7.7.4 The 'insitu' CBR derived above, is susceptible to change dependent upon weather conditions during construction. We recommend the insitu CBR of 2.6% 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'.

7.7.5 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. 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.

7.7.6 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.specificationforhighways.co.uk) 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.

7.7.7 The silty nature of the Made Ground 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 With regards to planned future use, Planning and Policy Statement 23 (PPS23) *'Planning and pollution control – Annex 2 – Development on land affected by contamination'* requires land owners / developers to ensure the proposed development is safe and suitable for use for the purpose for which it is intended. The developer is thus 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 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 with the aim of satisfying the requirements of PPS 23 in relation to the proposed development and indeed 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: 2001 *'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: 2001 for an explanation).

8.2.1.2 This section of the report produces a *'Conceptual model'* 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 damage 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 relation to 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 - by analysis of test data and other evidence

Table 8.2.4.1

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 a preliminary 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 categorisation and identified receptors

8.3.1 Site categorisation

8.3.1.1 The nature of the site has a significant influence the likely exposure pathways between potentially contaminated soils and potential receptors. On this basis, the current site use and the planned development has a significant influence on the conceptual model and analysis of any test data.

8.3.1.2 The site is currently occupied by a community campus incorporating educational facilities and offices.

8.3.1.3 It is understood that the proposed redevelopment includes offices, child welfare facilities and a caretakers flat.

8.3.1.4 Based on desk study and fieldwork observations, the near surface geology comprises of Made Ground overlying Lynch Hill Gravel, London Clay and the Lambeth Group. The Lynch Hill Gravel deposits are designated a minor aquifer. The Made Ground deposits are predominately granular and are considered to be permeable.

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)

8.3.2.2 This section of the report assesses those receptors listed above. Section 10 presents a risk assessment with 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 Based on the current site use, the critical site user is considered to be a **child**. This criterion has been used in the conceptual model for the current site use.

8.3.3.3 We understand the development is for mixed use including offices, child welfare services which will include children visiting the site on an occasional basis and a flat for the caretaker, which will include outside space. The critical end user for the office areas is considered to be an adult. The critical end user for the residential area is considered to be a child.

8.3.3.4 We understand that the child welfare facilities will be a 'drop-in centre' and therefore children are unlikely to be attending this part of the site on an everyday basis. We understand adults will be employed at the site full time. On this basis it is not clear which user will be most critical and therefore both adults and children will be considered.

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 Based on site observations and development proposals, vegetation is and will continue to be present at the site.

8.3.5 Water receptors

8.3.5.1 The western part of the site lies in an area designated a minor aquifer reflecting the near surface Lynch Hill Gravel deposits. The Made Ground deposits are considered to be permeable and therefore groundwater is considered to be a receptor.

8.3.5.2 The nearest surface watercourse is Regents Canal located approximately 850m to the north of the site. This watercourse is considered too remote from the site to be a potential receptor and will not be considered further.

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:

- Ingestion through the mouth.
  - Ingestion of indoor air-borne dusts
  - Ingestion of outdoor 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 indoor air-borne dusts
  - Inhalation of outdoor air-borne dusts
  - Inhalation of indoor vapours
  - Inhalation of outdoor vapours
- Absorption through the skin.
  - Dermal contact with dust
  - Dermal contact with soil

8.4.1.2 Based on our site observations, the site is currently used as a community campus incorporating schools, offices and non-productive garden areas. Pathways associated with the consumption of home-grown vegetables are not considered to be present.

8.4.1.3 All of the above pathways are considered relevant for the residential use of the site. Again, with reference to 8.4.1.2 above, pathways via the consumption of home-grown vegetables are not considered relevant for the office and child welfare site use.

8.4.1.4 For construction operatives, pathways associated with the consumption of home-grown vegetables are not considered to be relevant.

8.4.1.5 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 Based on current land and proposed land use it is considered **likely** that vegetation will be exposed to potentially contaminated soils. As the land use includes vegetation, it is considered likely that all of these exposure pathways would be present.

8.4.3 Pathways to controlled water

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 The Made Ground deposits are predominately granular therefore percolation and near-surface run-off are considered potential pathways.

8.4.3.3 The site does not lie in a floodplain therefore saturation by flood waters is not considered to be a potential pathway.

8.4.4 Elemental risk assessment

8.4.4.1 Based on our site observations, the site is currently used as schools and offices. The proposed development will not result in a change of site use. Based on this land use, the critical human receptor is considered to be a **child**. Based on this land use and critical receptor, we can provide the following elemental risk evaluation of possible pathways.

Assessment of possible pathways to site end user receptors

Receptor	Pathway	Probability of a chemical source causing harm
Site users Child welfare end users Office end users Construction operatives	Ingestion of indoor air-borne dusts Ingestion of outdoor air-borne dusts Ingestion of soil Inhalation of indoor air-borne dusts Inhalation of outdoor air-borne dusts Inhalation of indoor vapours Inhalation of outdoor vapours Dermal contact with dust Dermal contact with soil	Low likelihood
Domestic end users	Ingestion of soil attached to vegetables Ingestion of home grown vegetables	Low likelihood
Vegetation	Root uptake, deposition to shoots and foliage contact	Likely
Controlled waters	Percolation of water through contaminated soils	Likely
	Near-surface water run-off through contaminated soils	Likely

Table 8.4.2

8.4.4.2 Based on the assessments outlined above, there are many site uses with different critical users and exposure pathways. Furthermore, a number of the proposed end uses include site exposure durations different to those used in the standard site uses outlined in the CLEA model. To accurately assess the risks to site users under the different conditions outlined above would require the derivation of site specific exposure assessments for a number of the cases.

8.4.4.3 At this stage, to simplify this risk assessment, we will take the approach of assuming the least onerous of the standard exposure models, commercial/industrial, as an initial screen. By using this model, we will be assessing the risk to current site users and proposed end users of the office space at the site. Should potential risks be identified using this initial comparison, it will be clear that the area for domestic use will prove to be a potential risk. In addition, the identification of risk for an office user also suggests a risk to an adult working full-time in the child welfare space.

8.4.4.4 Should the simplified risk assessment suggest at any point that the site poses a low risk for a commercial land use then it will be necessary to derive a site specific exposure assessment fro children visiting the welfare facility at the site.

8.4.4.5 A commercial/industrial land use is also considered appropriate in assessing risks to construction operatives.

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
- Fieldwork observations

These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative processes/events 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 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 L) the site has no recorded history of any pollution events, or trading activities which could generate a source of contamination, or is located in close proximity to a landfill site.

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 STG1672B-02.

8.5.4.2 As a result of our site reconnaissance visit, we did not observe any obvious evidence of any current or recent activities on site or adjacent sites, which provide a potential source of chemical contamination.

8.5.5 Source assessment - Fieldwork observations

8.5.5.1 Made Ground soils exposed in exploratory excavations contained materials including brick, ash, metal and clinker suggesting a potential source of chemical contamination. We obtained samples of the potentially chemically impacted soils for subsequent laboratory testing.

8.5.6 Source assessment - summary

8.5.6.1 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 which could cause harm to humans / water receptors	Probability of risk occurring	Likely extent of contamination on site
On site				
Made Ground soils	Fieldwork observations	Metals PAH	Likely	Potentially site-wide
Adjacent sites				
None identified	N/A	N/A	N/A	N/A

Table reference 8.7.2

8.6 Laboratory testing

8.6.1 Testing regime – Human receptors

8.6.1.1 Based on our source assessment reported in Section 8.5 we have no evidence to identify any past or recent uses of the site or neighbouring sites which may have generated specific contamination. Made Ground soils were observed to contain materials suggesting a potential source of chemical contamination. In order to carry out a qualitative assessment, we have scheduled testing to measure the concentration of commonly occurring inorganic and organic contaminants.

8.6.1.2 Five samples were submitted for measurement of organic and inorganic contaminants. Obviously, additional testing (quantity and types) would allow a more accurate risk assessment to be made.

8.6.1.3 The results of laboratory determination of concentration of chemical contaminants are presented in Appendix H.

8.6.2 Testing regime – Water receptors

8.6.2.1 We have identified Made Ground soils as a potential source of chemical contamination and in order to produce a qualitative assessment, we have selected one soil sample for measurement the leachable concentrations of potential contaminants. Based on our conceptual model, it is considered unlikely that naturally deposited soils at the site have been affected by artificial contamination thus we have selected one sample of Made Ground. The testing included commonly occurring inorganic and organic contaminants where they are considered a risk to water resources.

8.6.2.2 It should be noted that we have only scheduled one sample for laboratory determination of leachable concentrations of contaminants described above. Further laboratory testing would increase the accuracy of the risk assessment.

8.6.3 Criteria for assessment of test data – Human receptors

8.6.3.1 Assessment of laboratory test data has been carried out using the following documents:

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

Table 8.6.3

8.6.3.2 Due to changes in guidance on contaminated land, items 6-8 and item 10 in Table 8.6.3 above have been withdrawn. However, in the absence of alternative guidance they have been used. Where new guidance is available, this has been followed in preference to superseded guidance.

8.6.3.3 Soil guideline values (SGVs) as outlined in documents listed under item 11 and 12 in Table 8.6.3 above, 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). These values 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). Where SGVs or GACs are not available, we have used the CLEA model to derive our own Soil Screening Values (SSV).

8.6.3.4 SGVs, GACs and SSVs 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.

8.6.3.5 Currently there is a toxicity report for inorganic cyanide but not organic cyanides. In the absence of both an SGV and GAC for this contaminant we have adopted the potentially conservative approach of considering a risk to human health where the concentration of cyanides (free and total) is above detectable limits.

8.6.3.6 With reference to Science Report SC050021 / Mercury SGV (Environment Agency, 2009) there is no evidence that the site has been subject to industrial processes that may have resulted in elemental mercury being present in near surface soils. Test data for mercury has therefore been assessed against the SGV for inorganic mercury.

8.6.3.7 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.

8.6.3.8 We have followed procedures outlined by the CIEH to compare measured concentrations of metals and PAH contaminants against guideline values. The guidance presents an approach to data analysis and includes the examination of data for potential outliers, assessment of the normality of the test data and the calculation of a 95% Upper Confidence Limit (UCL). The UCL provides an estimate of the population mean, based on test data, with a 95% confidence that the actual mean does not exceed this value. The UCL is compared to the guideline value for the site.

8.6.3.9 As outlined in Section 8.4, we have adopted a commercial/industrial land use as an initial screen of test results.

8.6.4 Criteria for assessment of test data – Construction operatives

8.6.4.1 We have adopted a commercial/industrial land use for construction operatives.

8.6.5 Criteria for assessment of test data – Vegetation

8.6.5.1 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 SGV should be adopted with the exception of copper and zinc. A value of 130mg/kg is adopted for copper and 300mg/kg for zinc.

8.6.5.2 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.

8.6.6 Criteria for assessment of test data – Controlled waters

8.6.6.1 For interpretation of test data in relation to water receptors we have directly compared measured values with the Environmental Quality Standards (EQS) and UK Drinking Water Standards (UKDWS). In the absence of EQS or UKDWS we have adopted World Health Organisation Drinking Water Guidelines (WHODWG)

8.6.6.2 EQS values are published by the Environment Agency in their publication, *"Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part 11A of the Environmental Protection Act 1990"*. EQS values for most inorganic contaminants in freshwater are dictated by the hardness of the receiving watercourse. The hardness of water is a measure of the concentration of calcium carbonate in the water. Although we have not sampled water from nearby watercourses, we have contacted the Environment Agency and have been advised that there is some test data for hardness in the River Thames, which is an ultimate receiving watercourse from surface waters downstream of the site. We are advised that over a two year monitoring period, the River Thames produced an average hardness of 326mg/l.

8.6.6.3 Using this information for List II substances (DOE Circular 7/89) we have compared the measured values with the EQS values relative to the hardness of the receiving watercourse assuming a worst case scenario of the watercourse supporting 'sensitive' aquatic life.

8.6.6.4 UKDWS are presented in the Water Supply (Water Quality) Regulations.

8.6.6.5 Following our receptor assessment (outlined in Section 8.4.2 above), we have adopted EQS values in preference to alternative guidelines where possible.

8.6.7 Evaluation of test data – Human receptors

8.6.7.1 Inorganic contaminants

8.6.7.1.1 Existing and proposed site users and construction operatives

8.6.7.1.1.1 Based on analysis of chemical test data, all 95% UCLs are below the relevant guideline values with the exception of lead. One of the samples was measured at 850mg/kg, above the guideline value of 750mg/kg. The 95% UCL for lead at the site is 1108mg/kg, again exceeding the guideline value of 750mg/kg.

8.6.7.1.2 Vegetation

8.6.7.1.2.1 The 95% UCL value for copper of 155.1mg/kg exceeds the guideline value of 130mg/kg. The 95% UCL is also above the guideline value for lead, as outlined above. The 95% UCL values for all other inorganic contaminants are below corresponding guideline values.

8.6.7.2 Organic contaminants

8.6.7.2.1 Existing and proposed site users, construction operatives and vegetation

8.6.7.2.1.1 Based on analysis of chemical test data, all 95% UCLs are below the relevant guideline values.

8.6.7.3 Summary

8.6.7.3.1 Following the examination of test data, lead is considered to present a risk at the site to site users, construction operatives and vegetation. While only one of the samples was measured at an elevated concentration, the 95% UCL was calculated above the guideline value for the site. The elevated lead concentration is associated with Made Ground.

8.6.7.3.2 Copper was identified at the site at levels that are potentially harmful to planting. We recommend that the contents of this report are passed to the landscape architect to allow a suitable planting scheme to be designed.

8.6.8 Evaluation of test data – Controlled waters

8.6.8.1 Inorganic contaminants

8.6.8.1.1 None of the measured concentrations of inorganic contaminants exceed the relevant guideline outlined in Section 8.6.6.

8.6.8.2 Organic contaminants (Polycyclic aromatic hydrocarbons)

8.6.8.2.1 For the analysis of PAH contamination, the sum of the following contaminants has been compared to a UKDWS.

- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Indeno(1,2,3-cd)pyrene

8.6.8.2.2 The summed concentration of the PAH 'suite' do not exceed the UKDWS. In addition the leachable concentration of benzo(a)pyrene and naphthalene, do not exceed their respective guideline values.

8.6.8.4 Summary

8.15.4 Based on the above we are of the opinion that there is not a significant possibility of significant harm being caused to water resources from ground conditions explored at the site.

8.7 Conceptual model

8.7.1 Following the assessments in the preceding Sections, we have produced the following risk assessment for the site:

Source	Pathway	Receptor	Contaminants posing a risk	Consequence of risk being realised	Probability of risk occurring	Level of risk
Onsite						
Made Ground soils	Ingestion of indoor air-borne dusts Ingestion of outdoor air-borne dusts Ingestion of soil Inhalation of indoor air-borne dusts Inhalation of outdoor air-borne dusts Inhalation of indoor vapours Inhalation of outdoor vapours Dermal contact with dust Dermal contact with soil	Existing and site users Construction operatives	Lead	Medium	Low likelihood	Moderate
	Root uptake, deposition to shoots and foliage contact	Vegetation	Copper Lead	Medium	Likely	Moderate
	Percolation and near surface run-off through contaminated soils	Water	None identified	-	-	-

Table 8.7.1

8.7.2 The conceptual model outlined above presents the least onerous assessment of test data. As a risk has been identified, we consider the site to pose a potential risk to all potential users of the site. While the risk to domestic users, which is considered to be the most conservative assessment, would be higher than that for commercial users, we would consider the "Level of risk" to remain as moderate.

8.8 Risk assessment summary and recommendations

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

8.8.2 Existing and proposed site users and vegetation

8.8.2.1 Following our risk assessments, we consider there to be a moderate risk to users of the site and vegetation. We recommend that a capping layer is introduced into all soft landscaping areas at the site. This capping will sever the pathways between receptors and the Made Ground at the site.

8.8.3 Construction operatives and other site investigators

8.8.3.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, moderate and would be minimised by taking adequate hygiene precautions 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.

8.8.3.2 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).

8.8.3.3 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.

8.8.4 Controlled waters

8.8.4.1 Based on the results of chemical testing, we are of the opinion that there is not a significant possibility of significant harm being caused to water resources from ground conditions explored at the site.

8.9 Statement with respect to PPS23 annex 2

8.9.1 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 Planning and Policy Statement 23 (PPS23) *'Planning and pollution control – Annex 2 – Development on land affected by contamination'*, and compliant with the Building Regulations Part C, *'Site preparation and resistance to contaminants and moisture'*.

8.10 On Site Monitoring

8.10.1 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 recommend investigation and testing be carried out accordingly.

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 gases 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.

9.1.2 With regards to planned future use, Planning and Policy Statement 23 (PPS23) requires developers to undertake appropriate risk assessments to demonstrate to the local planning authority that proposals adequately mitigate any potential hazards associated with ground contamination including soil gas. 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, gases generated by biodegradable matter. The potential for the development to be affected by Radon Gas is considered in Section 3 above. The principal ground gases 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%	Ventilation required in confined spaces
	5%	Potentially explosive when mixed with air
	30%	Asphyxiation
Carbon Dioxide	0.5%	8 hour exposure limit (WEL) (HSE)
	1.5%	15 min exposure limit (WEL)
	>3%	Breathing difficulties
	>5%	Death can occur

Table.9.1

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 '*Resistance to Contaminates*' (2004) 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 and if appropriate the identification of mitigation measures.

- 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).

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 gases and parameters for producing gases

Source and control of gases	
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 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 strong recommendation to avoid building within 50m of a new landfill site 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 gases.

9.3.2.2 Envirocheck reports one historical landfill site located some 835m to the east of the site. Records indicate the site was licensed for receipt of inert wastes and the licence has now lapsed. Such materials are unlikely to generate any significant quantities of landfill type gases. This landfill is also considered to be too remote to act as a potential source of ground gases. In addition, we have reviewed old Ordnance Survey maps and there is no obvious evidence of any quarrying in the area 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 significant 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 gases.

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 Gas migration

9.4.1 Exploratory excavations encountered a consistent deposit of Lynch Hill Gravel overlying London Clay and the Lambeth Group to depths of in excess of 35m. These deposits were all cohesive in nature and are, which in our opinion effectively impermeable and would significantly restrict both lateral and vertical migration of landfill type gases.

9.5 Conceptual model

9.5.1 Based on the above, we have been unable to identify a potential source of ground gases. In addition, a likely migration pathway is considered unlikely to exist. Our conceptual model is tabled below. On this evidence we are of the opinion that the site is at low risk of being affected by ground gases (carbon dioxide / methane) sufficient to potentially cause harm to human end users of the site, construction operatives or indeed buildings.

Conceptual model

Potential source origin	Potential pathway	Receptors at risk
None identified	None present	Low risk to site receptors

Table 9.5.1

9.5.2 In order to confirm the above conceptual model, and adopting a conservative approach, we have carried out gas monitoring in order to derive a quantitative risk assessment.

9.6 Development categorisation

9.6.1 With reference to BS 8485:2007 (table 2), the proposed development would be classified as *'Public building (which includes managed apartments, schools and hospitals)'.*

9.7 Monitoring observations

9.7.1 One standpipe has been installed at the site to a depth of 8m (refer Drawing STG1672B-05). Following CIRIA Report C665 (tables 5.5a, and 5.4b) we have assessed the site as low risk of generation potential of source ideally requiring 6 monitoring visits over a 3 month period.

9.7.2 We have returned to site on one monitoring visit to obtain measurements of landfill type gases at atmospheric conditions of 1009mb. Our observations/measurements are recorded in Appendix I. The concentration of methane was measured at below detectable limits and the concentration of carbon dioxide was measured at 0.2%. If flow was detected during our monitoring visit then this is recorded, but where no flow is detected then, following BS8485:2007, we have assumed flow at the detection limit of the monitoring equipment at 0.1l/s.

9.7.3 Gas monitoring results reported in Appendix I can be summarised as follows in respect to carbon dioxide and methane.

Test point	Methane			Carbon dioxide		
	Maximum concentration, C_{hg}, (%)	Maximum flow, q (l/hr)	Maximum gas flow rate, Q_{hg}(l/hr)	Maximum concentration, C_{hg}, (%)	Maximum flow, q (l/hr)	Maximum gas flow rate, Q_{hg}(l/hr)
BH03	0.00	0.1	0.00	0.2	0.1	0.00

Table 9.7.3

9.8 Classification of site characteristic gas situation

9.8.1 Using test data and with reference to table 1 of BS8485:2007, the site would be classified as **characteristic gas situation 1**. Clearly further monitoring will increase the accuracy of this risk assessment, however, in our opinion and based on the conceptual model and the results of monitoring to date, there is a low likelihood of encountering higher concentrations of ground gases during further monitoring visits. We are therefore of the opinion that the proposed development is at low risk from ground gases and there is no requirement for gas protective measures for new buildings at the site

9.9 Gas protective measures – new buildings

9.9.1 Based on monitoring, development categorisation, and the site characteristic gas situation (Section 9.8 above) and with reference to table 2 of BS8485:2007, the development does not require any gas protective measures.

9.10 Conclusion

9.10.1 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 gases (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 gases, and indeed implementation of further investigations to measure concentrations of ground gases. Again on the basis of evidence provided above, mitigation measures against ingress of ground gases into the proposed development are not considered necessary.

9.11 Statement with respect to PPS 23 annex 2

9.11.1 With reference to paragraph 9.9 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 Planning and Policy Statement 23 (PPS23) *'Planning and pollution control – Annex 2 – Development on land affected by contamination'*, 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.

Element	Interrogation		Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites	Made Ground	Unlikely	Box C6
		Lynch Hill Gravel	Unlikely	
		London Clay	Likely	
Past industrial uses	Brownfield site?		No	C2.1.2

Table 10.7.3

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. Where the history of the site is not known, it should be treated as brownfield until there is evidence to classify it 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'*).