Chemical Testing

Six soil samples recovered from the exploratory holes were tested for total concentrations of arsenic, cadmium, chromium, lead, mercury, selenium, nickel and benzo[a]pyrene (the CLEA suite), together with speciated polyaromatic hydrocarbons (PAH), boron, copper and zinc, phenols, total and free cyanide, hexavalent chromium, sulphate, sulphide and pH. The soil samples were also tested for organic content.

A single sample of made ground was separately tested so that the results could be compared with Waste Acceptance Criteria (WAC) detailed in the Interim Landfill (England and Wales) Regulations (Amendment) 2005 for waste.

GROUND CONDITIONS

The ground conditions encountered were broadly as expected from the geological records, topography and site history with the site covered by a variable, but generally thin, layer of made ground. This cover was usually underlain by the solid geology of the basal Bagshot Formation, and then the Claygate Member of the London Clay Formation and the underlying undifferentiated London Clay Formation at depth. The boreholes were terminated within the latter stratum.

A north-west to south-east longitudinal section detailing this sequence has been plotted across the site and is presented in Figure 1 within Appendix 7.

Made Ground

The car park surface layer of asphalt was penetrated by four of the six exploratory holes (BHs 1 and 2, TPs 1 and 2) and was 0.05m thick. This was laid upon a dark brown and dark grey or black sub-base of sandy gravel, which had a gravel fraction of flint, brick, ash, asphalt and concrete fragments. The sub-base layer was proved to depths between 0.35m and 0.60m below ground level.

The surface layer in TP 3, which was located within the grass verge adjacent the southern side of the car park, was firm brown slightly gravelly, slightly sandy clay. This topsoil fill had a gravel fraction of brick, flint, ash, asphalt and fragments of ceramic, and was 0.45m thick.

Borehole BH 3, positioned on the north-western side of the main house, found a 0.70m thick surface layer of soft, dark grey and black slightly gravelly, slightly sandy clay with a gravel fraction of brick, ash, flint, mortar and quartz. This covered a further 0.50m of soft clay fill and a 1.40m thick layer of firm orange brown and grey brown slightly sandy, gravelly clay with a gravel fraction of brick and rounded flint. This made ground was proved to 2.60m depth and appears to represent material used to raise the ground level adjacent this side of the main house during the terracing and remodelling of the sloping gardens.

Bagshot Formation

Beneath the made ground in four of the five exploratory holes within the car park (BHs 1 and 2, TPs 1 and 3), the Bagshot Formation was encountered. Initially in these two boreholes and TP 3, this was an orange brown slightly gravelly, silty fine and medium sand with a gravel fraction of rounded flint. Immediately beneath the made ground in TP 3 at 0.35m depth and below 0.75m (TP 3) or 1.20m (BHs 1 and 2), the Bagshot Formation was an orange brown and red brown slightly silty, or clayey, sandy gravel with occasional flint cobbles. The gravel fraction of this coarse grained layer was entirely of rounded flint.

This basal unit of the Bagshot Formation was proved to about 0.80m depth in TPs 1 and 3, but continued to depths of 2.70m and 2.90m below ground level in BHs 1 and 2, respectively. In the boreholes the gravel was initially very dense, becoming dense below 2.00m where thin bands of firm clay were present within it.

The 0.80m to 2.90m variation in the depth to the base of this stratum, and its absence in TP 2, is considered to reflect the erosional nature of the contact between the Bagshot Formation and the underlying Claygate Member, although this may have been exacerbated by cryoturbation during the glaciation that deposited Anglian Till just to the north of Highgate.

London Clay Formation – Claygate Member

The Claygate Member of the London Clay was met directly beneath the made ground at 2.60m in BH 3 and at 0.50m in TP 2, and underlying the Bagshot Formation at 0.80m to 2.90m below ground level.

This stratum was initially a firm orange brown and light grey mottled sandy clay/silt with occasional partings of silty fine sand and medium gravel size ferruginous concretions, which in the boreholes passed down below 5.00m to 6.30m (c.119.50mOD) into a medium dense brown, orange brown and grey silty fine sand with thin bands of orange brown sandy clay/silt. The three pits also encountered the sandy clay/silt below the surface layers and Bagshot Formation, and TP 1 was completed within these soils at 4.00m depth. Below about 3.80m depth in the two other trial pit, the clay/silt passed down into a brown and orange brown clayey or silty fine sand with occasional grey clay laminae and medium gravel size ferruginous concretions. These two excavations were completed within this sand at about 4.70m depth (120.60mOD).

With increasing depth the boreholes re-entered stiff brown and grey mottled sandy to very sandy clay/silt and then further layers of medium dense and locally dense brown and grey sandy silt with thin bands of stiff light grey sandy clay and occasional black carbonaceous traces.

These typical Claygate Member beds were proved to about 16.00m below ground level (c.109.50mOD) in BHs 1 and 2, and 13.70m (110.80mOD) in BH 3. The base of this Member has been taken where the clay was no longer very sandy and bands of sand were no longer present, which coincided with the onset of a dark grey colouration of the underlying soils of the undifferentiated London Clay.

London Clay Formation

The underlying, undifferentiated solid geology of the London Clay was initially a stiff dark grey and occasionally orange brown mottled sandy clay/silt with occasional ~~light brown~~ silt partings. Borehole BH 2 was completed at 16.50m depth in this stratum. The two other holes continued and found the London Clay to contain orange brown iron-stained fissures below about 108.50mOD. The stiff or very stiff, closely fissured and locally very closely fissured to stiff, grey brown clay below 16.00m (BH 3) and 18.20m (BH 1) had occasional brown silt and fine sand partings within it.

The London Clay did vary below 17.80m depth in BH 3, to a stiff sandy clay/silt with thin bands of sandy silt, and from 22.60m depth in BH 1 to very stiff clay with occasional silt partings. The London Clay was found to at least 20.00m (BH 3) and 25.00m (BH 1) below ground level.

Groundwater

The three trial pits were dry throughout excavation and on completion.

In the boreholes, water was first met at 9.00m (BH 1) and 13.20m (BH 2) depth within sandy silt units of the Claygate Member and rose about 2.00m during the fifteen minutes before boring resumed. In BH 1 this inflow was sealed out at 14.40m depth but a second strike occurred at 15.50m, which rose to 14.00m before drilling restarted and was then sealed out at 16.40m. In BH 3, a water seepage was recorded within the London Clay at 17.80m depth.

Water levels on completion of the three boreholes were noted at 24.10m, 13.90m and 20.00m, respectively, and then following casing removal at 13.60m and 9.00m in BHs 1 and 2, respectively.

Monitoring of the 13.00m and 15.00m long borehole standpipes during February and March 2009 recorded water levels at depths at about 11.00m (BH 1), 10.60m (BH 2) and 9.35m (BH 3) below ground level, which is approximately 114.90mOD (BHs 1 and 2) and 114.20mOD (BH 3).

Subsequent monitoring of the water levels in the three boreholes using dataloggers recorded fluctuations in the depth to groundwater in BH 1 between 10.91m and 11.10m; in BH 2 between 10.53m and 10.78m, and in BH 3 between 9.36m and 9.62m. The range of fluctuation was therefore between 0.19m and 0.26m and was found to be related to barometric pressure, with the lowest water levels generally coincident with the highest pressure readings.

Live Roots

Live roots were observed to depths of 0.40m (TP 3) and 1.30m (TP 1). No live roots were observed within TP 2.

Evidence of Contamination

Based on inspection the near surface made ground contained occasional fragments of ash and asphalt. No visual or olfactory evidence of hydrocarbon contamination was detected in the samples recovered by this investigation.

COMMENTS ON THE GROUND CONDITIONS IN RELATION TO FOUNDATION DESIGN AND CONSTRUCTION

The investigation confirmed the expected solid geology of the Bagshot and London Clay Formations at the position of the proposed 10m deep basement structure. At basement level, the medium dense sandy silt of the uppermost unit of the London Clay Formation, the Claygate Member, has bearing properties that should be sufficient to support the likely loads, particularly when the reduction in overburden pressure is taken into account. Indeed the structure will need to be designed to accommodate or withstand a small amount of base heave, although with the basement level broadly coincident with the groundwater table there should not be a risk of flotation.

Bearing Capacity

The construction of a 10m deep basement on this site will remove the surface layers of made ground, Bagshot Formation and about 8m of the clay/silt, fine sand and sandy silt of the Claygate Member.

The net allowable bearing pressure that could be applied on a 35m wide raft foundation cast on the medium dense sandy silt at 10m depth would be 160kN/m^2, based on the results of the SPTs and assuming that this stratum acts as a coarse grained soil, for immediate settlement of up to 25mm and continued for some depth beneath the bottom of the basement. However, as the sandy silt only continued to about 4m below basement level, it is estimated that immediate settlement would be less than 5mm and that long term consolidation settlement of the underlying compressible London Clay strata would take place over a longer time period and it is estimated that this would result in total settlement in the order of 50mm for this net pressure.

The likely uniformly distributed pressure applied by a basement raft was unknown at the time of report preparation. A net applied pressure of less than 160kN/m^2 would result in reduced settlement, pro rata, for example an $80kN/m^2$ net pressure could result in total settlement in the order of 25mm.

For the basement it is estimated that theoretical heave movement at the centre of a 35m wide and 10m deep excavation with a raft foundation applying a uniform net pressure of $160kN/m^2$, where $200kN/m^2$ of overburden pressure has been removed, would be in the order of 20mm to 25mm and consequently there could be 25mm to 30mm resultant settlement in this instance. However, for a raft applying a lower net pressure of only $80kN/m^2$ the theoretical base heave would be increased and in the order of 60mm to 65mm, so the resultant heave, once the reduced settlement in the order of 25mm is taken into account, would be in the order of 35mm to 40mm.

Heave would begin to take place soon after excavation and some of it may have dissipated prior to construction of the basement. However, the basement floor should be adequately reinforced to withstand potential upward movement and heave pressures in the order of perhaps $100kN/m^2$, although the presence of about 4m of sandy silt of the Claygate Member immediately below the basement floor is considered likely to mitigate such heave pressures.

The basement floor could be cast on the ground following proof rolling and careful inspection.

Excavations/Groundwater

The excavation of a basement to 10m below ground level will require the construction of close support to its sides, the control of groundwater, and the need to avoid undermining the adjacent listed structure.

The basement excavation envisaged may encounter groundwater 'perched' within the made ground and interbedded clay and sand layers of the Claygate Member at shallow depth. Such inflows should be countered using screened sump pump techniques. Groundwater was found to be present within the sandy silt of the Claygate Member at between 114.90mOD and

114.20mOD, between 9.30m and 11.10m below existing ground level, with minor fluctuations due to changes in barometric pressure.

During basement excavation and construction it will be necessary to depress the groundwater level below the 10m base of the excavation so that construction can take place in the dry and in order to avoid compromising the bearing properties of the soils at basement level. The sandy silt would be highly susceptible to rapid 'loss of strength'/excavation disturbance if inundated and so it will be necessary to depress the groundwater level using screened well points. The advice of specialist dewatering contractors should be sought prior to design of such measures in the soils encountered, particularly in relation to the potential for inducing settlement of the foundations of the adjacent listed building, and their attention drawn to the results of the falling head permeability tests undertaken within the standpipe installations.

The stability of excavations for the deep basement should not be relied upon in the short or long term. Excavations will therefore require support to remain stable and any excavated surfaces should be protected from deterioration since the soils revealed by the investigation are prone to rapid deterioration in the presence of water. Statutory safety precautions should not be neglected, especially where personnel are to enter excavations, when close side support will be required.

The use of a contiguous piled wall around the perimeter of the basement should provide support and reduce the scale of any dewatering required within the basement excavation, especially if a cut-off is achieved by taking the piled wall into the underlying relatively impermeable London Clay below about 16m depth (110mOD). The advice of specialist contractors in this field should be sought prior to proceeding with design.

Contiguous piling to a sufficient depth to mobilise adequate passive pressure below the basement level should be feasible on this site. The excavation of a 10m deep basement could then be undertaken between the contiguous piled walls. The soils beneath this site should be readily excavated using modern plant, however, the foundations and floors of former buildings within the site may well need to be broken out using hydraulic breaker attachments.

The base of the basement excavation should be inspected on completion to ensure that the condition of the soil complies with that assumed in design. Should pockets of inferior material be present, they should be removed and replaced with well graded hardcore or lean mix concrete. The excavated surface should be protected from deterioration and a blinding layer of concrete used where foundations are not completed without delay.

With groundwater at between 9.30m and 11.10m below ground level, and hence at a similar level to the floor of the proposed basement, it will be necessary to waterproof the basement in order to prevent the ingress of groundwater and percolating surface/rain water into the completed structure.

Piled Foundations

In the event that piled foundations are preferred to a basement raft, the ground conditions are considered suitable for bored or CFA, but not driven piles as the vibrations during installation of driven piles could damage the adjacent listed building. The advice of specialist piling contractors should be sought as to their preferred method of pile installation in these conditions on this site.

Preliminary working loads for a single bored pile may be estimated for design and cost purposes using pile bearing coefficients, which are based on the following assumptions.

1) The ultimate load on a pile would be the sum of the side friction/adhesion acting on the pile shaft together with the end bearing load.

2) The pile bearing properties throughout the full depth of the proposed 10m deep basement are ignored.

3) In clay and clay/silt the shaft adhesion and end bearing would be a function of the apparent shear strength values obtained from the triaxial compression tests and derived from standard penetration test results.

4) In sand and sandy silt, shaft friction would be a function of the in-situ standard penetration test results and effective overburden pressure. The latter would be calculated with the groundwater level at 10m below ground level.

5) A factor of safety of at least 2.0 would be used to assess pile working loads. If test loading of selected piles were not practical the factor of safety would be increased to at least 2.5

Item	**Ultimate Pile Bearing Value kN/m^2**
Shaft adhesion/friction in made ground/Bagshot Formation	Ignored
Average shaft adhesion in firm clay/silt (Claygate Member)	35
Average shaft friction in medium dense silty sand and sandy silt (Claygate Member) to 10m	35
Average shaft friction in medium dense silty sand and sandy silt (Claygate Member) below 10m	50
Average shaft adhesion in London Clay	75
End bearing in London Clay	1350

Using these coefficients it is estimated that a single 450mm diameter bored pile installed to 22m depth at BH 1, but discounting any pile bearing within 10m of the surface, would have an anticipated working load of 525kN, with a factor of safety of 2.5.

Different pile lengths, or diameters, from those detailed above would give different available working loads, which could be tailored to suit the working loads required.

A piling specialist should undertake final design of piles.

Retaining Walls

The contiguous piled walls of the proposed basement will act as retaining walls and will need to be designed accordingly. For a permanent retaining wall analysis effective stress parameters are appropriate and have been determined using effective stress testing in the laboratory or derived from in-situ penetration test results.

On this site, the design of retaining walls around the basement area may be based on the following stress parameters:

Table 5

Soil Type	Bulk Density (Mg/m^3) γ_B	Effective Shear Strength (kPa) c'	Angle of Shearing Resistance (degrees) ϕ'
Bagshot Formation	2.10	0	36
Claygate Member to 6m	2.00	16	30
Claygate Member below 6m	1.95	0	33
London Clay	2.05	22	24

Foundation Depths

The clay/silt soils of the Claygate Member within 3.00m of the surface across this site had modified plasticity indices between 9% and 24% and so are of low and medium volume change potential according to the National House Building Council (NHBC) Standards Chapter 4.2 'Building near trees' (2007). In open ground, well away from trees, a minimum footing depth below existing or finished ground level, whichever is greater, of 0.90m could be adopted in natural ground. On this site as the redevelopment scheme is a deep basement, foundations as shallow as 0.90m below ground level are unlikely, but may be required for ancillary structures and boundary walls.

The presence of a row of Lime trees within the south-eastern side of the site and an isolated Lime within the centre of the courtyard means that the depth affected by seasonal changes in moisture content may have been locally increased. Reference to the National House Building Council (NHBC) Standards Chapter 4.2 "Building near trees" (2007) indicates a minimum footing depth of 1.95m where a mature moderate water demand Lime tree is present close to a foundation in medium volume change potential soils.

Buried Concrete

Sulphate analysis of the soil and water samples tested gave results in Design Sulphate Class DS-1 of the BRE Special Digest 1, Table C2 (2005) presented in Appendix 8. The pH results were generally between 7.4 and 10.8 and so alkaline, but with a single slightly acidic result of 6.9.

Using the characteristic DS-1 soluble sulphate result and the recorded pH values an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1 would be considered appropriate for buried concrete on this site, as detailed in the above cited BRE document.

COMMENTS ON THE CHEMICAL TEST RESULTS

The results of the laboratory chemical testing from the investigation have been compared to CLEA Soil Screening Values (SSV) and Atkins Soil Screening Values (ASSV), which have been used as screening tools for use in the assessment of land affected by contamination. The hierarchy used by Ground Engineering for selecting Tier 1 screening values, following the withdrawal of previously published Soil Guideline Values (SGV), is SSV then ASSV.

CLEA Soil Screening Values based on CLEA model v1.03 (SSV)

Atkins Limited have derived ATRISKSOIL SSVs based on the 2008 guidance (SC050021/SR3 (the CLEA Report) and SC050021/SR2 (the TOX report)) for residential with plant uptake, residential without plant uptake and commercial/industrial land uses. They have based these on the default assumptions provided in the CLEA report which, it is understood, will be used in development of future Soil Guideline Values by DEFRA and the Environment Agency (EA). Atkins SSVs, for a conservative 1.0% and 2.5% soil organic matter (SOM), have been derived using CLEA model v1.03. These are provided under licence to Ground Engineering, and respective toxicology reports and technical details on the derivation of the SSVs can be provided on request.

ATRISKSOIL Series Soil Screening Values (ASSV)

ATRISKSOIL is a database compiled by Atkins Limited, which provides Soil Screening Values (UK applicable), under licence to Ground Engineering, for common contaminants not currently covered by CLEA Soil Screening Values. The Atkins Soil Screening Values for clarity have been referenced as ASSVs within the text of this report. The conceptual model, adopted by Atkins Limited, for the specified land uses is understood to be equally or more conservative than those incorporated in the CLEA model. The risk assessment tool is BP RISC

4.0 and the resulting ASSVs are recommended to be used as relatively conservative screening values. Respective toxicology reports and technical details on the derivation of the ASSVs can be provided on request.

Soil Assessment

The following standard land uses form the basis of the assessment in relation to soils:

- Residential use with and without plant uptake, representative of most sensitive land usage such as private and communal gardens.
- Commercial and industrial usage representative of buildings and areas covered by hardstanding, representative of commercial/industrial usage.

The intended purpose of the SSV and ASSV are as "intervention values" in the regulatory framework for assessment of human health risks in relation to land use. These values are not binding standards, but are intended to inform judgements about the need for action to ensure that a new use of land does not pose any unacceptable risks to the health of the intended users.

In summary Table 6 overleaf compares the test results with the SSVs and single ASSV in relation to the specified usage. A conservative soil screening criteria of 1.0% soil organic matter (SOM) has been used in this tabulation, since there is little variation between the SSV for the metals and benzo[a]pyrene at 1.0% or 2.5% SOM. The SSV for phenols at 1.0% SOM is less than that for 2.5% SOM.

The numbers of test results, which exceed these values, are also provided.

Table 6: Comparison of Chemical Test Results with SSVs and ASSV for Made Ground

Determinand	Number of Samples	Min Value (mg/kg)	Max Value (mg/kg)	Number of Samples Exceeding Soil Screening Criteria SSV & ASSV			Measured 95th Percentile (mg/kg)	Soil Screening Criteria SSV & ASSV (for 1.0% SOM)			
				Residential with plant uptake	Residential without plant uptake	Commercial/ Industrial		Assessment Method	Residential with plant uptake (mg/kg)	Residential without plant uptake (mg/kg)	Commercial /Industrial (mg/kg)
Arsenic	6	11	28	[redacted]	[redacted]	0	[redacted]	SSV	[redacted]	[redacted]	286
Cadmium	6	<0.1	0.42	0	0	0	0.30	SSV	7	20	232
Chromium	6	26	32	[redacted]	[redacted]	0	[redacted]	SSV	[redacted]	[redacted]	252
Lead	6	70	1200	[redacted]	[redacted]	0	[redacted]	SSV	[redacted]	[redacted]	6540
Mercury	6	<0.1	3.4	0	0	0	2.19	SSV	17	21	581
Selenium	6	<0.2	0.27	0	0	0	0.25	SSV	4	333	9549
Nickel	6	11	31	0	0	0	27.56	SSV	68	71	1054
Phenols	6	<0.3	<0.3	0	0	0	<0.30	SSV	213	15,379	37,000
Benzo[a]pyrene	6	<0.1	49	[redacted]	[redacted]	[redacted]	29.05	SSV	[redacted]	[redacted]	[redacted]
Boron	6	0.5	1.2	-	-	-	1.08	-	-	-	-
Copper	6	25	94	0	0	0	62.28	SSV	3750	7072	94,648
Zinc	6	42	230	0	0	0	154.36	SSV	24,500	66,682	1,350,792
Free Cyanide	6	<0.5	<0.5	0	0	0	<0.50	ASSV	34	34	34
Sulphide	6	<0.5	270	-	-	-	203.42	-	-	-	-

Discussion of Results and Statistics

The results of the laboratory analysis indicate the made ground locally contains elevated concentrations of arsenic and chromium, which exceeded the residential soil screening criteria. A single concentration of benzo[a]pyrene also exceeded the respective screening value for a commercial/industrial end use.

Measured total chromium concentrations were between 26mg/kg and 32mg/kg and all six samples exceeded the residential with plant uptake SSV of 13mg/kg. The toxicity of chromium depends upon its oxidation state, which generally comprises trivalent and hexavalent forms. Trivalent compounds are stable and most naturally occurring chromium is in the trivalent (chromic) state. Hexavalent chromium (chromate) rarely occurs naturally and the presence in soil is most likely to be from pollution. Hexavalent chromium is significantly more toxic than the trivalent form, and consequently the SSV assumes that all the chromium is present in the hexavalent form. The hexavalent chromium test results for the six samples analysed were all less than 5mg/kg, a concentration well below the SSV of 13mg/kg, and therefore the measured chromium concentrations would not be considered to present a significant risk to residential with plant uptake usage.

Statistical analysis, based on the mean value test, indicates that the US95 values for arsenic, benzo[a]pyrene and lead exceeded the corresponding screening values for a residential with plant uptake end use and a residential without plant uptake end use. Additionally the US95 value for benzo[a]pyrene exceeded the SSV for a commercial/industrial end use.

With the results of chromium discounted, the maximum value test was carried out on the arsenic, benzo[a]pyrene and lead test data in order to determine whether or not the highest values obtained are part of the same population, or statistical outliers. A summary is presented in Table 7 overleaf.

Table 7: Maximum Value Test

Determinand	Max Value mg/kg	T Calc Value	5% T-Critical Value (6 samples)
Arsenic	28	1.60	1.82
Lead	1200	1.74	1.82
Benzo[a]pyrene	49	1.07	1.82

The results show the T-Calc Values for arsenic, benzo[a]pyrene and lead are less than the respective 5% T-Critical Value and so the highest values determined are each part of the same populations.

The results of this analysis indicate that the made ground across the site would not be suitable for residential with or without plant uptake end use, owing to the presence of arsenic, lead and benzo[a]pyrene.

The made ground across most of the site would be considered suitable for a commercial/industrial end use, apart from the recorded benzo[a]pyrene contamination although this is considered to be derived from asphalt fragments from within the coarse grained sub-base material.

SOIL GAS MONITORING RESULTS

Three return visits to monitor gas levels at this site were made between 16th February and 16th March 2009 to record the concentrations of landfill type gases (methane, carbon dioxide and oxygen) in the standpipes installed in BHs 1, 2 and 3. The recorded concentrations of methane were below the 0.1% detection limit of the monitoring apparatus, whilst the carbon dioxide results were a maximum of 1.8%. Comparison of these monitoring results to the Building Research Establishment (BRE) guidance, BR 212, indicates that the set of methane results were well below the 1.0% BRE threshold, but that the maximum carbon dioxide results obtained from BH 1 on two of the three occasions exceeded the 1.5% BRE threshold. The recorded oxygen concentrations were occasionally slightly depleted compared with atmospheric conditions. The in-situ measurements confirmed negligible gas emission rates with recorded flow rates all less than 0.1l/hr.

Assuming a minimum positive flow rate of say 0.1l/hr, the results give a Gas Screening Value (GSV) of 0.0018l/hr and the concentrations of methane and carbon dioxide consequently fall into a Characteristic Situation 1, based on the modified Wilson & Card classification from CIRIA C665 'Assessing Risks Posed by Hazardous Ground Gases to Buildings' (2007). Characteristic Situation 1 requires no special precautions.

UPDATED CONCEPTUAL MODEL

Assessment of the potential linkage between ground contamination sources, human and environmental receptors have been assessed based on the desk study research and the intrusive ground investigation documented in the preceding sections of this report.

A generalised conceptual model, updated following the intrusive works, monitoring and testing, and targeted to provide coverage across the site, relative to the construction phase and completed development, is presented below in Table 8.

Table 8: Updated Conceptual Model Relative to Construction and Future Development

Receptors	Pathway	Estimated Potential for Linkage with Contaminant Sources			
		Drainage	Soil Beneath Site	Soil Gas	Ground Contamination Outside Site Boundary
Human Health – ground workers	Ingestion and Inhalation of contaminated Soil, Dust and Vapour	Low	Moderate	Low	Very Low
Human Health – users of completed development	Ingestion and Inhalation of contaminated Soil, Dust and Vapour	N/A	Very Low	Low	Very Low
Water Environment	Migration through ground into surface water or groundwater	N/A	Very Low	Very Low	Very Low
Flora and Fauna	Vegetation on site growing on contaminated soil	N/A	Very Low	Very Low	Very Low
Building Materials	Contact with contaminated soil	N/A	Very Low	Very Low	Very Low

Key to Table 8

RISK	Definition
Very High	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, or, there is evidence that severe harm to a designated receptor is currently happening. The risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) and remedial works may be necessary in the short term and likely over the long term.
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild
Very Low	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.
N/A	Not Applicable because the proposed development will remove the source.

COMMENTS ON GROUND CONTAMINATION IN RELATION TO PROPOSED DEVELOPMENT

Anticipated exposure scenarios relating to the site and future redevelopment works including remedial options as applicable, in the context of the conceptual model, are discussed as follows. The proposed development is understood to comprise the construction of a 10m deep basement and the reinstatement of the overlying courtyard following construction.

This investigation may not have revealed the full extent of contamination on the site and appropriate professional advice should be sought if subsequent site works reveal materials that may appear to be contaminated.

Contaminated Soil

The site is underlain by between 0.35m and 0.60m layer of made ground, locally increasing to 2.60m (BH 3) on the north-western side of the main building. The made ground contained statistically elevated concentrations of arsenic, lead and benzo[a]pyrene. These concentrations exceeded the residential screening criteria. Benzo[a]pyrene also statistically exceeded its respective screening value for a commercial/industrial land use.

Existing Drainage

Redundant foul or surface water drain runs, should be removed from beneath the site and precautions should ensure that any remaining effluent is directly disposed off-site. The integrity of existing drainage should be checked, and where they are to be retained, any damaged sections should be replaced prior to development. The latter measures should remove any future risk to human health and to the water environment.