7 Human Health Contamination Assessment

7.1 GENERAL APPROACH

Legislation and guidance on the assessment of contaminated sites acknowledges the need for a tiered risk based approach comprising:

Tier 1 Assessment: Comparison of site contaminant levels against generic standards and compliance criteria including an assessment of risk using the source-pathway-target model.

Tier 2 Assessment: Derivation of site specific risk assessment criteria and calculation of site specific clean-up goals.

7.2 RATIONALE RELATED TO PROPOSED REDEVELOPMENT

The redevelopment of the site comprises the construction of an 18 storey tiered residential tower with two basement levels and two 9 storey commercial buildings with one and two level(s) basements.

The existing single level basement present over much of the existing site will be maintained. Ground level is approximately 28mOD and the proposed dig level for the two level basement will be to approximately 21mOD, and to about 25.0mOD for the single level basement. This shall consist in the removal of the majority of the Made Ground and part of the Brickearth, River Terrace deposits and top of the London Clay in places. Cross-sections showing the ground conditions and the likely soils to be removed are presented in **Appendix F**.

In addition to the removal of the Made Ground as part of the basement excavation, hardstanding will be present at the base of the entire redevelopment area. The basement slab shall be in the order of 350mm in thickness. The clients brief requires a Grade 2 basement (degree of watertightness) for which the level of protection is that no water shall be allowed to penetrate the structure. This shall form a permanent barrier to the migration of any potential contaminants present in the ground. As a consequence, no ingestion or inhalation pathways of contaminants will be present at the site.

7.3 COMPLIANCE CRITERIA

As part of the contamination assessment the chemical results for soils have been screened against existing accepted compliance criteria, namely the Contaminated Land Exposure Assessment model (CLEA).

The CLEA analysis is usually undertaken for soil samples recovered from areas which are to be left in-situ and which may potentially pose a long term risk to human health.

To date, as part of the CLEA guidance the Environment Agency and DEFRA have published Soil Guideline Values for seven metals. In order to provide a consistent methodology for the assessment of various contaminants a series of Tier 1 screening values have been calculated by WSP. These values have been calculated using BP

RISC 4.0, a computer modelling tool designed (in part) to assess human health related risks presented by contaminated soil.

The default parameters inherent within the RISC model have been adjusted to reflect the findings of recent UK research. Input parameters consistent with the CLR series of documents have been adopted.

In the application of the screening values to a site the user recognises the limitations of the RISC (and CLEA) model. Specifically these relate to the absence of certain pollutant considerations such as risks to services, of fire and explosion, aesthetics, institutional perception, groundwater, surface waters, eco-toxicological risk and risks to buildings (amongst others). In addition, the screening values are not intended to be SGV's, as they do not specifically meet the requirements of legal definition of 'significant possibility of significant harm'.

Full details of the results of the CLEA assessment for the site, results of standard Tier 1 screening, screening values adopted and the methodology and rationale for calculation of screening values using BP RISC 4.0 are presented in **Appendix G**.

7.4 CLEA ANALYSIS OF DATA

7.4.1 General

Normally chemical data for soils are statistically analysed using methodologies published in EA R&D Publication CLR 7 - Assessment of Risk to Human Health from Land Contamination: An overview of the Development of Soil Guideline Values and Related Research. In particular, a mean value test and maximum value test are undertaken on the data set to determine the statistical significance of the results.

However, as all chemical data for soils relates to materials which will be removed to create the proposed basement, the CLEA statistical analysis of concentration results was not undertaken.

The laboratory results have been compared to their respective screening criteria.

7.5 METAL/INORGANIC CONTAMINANTS IN SOILS

7.5.1 Metal and Inorganic Contaminants in Soils – Results

The following section comprises the results of the chemical data set for soil samples retrieved from across the site. A total of thirty soil samples were analysed for a range of determinants. They were generally recovered at depths of between ground level and 3.0m bgl, with two samples taken at depths of 3.7-4.2m bgl and 7.3-7.8m bgl. Seventeen of these samples were recovered from the Made Ground, and thirteen from natural soils.

Full laboratory certificates of the chemical analysis are presented in **Appendix C.**

Table 7.1 summarises the results of chemical data for soils.

Table 7.1 Summary of Metal/Inorganic Chemical Data

Determinant	Range of Concentrations (mg/kg)	SGV or WSP Tier I Screening Criteria	Number Samples Exceeding Screening Criteria
Arsenic	3.5 – 37.0	500 (1)	0 of 30

Determinant	Range of Concentrations (mg/kg)	SGV or WSP Tier I Screening Criteria	Number Samples Exceeding Screening Criteria
Cadmium	<0.25 (DL) – 1.5	1400 [1]	0 of 30
Chromium	11.0 – 61.0	5000 [1]	0 of 30
Copper	5.4 – 2517.0	> [2]	N/A
Lead	5.9 – 2468.0	750 [1]	4 of 30
Nickel	10.0 - 64.0	5000 [1]	0 of 30
Zinc	17.0 - 1624.0	> [2]	N/A
Mercury	< 0.2 (DL) - 23.0	480 [1]	0 of 30
Boron	<0.5 (DL)- 14.0	> [2]	N/A
Barium	21.0 - 512.0	190000 [2]	0 of 30
Beryllium	<2.5 (DL)- 5.4	5400 [2]	0 of 30
Vanadium	18.0 - 157.0	3800 [2]	0 of 30
Cyanide	<0.2 (DL) - 4.0	53 [2]	0 of 30
Nitrate	15.0 - 884.0	-	N/A
Sulphide	<10.0 (DL)	-	N/A
pH	6.2 - 11.2	-	N/A
Water Soluble Sulphate	<50 (DL) – 4190.0	-	N/A

Notes
(1) CLEA SGV for Commercial/ Industrial end use.
(2) BP RISC 4.0 Screening Values (CLR 9 & 10 Compliant) for Commercial/ Industrial use
All values mg/kg unless stated.
DL Concentrations are less than laboratory detection limit.
- There are no available screening criteria for these contaminants

pH was recorded within the following range pH6.2 to pH11.2, indicating that the soil is slightly acidic to alkaline in composition. Sulphate concentrations range between <50mg/kg to 4190mg/kg.

7.5.2 Metal and Inorganic Contaminants in Soils – Assessment

With the exception of four lead concentrations, all metal and inorganic results are below their respective screening criteria.

The four lead concentrations exceeding the relevant screening criteria of 750mg/kg are:

- WS3 (2.5-3.0m): 2468mg/kg
- WS7 (0.5-0.8m): 914mg/kg

- TP2 (0.2-0.6m): 775mg/kg
- TPM1 (0.5-1.0m): 818mg/kg.

These slightly elevated lead concentrations are not considered to be of concern as the recorded sample depths are over the basement excavation depth.

The concentrations of metal and inorganic contaminants recorded at the site are therefore not considered to present a risk to the future site users.

7.6 ORGANIC CONTAMINANTS IN SOILS

7.6.1 Organic Contaminants in Soils – General

Tier 1 Screening values for organic contaminants in soils have also been calculated using BP RISC 4.0.

For PAH's, indicative Health Criteria Values have been used to calculate individual screening levels, with the exception of B(a)P and Naphthalene. These two contaminants have been calculated using published Toxicological data sourced from *RIVM report 711701 023 Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater* and also the WHO. Background exposure for non carcinogenics has been obtained from the *2002 EC document 'Polycyclic Aromatic Hydrocarbons – Occurrence in foods, dietary exposure and health effects'*. Additive effects are not considered within the calculation but may need to be considered where the total concentrations are considered to be elevated.

TPH-CWG analysis has been carried out in line with the TPH working group guidance. Tier 1 Screening Values have been calculated using BP RISC 4.0 for each of the aromatic and aliphatic carbon bands analysed. The Tier I Screening Value allows the concentrations to be compared for both inhalation and ingestion pathways for each of the carbon bandings analysed.

Full details of the results of standard Tier 1 screening of organic contaminants, screening values adopted and the methodology and rationale for calculation of screening values using BP RISC 4.0 are presented in **Appendix G**.

7.6.2 Organic Contaminants in Soils - Results

A total of thirty soil samples have been analysed for total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, MBTE and BTEX compounds; nine samples for PCBs and fifteen samples for speciated phenols.

Full laboratory certificates of the chemical analysis are presented in **Appendix C**.

Polycyclic Aromatic Hydrocarbons (PAHs)

A summary of chemical testing of soils for PAH contaminants is provided in **Table 7.3.**

Table 7.3 Summary of Organic Chemical Data for Soils – PAHs

Determinant	Range (mg/kg)	Tier 1 Screening Value (Ingestion pathway) (1)	Tier 1 Screening Value (Inhalation pathway) (1)	Number Samples Exceeding Screening Criteria
Naphthalene	<DL - 0.98	49000	1300	0 of 30
Acenaphthylene	<DL	5400	>	0 of 30
Acenaphthene	<DL	54000	>	0 of 30
Fluorene	<DL	110000	>	0 of 30
Phenanthrene	<DL - 2.20	54000	>	0 of 30
Anthracene	<DL - 0.36	810000	>	0 of 30
Fluoranthene	<DL - 3.40	5400	>	0 of 30
Pyrene	<DL – 2.80	54000	>	0 of 30
Benzo(a)anthracene	<DL – 1.90	540	>	0 of 30
Chrysene	<DL – 1.90	5400	>	0 of 30
Benzo(b)fluoranthene	<DL – 1.40	540	>	0 of 30
Benzo(k)fluoranthene	<DL – 1.20	540	>	0 of 30
Benzo(a)pyrene	<DL – 1.60	54	>	0 of 30
Indeno(1,2,3-cd)pyrene	<DL – 1.00	540	>	0 of 30
Dibenzo(a,h)anthracene	<DL	54	>	0 of 30
Benzo(g,h,i)perylene	<DL – 1.20	81000	>	0 of 30
TOTAL PAH	<DL – 20.0	-	-	N/A

Notes
(1) BP RISC 4.0 Screening Values (CLR 9 & 10 Compliant) for Commercial/ Industrial use.
> There is no risk at any concentration (for these less toxic and less volatile contaminants), or the contaminant cannot be present within soil at concentrations which would present a risk. This does not exclusively mean that there is no risk but may indicate a presence of product saturated soils or neat products. Where these conditions are encountered remediation activity is likely to be required.
DL Concentrations are less than laboratory detection limit.
N/A Not applicable.
- There are no available screening criteria for these contaminants.
All values mg/kg unless stated.

Total Petroleum Hydrocarbons (TPH's)

Thirty samples were analysed for TPH. A maximum of 969 mg/kg was recorded in TP2 (0.2-0.6m). A summary of chemical testing of soils for TPH contaminants is provided in **Table 7.4.**

Table 7.4 Summary of Organic Chemical Data for Soils – TPHs

Determinant	Range (mg/kg)	Tier 1 Screening Value (Ingestion pathway) (1)	Tier 1 Screening Value (Inhalation pathway) (1)	Number Samples Exceeding Screening Criteria
>C6-C8 (PRO)	<DL	900000	>	0 of 30
>C8-C10(PRO)	<DL	25000	320	0 of 30
>C10-C12	<DL	25000	>	0 of 30
>C12-C16	<DL	25000	>	0 of 30
>C16-C21	<DL	490000	>	0 of 30
>C21-C35	<DL - 479	490000	>	0 of 30
Total Aliphatics	<DL - 510	-	-	N/A
>C6-C7	<DL	49000	130	0 of 30
>C7-C8	<DL	49000	180	0 of 30
>C8-C10	<DL	9900	540	0 of 30
>C10-C12	<DL	9900	2500	0 of 30
>C12-C16	<DL	9900	>	0 of 30
>C16-C21	<DL	7400	>	0 of 30
>C21-C35	<DL - 161	250000	>	0 of 30
Total Aromatics	<DL	-	-	N/A
Total Hydrocarbons (C10-C35)	DL - 969	-	-	N/A
Total Hydrocarbons (C6-C35)	DL - 969	-	-	N/A

Notes
(1) BP RISC 4.0 Screening Values (CLR 9 & 10 Compliant) for Commercial/ Industrial use.
> There is no risk at any concentration (for these less toxic and less volatile contaminants), or the contaminant cannot be present within soil at concentrations which would present a risk. This does not exclusively mean that there is no risk but may indicate a presence of product saturated soils or neat products. Where these conditions are encountered remediation activity is likely to be required.
DL Concentrations are less than laboratory detection limit.
N/A Not applicable.
- There are no available screening criteria for these contaminants.
All values mg/kg unless stated.

None of the TPH concentrations were greater than the relevant screening criteria.

BTEX / VOC

Thirty samples were analysed for BTEX contaminants as part of the TPHCWG analysis and VOC analysis. The results are displayed in **Table 7.5**.

Table 7.5 Summary of Organic Chemical Data for Soils – BTEX

Determinant	Range (mg/kg)	Tier 1 Screening Value (Ingestion pathway) [1]	Tier 1 Screening Value (Inhalation pathway) [1]	Number Samples Exceeding Screening Criteria
MTBE	<DL	2500	1600	0 of 30
Benzene	<DL	790	8.2	0 of 30
Toluene	<DL	150[2]		0 of 30
Ethylbenzene	<DL	48000 [2]		0 of 30
m/p -Xylene	<DL - 0.007	990000	440	0 of 30
o-Xylene	<DL	990000	440	0 of 30

Notes
(1) BP RISC 4.0 Screening Values (CLR 9 & 10 Compliant) for Commercial/ Industrial use.
(2) CLEA SGV for Commercial / Industrial end use.
DL Concentrations are less than laboratory detection limit.
N/A Not applicable.
- There are no available screening criteria for these contaminants.
All values mg/kg unless stated.

All BTEX / VOC contaminants were below their respective screening criteria. Three m/p-Xylene concentrations marginally exceeded the relevant laboratory detection limit in WS8 (0.5-0.8m), WS10 (0.5-0.7m) and TP3 (0.15-0.3m).

Phenols

Fifteen samples were analysed for speciated phenols.

None of the eleven speciated phenol determinand concentrations exceed the laboratory detection limits in any of the locations tested across the site.

Polychlorinated Biphenyls

Nine samples were analysed for PCB contaminants.

All PCB results were below the laboratory detection limits.

7.6.3 Organic Contamination in Soils – Assessment

All results of the organic analysis were below their relevant screening criteria.

The concentrations of organic contaminants recorded at the site are not considered to present a risk to the future site users.

7.7 ASBESTOS IN SOILS

Nine samples from the Made Ground have been tested for the presence of asbestos. All results were negative.

The results are presented in **Appendix C.**

8 Controlled Waters Contamination Assessment

8.1 GENERAL

The risk posed to Controlled Waters beneath and within the vicinity of the site has been considered. The main Controlled Water receptor that has been identified is the groundwater present within the Minor Aquifer (Lynch Hill Gravel) underlying the site.

Based on the identified receptor, chemical data for groundwater have been compared against the following Tier 1 criteria as appropriate:

- Environmental Quality Standards (EQS).
- UK Surface Water (Abstraction for drinking water regulations 1996), DW2

The chemical data for groundwater are presented below, where those determinands displayed have exceeded laboratory detection limits. The complete groundwater results are presented in **Appendix C.**

8.2 CONTAMINANT IN GROUNDWATER

8.2.1 General

Groundwater samples were recovered from four of the monitoring wells installed (BH101, BH103, BH105 and BH106) for laboratory chemical analysis.

The four samples were recovered from the following horizons:

Exploratory Holes	Response Zone Strata
BH101	Lynch Hill Gravel
BH103	Lynch Hill Gravel
BH105	London Clay
BH106	Lynch Hill Gravel

8.2.2 Metal And Inorganic Contaminants In Groundwater

The groundwater results are summarised in Table 8.1 and those determinands with concentrations less than the laboratory limit of detection have been discounted from the table.

Table 8.1 Summary of Groundwater Chemical Data – Metals/Inorganics

Determinand	Concentration Range (µg/l)	Tier 1 Threshold (µg/l)	Samples Above Detection Limit	Number above Screening Criteria
Metals				
Copper	<DL - 6.7	28 (1)	3 of 4	0 of 4
Zinc	<DL - 13.0	125 (1)	1 of 4	0 of 4
Barium	30.0 - 46.0	1000 (2)	4 of 4	0 of 4
Boron	107	2000 (1)	1 of 1	0 of 1
Inorganics				
pH	7.5 – 8.1	N/A	N/A	N/A
Sulphate	60,000 – 90,000	250,000 (2)	4 of 4	0 of 4
Nitrate	26,000 – 48,000	50,000 (2)	2 of 2	0 of 2

Notes
(1). Environmental Quality Standards (EQS), based on total hardness of 250mg/l and the protection of salmonid fish.
(2). UK Surface Water (abstraction for drinking water regulations 1996) DW2.
DL Concentrations are less than laboratory detection limit.
N/A Not Applicable.

Metals

All of the metal concentrations analysed are less than the laboratory limit of detection and / or the relevant Tier 1 Screening Criteria.

Inorganics

All sulphide concentrations were below its Tier 1 Screening Value.

The two nitrate concentration are greater than the laboratory detection limit but below the screening criteria of 50,000µg/l.

Data indicate pH values to range from pH7.5 to pH8.1, indicating the groundwater to be near neutral to alkaline.

8.2.3 Organic Contaminants In Groundwater

All TPH concentrations were below their respective laboratory detection limits with the exception of the total hydrocarbons (C_{10-35}) in BH105 which has recorded a concentration of 164µg/l. This concentration is greater than the laboratory detection limit of 100µg/l but below the relevant guideline value of 200µg/l, derived from The Surface Waters (Abstraction for Drinking Water) Regulations 1996.

In the four groundwater samples tested, all PAH determinands were recorded at concentrations less than the laboratory limit of detection.

All BTEX contaminants were recorded at concentrations less than the laboratory limit of detection in the four groundwater samples analysed.

9 Ground Gas Assessment

9.1 GENERAL

A ground gas assessment has been undertaken to assess risks associated with carbon dioxide and methane to new buildings and their users. The results obtained have been compared with relevant guidance that includes the following:

- The Building Regulations 2006, Approved Document C, Section 2;
- Protecting Development From Methane, CIRIA Report 149, 1995;
- Landfill Gas, Waste Management Paper Number 27; and
- Construction of new buildings on gas-contaminated land, BRE Report, 1991.
- Protecting Developments from Methane, CIRA 149 Report 1995.

The Building Regulations set action levels for both methane and carbon dioxide from which an initial assessment can be made. The action threshold for methane is 1% while for carbon dioxide an initial consideration should be undertaken if gas concentrations exceed 1.5%. Action might be required if carbon dioxide concentrations exceed 5%. If these thresholds are exceeded, reference should be made to specific documentation to determine the nature and extent of the gas control measures required.

Guidance within the CIRIA 149 Report entitled "Protecting Developments from Methane", identifies a number of gas regimes based on the gas concentrations recorded during monitoring.

The CIRIA 149 report identifies six gas regimes summarised in **Table 8.1**.

Table 8.1 Summary of CIRIA 149 Gas Regimes

Gas Regime	Methane (% v/v)	Carbon Dioxide (% v/v)	Flow (metres/sec)
1	<0.1	<1.5	No flow
2	>0.1 – 1	>1.5 – 5	No flow
3	>1 – 5	>5	No flow
4	>5 – 20	<20	<0.01
5	>20	>20	>0.01 - 0.50
6	>20	>20	>0.50

It has been recognised that the traditional CIRIA approach is out of date and at times may lack clarity. Therefore the current DRAFT CIRIA guidance has been adopted which considers both the borehole gas volume flow rate and the recorded gas concentrations in order to assess the gas regime and if appropriate make recommendations regarding protective measures.

9.2 GROUND GAS RESULTS

From the ground gas monitoring, the site can be classified as Characterisation 1 based on the methodology of assessing the risk posed by ground gas from CIRIA guidance. The maximum methane readings were at or below the detection limit of 0.1%. The maximum recorded carbon dioxide reading was 0.5% within WS7 on 5th January 2007.

The flow rates recorded for the near surface soils were at or below the detection limit of 0.1l/hr, with the exception of the deep installation within the Thanet Sands which recorded a maximum flow rate of 1.3 l/hr. According to the CIRIA classification, gas protection measures are not required.

Due to the demolition works on site during the monitoring period access was not always possible. It is recommended that additional monitoring of ground gasses is undertaken to fully characterise the site, in particular the near surface deposits of Made Ground in WS7 and the River Terrace Gravels in BH101, BH103 and BH106.

10 Preliminary Geotechnical Assessment and Recommendations

10.1 PROPOSED DEVELOPMENT

The proposed development consists of two commercial blocks known as Buildings A and B separated by a mall, and a residential building to the north known as Building C which includes a 19 storey tower. Building A has 9 office floors and one level of plant, Building B has 10 office floors including the ground level lobby plus one level of plant. The three buildings stand above a common ground floor structure which is constructed over a single level basement below buildings A & B and a two level basement below building C.

The existing single level basement present over much of the existing site will be maintained. Ground level is approximately 28mOD and the proposed dig level for the 2 level basement will be to approximately 21mOD. The ground between 28m and 25mOD for the single level basement will be supported by temporary works. Piling platform level is anticipated to be at about 25mOD.

The basement slab will be supported on a void formed to negate the effect of uplift pressures acting on the underside of the slab. The basement slab will be designed to resist uplift pressures that will develop during the lifetime of the structure. The clients brief requires a Grade 2 basement.

The site has been formerly occupied by numerous structures, and the presence of below ground obstructions in the form of foundations needs to be considered as part of the detailed design. Pavement vaults are present below parts of the Osnaburgh Street frontage.

The site investigation has identified a perched water table within the River Terrace Gravels, close to the interface with the London Clay. Other water strikes were recorded at depth within the deposits present at the site.

A large substation is present to the east of the site and cable ducts carrying cables from this substation run close to the eastern boundary of the site. It is understood that part of the structure cantilevers over these ducts.

10.2 FOUNDATION DESIGN PARAMETERS

The ground conditions and parameters were derived using the site investigation data and published data.

10.2.1 Simplified Ground Profile

The following simplified ground profile was adopted for the purpose of design.

Strata	Depth to Top of Layer (m bgl)
Made Ground / Brickearth	0.0
River Terrace Gravels	2.0
London Clay	6.0
Very stiff Lambeth Group Clay	34.0
Very dense Lambeth Sand	47.0

Very dense Thanet Sand	48.0

A groundwater level of 5m bgl has been taken in the initial design comments made within this report.

10.2.2 Geotechnical Design Parameters

The following parameters were used within the geotechnical design.

Stratum	Effective Stress		Undrained shear strength, Cu (kN/m^2)	Bulk Density, γ (kN/m^3)	Undrained modulus of elasticity, Eu (MN/m^2)	Drained modulus of elasticity, E' (MN/m^2)	Poisson's Ratio, ν (drained)
	C'	ϕ'					
Made Ground	0	28°	-	19	-	5	0.3
Brickearth	0	20°	40	19	16	9.6	0.2
Terrace Gravels	0	38°	-	20	-	60	0.25
London Clay	0	21°	60 increasing to 120 at 10mbgl and 240 at 35mbgl		400.Cu	240.Cu	0.15
Lambeth Group Clay	5	23°	240 at 38mbgl, increasing to 500 at 47mbgl	20	400.Cu	240.Cu	0.15
Lambeth Group Sand	0	36°	-	20	-	200	0.25
Thanet Sands	0	36°	-	20	-	300	0.25

10.3 FOUNDATIONS

Foundations for the development are relatively high and as such it is proposed to adopt piled foundations to support structural loads.

10.3.1 Bored Piles – Design Considerations

The use of rotary bored or continuous flight auger (CFA) bored pile foundations have been considered terminating within the London Clay. The use of CFA techniques will ensure that the bore is supported at all times negating the requirement of groundwater

control and temporary support of the bore using casing or bentonite slurry as would be the case with traditional bored pile techniques.

The maximum shaft resistance along the shaft of the piles has been limited to 140 kPa in cohesive deposits.

The working load of the piles was assessed using an overall factor of safety of 2.25. The adoption of this factor of safety will require preliminary pile load tests and tests on working piles to be undertaken. This philosophy should be agreed with the District Surveyor.

10.3.2 Bored Piles – Assessment of Pile Capacity

The determination of pile capacity is assessed by determining the capacity of the both the shaft and base using the following relationships:

- Cohesive Soils

For the Ultimate Base Capacity, (Q_b):

$Q_b = (\pi.d^2/4).Nc.c_u$

Where; d = pile diameter

Nc = Bearing Capacity Factor (taken as 9.0)

C_u = undrained shear strength at the base.

For the ultimate shaft resistance (Q_s):

$Q_s = \pi.d.l.\alpha.c_u av$

Where; d = pile diameter

L = pile length

α = adhesion value (taken as 0.6)

$C_u av$ = average undrained shear strength over pile length.

- Cohesionless Soils

For the ultimate shaft resistance (Q_s):

$Q_s = \pi.d.L.k.\sigma v'.\tan\delta$

Where; d = pile diameter

L = pile length

K = coefficient of horizontal stress (taken as 0.8)

$\sigma v'$ = vertical effective stress (average)

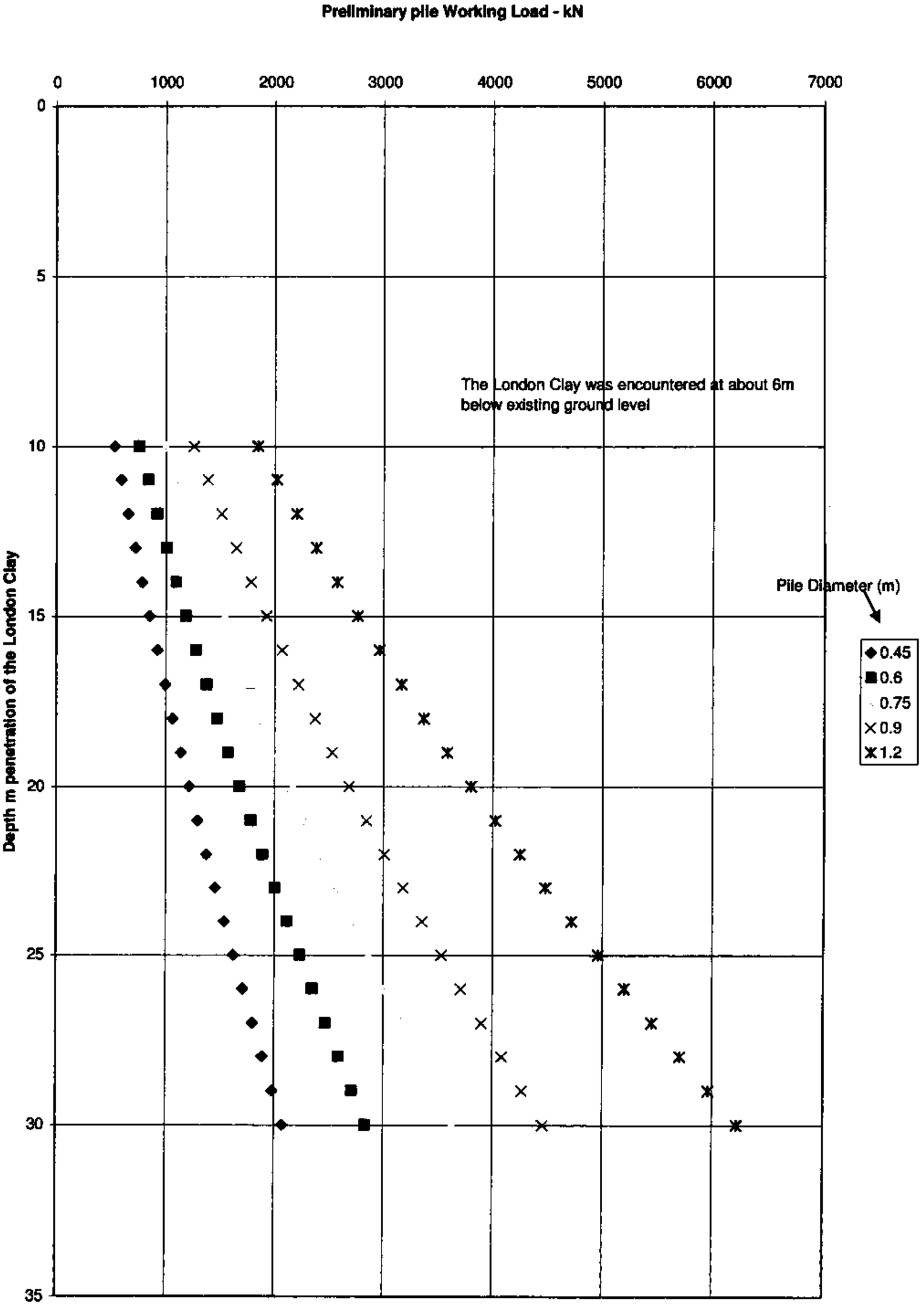
δ = angle of soil / pile friction.

It should be noted that excavation for the partial basement will lead to a relief of overburden pressure. This will result in limited tensile forces developing which will need to be accommodated by the piled foundations.

10.3.3 Bored Piles – Working Loads

The determination of safe working loads has been undertaken following the philosophy and geotechnical parameters outlined before. The shaft capacity to the top of the London Clay has been conservatively ignored.

Pile capacities have been assessed for various pile diameters (450, 600, 750, 900, 1200mm) and a range of penetration within the London Clay. The pile working loads given in the following tables do not consider the capacity of the reinforced concrete pile and this assessment will be required prior to the pile design being finalised. This consideration may limit the working load. The pile capacities are summarised below:



10.4 RETAINING WALLS

The proposed scheme comprises the construction of a single level of basement over much of the site with a two level basement below Building C in the north of the site. A Grade 2 basement in accordance with BS 8102 *'Protection of structures against water from the ground'* is required. The secant pile wall will be exposed within the basement in the permanent condition in the parking areas and will form the primary water barrier to the basement. A block work wall will be adopted within plant room or habitable areas.

The existing reinforced concrete basement slab within Jellicoe house is to be retained to the southern elevation. This is to limit the amount of demolition and foundation works around the relocated basement EDF substation.

Elsewhere, conventional reinforced concrete retaining walls will be constructed. These 300mm to 350mm thick walls will be formed against sheet piling jacked into position beside the existing basement walls or formed in open cut. The sheet piling is used as a permanent back shutter to the perimeter walls.

For the two level basement below Building C, there is insufficient space to form parts of the basement construction in open cut. Therefore, an embedded retaining wall is required in order to form the basement walls and provide support during the excavation to construct the basement slab. Within this area of the site, it is proposed to install a secant pile wall. This wall will be installed from the proposed piling platform level.

The proposed basement construction will therefore need to address the following issues;

- A tight and congested site;
- A variable thickness of Made Ground and River Terrace Deposits;
- Ground movements arising from the works and the effect of this movement on structures and services outside of the site;
- The presence of groundwater within the River Terrace Deposits;
- The presence of groundwater within the Lambeth Group Clays;
- Obstructions within the ground;
- The connection of the floor plates to the wall construction;
- Watertightness; and
- Tolerances of the proposed walling technique.

It is therefore recommended that some form of secant pile wall be adopted at the site to form the embedded retaining wall for the basement below Building C at the site. A key issue associated with this technique is the tolerances that can be achieved for the various types of secant pile walling available and these will be a function of the type of equipment used to form the piles and wall type adopted.

In summary the available wall types are;

- Hard – hard walls where the female piles are constructed from unreinforced or reinforced structural concrete;
- Hard – firm walls where the female piles are constructed from low strength concrete;
- Hard – soft piles where the female piles are constructed with an unreinforced cement-sand-bentonite water mix.

Different equipment is required to form these wall types with available techniques being standard rotary (SR), high torque rotary (HTR), standard CFA (CFA), high torque CFA (HTCFA), and cased CFA (CCFA).

As the strength of the female pile increases, the available piling techniques to form the male piles decrease with only CCFA and HTR being suitable to form hard-hard walls, CCFA, HTR or HTCFA being suitable for hard-firm walls and all techniques being suitable for hard soft walls. Problems with poor pile interlock and water ingress into basements occurs where inappropriate low power piling equipment has been used to form hard-firm or hard-hard walls.

The depth of the River Terrace Deposits at the site is reasonably consistent extending to about 6.0m to 7.0m bgl. It is recommended that the design of the wall is such that the interlock of the wall is guaranteed to the base of these deposits / top of the London Clay. This, in itself, will ensure interlock through the water bearing gravels.

It is anticipated that the piling will take place from an elevation of about 25mOD giving a depth from the piling mat to the gravel/clay interface of about 4 to 5m.

For a hard-firm wall constructed from the lower part of the site, a preliminary assessment indicates that a 600mm diameter pile wall with male piles at 900mm centres and a vertical tolerance of 1 in 125 will be required suggesting that HTCFA solution would be appropriate.

Prior to the construction of the wall, all obstructions along the line of the wall and in any areas where piles are to be installed should be removed. The HTCFA/CFA system can deal with brick obstructions but will not be able to penetrate concrete obstructions. A scalloped guide wall will be required to ensure the plan tolerance of the secant piles installed. The piling mat should be of a substantial thickness to ensure that verticality of the rig is maintained during the pile installation.

It is important to note that there are many inter connected issues that will affect the performance of the wall and its ability to reduce groundwater inflows into the basement area. Prior to changing any aspect of the wall design the follow on consequences of these changes should be considered.

The construction of the wall and subsequent basement excavation will have the potential to generate ground movements. For the proposed construction at this site, movement of the ground may occur due to;

- Construction of the wall and installation of the piles;
- Excavation in front of the wall; and
- Long term changes in pore pressures due to seepage.

10.5 BASEMENT SLAB

The basement slab will be supported on a void formed to negate the effect of uplift pressures acting on the underside of the slab. The basement slab will be designed to resist uplift pressures that will develop during the lifetime of the structure. The clients brief requires a Grade 2 basement.

10.6 BURIED CONCRETE

The laboratory tests indicate slightly acidic to alkaline conditions with pH ranging between 6.2 and 11.2. In the Made Ground, test results generally indicate alkaline

conditions with pH values between 8.1 and 11.2. In natural soils, pH values range between 6.2 and 10.7.

Generally the water soluble sulphate concentration ranges from 0.01g/l to 2.61g/l. In accordance with BRE Special Digest 1, the Design Sulphate class is DS-3 and the Aggressive Chemical Environment for Concrete Classification is AC-3.

10.7 ACCESS ROADS, HARDSTANDING AND CAR PARKING

The entire site area will be covered by a single to two level basement. Therefore any access roads and hardstanding areas will be built off the basement level.

11 Revised Conceptual Site Model

In this section, the potential source-pathway-receptor linkages outlined in the Preliminary Conceptual Site Model (Section 3) are re-assessed in light of the findings of the site investigation carried out.

11.1 CONCEPTUAL SITE MODEL

The potential pollutant linkages that have been identified are presented in **Table 11.2**.

11.1.1 Sources

Onsite Soil

The concentrations of metal, inorganic and organic contaminants recorded within the soils beneath the site have been assessed relative to a commercial screening criteria and the results indicate that under a commercial end use there is no risk to human health.

Ground Gas

At the time of writing this report no concentration exceeding the updated DRAFT CIRIA guidance levels were recorded. The concentrations are not thought to constitute a risk. Further monitoring is required to fully characterise the site.

11.1.2 Pathways

Human Health

- *Direct Exposure:* Construction/maintenance workers may be exposed in short term to contaminants present within the ground by dermal contact, ingestion and/or inhalation of contaminated dust/vapours. However, no significant contamination was encountered during the site investigation other than lead at four locations. The risk can be mitigated by the use of appropriate personal protective equipment.

  In the long term, there will be no direct exposure of human health to contaminant due to the presence of hardstanding across the site and the removal of the Made Ground as part of the basement excavation.

Controlled Waters

- Groundwater could act as a migratory pathway for contaminant transport into local water features. However, the presence of a concrete slab and walls, designed such that the basement is watertight, will form a barrier preventing the migration of contaminant onto the site.
- Similarly, the presence of the basement structure and the associated excavation of the material in which slightly elevated lead concentrations have been recorded will remove the risk of contaminant leaching to groundwater.

Surface Water Run-Off

- Migration of contaminants via surface water run-off onto or away from the site will be prevented by the presence of hardstanding at ground level across the entire site and

by the fact that contaminated material will be removed as part of the basement excavation.

11.1.3 Receptors

On Site

No potential on site receptors have been identified because:

- there are no contaminant migration pathways identified, therefore there are no long term risks to human health of exposure to contaminants;
- with the exception of four lead concentrations, this investigation has not identified significant contamination.

Off Site

No off site receptors have been identified.

11.2 POLLUTANT LINKAGE ASSESSMENT

The risk posed to the identified receptors from the contamination encountered has been assessed in terms of the degree of contamination and the potential exposure pathways that may exist. A summary of the plausible pollutant linkages is presented in **Table 11.1.**

Table 11.1 Summary of Plausible Pollutant Linkages

EXPOSURE PATHWAY	Active / Inactive	(✓) / (✗)
HUMAN HEALTH (DIRECT EXPOSURE)		
Exposure to contaminated soils via ingestion/dermal contact (site users).		✗
Exposure to contaminated soils via ingestion/dermal contact (maintenance and construction workers).		✓
Four slightly elevated lead concentrations were detected in the Made Ground at four locations. Construction workers might be exposed to this contaminant. The potential risk to workers can be mitigated by the use of appropriate PPE.		
HUMAN HEALTH (INDIRECT EXPOSURE)		
Indoor exposure via enclosed space accumulation of volatile vapours.		✗
Outdoor exposure to volatile vapours.		✗
No concentration exceeding the updated DRAFT CIRIA guidance levels were record. This is not considered to pose a risk to future site users.		
Potable water supply pipes		✗
No significant contamination was identified.		
CONTROLLED WATERS		
Migration on to third party land (Statutory Nuisance).		✗

EXPOSURE PATHWAY	Active	(✓)
	Inactive	(*)
The basement concrete slab and walls will act as a barrier to the migration of contaminant.		
Impact from third party sources (Statutory Nuisance)		
Contamination of surface waters		*

11.3 QUALITATIVE RISK ASSESSMENT

The Qualitative Risk Assessment has been made by reference to the ***CIRIA (C552) Publication; Contaminated Land Risk Assessment: A Guide to Good Practice (2001).***

Within this document evaluation and assessment is carried out by comparison of the probability against the consequences of a particular risk. The matrices used for this assessment has been reproduced as **Table 11.2.**

Table 11.2 Comparison of Consequence against Probability

		Consequences			
		Severe	Medium	Mild	Minor
Probability	High likelihood	**Very high risk**	**High risk**	**Moderate risk**	Moderate/low risk
	Likely	**High risk**	**Moderate risk**	Moderate/low risk	Low risk
	Low likelihood	**Moderate risk**	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

No potential environmental liabilities have been identified as there are no potential migration pathways. Following the risk matrices in **Table 11.2** the probability of the identified contaminants impact on construction and maintenance and future site users are as presented in **Table 11.1**.

Overall the site is considered to represent a low environmental risk.

12 Conclusions and Recommendations

12.1 INTRODUCTION

The following recommendations are based upon observations and conclusions based on this investigation and pertinent findings of the desk study discussed in previous sections of this report.

12.2 GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the basement walls be constructed using embedded retaining walls. The basement slab will need to be designed for uplifting pressures resulting from both the groundwater and soil heave. Piled foundations are recommended for the basement.

12.3 ENVIRONMENTAL CONCLUSIONS AND RECOMMENDATIONS

12.3.1 Land Contamination

Limited soil contamination was identified during this investigation, however this does not elevate the risk rating of the site as this material will be removed as part of the basement excavation. The impact of any lead onsite can be mitigated by ensuring that construction workers are adequately protected and that a suitable health and safety management scheme is operated during construction activities.

12.3.2 Offsite disposal of basement material

The proposed basement development on the site will generate a significant amount of Made Ground and natural soils as spoil. This material will need to be classified prior to disposal off site.

12.3.3 Ground Gases

From the ground gas monitoring, the site can be classified as Characterisation 1 based on the updated CIRIA guidance. The site is unlikely to represent a risk to future site users.

12.4 RISK TO CONTROLLED WATERS

The risk to controlled groundwater is negated by the removal of the potential sources of contamination within the Made Ground as part of the basement construction. Furthermore this investigation did not identify any significant contamination in the groundwater.

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