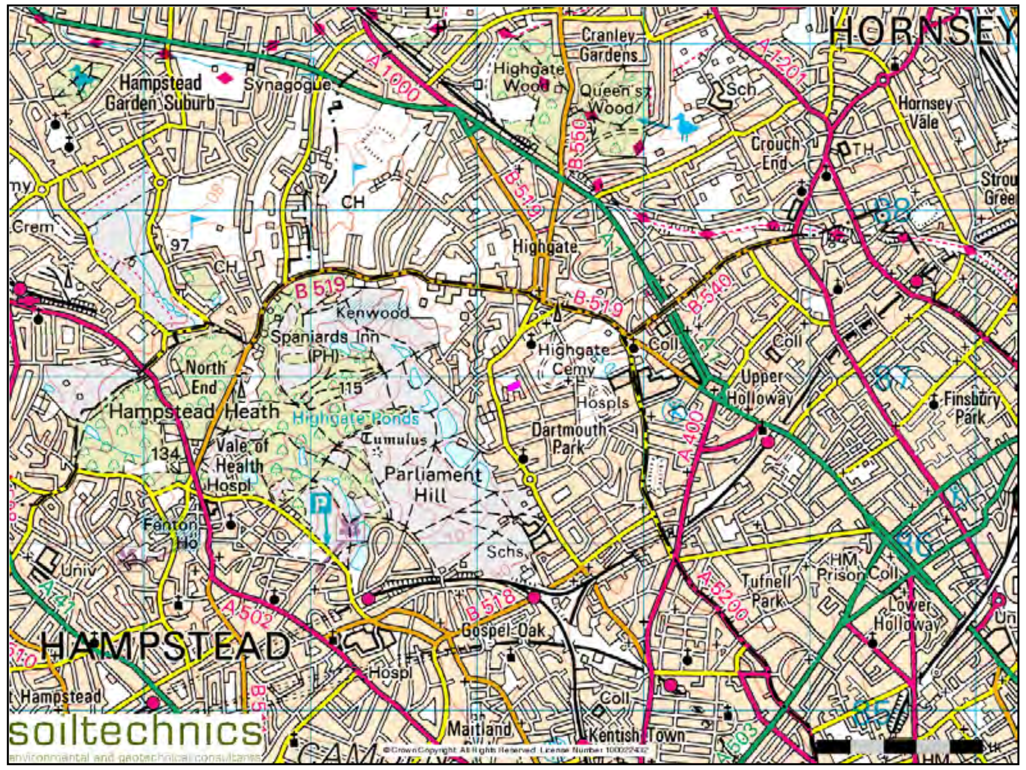
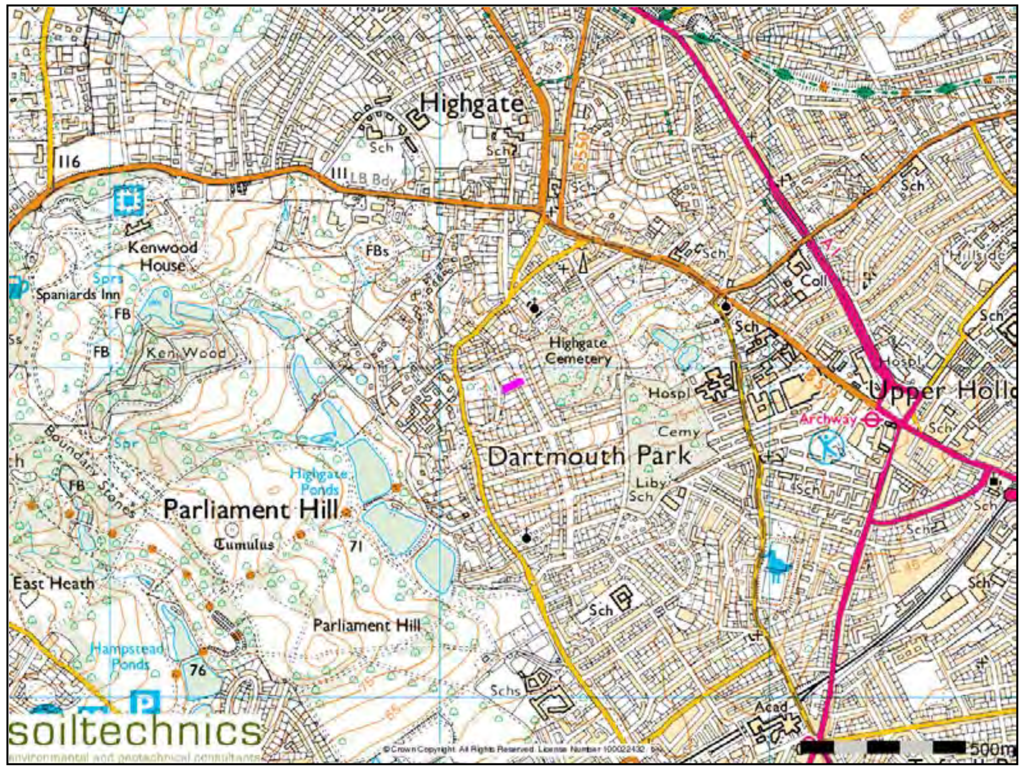
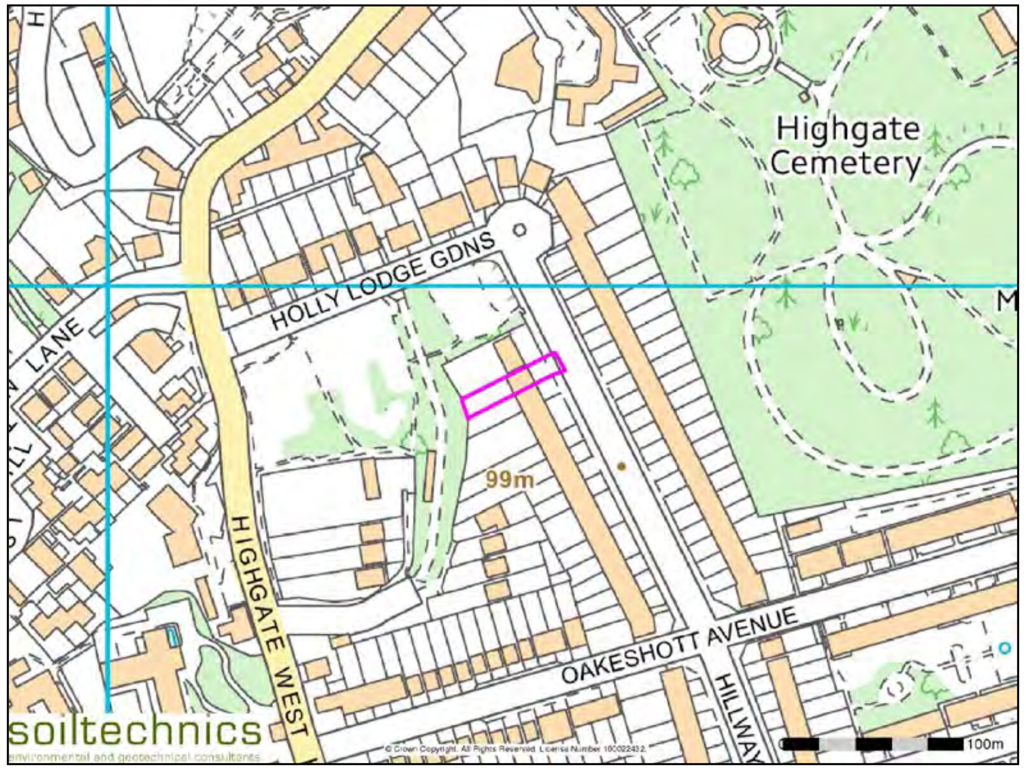


Neighbourhood extract from Ordnance Survey map



Town extract from Ordnance Survey map



Detail extract from Ordnance Survey map

Title	Scale	Drawing number
Site location plan	Not to scale	01

95 Hillway,
Highgate, London

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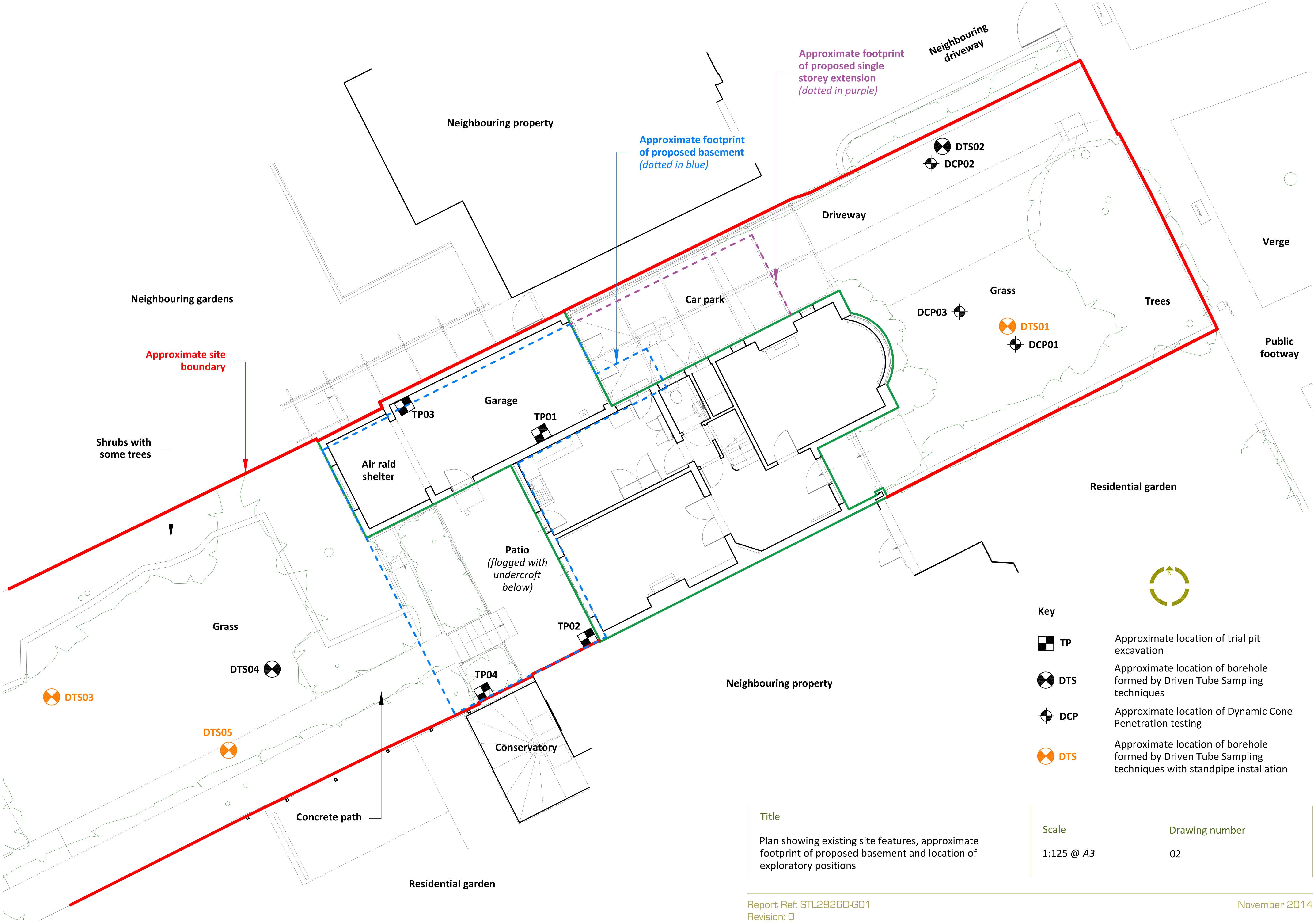

Key

	TP	Approximate location of trial pit excavation
	DTS	Approximate location of borehole formed by Driven Tube Sampling techniques
	DCP	Approximate location of Dynamic Cone Penetration testing
	DTS	Approximate location of borehole formed by Driven Tube Sampling techniques with standpipe installation

Title	Scale	Drawing number
Plan showing existing site features, approximate footprint of proposed basement and location of exploratory positions	1:125 @ *A3*	02

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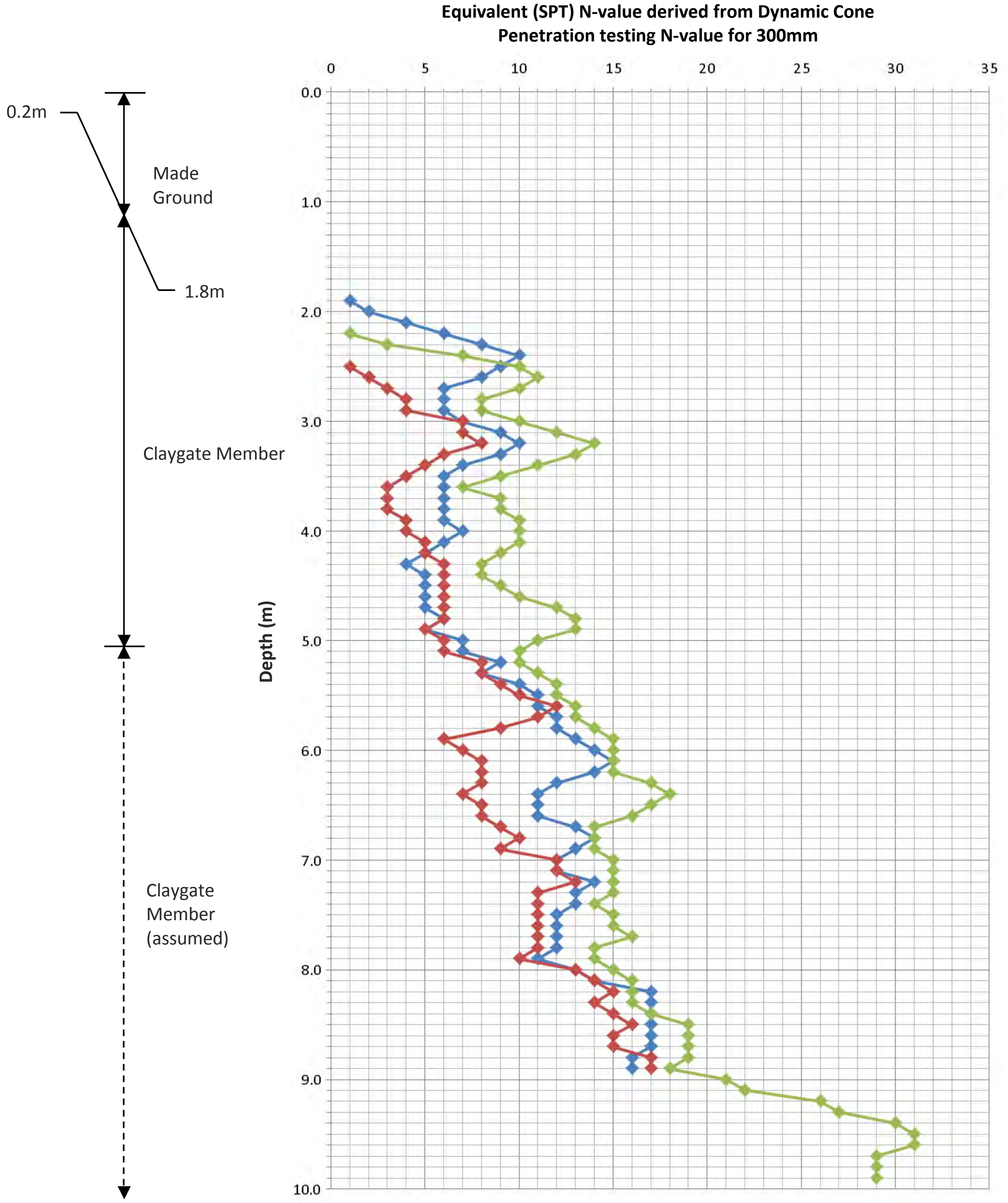

Density	V. loose	Loose	Medium dense	Dense

Key DCP01 DCP02 DCP03

Notes

1) Density descriptions obtained from EN ISO 14688-2:2004

Title	Scale	Drawing number
Plot summarising insitu density testing utilising dynamic cone penetration (DCP) techniques	As shown	03

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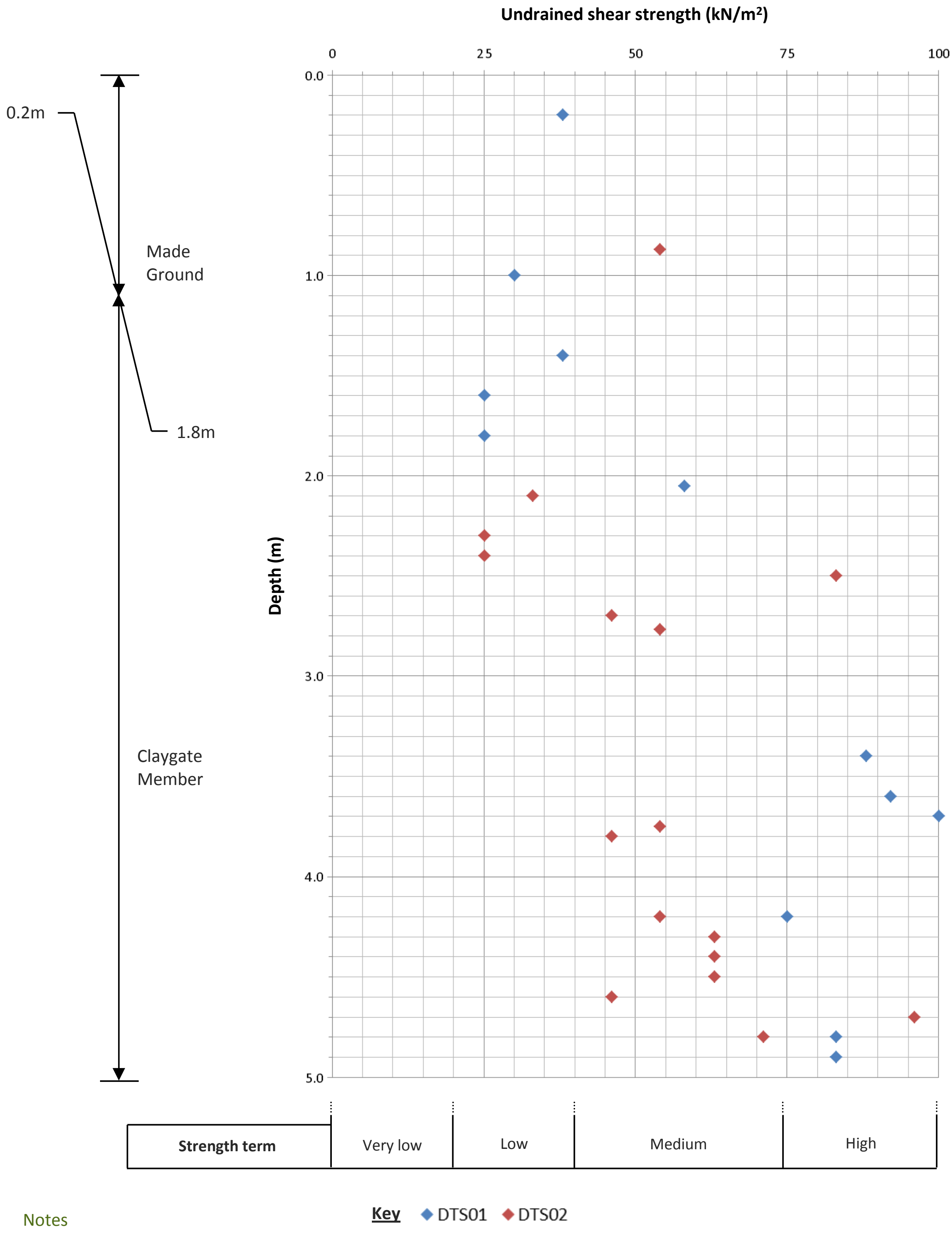

Notes

1) Strength terms obtained from EN ISO 14688-2:2004
2) Equivalent undrained shear strength derived by multiplying Pocket Penetrometer (PP) results by 50

Title	Scale	Drawing number
Plot summarising results of pocket penetrometer determinations	As shown	04

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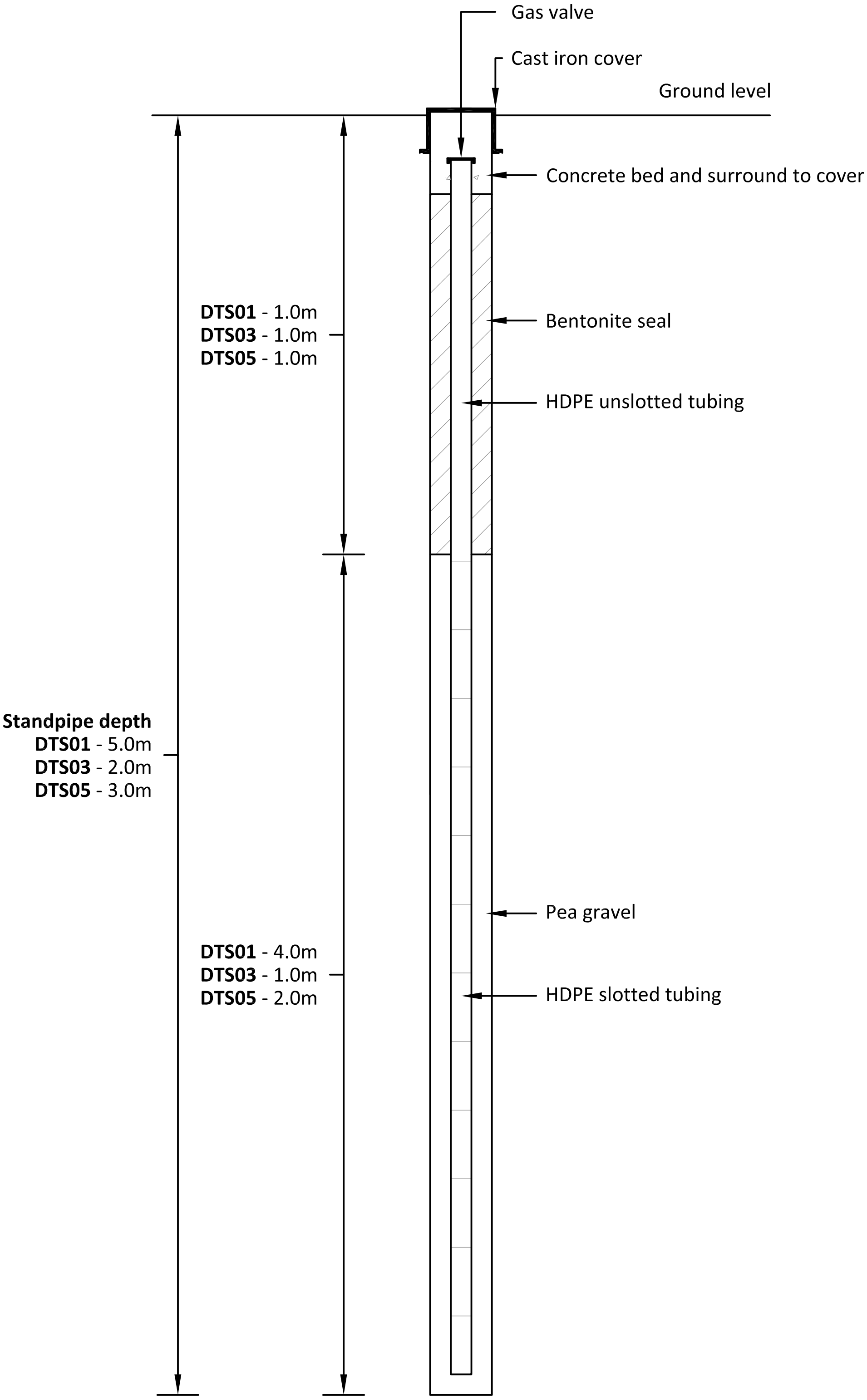

Title	Scale	Drawing number
Section showing construction of gas monitoring standpipes installed in boreholes DTS01, DTS03 and DTS05	Not to scale	05

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Definition of geotechnical terms used in this report - foundations

Strip foundations.
A foundation providing a continuous longitudinal ground bearing.

Trench fill concrete foundation.
A trench filled with mass concrete providing continuous longitudinal ground bearing.

Pad foundation.
An isolated foundation to spread a concentrated load.

Raft foundation.
A foundation continuous in two directions, usually covering an area equal to or greater than the base area of the structure.

Substructure.
That part of any structure (including building, road, runway or earthwork) which is below natural or artificial ground level. In a bridge this includes piers and abutments (and wing walls), whether below ground level or not, which support the superstructure.

Piled foundations and end bearing piles. A pile driven or formed in the ground for transmitting the weight of a structure to the soil by the resistance developed at the pile point or base and the friction along its surface. If the pile supports the load mainly by the resistance developed at its point or base, it is referred to as an end-bearing pile; if mainly by friction along its surface, as a friction pile.

Bored cast in place pile.
A pile formed with or without a casing by excavating or boring a hole in the ground and subsequently filling it with plain or reinforced concrete.

Driven pile.
A pile driven into the ground by the blows of a hammer or a vibrator.

Precast pile.
A reinforced or prestressed concrete pile cast before driving.

Driven cast in place pile.
A pile installed by driving a permanent or temporary casing, and filling the hole so formed with plan or reinforced concrete.

Displacement piles.
Piled formed by displacement of the soil or ground through which they are driven.

Skin friction.
The frictional resistance of the surrounding soil on the surface of cofferdam or caisson walls, and pile shafts.

Downdrag or negative skin friction. A downwards frictional force applied to the shaft of a pile caused by the consolidation of compressible strata, e.g. under recently placed fill. Downdrag has the effect of adding load to the pile and reducing the factor of safety.

Definition of geotechnical terms used in this report – bearing values

Ultimate bearing capacity.
The value of the gross loading intensity for a particular foundation at which the resistance of the soil to displacement of the foundation is fully mobilised.

Presumed bearing value.
The net loading intensity considered appropriate to the particular type of ground for preliminary design purposes. The particular value is based on calculation from shear strength tests or other field tests incorporating a factor of safety against shear failure.

Allowable bearing pressure.
The maximum allowable net loading intensity at the base of the foundation, taking into account the ultimate bearing capacity, the amount and kind of settlement expected and our estimate of ability of the structure to accommodate this settlement.

Factor of safety.
The ratio of the ultimate bearing capacity to the intensity of the applied bearing pressure or the ratio of the ultimate load to the applied load.

Definition of geotechnical terms used in this report – road pavements

The following definitions are based on Transport and Road Research Laboratory (TRRL) Report LR1132.

Equilibrium CBR values.
A prediction of the CBR value, which will be attained under the completed pavement.

***Thin pavement*.**
A thin pavement (which includes both bound and unbound pavement construction materials 1 in 300mm thick and a thick pavement is 1200mm thick (typical of motorway construction).

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Definition of geo-environmental terms used in this report

Conceptual model
Textual and/or schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the basis of the information obtained from the investigatory process.

Contamination
Presence of a substance which is in, on or under land, and which has the potential to cause harm or to cause pollution of controlled water.

Controlled water
Inland freshwater (any lake, pond or watercourse above the freshwater limit), water contained in underground strata and any coastal water between the limit of highest tide or the freshwater line to the three mile limit of territorial waters.

Harm
Adverse effect on the health of living organisms, or other interference with ecological systems of which they form part, and, in the case of humans, including property.

Pathway
Mechanism or route by which a contaminant comes into contact with, or otherwise affects, a receptor.

Receptor
Persons, living organisms, ecological systems, controlled waters, atmosphere, structures and utilities that could be adversely affected by the contaminant(s).

Risk
Probability of the occurrence of, and magnitude of the consequences of, an unwanted adverse effect on a receptor.

Risk Assessment
Process of establishing, to the extent possible, the existence, nature and significance of risk.

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Definition of environmental risk/hazard terms used in this report.

Based on CIRIA report C552 '*Contaminated land risk assessment – A guide to good practice*'.

Potential hazard severity definition

Category	Definition
Severe	Acute risks to human health, catastrophic damage to buildings/property, major pollution of controlled waters
Medium	Chronic risk to human health, pollution of sensitive controlled waters, significant effects on sensitive ecosystems or species, significant damage to buildings or structures.
Mild	Pollution of non sensitive waters, minor damage to buildings or structures.
Minor	Requirement for protective equipment during site works to mitigate health effects, damage to non sensitive ecosystems or species.

Probability of risk definition

Category	Definition
High likelihood	Pollutant linkage may be present, and risk is almost certain to occur in long term, or there is evidence of harm to the receptor.
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term
Low likelihood	Pollutant linkage may be present, and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable.

Level of risk for potential hazard definition

Probability of risk	Potential severity			
	Severe	Medium	Mild	Minor
High Likelihood	Very high	High	Moderate	Low/Moderate
Likely	High	Moderate	Low/Moderate	Low
Low Likelihood	Moderate	Low/Moderate	Low	Very low
Unlikely	Low/Moderate	Low	Very low	Very low

Refer sheet 2 for definitions of 'very high' to 'low'

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Definition of environmental risk/hazard terms used in this report.

Based on CIRIA report C552 '*Contaminated land risk assessment – A guide to good practice*'.

Risk classifications and likely action required:

Very high risk
High probability that severe harm could arise to a designated receptor from an identified hazard OR there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised is likely to result in substantial liability. Urgent investigation and remediation are likely to be required.

High risk
Harm is likely to arise to a designated receptor from an identified hazard. This risk, if realised, is likely to result in substantial liability. Urgent investigation is required and remedial works may be necessary in the short term and are likely over the long term.

Moderate risk
It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is likely that the harm would be relatively mild. Investigation is normally required to clarify risks and to determine potential liability. Some remedial works may be required in the long term.

Low risk
It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that this harm, if realised, would at worst normally be mild.

Very low risk
It is a low possibility that harm could arise to a designated receptor. On the event of such harm being realised it is not likely to be severe.

Gaseous contamination - Extract copy of table 3 of BS8485:2007 Solutions scores

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Venting/dilution (see Annex A of BS8485)			
Passive sub-floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc) [A)]	Very good performance	2.5	*Ventilation performance in accordance with Annex A of BS8485.*
	Good performance	1	*If passive ventilation is poor this is generally unacceptable and some form of active system will be required.*
Subfloor ventilation with active abstraction/pressurization (venting layers can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc)A)		2.5	*There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.* *Active ventilation can always be designed to meet good performance.* *Mechanically assisted systems come in two main forms: extraction and positive pressurization*
Ventilated car park (basement or undercroft)		4	*Assume car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F and IStructE guidance.*
b) Barriers			
Floor Slabs			*It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum.*
Block and beam floor slab		0	
Reinforced concrete ground bearing floor slab		0.5	
Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab		1.5	*Breaches in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances.*
Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints		1.5	
Fully tanked basement		2	
c) Membranes			
Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation [B), C)]		0.5	*The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installations, and the integrity of joints.*
Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) [B), C)]		1	
Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation.		2	
d) Monitoring and detection (not applicable to non-managed property, or in isolation)			
Intermittent monitoring using hand held equipment		0.5	Where fitted, permanent monitoring system ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.
Permanent monitoring and alarm system [A)]	Installed in the underfloor venting/dilution system	2	
	Installed in the building	1	
e) Pathway Intervention			
Pathway intervention		-	*This can consist of site protection measures for off-site or on-site sources (see Annex A of BS8485)*

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

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

[B)] If a 200g DPM material is to function as a gas barrier it should be installed according to BRE 212)/BRE 414), being taped and sealed to all penetrations.

[C)] Polymeric Materials > 1 200g can be used to improve confidence in the barrier. Remember that their gas resistance is little more than the standard 1 200g (proportional to thickness) but their physical properties mean that they are more robust and resistant to site damage.

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List of documents used in assessment of chemical contamination

No.	Title	Publication reference / publisher
1	Human health toxicological assessment of contaminants in soil	EA Science Report – SC050021/SR2
2	Updated technical background to the CLEA model	EA Science Report – SC050021/SR3
3	CLEA Software (Version 1.03 beta) Handbook	EA Science Report - SC050021/SR4
4	Guidance on comparing Soil Contamination Data with a Critical Concentration	CIEH
5	Generic Assessment Criteria for Human Health Risk Assessment	LQM/CIEH
6	Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research	R&D Publication, Contaminated Land Report CLR 7
7	Contaminants of Soil: Collation of Toxicological Data and Intake Values for Humans	R&D Publication, Contaminated Land Report CLR 9
8	The Contaminated Land Exposure Assessment Model (CLEA): Technical Basis and Algorithms	R&D Publication, Contaminated Land Report CLR 10
9	Model Procedures for the Management of Land Contamination	R&D Publication, Contaminated Land Report CLR 11
10	Contaminants in Soil: Collection of Toxicological Data and Intake Values for Human Values	R&D Publications, Tox. 6
11	Soil Guideline Values for Contamination (2002)	R&D Publications, SGV 10
12	Soil Guideline Values (2009)	EA Science Reports – SC050021

CIEH	Chartered institute of Environmental Health
LQM	Land Quality Management
EA	Environment Agency