Land Science

GODWIN AND CROWNDALE ESTATE

PHASE II GEOTECHNICAL AND GEO-ENVIRONMENTAL INVESTIGATION

LONDON BOROUGH OF CAMDEN

28/06/2019

Site:	**GODWIN AND CROWNDALE ESTATE**	
Title:	**PHASE II GEOTECHNICAL AND GEO-ENVIRONMENTAL INVESTIGATION**	
Project:	**CONSTRUCTION OF 10NO. RESIDENTIAL DWELLINGS**	
Client:	**LONDON BOROUGH OF CAMDEN**	
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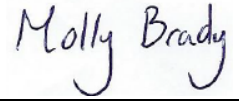
Prepared by:		**MOLLY BRADY M.Sci.** **Project Geologist**
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CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

1.1 General

Land Science was instructed by London Borough of Camden to undertake a phase II geotechnical and geo-environmental investigation in relation to the proposed development of 10.no dwellings within the current grounds of the Godwin and Crowndale Estate, Crowndale Road, London, NW1 1NW. The location of the site is shown on Figure 1, which is centred at grid reference TQ 294 833.

1.2 The Site

The area under investigation comprised a public area to the rear of the Godwin and Crowndale residential buildings. This area included a car park, Multi Use Games Area (MUGA), and communal landscaped gardens.

The layout of the existing site is indicated on Figure 2, and a walkover survey is presented in section 3.0. The area was approximately 1.20 hectares. It was understood that the Client was in ownership of the site, and that this investigation was not a pre-purchase appraisal.

1.3 Form of Development

The proposed development was understood to comprise the construction of ten new residential dwellings with private gardens and landscape improvements to the courtyard of the Godwin and Crowndale Estate. Figure 3 illustrates the layout of the proposed redevelopment. The findings may change if the development proposals are revised.

1.4 Previous Investigations

Land Science previously conducted a Phase I Desk Study for this site in June 2019. That report has been referenced where appropriate and the recommendations therein have formed the basis for the scope of this Phase II assessment.

The recommendations included the following;

- Shallow boreholes, or trial pits, to assess the composition and depth of any Made Ground and any field evidence of contamination into the underlying soils.
- Selected samples (including materials bearing field evidence of contamination) should be sent for laboratory analysis. The main analytical suite is identified below.
- Positions should be located in areas of concern; i.e. targeted to specific points of potential contamination such as previous dwelling location, and in receptor sensitive locations such as in proposed garden areas, below the footprint dwellings, in the location of buried services, etc.
- Positions should be located adjacent to the site boundaries to evaluate the potential for contamination to have migrated laterally off site and impact on adjacent land users.

The analytical suite, based on the known site history and walkover survey, should include:

- General parameters: Acidity (pH), fraction of organic carbon.
- Metals; Arsenic, Cadmium, Chromium (total), Lead, Mercury, Selenium, Boron, Copper, Nickel and Zinc.
- Non metals: water soluble Sulphate, Sulphide, total Cyanide
- Visual asbestos screening of all Made Ground samples. Where possible asbestos fibres or ACMs are identified, these should be examined under a microscope to determine type.

The phase II investigation has been carried out on these recommendations.

1.5 Scope of Works

In accordance with the scope and the client's requirements, the Phase II investigation was to comprise the following:

- 5no. dynamic (windowless) sampler boreholes to 5.0m.
- A 15m deep cable percussive borehole.
- A preliminary falling head soakage test within a borehole.
- Laboratory testing.

The fieldwork was conducted broadly as planned on 21/05/2019 - 22/05/2019 under the supervision of Land Science.

1.6 Geotechnical Objectives

A geotechnical investigation was required to provide an interpretation of ground conditions with respect to foundations, pavements, soakaways, concrete specification and excavations.

1.7 Geo-Environmental Objectives

A phase II (intrusive investigation) was required, to provide a generic quantitative risk assessment (GQRA) in respect of the proposed redevelopment, adjacent land uses, and the wider environment, in the context of the planning regime.

1.8 Standards

Where practicable, the investigation was undertaken in accordance with the following standards and guidance:

- Model Procedures for the Management of Contaminated Land, DEFRA and Environment Agency, September 2004 ("CLR11").
- Guiding Principles for Land Contamination, Environment Agency, March 2010, ("GPLC").
- National Planning Policy Framework, July 2018.
- Building Regulations Approved Document C: Site preparation and resistance to contaminants and moisture, HM Government, July 2013.
- NHBC Standards Chapter 4.1: Land Quality - Managing Ground Conditions, 2018 edition.
- BS 5930:2015 Code of Practice for Site Investigations
- BS 1377:2018 Soils for Civil Engineering Purposes

Other technical sources have been cited in respect of specific aspects of the investigation, as referenced throughout the text.

1.9 Confidentiality and Limitations

This report may be relied upon by the Client and their agents and consultants, and should be read and used only in full.

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1.10 Regulators and Approvals

It is recommended that this report is submitted to any relevant authorities for their own assessments and to provide their approval or comments accordingly. This should be in good time before commencing on site.

1.11 Variations with time

The report relates to conditions revealed at the time of the investigation. A number of parameters may vary over time, particularly groundwater levels, ground gas compositions, or concentrations of contaminants.

2 INTRUSIVE INVESTIGATION

A factual record of the conditions encountered during the physical investigation of the site is presented in the following sections.

2.1 Investigation Strategy

Based on the findings of the conceptual site model and the geotechnical objectives, the intrusive investigation was based on the following strategy:

Aspect	Position	Targets			Testing, installations etc
		Depth / strata	Existing Location	Proposed Location	
Dynamic Sampler boreholes	WS1	5.0m	Next to MUGA within Godwin Court Courtyard	NE corner of proposed development; Location of previous dwellings	FHST, HP, SV
	WS2	5.0m		Perimeter of proposed development; Proposed	HP, SV
	WS3	5.0m	Garden area beside Crowndale Court	Close to NE corner of development; adjacent soft landscaping	HP, SV
	WS4	5.0m	Road	Road on SW corner of development	HP, SV
	WS5	5.0m	SE corner of current car park	SE corner of proposed development; on site boundary within proposed gardens	HP, SV
Cable Percussive	BH1	15.0m	Car Park	Centre of proposed development	SPT
HP – Hand Penetrometer FHST – Falling Head Soakage Test			SV – Shear Vane SPT – Standard Penetration Test		

An explanation of the excavation and testing types are given in the following sections.
WS1 was drilled to 3.00m but was terminated as the Made Ground was collapsing into the hole (this hole was then changed to WS1.1), a second hole (WS1.2) was drilled next to WS1.1 and achieved a depth of 5.00m.

WS3 was terminated at 3.00m on an obstruction, possibly a very large root. WS4 could not be drilled due to a number of services encountered. Attempts were made to move this position, but the estate committee expressed concerns with the potential damage to the Multi Use Games Area (MUGA) surface.

2.2 Dynamic (Windowless) Sampling (WS)

Dynamic Sampling entails 1m long hollow tubes with liners driven into the ground and retracted in order to obtain samples. The process is repeated sequentially to the target depth, unless impenetrable strata or borehole instability prevent further progress. The liners are split, logged, tested, and subsampled. Sample compression can occur within the liners, and the sampler can sometimes become blocked. Sample recovery is typically class 2 as defined in Eurocode 7.

2.3 Cable Percussive Boreholes (BH)

Cable Percussion is a traditional drilling technique which essentially involves repeatedly dropping a hollow sampling tube from height into the ground, and removing any plug of soil that is retrieved. Clay cutters, chisels, a shelling attachment and casing can also be used down the hole.

2.4 Standard Penetration Test (SPT)

A Standard Penetration Test is used to determine the bearing capacity of soils. A sampler attached to a drilling rod is driven into the ground for 450mm by a 63.5kg weight free-falling 760mm for each blow. The number of blows required to penetrate the last 300mm is recorded and an N-Value is obtained for the tested soil layer. The initial 150mm of penetration, known as the seating blows are disregarded (Smith, 2014).

3 GROUND CONDITIONS

3.1 General

The expected ground conditions were anticipated to comprise made ground over superficial deposits and London Clay Formation to depth. The investigation confirmed the anticipated ground conditions.

A summary of the encountered conditions is presented below.

Base Depth m						Strata
WS1.1	WS1.2	WS2	WS3	WS5	BH1	
-	-	-	-	-	0.20	Hardstanding
2.80	2.50	2.70	1.10	2.00	2.30	Made Ground
3.00	5.00	5.00	5.00	5.00	15.00	London Clay Formation

The identification of materials encountered as specific geological strata is tentative and should be used as a guide, and interpolation between or below investigation points should be treated with caution.

3.2 Hardstanding

Positions BH1 was located within the tarmacadam surfaced car park. The hardstanding was proved to a depth of 0.20m.

3.3 Made Ground

Made Ground was encountered to depths of between 1.10 and 2.80m, deeper made ground was identified in the north west of the site. The Made Ground generally comprised gravelly clayey sand and sandy gravelly clay. Gravel included brick, glass, tile and concrete fragments.

3.4 London Clay Formation

London Clay Formation was proven to the base depths of all positions and generally comprised orangish brown, bluish grey and purplish grey clay with occasional selenite. Occasional sandy lenses are also identified.

3.5 Roots and Rootlets

Several tall mature trees were identified within the investigation area. Roots and rootlets were identified in WS1.1, WS1.2, WS2 and WS3 to a max depth of 0.30m.

3.6 Field Evidence of Contamination

No evidence of possible soil contamination (such as staining, malodours, or brightly coloured soils) was identified in the field.

Made Ground was identified in all holes to a maximum depth of 2.80m, and such materials may be imported from an unknown source or mixed with hazardous materials, and as such may contain a wide range of potential contaminants. All such materials should be treated as suspect unless proven otherwise. Testing has been carried out, as described in section 5.

3.7 Groundwater

Groundwater was not encountered during excavation of any of the investigative positions.

3.8 Stability

WS1.1 was terminated early due to a collapse, this was likely due to the nature of the Made Ground with loose brick and other material falling into the borehole during drilling.

4 GEO-ENVIRONMENTAL TESTING

4.1 Geochemical Laboratory Analysis

Samples were selected for geochemical analysis, based on the following rationale:

- Representative samples of Made Ground were analysed for a routine screening suite. The samples were taken from all boreholes, given the exposure pathways identified in the CSM.
- Samples of Made Ground from WS3 and BH1 were screened in the laboratory for asbestos such as flecks of fibrous lagging and in asbestos containing materials such as cement board etc.

The scope and extent of testing was considered appropriate and in accordance with the Conceptual Site Model and preliminary risk assessment.

A summary of the testing scheduled is given below:

Sample	Suite				
	LS1	Asbestos	TOC	Mineral Oil	PH&SO4
WS1.1 (0.40m)	✓	✓	-	-	-
WS1.2 (0.30m)	-	-	-	-	✓
WS1.2 (0.40m)	-	-	✓	-	-
WS1.2 (0.40m)	-	-	✓	-	-
WS1.2 (0.40m)	-	-	✓	-	-
WS1.1 (0.40m)	-	-	✓	-	-
WS2 (0.50m)	✓	✓	-	-	-
WS3 (0.30m)	-	-	-	-	✓
WS3 (0.50m)	-	✓	-	-	-
WS5 (0.35m)	✓	✓	-	✓	-
BH1 (14.00m)	-	-	-	-	✓

The relevant screening suites are defined below. Where duplicate analysis exists between suites, each test is performed only once:

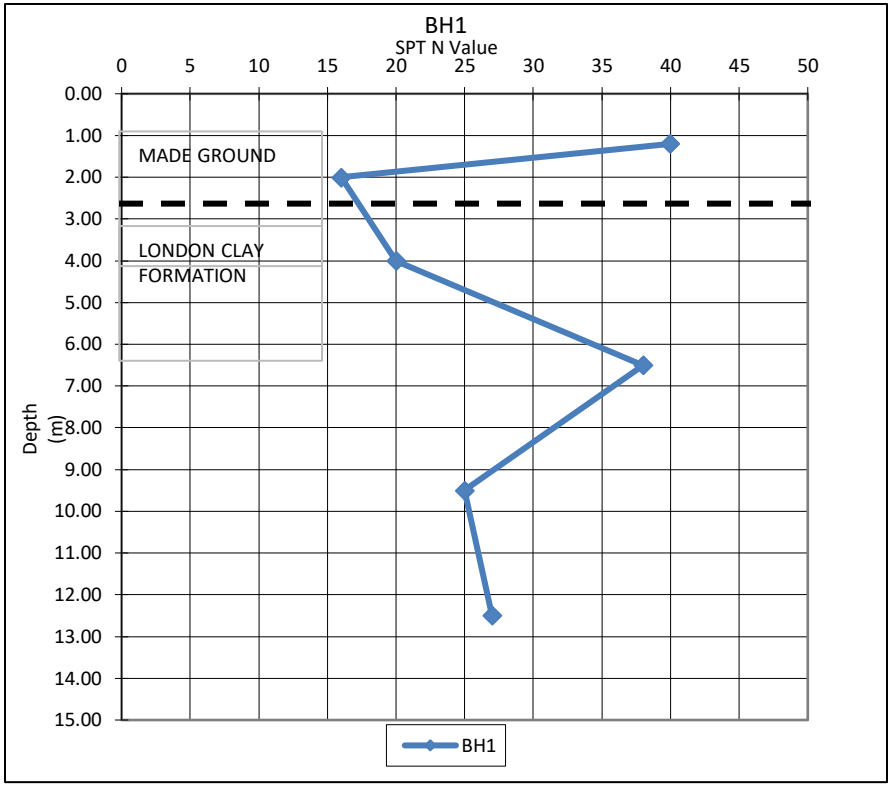
Suite	Definition
LS1 (soil)	Screening suite: pH, fraction of organic carbon, Metals and Non Metals, water soluble Sulphate, Sulphide, total Cyanide, total Phenols, speciated PAH's.
Asbestos	Asbestos screen: Laboratory screening for fibres and Asbestos Containing Materials; identification where identified. Using polarising light and dispersion staining as described in HSG 248, HSE Contract Research Report No 83/1996and in Davies et al, 1996.
TOC	Total Organic Carbon: TOC methods utilise heat and oxygen, chemical oxidants or a combination of these to convert organic carbon to Carbon dioxide (CO2). The evolved CO2 is then measured.
PH&SO4	Measure of the acidity or alkalinity of a soil. Measure of sulphates in soil.

The results of geochemical analysis are discussed in section 7.0.

5 GEOTECHNICAL FIELD TESTING

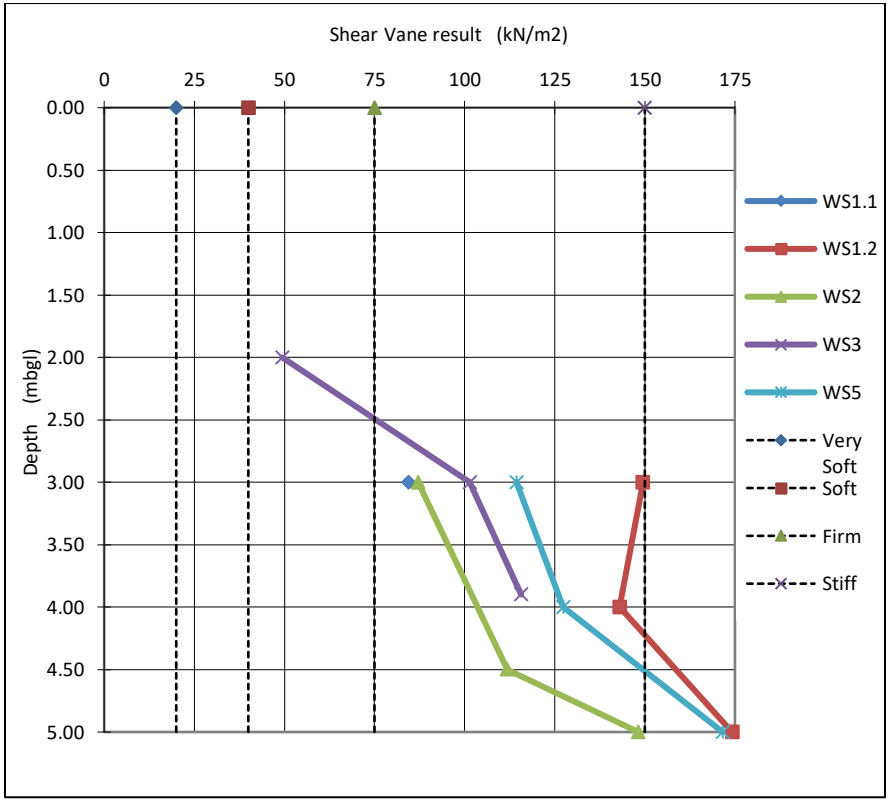
5.1 Standard Penetration Testing (SPT's)

In-situ standard penetration tests (SPT's) were undertaken within CP1, in order to assess the relative density of the materials encountered. The blow count (N) to drive the cone 300mm after any seating blows is recorded, and is used as a measure of the relative density of granular soils (as defined in BS5930:2015). The results may also be used to estimate the consistency of cohesive soils, using an empirical correlation. The results are summarised below.



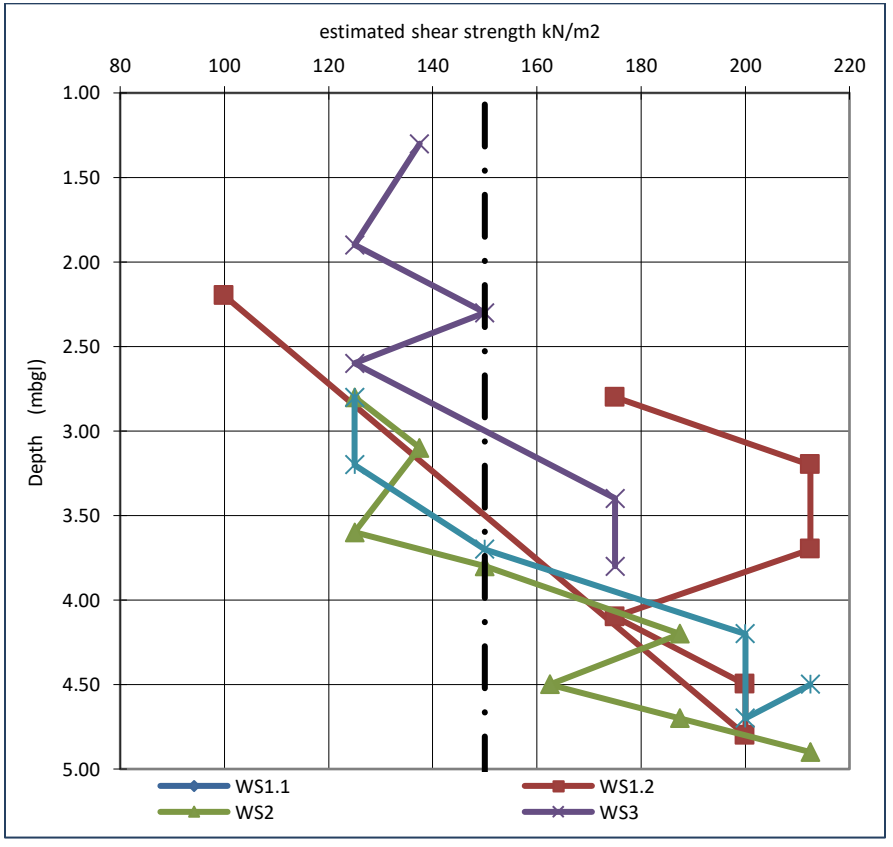
5.2 Shear Vanes

Laboratory shear vane tests were performed on samples of cohesive materials recovered within the boreholes. The test provides a direct estimate of undrained shear strength, and in turn may be used to give an indication of consistency as defined in BS5930. The results are summarised below.



5.3 Penetrometers

Hand penetrometer tests were performed on samples of cohesive materials recovered within the boreholes. The test is used to approximate undrained shear strength and in turn has been used to give an indication of consistency as defined in BS5930. The results are summarised below.



5.4 Soakage Testing

A falling head soakage test was undertaken in WS1.2. The water level fell 0.075m in 135mins. The readings were insufficient to calculate a soil infiltration rate.

6 GEOTECHNICAL LABORATORY TESTING

Laboratory quick undrained single stage triaxial tests were undertaken on selected "undisturbed" samples recovered from BH1, as summarised below. The mode of failure was generally brittle.

Strata	Depth	Bulk density (Mg/m^3)	Dry density (Mg/m^3)	Undrained Shear strength (kPa)	Mode of Failure
London Clay Formation	8.00-8.45	1.97	1.57	72	Brittle
	11.00-11.45	2.07	1.65	197	Compound
	14.55-15.00	1.92	1.55	160	Brittle

Geochemical testing for water soluble Sulphate and pH were undertaken, and the results are summarised on the following table.

Strata	No. of tests	Water soluble Sulphate (SO_4 g/l)	pH (value)
Made Ground	6	0.078-0.35	8.1-10.6
London Clay Formation	1	0.88	8.80

7 GEOTECHNICAL ASSESSMENT

The following recommendations have been made with respect to geotechnical design.

7.1 General Foundation Design

The proposed development was understood to comprise the construction of ten new residential dwellings with private gardens and landscape improvements to the courtyard of the Godwin and Crowndale Estate

Significant thicknesses of Made Ground were encountered across the site, to depths order of 2.80mbgl. The depth and composition of the Made Ground was such that shallow foundations might not be economical or practical to construct.

On this basis, it is recommended that consideration may be given to an alternative foundation solution, such as the use of piles.

7.2 Volume Change Potential

Soil shrinkability has been assessed following the NHBC Standards Chapter 4.2 (January 2018 edition). It is recommended that the advice of this publication (or similar guidance) is taken when designing and constructing foundations in the zone of influence of trees and hedgerows that currently exist, are to be planted, or have recently been felled.

Strata	% passing 425µm sieve	Modified Plasticity Index	Shrinkability classification
London Clay Formation	-	>40%	High volume change potential

Specifications for heave precautions on high volume change potential soils are summarised below. In addition to the depths marked *, localised deepening of foundations will be required in the influence of trees; it will be necessary to evaluate tree species and height in relation to the proposed building footprints. If not already carried out, an arboricultural survey will be required.

Volume Change Potential		High
Minimum void dimension	Against side of traditional foundations and ground beams etc.	35mm
	Beneath ground beam and suspended in-situ concrete ground floors etc.	150mm
	Beneath suspended precast concrete or timber floors etc.	300mm
Minimum allowance for potential ground movement for new drains		150mm

All foundations should extend below any major root zones or desiccated soil encountered, and trenches should be carefully inspected accordingly.

7.3 Piled Foundations

The working load for piled foundations will depend on the installation technique, the dimensions of the individual piles and any pile groups, in addition to the ground conditions. The construction of piled foundations is a specialist job and the advice of a reputable contractor should be sought prior to finalising the design.

Whilst driven piles may give a higher working load compared to a bored pile, their use may be prevented due to the proximity of adjacent structures. Preliminary working load capacities have been calculated for varying diameters of bored piles taken into the London Clay Formation, below:

Depth (m)	300mm diameter	450mm diameter	600mm diameter
11	205	340	495
13	240	380	530
15	300	470	665

These working loads have been calculated on the basis of the ground and groundwater conditions encountered within the boreholes and based on the following assumptions:

- The contribution to the working load on the upper 3.00m has been ignored.
- A factor of safety of 3 was used on the skin friction and end bearing working loads respectively.

Piles should be taken at least five times the pile diameter into the founding strata.

The bearing values given are applicable to single vertically loaded piles. Where groups of piles are to be constructed, the bearing value of each individual pile should be reduced by a factor of 0.8 and a calculation made to check for the factor of safety against block failure.

In accordance with the NHBC Standards, heave precautions may be required on the upper portions of piles and on ground beams within the zone of influence of trees.

7.4 Ground Floor Slabs

Given the proposals for a piled foundation design it is understood that all ground floor slabs will be fully suspended, with a suitable minimum void space.

7.5 Excavations

The risks arising from excavation works should be properly assessed and appropriate safety precautions should be adopted. Reference may be made to various guidance including BS8000-1:1989, BS6031:2009 and CIRIA C97.

The likelihood of excavation instability through different strata has been assessed as summarised below. It should be noted that all open unsupported excavations have the potential to collapse. Excavations which are to remain open for prolonged periods will require trench support.

Strata	Stability
Topsoil/Made Ground	Generally unstable. May be battered back to a safe angle. Deeper excavations may require trench support.

It is considered that normal-rated plant and machinery will be sufficient for undertaking excavations. Care should be taken so as not to undermine existing structures, services, or adjacent property.

Adjacent excavations should generally be tackled in order of depth with the deepest first. Vehicles and spoil heaps etc. should not surcharge excavations, and edge protection and fencing should be used as appropriate. Frozen materials should not be used as backfill.

7.6 Pavements

The formation level for pavements is expected to comprise Made Ground at 450mm depth.

The Made Ground was of a mixed composition, and the engineering characteristics of such soils are highly variable and unpredictable. Due to the variability of the Made Ground it would be prudent to assume the material to be frost susceptible throughout, thus a minimum pavement thickness of 450mm would be appropriate.

The formation level should be carefully inspected, and any soft or loose zones should be removed and replaced with engineering fill, well-compacted in layers to a suitable specification. Consideration might be given to installing geotextiles. All engineering fill should be granular and non-frost susceptible (i.e. <10% fine material passing 425µm sieve).

Any hard spots in the formation level such as old foundations may induce reflective cracking in the pavement and allowance should be made for removing any slabs or other hard spots etc. that may be present.

It is assumed that all estate roads will be privately maintained. Where any roads are to become adopted by the relevant Highways Authority, they should be consulted in order to confirm local specifications and design parameters. Further testing may be required.

7.7 Building Materials

Based on BS8500-1:2015+A1:2016, the results of the Sulphate and pH analyses fell into Class DS-2 and an ACEC class AC-2 is deemed appropriate. The advice of this publication should be taken for the design and specification of all sub surface concrete.

Buried plastics used for potable water supplies should be upgraded to resist chemical contamination. Metal or aluminium barrier pipework will be acceptable. No pipework should be laid where there is evidence of hydrocarbons.

7.8 Surface Water Drainage

Given the low permeability of shallow soils, it is unlikely that soakaways will perform satisfactorily at this site. Consideration might be given other means of disposal such as discharge to surface water sewer.

8 HUMAN HEALTH RISK ASSESSMENT

8.1 General

A Tier 1 Generic Quantitative Risk Assessment (GQRA) has been prepared for soil contamination. It should be noted that the presence of a possible contaminant does not necessarily imply that a site or area is contaminated or that there is any unacceptable risk to human health.

The conceptual site model identified a potential pollutant linkage between made ground and End Users & Adjacent Land Users.

Source	Pathway	Receptor
Soils: Made Ground	Dermal contact Inhalation Ingestion	End Users
	Inhalation	Adjacent Land Users

8.2 Screening Values

Several different partly overlapping schemes are currently in use in the UK, based on the Environment Agencies CLEA Model but with differing toxicological parameters. For the purpose of this report these schemes have and have been applied in the following hierarchy:

- Suitable For Use levels (S4UL) recently published by LQM in association with the CIEH.
- Category 4 Screening Levels (C4SL) recently published by the DEFRA and CL:AIRE.

The soil chemical analysis results have been compared against respective screening values for residential with vegetation land uses.

Whilst other standards exist, such as the LQM Generic Assessment Criterion and the Environment Agency's Soil Guideline Values, these are considered to have been superseded by the above publications.

For contaminants where the respective screening value is dependent on Soil Organic Matter (SOM), the corresponding value for 2.75% was used (the arithmetic mean SOM value for the soil was 2.5%).

Where no standard exists, the contaminant is either not considered a priority in terms of human health (at least in the scenario being considered), or no screening value has been published.

The results showed that Lead and Mercury both exceeded the screening values in 2no locations.

8.3 Statistical Analysis (no)

In accordance with CL:AIRE *Guidance on Comparing Soil Contamination Data with a Critical Concentration*, the use of statistical tools was not considered appropriate in this instance. There was not a sufficient quantity of data to enable this type of analysis. The results of the chemical analysis have therefore been compared directly against the respective standards.

8.4 Other Substances

The screening value for Mercury was based on the elemental form, which was the lowest set of standards. Elemental Mercury is very unlikely to occur in soils and the less conservative screening values for Inorganic or Methyl Mercury may be more appropriate. WS1.1 – 0.4m and WS2 0.5 both exceeded the threshold for elemental mercury. Additional specialist speciated mercury testing could be considered.

8.5 Asbestos

A total of 4 samples of Made Ground were screened for the presence of Asbestos, and a summary of the results is presented below.

Soil	Sample	Asbestos present	Type	Quantification
Made Ground	WS1.1 (0.40m)	Detected	Chrysotile	< 0.001
	WS2 (0.50m)	Detected	Chrysotile	< 0.001
	WS3 (0.50m)	None detected	-	-
	WS5 (0.35m)	None detected	-	-

The samples that contained Asbestos were below the detection limit (< 0.001), therefore the risk is considered negligible. However, there is no 'safe' limit and a risk assessment framework by CL:AIRE or CAR:SOIL should be prepared.

8.6 End Users

The results of the chemical analysis indicated elevated concentrations of Lead & Mercury in WS1.1 & WS2. Localised remediation or further investigation was therefore considered necessary in this respect.

8.7 Adjacent Land Users

Surrounding land uses were identified to comprise residential housing and public spaces, analogous with the proposed development on site. With reference to section 8.6, a possible risk was posed to human health from elevated Lead and Mercury. It is therefore concluded that the soils on this site pose a possible significant risk to surrounding residential land uses. Further detailed risk assessment is recommended in this respect.

8.8 Conclusions

The results of the chemical analysis indicated that elevated lead and mercury levels in WS1.1 and WS2. Either remediation or further investigation was therefore considered necessary in this respect.

The extent of Made Ground was more significant than anticipated and the testing regime is insufficient for a 10no housing development of 1.2 hectares. The advice of the local authority contaminated land officer should be sought. This report should be treated as preliminary.

A copy of this report should be submitted to the relevant authorities for approval in sufficient time prior to commencement on site.

A suitably qualified Environmental Consultant should prepare a full *Implementation, Verification Monitoring and Maintenance Plan*. An appropriate level of supervision and testing will be required, to form part of a formal *Verification Report*.

9 BUILT ENVIRONMENT RISK ASSESSMENT

9.1 General

The conceptual site model identified a potential pollutant linkage between made ground and End Users & Adjacent Land Users.

Source	Pathway	Receptor
Soils: Made Ground	Plant uptake Chemical attack	Soft landscaping Structural concrete Potable water supplies

9.2 Soft Landscaping

A number of documents include guidance on screening levels of phytotoxic contaminants within soils, including:

- BS3882:2015 "Specification for topsoil and requirements for use" (although stipulated as not to be used in contaminated land risk assessment).
- ICRCL in publication 70/90 1990 'Notes on the Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing' (although indirectly withdrawn) (where marked *).

The results of the chemical analysis for determinands known to pose a potential phytotoxic risk to plant growth are summarised on the following table, together with the respective adopted screening values for plant growth. The results of the chemical analysis were evaluated singularly without the use of statistical tools.

Determinand	Phytotoxicity Value (mg/kg)			Results in excess of screening value
	pH <6.0	pH 6.0-7.0	pH >7.0	
Zinc	<200	<200	<300	WS2 0.50m (750mg/kg)
Copper	<100	<135	<200	None
Nickel	<60	<75	<110	None
Cadmium *	50			None
Arsenic *	1,000			None

On this basis, it was concluded that elevated Zinc in the vicinity of WS2 might pose a risk of phytotoxic effects on plant growth. Therefore, remedial measures were considered necessary in this respect.

This aside, materials generally considered physically suitable for soft landscaping purposes were not encountered within the investigative positions, and verifiably suitable topsoil or sub-soil is likely to be necessary in order to facilitate and sustain plant growth in soft landscaped areas. The materials should meet the chemical standards set out in BS3882.

9.3 Structural Concrete

Recommendations with respect to Sulphate and buried concrete are made in section 7.7. The results of the Sulphate and pH analyses fell into Class DS-2 and an ACEC class AC-2 is deemed appropriate. Buried plastics used for potable water supplies should be upgraded to resist chemical contamination.

10 PRELIMINARY WASTE ASSESSMENT

10.1 General

Waste may be defined as any substance or object in Annex 1 of the Waste Framework Directive[1] which the holder discards, intends to discard, or is required to discard. Subject to certain provisions, soils may either be handled as either:

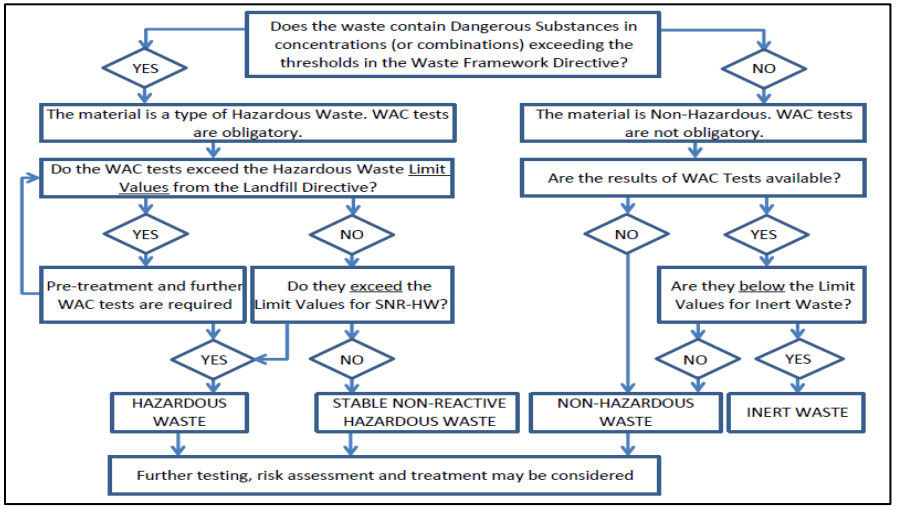
- Non-Waste, and re-used (on or off-site), or
- Waste, and disposed of (to a waste management facility).

Given the confines of the site, it was anticipated that all materials would be disposed of from site as waste.

The waste producer has a legal duty of care to ensure that waste materials are handled properly and sent to the appropriate licenced facility. Further inspection, testing, segregation etc will be required on site, and the advice of a suitably qualified consultant sought wherever necessary. Substantial tax penalties and fines are being levied by the regulators. The advice contained in this section is preliminary only.

10.2 Waste Disposal

Where materials are not re-used they must be handled as Waste, and must be sent to a licenced waste management facility. The classification of waste is prescribed under the Waste Framework Directive[2] and the Landfill Directive[3], as summarised below. Different waste management facilities may also have specific acceptance criteria, and their advice should be sought.



The results of the soil analysis have been classified as follows:

Soil	Hazardous		Non Hazardous		Details
	Hazardous	Stable Non-Reactive	Non-Hazardous	Inert	
Made Ground (WS1.1 0.40m & WS2 0.50m)	✓				HP7 by way of Carc. 1A; H350 (Lead). **WAC testing not carried out**.
Made Ground (WS5 0.35m)			✓		Non hazardous. **WAC testing not carried out**

WAC testing may be considered for soils identified as Non-Hazardous, as the tests may enable those materials to be re-classified as Inert and therefore represent a potential saving on disposal costs.

With reference to the current List of Wastes (formerly European Waste Catalogue), waste soils and stone derived from construction and demolition sites may be disposed of under either of the following codes as appropriate:

Waste	Code	Description
Hazardous	17 05 03*	soil and stones containing dangerous substances
Non-Hazardous	17 05 04	soil and stones other than those mentioned in 17 05 03

(Note, the asterix is a Mirror Entry, as defined in the List of Wastes, conferring the relationship with the non-hazardous code 17-05-04).

11 SUMMARY AND CONCLUSIONS

This summary is a brief precis of the main findings and conclusions of the investigation. For detailed information, the reader is referred to the main report.

11.1 General

The intrusive investigation included 5no Dynamically Sampled positions and 1no Cable Percussion borehole. The area under investigation comprised a car park, Multi Use Games Area (MUGA), and communal landscaped gardens. The proposed development comprised ten new residential dwellings with private gardens and landscape improvements.

11.2 Soils Encountered

Strata	Depth m	Summary
Hardstanding	0.20	Asphalt
Made Ground	1.10 - 2.80	Gravelly clayey sand and sandy gravelly clay. Gravel included brick, glass, tile and concrete.
London Clay Formation	15.00+	Comprised orangish brown, bluish grey and purplish grey clay with occasional selenite.

11.3 Groundwater

No groundwater was encountered within 15m depth.

11.4 Foundations

Piled foundations are recommended and design parameters are given. The formation should be treated as being high volume change potential.

11.5 Excavations

Generally likely to remain stable. Risk assessments should be prepared and appropriate safety measures provided.

11.6 Pavements

The formation level for pavements is expected to comprise Made Ground at 450mm depth. Due to the variability of the Made Ground, assume the material to be frost susceptible.

11.7 Building Materials

DS-2 and AC-2 in accordance with BS8500. Water supply pipe work will require protection from aggressive soil contaminants.

11.8 Soakaways

A preliminary falling head soakage test was undertaken within WS1.2. However, the percolation was extremely poor and a soil infiltration rate could not be calculated.

11.9 Radon Protection

No issues with respect to Radon gas have been identified.

11.10 Soil Contamination

The results of the chemical analysis indicated an elevated concentration of Lead & Mercury in WS1.1 & WS2. Either remediation or further investigation was therefore considered necessary in this respect.

11.11 Waste Disposal

Preliminary chemical results classified the Made Ground as Hazardous within the proposed soft landscaped gardens. Further testing is recommended by the contractor, as part of a materials management plan. It is likely that natural soils could be handled as Inert Waste.

11.12 Further Action

Further investigation will be required into the presence of Lead & Mercury and additional site investigation in consultation with the local authority contaminated land officer. A Remediation Method Statement should be prepared. This report should be submitted to relevant regulatory bodies and warranty providers in good time for approval.

REPORT CONDITIONS

Interpretation of ground conditions inherently depends on the conditions revealed by a limited data set. Land Science takes all reasonable professional care in preparation of this report, using current standards and industry best practice. However, we accept no liability whatsoever expressed or implied in respect of:

- The scope, extent or design of an investigation.
- Any conditions not directly revealed by the investigation.
- Published standards or methodologies used or adopted in this report.
- The opinion of any other party including any regulator, authority or stakeholder.
- Any dispute, claim or consequential loss arising from this report.
- Any matter other than ground conditions in the area under investigation.

Information contained in this report is intended for the use of the Client and his agents for the purposes set out, and we accept no liability for its use by other party or for any other purpose.

This report makes no representation on other matters such as ecology, agronomy, arboriculture, structural condition, building materials, boundaries and planning etc.

No aspect of this report should be taken as a guarantee whatsoever that a site is free of pollution, contamination or hazardous materials.

The levels of mobile liquid or gaseous contaminants may vary over time. Further or additional investigation may be necessary.

GLOSSARY OF TERMS

ACM	Asbestos Containing Material
BGS	British Geological Survey
BRE	Building Research Establishment
BS	British Standard
CBR	California Bearing Ratio
CDM	Construction Design and Management regulations
CIRIA	Construction Industry Research and Information Association
CL:AIRE	Contaminated Land: Applications in Real Environments
CLEA	Contaminated Land Exposure Assessment model
CoC	Chemical of Concern
CSM	Conceptual Site Model
EA	Environment Agency
EQS	Environmental Quality Standards
FOC	Fraction of Organic Carbon
GAC	Generic Assessment Criterion
mbgl	Meters Below Ground Level
NHBC	National House Building Council
mod	Metres above Ordnance Datum
PAH's	Polycyclic Aromatic Hydrocarbons
PCoC	Potential Contaminant of Concern
PBET	Physiological Based Extraction Testing
PHE	Public Health England
PID	Photo-Ionisation Detector
PQRA	Preliminary Quantitative Risk Assessment
PSD	Particle Size Distribution Test
RMS	Remediation Method Statement
SGV	Soil Guideline Value
SOM	Soil Organic Matter
SPZ	Source Protection Zone
SPT	Standard Penetration Test
SSSI	Sites of Special Scientific Interest
ST-WEL	Short Term Workplace Exposure Limit
SVOC's	Semi-Volatile Organic Compounds
TPH	Total Petroleum Hydrocarbons
TRRL	Transport Road Research Laboratory
TWA-WEL	Time Weighted Average Workplace Exposure Limit
UK HBF	United Kingdom House Building Federation
VOC's	Volatile Organic Compounds
WAC	Waste Acceptance Criteria

ACCOMPANYING NOTES – SOIL CONTAMINATION

Screening Suites

The LS1 routine screening suite is based broadly upon determinands listed within the former ICRCL guidance note 59/83 2nd edition 1987, CLR publication CLR8, and Environment Agency R&D66 publication. Additional testing for stone and moisture content, fraction of organic carbon ('foc'), and pH value, were also undertaken. Given that Sulphate is not a priority in terms of human health, water soluble Sulphate is analysed instead in order to assess the risks posed to the built environment.

Site Workers

Site managers are responsible for the safety of persons in their employ under a variety of instruments including the CDM regulations and Health & Safety at Work Act. In terms of working on contaminated sites, guidance can be sought from the CIRIA publication entitled "A Guide for Safe Working on Contaminated Sites".

Any work in confined spaces confined spaces should only be carried out following appropriate risk assessment and following suitable safety protocols in accordance with the HSE guidance entitled "Work in Confined Spaces". A detailed risk assessment can be prepared in this respect, but is outside the scope of this appointment.

Discovery Strategy

Unexpected soil conditions may be encountered during the process of site demolition and construction. Examples may include oily pockets within the soil, pockets of cement boarding or fibrous materials within the soil, black ashy materials, soils exhibiting strong odours, brightly coloured materials, and former structures or brickwork.

Should previously undiscovered contamination be encountered during construction by the ground worker's, this should be reported to the Geo-Environmental Consultant immediately in order that any necessary inspection may be made. All site workers should be made aware of their responsibility to observe, report, and act on any potentially suspicious or contaminated materials they may encounter.

Primary and Secondary Sources

The secondary sources used in this report are: soil, groundwater and ground gases, as summarised below:

Secondary source	Summary
Soil	Contaminants bound into or entrained with the soil matrix, for instance ashes, clinkers, bituminous materials, asbestos containing materials, etc. Also, soils may become contaminated by other activities, such as leaking chemical storage, drainage and the like, becoming bound into the soil mineralogy or organic matter. Soils may also generate soil-borne dusts and volatile organic compounds may generate organic vapours.
Volatile vapours	Many organic compounds are either volatile or semi volatile (at different temperatures and pressures) which mean they will volatilise and generate vapours. In an enclosed system, the ratio of vapours to other compartments will come into equilibrium, but in open systems the process may continue until the source has been depleted.
Ground gases	Organic matter, including wastes, hydrocarbons and other compounds, will decay through microbial action. This will primarily release Carbon Dioxide but may also release Methane under anaerobic conditions. This may be an issue in natural soils (e.g. alluvium and dock silt) in man-made soils (e.g. landfill sites and filled ground) and other environments (e.g. mine workings).
Groundwater	Contaminants may dissolve into pore water which in turn can percolate downwards into the groundwater table. Rapid discharge of fluids may also enter groundwater directly. Organic compounds may form separate light or dense non-aqueous phase liquids upon or at the base of the water column. Organic contaminants may generate organic vapours.

[1] Revised EU Waste Framework Directive 2008 2008/98/EC [transposed into English law under The Waste (England and Wales) Regulations 2011]

REFERENCES

[2] Revised EU Waste Framework Directive 2008 2008/98/EC [transposed into English law under The Waste (England and Wales) Regulations 2011]

[3] European Community (EC) Directive 1999/31/EC [transposed into English law under the Landfill (England and Wales) Regulations 2002]