



Geo-Environmental Report

Oak Park Health and Wellbeing Campus, Havant.

for:

Ashley House PLC



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Executive Summary

Proposed Development

An extra care facility is proposed.

Investigation

Site works were undertaken by Enzygo Ltd. in November 2014, together with a desk study, monitoring and preliminary soil infiltration testing.

Ground Conditions

Ground conditions were noted to comprise Made Ground over superficial deposits and London Clay. Groundwater was encountered at depths of between 1.3m and 4m bgl.

Contamination

No evidence of contamination has been identified from the desk study or ground investigation other than ash in Made Ground within the area of the infilled gravel pit. Elevated PAH was identified in the Made ground to the infilled gravel pit and it is recommended that this is remediated with cover soils as part of the soft landscape works.

Foundations

Piled foundations are recommended.

Pavements

An equilibrium CBR of 5% is recommended. Soils are not considered to be frost susceptible.

Re-use of Materials

Soils are not considered suitable for re-use as an engineered fill.

Buried Concrete

It is considered that Class AC-1s conditions of Special Digest 1 can be used.

Drainage

Soakaways tests confirm soil infiltration rates of between 5.9E^{-5} m/s and 3.1E^{-3} m/s.

Gas and Radon

Gas monitoring identifies that characteristic situation 1 applies.

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1.0 INTRODUCTION

Background

- 1.1 Enzygo Limited has been commissioned by Ashley House PLC to prepare a Geo-Environmental Report for a site in Havant, Hampshire.

Proposed Development

- 1.2 The proposed development is shown on Drawing 141112 Penoyre and Prodad and comprises an integrated development consisting of assisted living accommodation, extra care housing and a community hub together with associated landscaping and infrastructure. The
- 1.3 The proposed development layout is incorporated in to the Site Plan prepared by Enzygo Ltd as Drawing CRM.1112.005.GE.D.001.

Objectives

- 1.4 The objectives of the study are to:
- Review historical plans, geology, hydrogeology, site sensitivity, mining records and any local authority information available in order to complete a Desk Study;
 - Review any existing site investigation information made available;
 - Undertake a targeted ground investigation;
 - Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors; and
 - Provide a factual and interpretative report relating to the desk study and site investigations. Provide a revised conceptual model and recommendations on any potential development issues and mitigation measures, where appropriate.
 - Provide geotechnical recommendations in relation to foundations and infrastructure.

Risk Classification

- 1.5 Enzygo has utilised the available information, together with our experience to assess the likely risks to development from land quality issues. Definitions of the risk terms used are provided on the following table.

Risk	Description
Negligible	No contamination risk has been identified which is likely to affect development.
Low	No significant contaminated land risks have been encountered affecting development and a low risk that remediation will be required.
Low-Moderate	There are unlikely to be significant contaminated land issue associated with the site which will adversely affect its re-development. However, minor or localised contamination may be present requiring remediation. Remediation should be possible under a discovery strategy and with a call out service.
Moderate	Some potential contaminated land risks have been encountered or identified which may affect re- development. The risks identified are unlikely to affect the entire site or preclude development. Remediation is considered feasible as part of the development process and no further investigation is considered necessary.
Moderate-High	Some potentially significant contaminated land risks have been identified at the property that requires remediation. It is recommended that a separate remedial methodology is prepared supported by a site specific risk assessment
High	Significant potential contaminated land risks have been identified and remediation is required supported by further intrusive ground investigation, risk assessment and remedial design.

- 1.6 Where adverse risks from ground instability are identified these are discussed within the report.

2.0 SITE SETTING

Site Description

Item	Description
Site Address	Levant Drive, Oak Park, Havant, PO9 2EL.
National Grid Reference	472032,107121
Site Area	1.9 Ha

Current Site Description

- 2.1 The following site description has been compiled from the site inspection of the proposed development area undertaken by Enzygo staff, together with current maps and aerial photographs.
- 2.2 At the time of the investigation the site was occupied by open land with poor quality grass cover.
- 2.3 Within the north western corner of the site was an area of tarmac hardstanding associated with a former area of car paring.
- 2.4 Within the south eastern corner of the site is an area of concrete and tarmac hardstanding associated with a former school site and associated car parking.
- 2.5 A water course is present along the western area of the site trending north to south. The water course was noted to be lined by tree and bush hedges.
- 2.6 The site is bordered to the north by a tree lined hedge and grass landscape strip separating it from Crossland Drive beyond. The western boundary of the site is a tree and bush lined hedge separating it from Leigh Road.
- 2.7 The site is bordered by Levant Drive to the south and a tarmac footpath to the west.
- 2.8 A post and wire fence surrounds the site with gated providing access of Leigh Road and Levant Drive.

Surrounding Area

2.9 The surrounding land uses are summarised as follows:

Direction	Land Use
North	Crosland Drive with residential use beyond.
East	Open space with residential use beyond.
West	Leigh Road with health care and residential use beyond.
South	Levant Drive with health care and residential use beyond.

2.10 No significant sources of contamination were identified on or adjacent to the site.

3.0 SITE HISTORY

- 3.1 A review of historical Ordnance Survey maps and information pertinent to the site and within a 250m radius is summarised below:

Potentially Contaminative Historical Land Use		
Map Edition	On Site	Surrounding Area
1869	Field with water course within eastern area of site flowing N to S.	Fields 0m N, E & S. Leigh Road 0m W. Farm 20m W. House 150m SW. Gravel Pit 120m N.
1897	Old Gravel Pit in NW corner of site.	Gravel Pit 120m N infilled. Allotments 240m SE. Building 150m NE.
1909	No change.	Building 130m E. Additional buildings 130m W.
1932	No change.	Houses 150m S & SW. Houses 150m SE.
1940	No change.	Petersfield Road 80m W. Houses 200m E. Additional houses 120m S.
1951	No change.	Houses 200m N
1956	No change.	Housing development 50m NW. Public House 70m W.
1960	School.	Houses 50m S. Crosland's Drive 10m N. Residential Development 30m N
1963	Gravel pit infilled.	Playing Fields 0m E. School 0m S. Housing development 20m SE.
1975	No change.	No change.
1986	No change.	No change.
1991	No change.	No change.
1995	School demolished. Education Office in SE corner.	Levant Drive 0m S. Open space 20m S.
2002	No change.	Residential development on playing fields 40m E.
2010	No change.	Health care building 20m S.
2014	No change.	No change.

- 3.2 Google Earth shows an office unit with car parking within the north western corner of the site between 2004 and 2011. Its absence on the historical maps indicates that the office development was demolished before 2010.
- 3.3 There is a negligible risk of ground contamination from the infilled old gravel pit on site and from demolition of former buildings. Gas risk from the infilled gravel pit is not considered significant as infilling does not generally include significant putrescible material.
- 3.4 The old gravel pit 120m north is considered too far from the site to be a significant risk.
- 3.5 No other significant risks are identified from the historical maps.

4.0 ENVIRONMENTAL SETTING

Ground Conditions

- 4.1 The British Geological Survey (BGS) indicates that the site is underlain by the following geological sequence:

Geological Unit	Type	Description	Aquifer Classification
Drift (West)	River Terrace Deposits.	Sand and Gravel	Secondary A
Drift (East)	Head	Clayey Gravel	Secondary A
Solid.	London Clay	Silty Clay	Unproductive

- 4.2 There are no records of Made Ground within 500m of the site.
- 4.3 There are no records of faults on or close to the site.
- 4.4 There are no records of landslips on or close to the site.
- 4.5 BGS borehole records within the northern area of the site show the presence of soft clays and loose sand to 3m depth, which are likely to be the Head Deposits.
- 4.6 Records of background soil chemistry do not show any elevated concentrations.

Groundwater

- 4.7 The recorded permeability of the drift geology is low to high reflecting the variable nature of these deposits. The recorded permeability of the solid geology is low consistent with clay.
- 4.8 The GroundSure Report shows that the site is not located within a Source Protection Zone.
- 4.9 There are no groundwater abstraction wells within 1km of the site.
- 4.10 The site is shown by the BGS as being at risk from groundwater flooding from superficial deposits. This likely to be from the water course on site.

Mining

- 4.11 No historical or current coal mining extraction has been identified within 1000m of the site.
- 4.12 No other mining activities are identified within 1000m of the site.

Natural Cavities

- 4.13 No natural cavities are identified within 1000m of the site.

Ground workings

- 4.14 No ground workings additional to those discussed within the historical map search have been identified within 250m of the site. No new risks are identified.

Hydrology

- 4.15 There is an un-named water course within the east of the site, which is a Primary River. A culverted water course is present along the northern site boundary which discharges in to the Primary River.
- 4.16 There are no surface water abstractions within 2000m of the site.
- 4.17 The site is located partly within flood zones 2 and 3 associated with the on-site water course. A separate Flood Risk Assessment is being undertaken.

Radon Risk Potential

- 4.18 The Groundsure Report indicates that no Radon protection measures are required.

Natural Hazards Finding

- 4.19 BGS information presented within the Groundsure Geosight report identifies the following ground conditions:

Hazard	Risk Designation (Groundsure)
Coal Mining	No Risk identified.
Collapsible Ground	Very Low/Low.
Compressible Ground	Negligible.
Ground Dissolution	Negligible.
Landslide	Very Low.
Running Sand	Negligible/Low.
Swelling / Shrinking Clay	Low.

- 4.20 No significant ground risks are identified.

Sensitive Land Uses

- 4.21 The site comprises open space and as such it is considered to be of low sensitivity.
- 4.22 There are no ecological sensitive designations on or close to the site.

- 4.23 English Heritage has not identified any listed buildings or scheduled ancient monuments on the site.

Environmental Sensitivity

- 4.24 Overall the site is currently considered to be of **Low/Moderate** sensitivity due to the following:

- The underlying stratum is classified as an Secondary A Aquifer;
- The site is not within a Source Protection Zone and there are no groundwater abstractions within 500m of the site; and
- A water course is present within the site and the underlying Secondary Aquifer may act as a pathway.

- 4.25 The proposed end use of the site includes residential use and so the future sensitivity will be high for end users.

Industrial Land Uses.

- 4.26 Potentially contaminative industrial uses identified within 250m of the site generally comprise light industrial uses and electrical features. None of the features are located close enough to the site to pose a significant risk.
- 4.27 There are no petrol filling stations within 500m of the site.
- 4.28 There are no high pressure pipelines within 500m of the site.
- 4.29 The potential contamination risks identified on and adjacent to the site from the register of industrial activities are dismissed.

5.0 CONSULTATIONS

Regulatory Database

- 5.1 The following information has been obtained from a commercially available environmental database. The summary table only includes records not otherwise detailed in the report.

Environmental Permits, Incidents and Registers	0 -250m	250-500m	Details
Site determined as contaminated land	0	0	Not Applicable.
Authorised industrial processes	0	11	Use of organic chemicals 280m E. Not considered a risk to the site.
Registered radioactive substances	0	0	
Enforcements, prohibitions or prosecutions	0	0	Not Applicable.
Pollution Incidents	0	15	Category 3 (Minor) impact to water from fuel. Nearest 306m E and not considered a risk to the site.
Consents issued under the Planning (Hazardous Substances) Act 1990	0	0	Not Applicable.
Control of Major Accident Hazard (COMAH)/ Notification of Installations Handling Hazardous Substances (NIHHS) sites	0	0	Not Applicable.
Records of Licensed Discharge Consents	0	2	Effluent discharge the nearest being 371m S. No risk identified to the site.

- 5.2 No significant risks to the site have been identified.

Landfill Sites and Waste Treatment Sites

- 5.3 There are no operational or historic landfills within 500m of the site.
- 5.4 There are two waste facilities within 500m of the site. The nearest is a waste transfer station located 402m south of the site and is not considered to pose a risk.
- 5.5 There are no significant risks from waste operations.

6.0 PRELIMINARY CONCEPTUAL MODEL

Source	Location	Exposure Pathway	Potential Receptor	Probability of Exposure	Details
Human Health					
Asbestos, Hydrocarbon and metals	Infilled Quarry.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Negligible.	Unlikely to contain significant contaminated materials.
Asbestos, Hydrocarbon and metals	Former Buildings	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Negligible.	Unlikely to be significant contamination.
Asbestos, Hydrocarbon and metals.	Potential localised spillage on site.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Negligible.	No source identified and low sensetivity end use.
Hydrocarbon and metals.	Potential migration from off-site source.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No significant off site risks identified.
			Site users.		
Ground Gas.	Landfills	Inhalation & Explosive.	Construction Workers.	Dismissed.	No source.
			Site users.		
	Infilled gravel pit.	Inhalation & Explosive.	Construction Workers.	Dismissed.	Unlikely to include significant putrescible material.
			Site users.		
Groundwater					
Hydrocarbon and metals.	On site source.	Vertical Migration.	Groundwater.	Negligible.	Secondary Aquifer but no source identified.
Surface Water					
Hydrocarbon and metals.	On site source.	Horizontal Migration.	River Network.	Negligible.	Water course on site but no significant source identified.
Environmental Receptors					
On site contaminants		Ingestion dermal and inhalation.	Ecology.	Dismissed.	No sensitive ecology designation.
		Direct.	Archaeology.	Dismissed.	None present.
		Direct.	Geology.	Dismissed.	None present.
		Phytotoxic.	Woodland.	Dismissed.	None present.
		Phytotoxic.	Crops.	Dismissed.	None present.
		Ingestion dermal and inhalation.	Livestock.	Dismissed.	None present.
Building Services					
On site contaminants		Direct.	Historic Buildings.	Dismissed.	None present.
		Direct.	Proposed Buildings.	Dismissed.	No source identified.
		Permeate into pipework.	Water Pipes.	Dismissed.	No source identified.

6.1 Primary risk is from potential Made Ground on site.

7.0 SITE INVESTIGATION

General

- 7.1 A ground investigation was undertaken based on the findings of the desk study and taking account of the proposed development layout. Site works were undertaken using trial pits (TP1 to TP17), soakaways (SA1 to SA3) and two cable percussive boreholes (BH1 to BH3) during November 2014. The works undertaken are shown on Drawing CRM.1112.005.D.001 and summarised in the table below:

Rational	Exploratory Holes	Notes
Historic Gravel pit.	TP1	Located in area of infilled pit.
Foundations to proposed structures.	TP1, TP3, TP4, TP10, TP11, TP12, TP13, TP15, TP17 & BH1 to BH3	Located below proposed buildings.
Groundwater and gas monitoring.	BH1 to BH3	Installations within drift deposits.
Former School.	TP2, TP3, TP4, TP5, TP6, TP7, TP9, TP10, TP13 & TP15	Within areas of former school buildings shown on historical maps.
Former Office.	TP1, TP14, TP16 & TP17	Within NW corner of site.
Former Education Centre.	TP8, TP9, TP13 & TP15	Within SE corner of site.
Soil Infiltration.	SA1 to SA3	BRE 365 tests.
Pavement design.	TP2, TP5, TP6, TP14 & TP16	Below road and car parking.
Soft landscaping.	TP1, TP7, TP8, TP9, TP10 & TP15,	Below proposed landscape areas.
General site coverage	TP1 to TP17 & BH1 to BH3.	Coverage across the site.

- 7.2 The density of granular soils and shear strength of the cohesive soils was measured using a Standard Penetration Tests (SPT). Results are included on the logs presented in Appendix B.
- 7.3 Representative soil samples were collected for chemical and geotechnical testing. Soil samples destined for chemical analysis were collected in appropriate containers provided by the analytical laboratory. Samples were stored in cool boxes prior to dispatch to the laboratory for analysis. All samples were collected using appropriate sampling equipment that was cleaned at each sampling location.
- 7.4 Generally samples were collected from Made Ground, which may contain potential inclusions of contaminating materials and also materials displaying evidence of potential contamination.
- 7.5 In the absence of any evidence of contamination samples were collected near surface as this material is more likely to be contaminated by surface spillages and also will potentially be in contact with future residents.

Soakaway Test

- 7.6 Soakaway test was undertaken in areas of proposed pavement construction. These tests were undertaken following the ground investigation so that the locations could be optimised.
- 7.7 Tests were undertaken in accordance with BRE 365 at locations and depths agreed with the drainage engineer.

Laboratory Testing

- 7.8 Samples for geotechnical testing were sent to the laboratories of GSSL, which is UKAS accredited, for the following analysis:
- California Bearing Ration (CBR) tests undertaken on samples re-compacted to mimic sub-formation following proof rolling;
 - Particle size distribution tests;
 - Atterberg Limits determinations; and
 - Soluble sulphate and pH.
- 7.9 Samples for chemical analysis were sent to the Environmental Laboratories Ltd who are NAMAS and MCERTS accredited. Samples were tested for the CLEA metal suite, pH, sulphate, cyanide, phenols, speciated Polycyclic Aromatic Hydrocarbons (PAH), organic carbon, banded Total Petroleum Hydrocarbon (TPH) and asbestos screen. Two stage WAC tests were also undertaken to assist with waste classification.

8.0 GROUND AND GROUNDWATER CONDITIONS

Summary of Ground and Groundwater Conditions

8.1 The investigations undertaken by Enzygo Ltd and RML identified the following strata:

Strata	Summary Description	Thickness (m)
Topsoil like Made Ground	Dark grey sandy gravelly clay with fine roots, brick fragments.	0.2 to 0.4
Made Ground	Tarmac and concrete over grey sandy gravelly clay with fragments of brick varying to brick and concrete sub base.	0.2 to 1.0
Superficial Deposits.	Firm orange brown slightly sandy gravelly CLAY. Gravel comprises flint.	0 to 2.75
	Loose becoming medium dense with depth yellow brown sandy clayey flint GRAVEL and SAND.	0.9 to 4.2
Solid Geology.	Firm becoming stiff with depth grey brown silty CLAY.	>12
Groundwater	Seepage	1.3 to 4 bgl

8.2 Details of the ground and groundwater conditions encountered are given on the exploratory hole records included in Appendix B and are summarised in the sections below:

Made Ground

- 8.3 Made Ground was encountered across the site. Within soft landscape areas it was noted to comprise dark grey sandy gravelly clay with fine roots, brick fragments consistent with re-worked topsoil like material.
- 8.4 Within areas of hardstanding the Made Ground was noted to comprise 50mm to 100mm of tarmac or concrete over grey sandy gravelly clay with fragments of brick. In places this was noted to be overlain by brick and concrete gravel sub base.
- 8.5 Within Trial Pit TP4 a concrete slab was noted at a depth of 0.8m below ground level (bgl) which is likely to be a floor slab to a former building.
- 8.6 Trial pit TP1, located within the former gravel pit encountered clayey gravel consistent with back cast natural soils. No evidence of organic material or contamination was noted.

Superficial Deposits

- 8.7 Natural soils were noted to comprise firm orange brown slightly sandy gravelly clay. The gravel comprises flint. This is underlain by loose becoming medium dense with depth yellow brown sandy clayey flint gravel and sand.
- 8.8 The nature of the superficial deposits were similar across the site with no obvious differences between the outcrops of River Terrace Deposits and Head Deposits noted.

Solid Geology

- 8.9 London Clay was encountered at depths of between 1.6m and 4m bgl and were noted to comprise firm becoming stiff with depth grey brown silty clay.

Visual and Olfactory Evidence of Contamination

- 8.10 No visual or olfactory evidence of contamination was encountered during the site works.

Soil Strength

- 8.11 Undrained shear strength of cohesive soils have been assessed using the Standard Penetration Test (SPT) results using the correlations of Stroud and Butler. Density of granular soils have been assessed from the SPT values.
- 8.12 The cohesive superficial deposits were noted to be firm clays. The granular superficial deposits recorded SPT values of between 8 and 19, increasing with depth consistent with loose becoming medium dense sand and gravels.
- 8.13 Undrained shear strength within the London Clay was noted to increase from 40kN/m² at 3m depth bgl to over 150kN/m² at 15m bgl.

Groundwater

- 8.14 Groundwater was encountered within the granular superficial deposits at depths of between 1.3m and 4m bgl. Subsequent monitoring visits are summarised below:

Exploratory Hole	Depth m(bgl)
	11-12-14
BH1	2.93
BH2	2.01
BH3	1.92

Ground Gas

- 8.15 Ground gas was monitored during the return visits and the results are summarised on the table below:

Exploratory Hole	Atmos pressure (Mb)	Flow (l/hr)	CH4		CO2		O2
			Concentration (%)	GSV (l/hr)	Concentration (%)	GSV (l/hr)	Concentration (%)
11-12-14							
BH1	1011	<0.1	<0.1	<0.0001	1.7	<0.0017	16.8
BH2	1011	<0.1	<0.1	<0.0001	<0.1	<0.0001	21.4
BH3	1011	<0.1	<0.1	<0.0001	1.0	<0.0010	20.1

Soil Infiltration

- 8.15 BRE 365 soakaway tests were undertaken at three locations (SA1 to SA3) within areas of proposed hardstanding. Tests were undertaken in accordance with BRE 365 with three test cycles per pit.
- 8.16 Soakaway test locations were agreed with the drainage engineer and were undertaken at depths of 2m bgl with water filled to 1m bgl. Soakaway sheets are included in Appendix B and the results are summarised in the table below:

Exploratory Hole	Ground	Test No	Soil Infiltration Rate
SA1	Superficial Deposits.	Test 1	1.9 E ⁻³ m/s
		Test 2	3.1 E ⁻³ m/s
		Test 3	2.2 E ⁻³ m/s
SA2	Superficial Deposits.	Test 1	6.3 E ⁻⁴ m/s
		Test 2	6.4 E ⁻⁴ m/s
		Test 3	3.7 E ⁻⁴ m/s
SA3	Superficial Deposits.	Test 1	1.4 E ⁻⁴ m/s
		Test 2	9.8 E ⁻⁵ m/s
		Test 3	5.9 E ⁻⁵ m/s

9.0 CONTAMINATION ASSESSMENT

General

- 9.1 A Tier I risk assessment has been undertaken using available and current screening values for human health and where appropriate controlled waters. The risk assessment is undertaken based on the findings of the preliminary conceptual model presented in Section 6. Based on the contamination testing and Tier I assessment a revised Conceptual Model has been prepared, which is presented later in this section.
- 9.2 Where significant risks are identified remedial measures are recommended.

Human Health

- 9.3 Assessment of the risks to human health has been undertaken by comparing the soil quality data with reference values obtained from the Contaminated Land Exposure Assessment (CLEA), Soil Guideline Values (SGV) and General Acceptance Criteria (GAC) published by LQM/CIEH. A summary table of the reference values is included in Appendix C.
- 9.4 Where an exceedance is identified the risk is assessed by considering the sensitivity of the proposed development and the potential pathway. Given the limited contact time by site users it is considered that the GAC values for residential end use is applicable for the proposed development.
- 9.5 Results of the chemical testing are included in Appendix C.
- 9.6 The soil quality shows exceedances of the reference values for residential use in the following sample only.

Exploratory Holes	Determinant	GAC (mg/kg)	Concentration (mg/kg)
TP1 @ 0.2m	Benzo(a)pyrene	0.83	3.2
	Indeno (123 cd) pyrene	3.2	3.3
	Dibenzo(ah)anthracene	0.76	0.8

- 9.7 The PAH is associated with Made Ground material within the infilled former gravel pit and is likely to be from ash material noted in the soils. A double ratio plot undertaken on the chemical results confirms the source to be coal derived combustion products consistent with site observations.

- 9.8 The concentration of Benzo(a)pyrene BaP is below the Category 4 screening values recently developed to represent significant risk to health, however the other PAH compounds exceed the GAC and as such remediation is proposed.
- 9.9 No asbestos was detected.

Controlled Waters

- 9.10 Where groundwater samples have been analysed the results are compared against reference values. These reference values are summarised in Appendix C and are taken from Fresh Water Environmental Quality Standards (EQS), UK Drinking Water Standards and World Health Organisation (WHO) values for Drinking Water.
- 9.11 Where the controlled waters receptor is a surface water course then the EQS are used as the primary reference value. Drinking Water Standards and WHO values are used where EQS values are not available. An assessment of likely risk is then made based on a source-pathway-receptor model. Where the receptor is potable groundwater resources the Drinking Water Standards and WHO values are used.
- 9.12 The only exceedance above GAC values for residential use are PAH associated with ash. These are bound up in a vitrified form and therefore are of low solubility and mobility. Therefore the risk to ground water and surface water resources are dismissed based on the absence of mobile contamination sources at the site.

Ground Gas

- 9.13 Following the guidance provided in CIRIA C665 an initial assessment is undertaken to determine if there are any significant sources of potential ground gas. Such sources include landfills, organic clays and made ground incorporating putrescible materials such as rags, paper and wood. Where no significant source is identified no further assessment is necessary.
- 9.14 Where significant potential risk from ground gas has been identified from the Initial Conceptual Model and the intrusive ground investigation works ground gas monitoring is undertaken and the results of the monitoring are compared against the Gas Screening Values given in CIRIA Report 665. From this the Characteristic Situation is identified and remedial measures proposed.
- 9.15 When assessing the risk and type of remedial measures appropriate consideration is given to the likely construction of the development, the nature of the gas posing a risk and the

nature of the likely source. The use of engineering judgement when determining risk from ground gas is consistent with the recommendations given in CIRIA C665.

- 9.16 No significant sources of ground gas were noted from the desk study. Made Ground was encountered on site but this did not include putrescible materials. As such there is not considered to be a significant risk from ground gas.
- 9.17 Gas monitoring was undertaken during a return visit to monitor groundwater levels. Ground gas has not recorded significant concentrations of Methane or Carbon Dioxide. No detectable gas flow rates were measured.
- 9.18 Therefore it is considered that Characteristics Situation 1 applies.

Revised Conceptual Model

- 9.19 The Initial Conceptual Model presented in Section 6 has been revised based on the findings of the ground investigation and the revised Conceptual Model is presented overleaf:

Source	Location	Exposure Pathway	Potential Receptor	Probability of Exposure	Details
Human Health					
PAH	Made Ground TP1	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Low.	Communal garden. Remediation proposed.
Asbestos, Hydrocarbon and metals.	Unforeseen Contamination	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Negligible.	Discovery Strategy.
Asbestos, Hydrocarbon and metals	Infilled Quarry.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No exceedance of GAC.
			Site users.		
Asbestos, Hydrocarbon and metals	Former Buildings	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No exceedance of GAC.
			Site users.		
Asbestos, Hydrocarbon and metals.	Potential localised spillage on site.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No exceedance of GAC.
			Site users.		
Hydrocarbon and metals.	Potential migration from off-site source.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No significant off site risks identified.
			Site users.		
Ground Gas.	Landfills	Inhalation & Explosive.	Construction Workers.	Dismissed.	No source and no gas measured.
			Site users.		
	Infilled gravel pit.	Inhalation & Explosive.	Construction Workers.		
			Site users.		
Groundwater					
Hydrocarbon and metals.	On site source.	Vertical Migration.	Groundwater.	Dismissed.	. No significant mobile source identified.
Surface Water					
Hydrocarbon and metals.	On site source.	Horizontal Migration.	River Network.	Dismissed.	No significant mobile source identified.
Environmental Receptors					
On site contaminants		Ingestion dermal and inhalation.	Ecology.	Dismissed.	No sensitive ecology designation.
		Direct.	Archaeology.	Dismissed.	None present.
		Direct.	Geology.	Dismissed.	None present.
		Phytotoxic.	Woodland.	Dismissed.	None present.
		Phytotoxic.	Crops.	Dismissed.	None present.
		Ingestion dermal and inhalation.	Livestock.	Dismissed.	None present.
Building Services					
On site contaminants		Direct.	Historic Buildings.	Dismissed.	None present.
		Direct.	Proposed Buildings.	Dismissed.	No source identified.
		Permeate into pipework.	Water Pipes.	Dismissed.	No source identified.

Remediation

- 9.20 It is considered that the existing Made Ground is not a suitable planting medium and as such it is recommended that 300mm of clean Topsoil is placed within communal open space areas.
- 9.21 The exceedance of PAH above the residential GAC is located within an area of soft landscaping. Therefore it is considered that the placement of clean cover soils as part of the development works will provide a suitable barrier between elevated PAH and future site users.
- 9.22 It is recommended that a geotextile separator is placed at the base of the cover soils. It is likely that imported soils will require testing. The frequency should be agreed with the Local Planning Authority but is likely to be one sample per 100m³.
- 9.23 No other remediation is proposed.
- 9.24 If unforeseen contamination is encountered during construction works such as localised spillage outside the areas investigated an Environmental consultant will be available on a 'call out' basis to undertake an assessment of risk. If 'unforeseen contamination' is encountered the discovery strategy will be to remove the source as it is likely to be very limited in extent and the Local Planning Authority advised.

Waste Classification

- 9.25 Two part WAC tests have been undertaken across the site, the results of which are included in Appendix C.
- 9.26 The Waste Management paper 2 has recently been updated to version 3 which states that that sites which previously could be considered 'uncontaminated land' surplus soils if they did not exceed the GAC values now requires the landfill to make an appropriate assessment of the waste classification. As such final assessment will be undertaken by the receiving landfill based on the requirements of their permit.
- 9.27 It is considered that soils should be deemed as inert.

10.0 GEOTECHNICAL ASSESSMENT

Proposed Development

- 10.1 The proposed development will comprise three storey buildings with car parking. The structural loading is not known and is assumed to be 100kN per m run for assessment purposes. Using a typical column spacing of 8m a preliminary column loading of 800kN is assumed.
- 10.2 It is considered that the scheme meets the criteria of Geotechnical Category 1 of Eurocode 7.

Ground Conditions

- 10.3 Ground Conditions comprise of Made Ground over superficial deposits comprising firm clay and loose to medium dense sand and gravel. Superficial deposits are underlain by London Clay. Groundwater was encountered at depths of between 1.4m and 4m bgl.

Site Preparation

- 10.4 The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the Specification for Highway Works. This should include:
- Any redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill; and,
 - Any buried structures and old foundations encountered on site should be excavated from below the proposed structures with the resulting void backfilled.

Foundations

- 10.5 Consideration has been given to the use of conventional shallow foundations and assessing soils as both cohesive and granular. Using a presumed bearing capacity of 100kN/m² gives predicted settlements of between 30mm and 50mm. Based on the high predicted settlements and shallow groundwater encountered it is recommended that piled foundations are used.
- 10.6 A preliminary pile design has been undertaken based on the following parameters:
- The upper 1m is ignored due to the presence of Made Ground and soft to firm clay.

- Groundwater depth of 1.5m bgl is used.
- A global factor of safety of 2.5 has been used.

10.7 The following preliminary pile working loads have been calculated:

Depth bgl	Working Load kN		
	300mm	450mm	600mm
10m	160	280	400
15m	300	500	700

- 10.8 Final pile design should be undertaken by a specialist contractor who can use pile test records to agree lower factors of safety and thereby generate a more cost effective pile design.
- 10.9 Foundation design should take account of shrinkage potential of the cohesive Superficial Deposits. Soils are classified as being of moderate shrinkage potential in accordance with NHBC Standards. No evidence of desiccation was noted from these soils.

Ground Floor Slab

- 10.10 Suspended floor slabs are recommended.

Pavement Construction

- 10.11 An assessment of the likely California Bearing Ratio (CBR) has been assessed from the following sources:
- Description of the materials encountered in the exploratory holes;
 - Laboratory CBR tests undertaken on samples re-compacted to mimic proof rolling; and
 - Guidance given in HD25/94 and 73/06.
- 10.12 Based on this it is recommended that a design CBR of 5% is used. The formation should be proof rolled and any areas of soft material excavated and removed. Soils are not considered frost susceptible.

Materials Re-use

- 10.13 An assessment of the shallow soils suitability for re-use has been undertaken using the following parameters:
- Laboratory CBR tests undertaken on re-compacted samples to mimic proof rolling.
 - Grading analysis; and

- Description of the soils.

10.14 It is considered soils are too variable to be suitable for re-use as engineered fill.

Drainage

10.15 Soil infiltration rates of between 5.9E^{-5} m/s and 3.1E^{-3} m/s were measured from soakaway tests.

10.16 Chemical results should be provided to the water authority to confirm the design of potable water supply pipes.

Buried Concrete

10.17 Results of the sulphate testing indicate that soils have soluble sulphate concentrations of less than 0.5 g/l by consistent with DS1 Conditions of BRE Special Digest 1 and as such buried concrete may be designed in accordance with ACEC Class AC-1.

Excavation

10.18 Based on the various site observations it is considered that excavations should be feasible with normal construction plant.

10.19 Use of a breaker will be required should old foundations and floor slabs be encountered. It is also recommended that the locations of proposed pile caps are pre-dug to identify and grub out any old foundations.

10.20 Excavations where access is required should be supported in accordance with CIRIA RR97.

APPENDIX C – CHEMICAL TESTING

Human Health Assessment Reference Values

Determinant	Units	GAC Value						Primary Pathway
		Residential			Commercial			
Arsenic	mg/kg	32			640			Ingestion
Cadmium	mg/kg	10			230			Ingestion
Chromium	mg/kg	3000			30400			Ingestion
Chromium IV	mg/kg	4.3			35			Ingestion
Lead	mg/kg	310			590			Ingestion
Mercury	mg/kg	170			3600			Inhalation
Nickel	mg/kg	130			1800			Ingestion
Selenium	mg/kg	350			13000			Ingestion
Copper	mg/kg	2330			71700			Ingestion
Zinc	mg/kg	3750			665000			Ingestion
Cyanide	mg/kg	791			16200			Ingestion
Phenol	mg/kg	210			1100000			Ingestion
SOM	%	1	2.5	6	1	2.5	6	
Napthalene	mg/kg	1.5	3.7	8.7	200	480	1100	Inhalation
Acenaphtylene	mg/kg	170	400	850	84000	97000	100000	Dermal and ingestion
Acenaphthene	mg/kg	210	480	1000	85000	98000	100000	Ingestion
Flourene	mg/kg	160	380	780	64000	69000	71000	Ingestion
Phenanthrene	mg/kg	92	200	380	22000	22000	22000	Dermal and ingestion
Anthracene	mg/kg	2300	4900	9200	530000	540000	540000	Dermal and ingestion
Fluoranthene	mg/kg	260	460	670	23000	23000	23000	Dermal and ingestion
Pyrene	mg/kg	560	1000	1600	54000	54000	54000	Dermal and ingestion
Benzo(a)Anthracene	mg/kg	3.1	4.7	5.9	90	95	97	Dermal and ingestion
Chrysene	mg/kg	6	8	9.3	140	140	140	Dermal and ingestion
Benzon(b/k)Flouranthene	mg/kg	5.6	6.5	7	100	100	100	Dermal and ingestion
Benzo(a)Pyrene	mg/kg	0.83	0.94	1	14	14	14	Dermal and ingestion
Indeno(123-cd)Pyrene	mg/kg	3.2	3.9	4.2	60	61	62	Dermal and ingestion
Dibenzo(a,h)Anthracene	mg/kg	0.76	0.86	0.9	13	13	13	Dermal and ingestion
Benzo(ghi)Perylene	mg/kg	44	46	47	650	660	660	Dermal and ingestion
TPH C ₅ -C ₆ Aliphatic	mg/kg	30	55	110	3400	6200	13000	Inhalation
TPH C ₆ -C ₈ Aliphatic	mg/kg	73	160	370	8300	18000	42000	Inhalation
TPH C ₈ -C ₁₀ Aliphatic	mg/kg	19	46	110	2100	5100	12000	Inhalation
TPH C ₁₀ -C ₁₂ Aliphatic	mg/kg	93	230	540	10000	24000	49000	Inhalation
TPH C ₁₂ -C ₁₆ Aliphatic	mg/kg	740	1700	3000	61000	83000	91000	Inhalation
TPH C ₁₆ -C ₃₅ Aliphatic	mg/kg	45000	64000	76000	1600000	1800000	1800000	Inhalation
TPH C ₃₅ -C ₄₄ Aliphatic	mg/kg	45000	64000	76000	1600000	1800000	1800000	Ingestion
TPH C ₅ -C ₇ Aromatic	mg/kg	65	130	280	28000	49000	90000	Inhalation
TPH C ₇ -C ₈ Aromatic	mg/kg	120	270	611	59000	110000	190000	Inhalation
TPH C ₈ -C ₁₀ Aromatic	mg/kg	27	65	151	3700	8600	18000	Inhalation
TPH C ₁₀ -C ₁₂ Aromatic	mg/kg	69	160	346	36000	37000	37800	Ingestion
TPH C ₁₂ -C ₁₆ Aromatic	mg/kg	140	310	593	28000	28000	28000	Ingestion
TPH C ₁₆ -C ₂₁ Aromatic	mg/kg	250	480	770	28000	28000	28000	Ingestion
TPH C ₂₁ -C ₃₅ Aromatic	mg/kg	890	1100	1230	28000	28000	28000	Ingestion
TPH C ₃₅ -C ₄₄ Aromatic	mg/kg	890	1100	1230	28000	28000	28000	Ingestion
Benzene	mg/kg	0.08			95			Inhalation
Toluene	mg/kg	119			4400			Inhalation
Ethylebenzene	mg/kg	65			2800			Inhalation
Xylene	mg/kg	42			3200			Inhalation

Controlled Waters Assessment Reference Values

Determinant	Unit	EQS Freshwater	Uk DWS	WHO
Arsenic	ug/l	50	10	10
Boron	ug/l	2000	1000	0.3
Cadmium	ug/l	5	5	3
Chromium	ug/l	5 – 250	50	50
Lead	ug/l	4 – 250	25	10
Mercury	ug/l	1	1	1
Selenium	ug/l		10	10
Copper	ug/l	1 – 28	20000	2000
Nickel	ug/l	50 – 200	20	70
Zinc	ug/l	8 – 50	5000	3000
Sulphate	mg/l	400	250	250
PAH	ug/l		0.1	
Anthracene	ug/l	0.02		
Napthalene	ug/l	10		
Benzo(a)Pyrene	ug/l	0.03		0.01
Fluoranthene	ug/l	0.02		
Benzene	ug/l	30	1	10
Toluene	ug/l	50		
Ethylbenzene	ug/l	20		
Xylene	ug/l	30		
TPH	ug/l			
C ₅ – C ₆ Aliphatic	ug/l			15000
C ₆ – C ₈ Aliphatic	ug/l			15000
C ₈ – C ₁₀ Aliphatic	ug/l			300
C ₁₀ – C ₁₂ Aliphatic	ug/l			300
C ₁₂ – C ₁₆ Aliphatic	ug/l			300
C ₁₆ – C ₃₆ Aliphatic	ug/l			N/A
C ₆ – C ₇ Aromatic	ug/l			10
C ₇ – C ₈ Aromatic	ug/l	50		10
C ₈ – C ₁₀ Aromatic	ug/l	20		300
C ₁₀ – C ₁₂ Aromatic	ug/l			1000
C ₁₂ – C ₁₆ Aromatic	ug/l			1000
C ₁₆ – C ₂₁ Aromatic	ug/l			90
C ₂₁ – C ₃₅ Aromatic	ug/l			90



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