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 1 sample of Made Ground, 1 sample of Lynch Hill Gravel and 1 sample of London Clay. The test result for each soils type represents the characteristic value (refer to table 10.7.7).

10.7.4.2 We assume foundations will not be in contact with disturbed ground (as defined in BRE SD:1). We, therefore, have not considered Oxidisable Sulphates or Total Potential Sulphate content.

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 Made Ground soils are characteristic of 'mobile groundwater' conditions while Lynch Hill Gravel and London Clay soils represent 'static' groundwater conditions.

10.7.6 Assessment of pH

10.7.6.1 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, Lynch Hill Gravel and London Clay equates to the measured values.

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.

Soil type	No. of samples	Characteristic pH	Groundwater mobility	Characteristic sulphate (mg/l)	DS class	ACEC class
Made Ground	1	8.2	Mobile	100	DS-1	AC-1
Lynch Hill Gravel	1	8.1	Static	30	DS-1	AC-1s
London Clay	1	8.4	Static	160	DS-1	AC-1s

Table reference 10.7.7

10.7.7.2 As more than one soil source has been tested, the more onerous of design sulphate class and ACEC class should be adopted.

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 The concentration of extractable chloride was measured at below 0.4% in 1 sample of Made Ground, 1 sample of Lynch Hill Gravel and 1 sample of London Clay. Based on this, 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/groundwater was measured exceeding 5.5 and on this basis the risk of concrete being affected by acidic conditions is considered low.

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 The concentration of soluble magnesium was measured at below detectable limits in 1 sample of Made Ground, 1 sample of Lynch Hill Gravel and 1 sample of London Clay. Based on this, we would consider the risk of magnesium requiring special consideration with respect to enhancement of exposure class for this contaminant in isolation to be low.

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 Although groundwater was encountered by the investigation, we have not been able to obtain water samples for measurement of concentration of ammonia. 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. As no significant concentrations of chemical contaminants have been identified at this site in combination with near neutral pH conditions it is considered unlikely that ground conditions are sufficiently aggressive to cause damage to brickwork/clay pipes.

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 is 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 At this site the pH of the soils was near neutral (within the range of 6.5 to 8.5) and it is considered unlikely that groundwater will be in contact with stainless steel components (unless we are advised otherwise) thus the risk of ground conditions at the site affecting stainless steel is considered low.

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 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 are not considered significantly extreme and this it is considered unlikely that ground conditions at the site would significantly affect lead.

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, there is no evidence of significant concentrations of acids or alkalis, indicating the risks of ground conditions at the site affecting PE and PVC materials are considered low.

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 Risk assessment

10.24.2.1 Plastic pipe performance has been the subject of a WRc report. The report risk ranks differing previous site uses in relation to the use of plastic pipes which is summarised in the following table.

Type A = High risk
Asbestos works, chemical works, gasworks, hazardous waste treatment, wood preservative use/manufacture, landfill sites, metal mines, smelters, foundries, steel works, munitions production/testing sites, oil and fuel production / storage / use, paper and printing works, pesticide manufacture, pharmaceutical manufacture, scrap yards, sewage works, tanneries.
Type B = Suspect sites
Dry cleaners, electric/electrical equipment manufacture, fertiliser storage, garage/filling stations, mechanical engineering works, metal finishing installations, paint and ink manufacture, railway land, textile production, research laboratories, road haulage yards.
Type C = Low risk
Agriculture, brewing and distilleries, food preparation and storage.

Table 10.24.2 Risk ranking of former land use with respect to use of plastic pipes.

10.24.2.2 The WRc report also provides advices on the type of pipe material appropriate for the type of contamination present. An extract is provided below.

Material groups

Group 1. Organic contamination
- PE sleeved ductile iron.
- Tape wrapped or coated steel.
- Sheathed copper.
- Wrapped metal fittings.
- Protection for joints and seals.
- Clean suitable backfill.
- Seek specialist advice on use of PVC-U or GRP pipes.

Group 2. Mixed contamination
- Plastic-coated or wrapped metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Protection for joints and seals.
- Clean suitable backfill.

Group 3. Inorganic contamination
- Plastic pipes.
- Plastic-coated metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Clean suitable backfill.
- Seek specialist advice on use of GRP pipes.

Group 4. No significant organic or inorganic contamination
- Material of choice.

For all material groups, good pipe laying practice must be followed.

10.24.2.3 The WRc report also refers to testing suites in relation to both inorganic and organic contamination. With respect to inorganic contamination, the WRc report acknowledges the purposes of this is for a risk assessment in relation to human health for construction operatives with the effects of such contaminants affecting plastic drinking water pipes limited.

10.24.2.4 The WRc report indicates that permeation of plastic pipes by organic solvents and substances was a major problem. The WRc report produces the following groups of compounds to which trigger concentrations were assigned.

Group 1(a) Compounds:	**Group 1 (b) Compounds:**
Carbon tetrachloride	Dichloromethane
Trichloroethane	1,2-dichloroethane
Tetrachloroethane	1,1,1-trichloroethane
Benzene	1,2-dichloropropane
Toluene	vinyl chloride
Xylenes	methyl bromide
Chlorobenzene	dichlorobenzenes
	Trichlorobenzenes
	Ethylbenzene

The above chemicals relate to fuels and volatile organic compounds.

10.24.2.5 We are aware that water companies have their own testing regime to assist in selection of an appropriate material supply of drinking water to the site and would, therefore, recommend a copy of this report is provided to the water company to allow them to specify the appropriate pipeline material.

10.24.2.6 We would only carry out laboratory testing to measure concentrations of organic contaminants listed in the WRc report (refer 10.24.2.4 above) if the site is known to or is suspected of using/processing these chemicals and at this site we have no evidence to suspect the use of such chemicals.

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 Landfill issues

11.1 Disposal of soils off site

11.1.1 Using available investigatory data we have produced a separate report to classify soils likely to be excavated at the site for off site disposal.

11.2 Landfill tax

11.2.1 Disposal of soils to landfill sites is normally subject to landfill tax with rates varying from year to year based on government policy. Current information on rates of landfill tax can be obtained from the HM Revenue and Customs website.

12 Further investigations

12.1 At this stage we do not consider further investigations to be necessary.

13 Remediation strategy and specification

13.1 Introduction

13.1.1 This remediation statement has been produced with a view to isolating and clarifying remedial measures outlined in our main ground investigation report for the site. The objective of remediation works described in this report is to render the site *'fit for purpose'* in relation to the proposed development.

13.1.2 We understand the development will comprise the construction of offices, child welfare facilities and a caretaker's flat.

13.1.3 This remediation statement only considers the process of remedial action in terms of addressing contamination recognised to date. If during development, contamination not previously identified, is found to be present at the site, then an addendum method statement will be required, and the appropriate measures taken on site.

13.1.4 All sampling and laboratory analysis associated with the recommended remediation will be undertaken following nationally recognised guidelines and standards that are appropriate at the point of investigation. Laboratory analysis must be commissioned with testing houses that are suitably experienced and are MCERTS accredited with a quality assurance system.

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
Independent inspectors such as NHBC / Building control	To ensure procedures are implemented and compliance with building regulations
Project design team	To allow for remedial measures in the design
Project landscape consultant	To ensure compatibility of cover system proposed in this document with landscape requirements
Supplier of remediation materials	To ensure compliance with specification.

13.1.5 This statement has been prepared to assist in the process of the proposed development and it normally will require distribution to the following parties prior to implementation, although this list may not be exhaustive.

13.2 Summary of results of investigations leading to recommendations for remediation

13.2.1 Investigations and assessment of chemical contamination is described primarily in Section 8. A summary of chemical contamination at the site is detailed below.

13.2.2 Evaluation of contamination - human receptors

13.2.2.1 Lead was measured at concentrations above soil guideline values within the Made Ground. The risk assessment relating to soil contamination was based on the least onerous assessment criteria therefore soils are considered to pose a risk to the health of all site users. Remediation is therefore considered appropriate.

13.2.3 Evaluation of contamination - water receptors

13.2.3.1 Based on the results of investigatory data, 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.

13.3 Remediation strategy

13.3.1 The provision of buildings and hardstanding areas across the site will sever the pathway to end-users by preventing human access to contaminated soils.

13.3.2 In proposed garden/landscaped areas, an imported capping layer (cover system) of chemically 'clean' soils will be introduced to sever the pathway between contaminants and end-users, thus minimising the risk of human contact with soils containing contaminants which have the potential to cause harm to human health. Due to the presence of mature trees, we understand that the landscape architect and arboriculturist will consider the need for a capping layer in the landscaping design.

13.3.3 We recommend that the design of the capping system is approved by the Local Authority prior to its implementation.

13.3.4 Following installation of the cover system described above, the capping thickness will require independent measurement to validate the correct thicknesses have been provided in landscaped/garden areas.

13.4 Specification for imported capping materials

13.4.1 General

13.4.1.1 All imported capping materials (cover systems) shall be sampled and tested to demonstrate they are *'fit for purpose'* before being brought onto site.

13.4.2 Capping materials

13.4.2.1 Capping materials shall be specified by the landscape architect. The imported material should be considered suitable for use with respect to chemical concentrations.

13.4.3 Rate of testing / sampling

13.4.3.1 If different sources are to be utilised for topsoil/capping, each source shall be investigated.

13.4.3.2 Capping materials shall be from a source where at least 8 representative soil samples have been taken, subject to a minimum rate of at least 3 samples per $100m^3$

13.4.4 Testing regime

13.4.4.1 Human receptors

13.4.4.1.1 The testing regime really is dependant upon the history of the site where the capping materials are sourced. Past historical uses (from a potential chemical contamination viewpoint) of the source site will dictate the required testing regime potentially requiring additional testing to target / investigate concentrations of contaminants used at the source site where they are harmful to human health. At this stage we cannot specify the scope and indeed the need for such site specific testing as the source of the imported fills is not known.

13.4.4.1.2 As a minimum testing shall be scheduled to measure the concentrations of commonly occurring inorganic and organic contaminants (listed in Table 13.4.7 below where SGVs and GACs are available).

13.4.4.2 Water receptors

13.4.4.2.1 The materials forming the cover system, may exhibit a degree of permeability, and thus the potential for any chemical contaminants contained in the soils to leach and thus migrate towards groundwater resources, although the risk of this occurring is dependant upon the location of the water table and indeed the permeability of the soils above the water table. Conversely, leachable contaminants could migrate laterally from cover system towards surface water resources. In order to minimise this risk, the soils forming the cover system shall be tested to determine leachable concentrations of potential contaminants. As with testing regimes associated with human health, the testing regime really is dependant upon the history of the site where the capping materials are sourced. At this stage we cannot specify the scope and indeed the need for such site specific testing as the source of the imported fills is not known.

13.4.4.2.2 As a minimum testing shall be scheduled to measure the leachable concentrations of commonly occurring inorganic and organic contaminants where they are considered a risk to harming water receptors (listed in Table 13.4.7 below where leachate guideline values are available).

13.4.5 Maximum concentrations (Human receptors)

13.4.5.1 Soil guideline values (SGVs) as outlined in *'Soil Guideline Values for Contamination (2002)'* R&D Publications and the latest publications *'Soil Guideline Values (2009)'* EA Science Reports 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 adopt 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). Other assessment criteria can be used providing the values have been derived using a robust methodology, compatible with nationally (UK) recognised research publications.

13.4.5.1 Where published soil guidelines are not available for a contaminant Generic Assessment Criteria (GAC) values shall be used. 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'*. Other assessment criteria can be used providing the values have been derived using a robust methodology, compatible with nationally (UK) recognised research publications.

13.4.5.2 There is currently no SGV, GAC or indeed a toxicity report for sulphur. Having carried out a significant amount of in house research, we have not been able to produce any criteria which would allow us to determine a concentration for sulphur which may be considered a risk to human health. According to the United States Environmental Protection Agency (USEPA), '*sulphur poses very little if any risk to human health*'. Contact with natural sulphur at low levels over many years is generally recognised as safe. Health studies of mineworkers exposed to sulphur dust and sulphur dioxide throughout their lives show that they often had eye and respiratory disturbances including bronchitis and chronic sinus effects. These effects, however, relate to continued exposure to high concentrations of sulphur dust. On this basis, unless the source of the capping materials is clearly significantly contaminated with sulphur (which would be reflected in test data) providing concentrations are at or marginally above detectable limits (100mg/kg), the risk of causing significant harm to human end users of the site is not considered significant.

13.4.5.3 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 the potentially conservative approach, limiting concentrations to or about detectable limits shall be adopted (around 1mg/kg)

13.4.6 Maximum concentrations (water receptors)

13.4.6.1 For interpretation of test data in relation to water receptors measured concentrations of leachable contaminants shall be directly compared with the Environmental Quality Standards (EQS) as published by the Environment Agency. In the absence of EQS UK Drinking Water Standards shall be adopted.

13.4.7 Maximum concentrations (summary)

13.4.7.1 The following table summarises the maximum concentrations of chemical contaminants which shall not be exceeded in imported capping materials.

Contaminant	Maximum allowable concentration and test criteria (Human Receptors)		Maximum concentration (μg/l)
	SGV (mg/kg)	GAC (mg/kg)	
Total concentration			**Leachate concentration**
Inorganic contaminants			
Arsenic	32	-	50
Barium	-	-	700
Boron	-	291	2000
Beryllium	-	51	-
Cadmium (pH to 7.4)	10	-	5
Copper	-	2330	1
Chromium	-	3000	5
Cyanide (free)	See paragraph 13.4.5.3	-	-
Cyanide (total)	See paragraph 13.4.5.3	-	50
Lead	450	-	4
Mercury	1	-	1
Nickel	130	-	50
Nitrate	-	-	50000
Selenium	350	-	10
Sulfur	See paragraph 13.4.5.2	-	-
Sulfate	-	-	400000
Sulfide	-	-	0.25
Vanadium	-	75	20
pH	-	-	-
Organic contaminants			
Acenaphthene	-	210	
Acenaphthylene	-	170	
Anthracene	-	2300	
Benzo(a)anthracene	-	3.1	
Benzo(a)pyrene	-	0.83	
Benzo(b)fluoranthene	-	5.6	
Benzo(g,h,i)perylene	-	44	
Benzo(k)fluoranthene	-	8.5	
Chrysene	-	6	
Dibenzo(a,h)anthracene	-	0.76	
Fluoranthene	-	260	
Fluorene	-	160	
Indeno(1,2,3-cd)pyrene	-	3.2	
Naphthalene	-	1.5	
Phenanthrene	-	92	
Phenols	420	-	
Pyrene	-	560	

Table 13.4.7

13.4.8 Information required

13.4.8.1 It is critically important that the imported capping material will minimise the risks of causing harm to human end users of the site. It is necessary to demonstrate the imported capping materials are 'fit for purpose', and relevant and current test result certificates are an important part of the necessary compliance documentation. Compliance documentation will be provided to other interested parties such as:-

- Local authority planning department to discharge planning permissions
- Checking bodies such a NHBC and Building Control (For compliance with building regulations)
- Potential purchasers of the buildings (and their legal advisors)
- Environment Agency (controlling body for ground / surface water resources)

Based on the above it is important to provide compliance documentation prior to importation to site, thus avoiding abortive works and delays to the construction programme with its potential financial penalties.

13.4.8.2 Compliance documentation shall include the following

- Copies of test result certificates signed by a MCERTS accredited laboratory which is signed and dated.
- Source and supplier of the capping material.
- Delivery notes confirming the material originates from the stated source (will form part of the subsequent validation reporting)

13.4.8.3 A cover system material supply schedule for completion by the supplier is presented in Appendix I.

13.5 Validation report

13.5.1 The thickness of the completed cover system will require verification by an independent consultant. We can carry out such investigations on further instructions.

13.5.2 Following completion of remedial works detailed above, a closure report which provides details of all work undertaken as part of the remediation process will have to be prepared. The closure report will include details of imported materials to form the cover system, its thickness and thus verification of its fitness for purpose.

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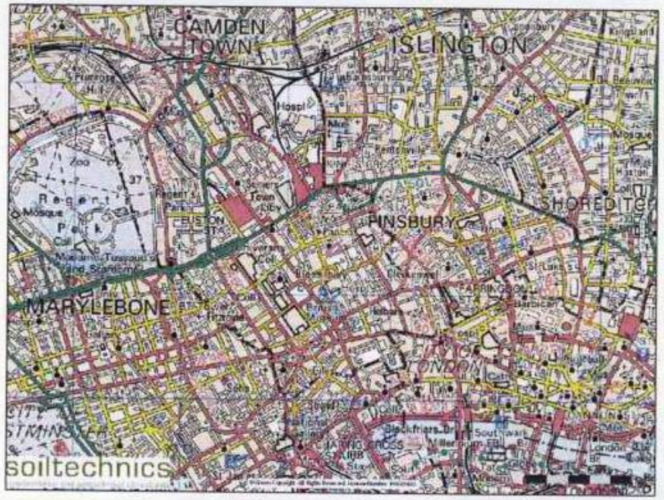
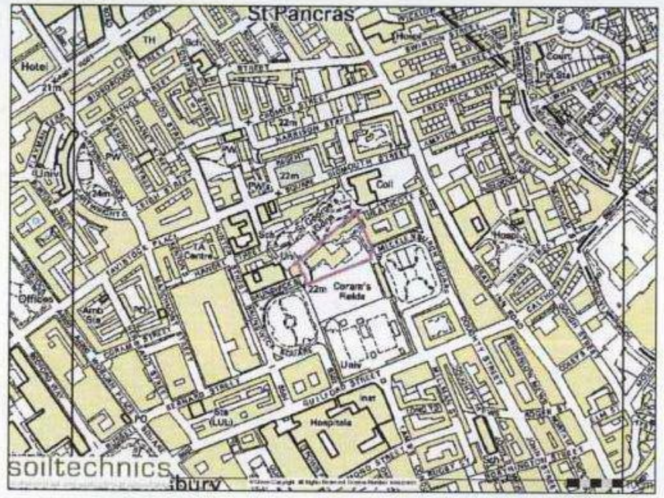
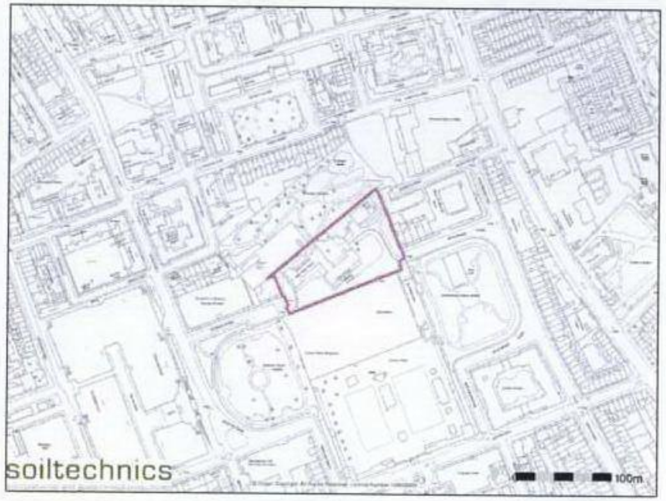


Extract from Ordnance Survey map at 1:50000 scale



Extract from Ordnance Survey map at 1:10000 scale



Extract from Ordnance Survey map at 1:5000 scale

Title	Scale	Drawing number
Site location plan	Not to scale	01

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Notes

1. Drawing supplied by AKT

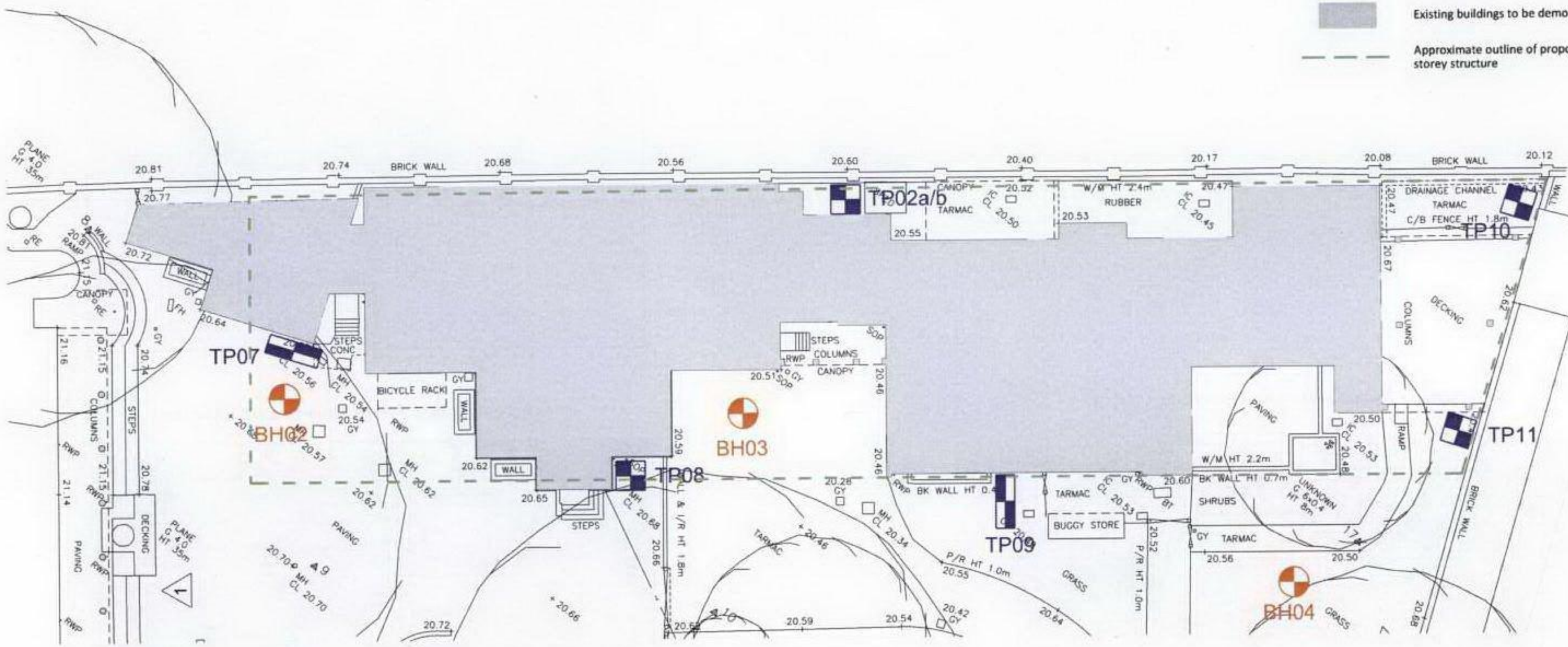
Key

BH02 — Approximate location of borehole formed by cable percussive techniques

TP01 — Approximate location of trial pit excavation

Existing buildings to be demolished

Approximate outline of proposed 4 storey structure



Title	Scale	Drawing number
Plan showing existing site features, location of exploratory positions and plan area for proposed development	1:250 @ A3	02

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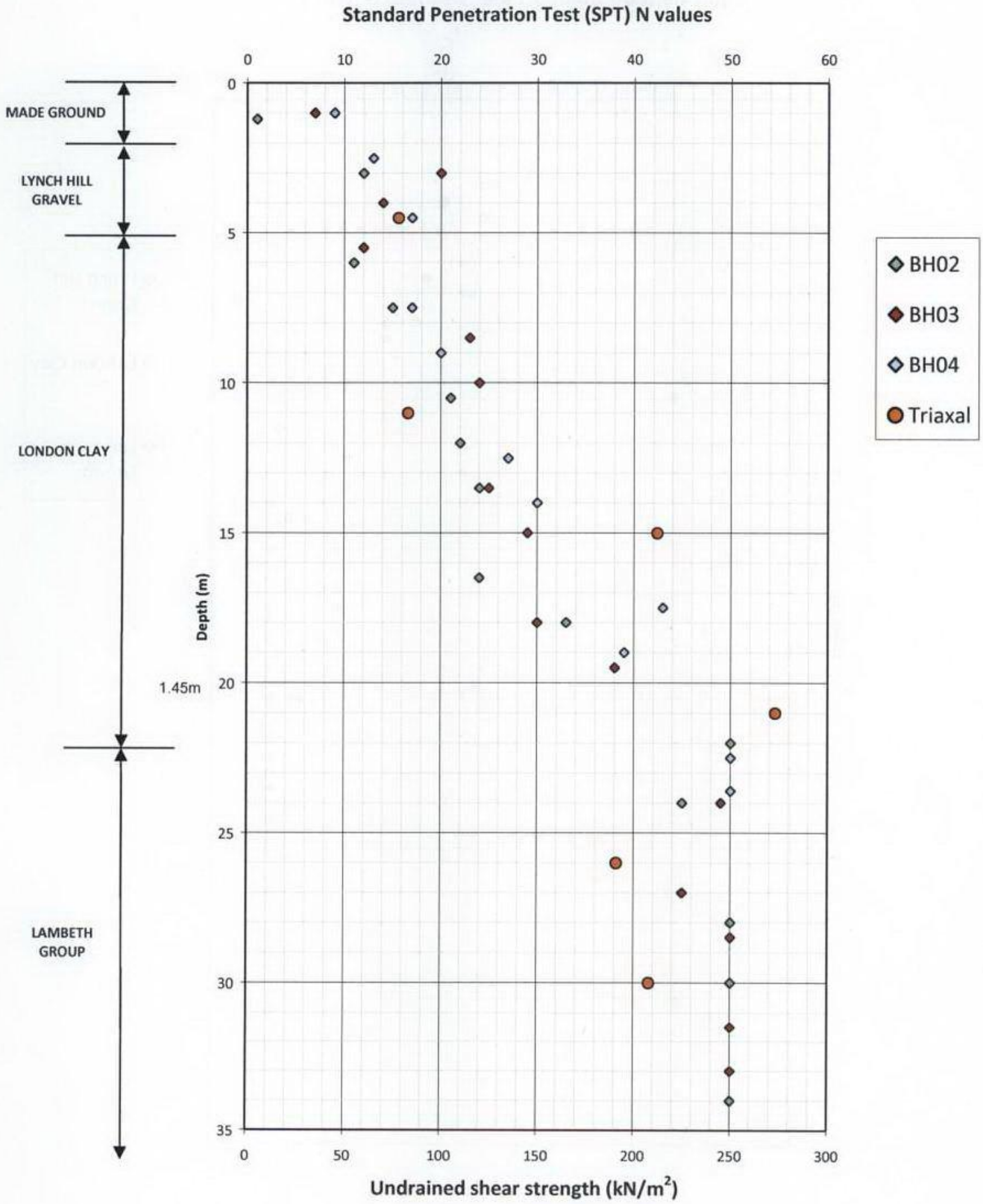
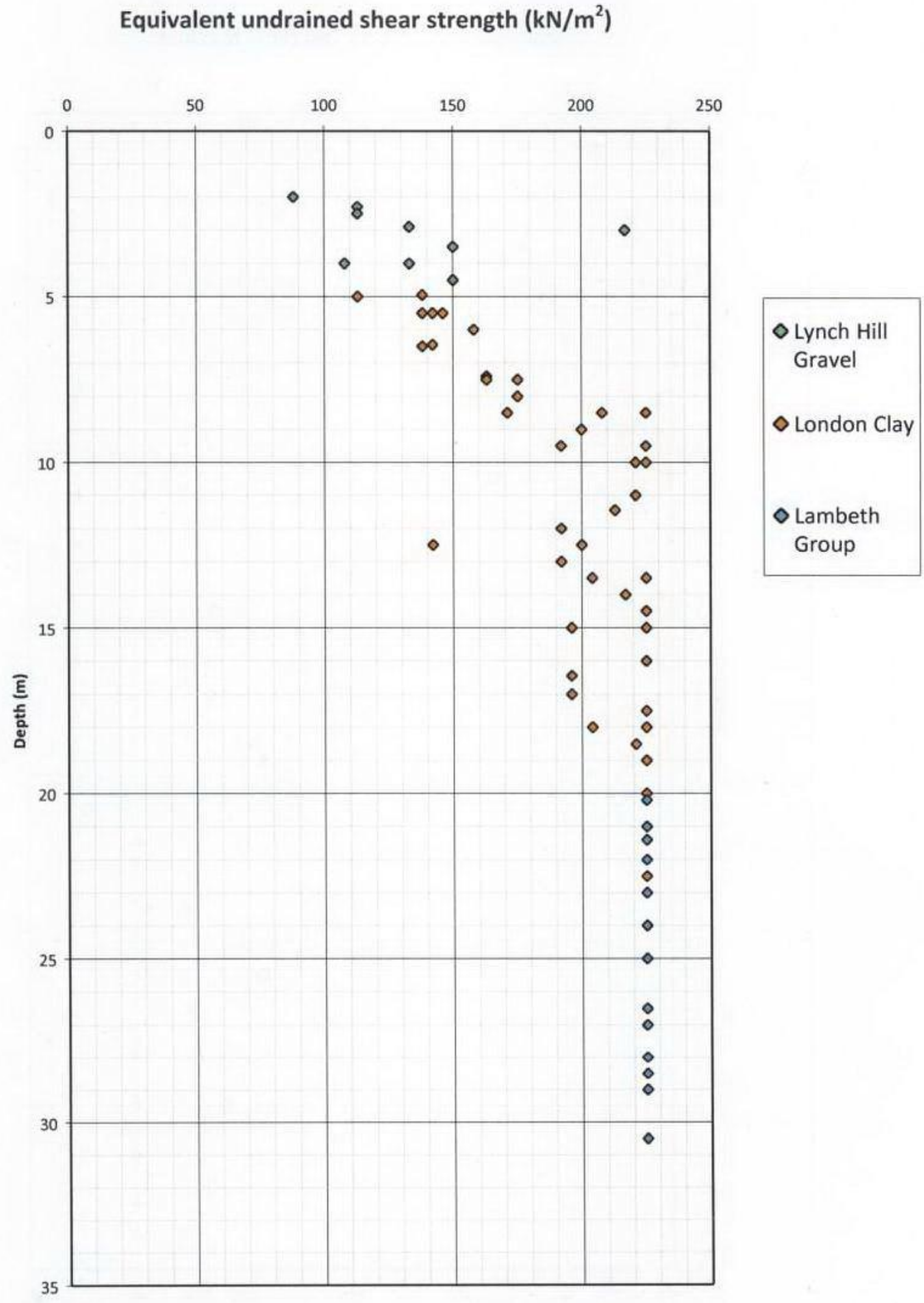


NOTES	Title
1) Strength/density descriptions obtained from BS5930:1999	Plot summarising in-situ density testing derived from Standard Penetration (SPT 'N') testing
	Date: 24.03.10
	Location plan on Drawing number: STG1672B-02



NOTES

1) Undrained shear strength derived from pocket penetrometer determinations multiplied by a factor of 50

Title

Plot summarising in-situ shear strength testing derived from Pocket Penetrometer results

Date	Location plan on Drawing number
19.04.10	STG1672B-02

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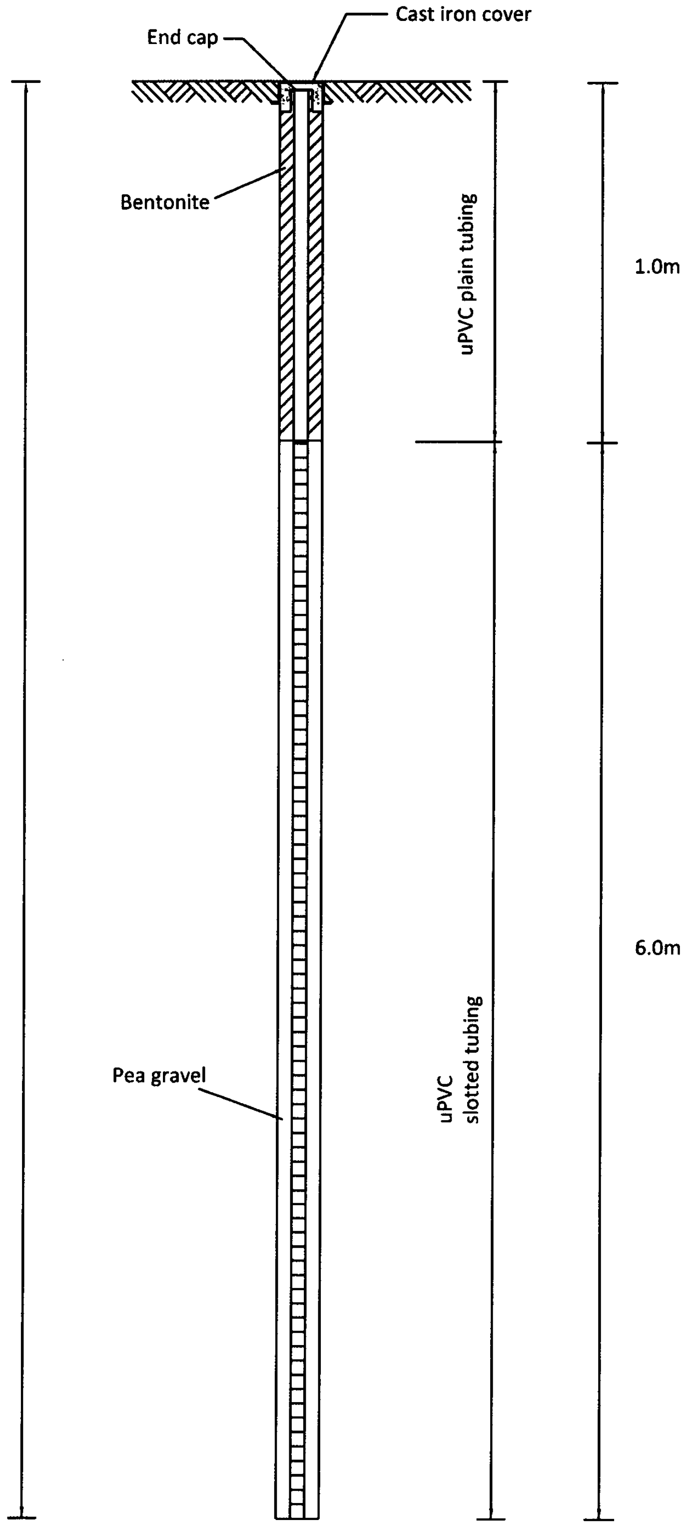

Date	Water level (mbgl)
18/03/2010	2.25m
07/04/2010	2.23
24/04/2010	2.52

Notes:

title	scale	drawing number
Section showing construction of combined gas and groundwater monitoring standpipe installed in borehole BH03	**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).

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'