Land Science

[redacted]

GEOTECHNICAL INVESTIGATION

[redacted]

25TH JANUARY 2021

[redacted]

Site:	[redacted]
Title:	**PHASE II GEOTECHNICAL INVESTIGATION**
Project:	**DEMOLITION OF COMMERCIAL BUILDINGS AND ERECTION OF TWO DWELLINGS**
Client:	[redacted]
Contact:	[redacted]
Date:	**25TH JANUARY 2021**
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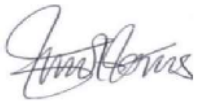
Authorised by:		**ELLIOT TOMS CEnv M.Sc., B.Sc. (Hons.), FGS, MIEnvSci** **Managing Director**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1 INTRODUCTION

1.1 General

Land Science was instructed to undertake a Geotechnical Investigation in relation to the proposed erection of two detached dwellings at [redacted] The location of the site is shown on Figure 1, which is centred at grid reference [redacted]

1.2 Client

The Client for this appointment was [redacted] This report may be used by this named client only and is subject to the confidentiality notice set out in section 3.1 and cannot be relied upon by any other party as set out in the report conditions.

1.3 The Site

The area under investigation comprised a roughly rectangular shaped parcel of land covered in a thin layer of demolition rubble with a large mound of rubble to the south of the site following the recent demolition of commercial units on site.

The layout of the existing site is indicated on Figure 2, and a walkover survey is presented in section 6.0. The area was approximately 0.44 hectares. It was assumed that the Client was in ownership of the site, and that this investigation was not a pre-purchase appraisal.

1.4 Form of Development

The proposed development was understood to comprise the construction of two detached dwellings with garages. The proposed development was covered under planning application number [redacted] Figure 3 illustrates the layout of the proposed redevelopment. The findings of this report may be not valid if the proposed development is altered.

1.5 Previous Investigations

The following previous investigations relevant to the site were identified on the local authority planning portal:

- Contamination Risk Assessment, Environmental Assessment Services Ltd, February 2014

1.6 Scope of Works

The proposed scope of works was to comprise the following:

- 6no. dynamic (windowless) sampler boreholes
- 6no super heavy dynamic probes

The fieldwork was conducted on 5th January 2021, under the supervision of Land Science.

1.7 Geotechnical Objectives

A Ground Investigation Report was required in order to provide an interpretation of ground conditions with respect to proposed foundations, pavements, concrete specification and excavations.

2 STANDARDS AND REFERENCES

2.1 Standards

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

- BS 5930:2015 Code of Practice for Site Investigations
- BS 1377:2018 Soils for Civil Engineering Purposes
- BS 8004:2015 Code of Practice for Foundations
- BS EN 1997-2:2007. Eurocode 7: Geotechnical Design – Part 2: Ground Investigation and testing.

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

2.2 References

A number of technical references have been referred to in the preparation of this document, including:

- Smith, I. (2014) Smith's Elements of Sil Mechanics. Chichester. Wiley Blackwell. 9th Edition.
- Highways England 2009. Interim Advice Note 73/06 revision 1: Design Guidance for Road Pavement foundations (draft HD25)

2.3 Notes

If a long delay exists between the investigation and commencement on site, it may be necessary to check whether any standards have changed in the intervening period.

3 REPORT CONDITIONS

3.1 Report Conditions

This report is issued subject to the conditions set out in section 3 and the terms and conditions of appointment agreed with the Client.

3.2 General

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.

Land Science does not accept any risk or any direct or consequential liability relating to ground conditions. The client should understand their risks and liabilities and seek further professional advice.

No aspect of this report constitutes a design. Where this information is used in design, the designer should verify that the information has been used appropriately.

3.3 Confidentiality

This report may only be relied upon by the Client and their design team, and should only be read and used in full. No responsibly will be accepted where this report is used, by any other party, who do so at their peril. The report may not be relied upon or transferred to any other parties without the express written agreement of Land Science.

3.4 Third Party Information

Third party information used in the production of this report has been relied upon as being accurate. Land Science cannot warrant or accept any liability for errors and/or omissions in third party information.

3.5 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 in case additional work is to be carried out.

Standards, technical guidance and regulatory positions change over time and which may therefore affect the findings and recommendations made in this report. This should be verified by the client prior to any critical contractual points or commencing on site.

3.6 Variations with time

The report relates to conditions revealed at the time of the investigation and any monitoring visits. A number of parameters may vary over time or seasonally. Groundwater levels, ground gas compositions, or concentrations of contaminants are particularly variable in this respect. Further monitoring or verification should be considered as appropriate.

3.7 Other Matters

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.

4 SITE SETTING

4.1 Geological Mapping

Based on mapping published online by the British Geological Survey (BGS), the geology of the site was anticipated to comprise the following succession:

Strata	Generic description
River Terrace Deposits	Sand and gravel, locally with lenses of silt, clay or peat.
Weald Clay Formation	Dark grey thinly bedded mudstones (shales) and mudstones with subordinate siltstones, fine- to medium-grained sandstones, including calcareous sandstone, shelly limestones and clay ironstones.

4.2 Historical Borehole Records

Records of old boreholes are held by the BGS. However, no relevant borehole records were available within the vicinity of the site.

The Contamination Risk Assessment carried out by Environmental Assessment Services Ltd in February 2014 contained trial pit logs (TP1-TP6) and photos. In summary, the succession in the northern part of the site comprised concrete hardstanding (approx. 0.10m deep) over made ground/fill described as *"sandy soil, brick and gravel"* and *"chalk fill"* (approx. 0.15-0.40m deep). The fill overlies *"natural ground comprising sandy clay (alluvial deposits) becoming stiffer with depth (Weald Clay)."* The south of the site was a chalk surfaced yard with underlying *"natural ground (clay)"*.

Photographs of each trial pit were available within the report. The photos show a small amount of water at the base of TP1 and TP2. A very small amount of water also appeared to be present within TP4 and TP5. These may be small water seepages from the surface.

4.3 Hydrogeology

Based on the geology and topography of the local area, a relatively shallow groundwater table was anticipated.

4.4 Radon Potential

The requirement for Radon Protection Measures (RPM) has been assessed in accordance with BRE 211:2015. Public Health England and the BGS estimate the potential for radon and the requirement for Radon Protection Measures on site as follows:

Probability	Protection Measure
Less than 1% of homes are estimated by PHE to exceed the threshold for Radon gas in residential dwellings.	No Radon Protection Measures (RPM) are required for new dwellings or extensions constructed at this location.

4.5 Aquifer Designations

The Environment Agency classifies geological units across England into different designations as Aquifers. The designations for strata beneath the site are given below, which corresponds to an overall designation as a Secondary A Aquifer.

Strata	Classification	Details
Superficial (River Terrace Deposits)	Secondary A	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
Bedrock (Weald Clay Formation)	Unproductive Strata	Low permeability strata that have negligible significance for water supply or river base flow

4.6 Source Protection Zones

A groundwater Source Protection Zone (SPZ) is an area of protection placed around a well or borehole that supplies groundwater of potable quality. No SPZs were identified on or within 250m of the site according to the Environment Agency.

4.7 Surface Water Flooding

Land potentially susceptible to flooding from seas, rivers, reservoirs and surface water is identified by the Environment Agency. Current mapping indicated the following:

Source	Details
Rivers and Seas	Very low risk means that each year this area has a chance of flooding of less than 0.1%. Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
Reservoirs	
Surface water	Low risk means that each year this area has a chance of flooding of between 0.1% and 1%. Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.

4.8 Landfill Sites

No landfill sites were identified within 500m of the site.

4.9 Geological Hazards

The BGS produce hazard assessment maps for a selection of common geotechnical datasets, and the classifications referring to the site (and immediate vicinity – if relevant) are summarised below:

Dataset	Location	Hazard
Shrinkability	On site	Low
Running Sands		Very Low
Landslide		
Collapsible		
Compressible Ground		No Hazard
Dissolution		

4.10 Mining and Natural Cavities

A search of various databases for coal mining, mining, brine compensation, and natural cavities was carried-out, and the findings are summarised on the following table:

Database	Results
CBSCB Compensation District	No features found
Coal Mining Affected Areas	
Mining Instability	No features found
Man-Made Mining Cavities	
Natural Cavities	
Non Coal Mining Areas of Great Britain	features found – "Highly Unlikely Risk" - BGS

5 SITE HISTORY

5.1 Historical Maps

Historical maps dating between 1875 and 1982 were reviewed to identify the history of the site and local area.

In summary, the site comprised an open field until 1961, at which point two barn-type buildings are noted.

The local area comprised largely open fields with occasional farm buildings and limited urbanisation throughout this period. A pond and an east-west running river were noted approximately 150m south of the site from 1975 onwards.

The key apparent features noted on site and the surrounding area are summarised below.

Land use	Location	Dates	Description
Open field	On site	1875-1961	• Open, undeveloped field
Barn Buildings		1961-1982	• Narrow buildings noted by 1961. • Large, barn buildings noted by 1977.
[redacted]	1m E	1875-1982	• Comprised several rectangular buildings with a central yard area in 1875. • Noted as [redacted] by 1897. • Grew, gradually in size throughout this period. • By 1911, a pond and several tanks are noted within the farm. • No further significant changes were noted

A large farmhouse is noted immediately to the west of the site at present day. Excluding this, the last historical map is commensurate of present day.

5.2 Aerial Photographs

Aerial photographs dating between 2001 and 2020 available online were also reviewed. In summary, the site comprised a rectangular parcel of land covered in hardstanding containing two large barn buildings. The local area comprised open fields with [redacted] to the east and a large farmhouse and stables to the west.

5.3 Planning Portal

A search of the [redacted] planning records was made. The following applications relevant to the site were identified:

Date	Reference	Address	Summary title
24/11/2018	[redacted]	[redacted]	Demolition of commercial buildings and erection of two dwellings

This application contained a Contamination Risk Assessment. The site investigation, comprised six shallow trial pits and identified *"some minor contamination at the site posing some potential risk to unprotected polyethylene water mains and future site users when in contact with soil in the proposed garden areas."* The encountered ground conditions have been summarised in Section 4.2. The report gives recommendations for remedial measures.

6 SITE WALKOVER

6.1 General

A site walkover was undertaken as part of the fieldwork on 5th January 2021. Photographs of the site are provided in Appendix A.

6.2 Site Layout

The area under investigation comprised a roughly rectangular shaped parcel of land largely covered in scattered rubble, with a large circa 3.00m high mound of rubble in the southern extent. The rubble comprised of brick and concrete that appeared to have been crushed. Occasional metal fragments were noted.

The site was bounded to the east by a brick wall of varying height with several vertically protruding metal beams. These appeared to be from previous demolished buildings.

The northern boundary was lined with lined with shrubs and several tall mature deciduous trees. The western boundary comprised trees and bushes in the northern half and a tall brick wall in the southern half.

A roughly 3.00m wide slab of concrete ran two thirds the length of the site immediately adjacent to the eastern boundary.

6.3 Surrounding Area

The site was located in a predominantly rural area with Falconers Farm to the east and dwellings and stables to the west. The site fronted onto Sincox Lane.

6.4 Elevation and Topography

The topography of the local area was generally flat and level. The site was also generally flat and level and was located at an approximate elevation of 18.0mOD.

6.5 Ground Conditions

No evidence of existing soil conditions was observed, such as open excavations or the like. However, building rubble was present at the surface across the site.

6.6 Surface Water and Groundwater

Large puddles were present throughout the site. A large pond was noted in the garden of the dwelling approximately 20m to the east.

6.7 Trees and Vegetation

Numerous tall mature deciduous trees were noted immediately adjacent to the north and west boundaries. Numerous tall mature coniferous trees were noted in the south east of the site.

The southernmost extent of the site was noted to be overgrown with brambles and ivy along the boundary.

A detailed arboricultural survey was outside the scope of this report. A survey may be required for tree root protection purposes or for assessing the depth of foundations in the vicinity of trees.

There was no immediate evidence of invasive plant species, although this was not a full survey.

7 INTRUSIVE INVESTIGATION

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

7.1 Investigation Strategy

Based on the findings of the geotechnical objectives, the intrusive investigation was based on the following strategy:

Aspect	Position	Targets			Testing
		Depth	Existing Location	Proposed Location	
Dynamic Sampler Boreholes (DS)	DS01	3.00m	Adjacent to existing/previous building	Footing of proposed dwelling	SHDP
	DS02	5.00m			
	DS03	5.00m		Adjacent to proposed dwelling	
	DS04			Footing of proposed dwelling	
	DS05	3.00m			
	DS06			Adjacent to proposed dwelling	

An explanation of the excavation and testing types are given in the following sections.

Both DS02 and DS04 refused upon dense silt and were therefore terminated prematurely at 4.50m and 4.00m respectively.

7.2 Dynamic (Windowless) Sampling (DS)

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.

7.3 Super Heavy Dynamic Probing (SHDP)

Dynamic Probing involves hammering a cone point into the ground and recording the number of blows required for each increment of penetration. The mass and falling height of the hammer, the energy efficiency, the dimensions of the cone, the rod specifications and rod friction are important considerations. A range of configurations are prescribed in Eurocode 7 and EN ISO 22476-2; the type deployed was *DPSH-A*.

8 GROUND CONDITIONS

8.1 General

The expected ground conditions were anticipated to comprise Made Ground over River Terrace Deposits over Weald Clay Formation to depth. The investigation confirmed the anticipated ground conditions.

A summary of the encountered conditions is presented below.

Base Depth m						Strata
DS01	DS02	DS03	DS04	DS05	DS06	
0.45	0.30	0.20	0.20	0.15	0.20	Made Ground
3.00	3.05	3.70	3.80	3.00	3.00	River Terrace Deposits
-	4.50	5.00	4.00	-	-	Weald 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.

8.2 Made Ground

Made Ground was encountered to depths of 0.15-0.45m, and generally comprised brown grey very sandy clayey GRAVEL. Sand is fine to coarse. Gravels are fine to coarse brick and concrete fragments.

8.3 River Terrace Deposits

River Terrace Deposits were encountered to depths of 3.00-3.80m and generally comprised orange grey mottled very sandy silty CLAY. Sand is fine to medium. Contained rare angular limestone fragments. Carbonaceous fragments were also noted within these deposits.

8.4 Weald Clay Formation

Below the River Terrace Deposits, the Weald Clay Formation was encountered to depths of 5.00m and generally comprised dark grey slightly clayey slightly sandy SILT. Sand is fine to coarse. The formation was noted to be fissured in places and became denser with depth.

8.5 Roots and Rootlets

No roots were identified. Rootlets were identified in all boreholes to varying depths, shown in the table below:

Position	Rootlets
DS01	0.45-1.20m; abundant decayed rootlets 1.20-3.00m; occasional decayed rootlets
DS02	0.30-0.90m; abundant decayed rootlets 0.90-1.60m; occasional decayed rootlets
DS03	0.20-2.15m; abundant decayed rootlets 2.15-3.70m; occasional decayed rootlets
DS04	0.20-1.10m; abundant decayed rootlets
DS05	0.15-1.70m; occasional decayed rootlets
DS06	0.40-2.00m; abundant decayed rootlets 2.00-3.00m; occasional decayed rootlets

8.6 Field Evidence of Contamination

Made Ground was identified in all boreholes to base depths of 0.45m, 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.

8.7 Groundwater

Groundwater was struck during the excavation of DS03, DS04 and DS06 with short-term standing water depths in the order of 4.45, 1.80 and 0.28m respectively after 20 minutes. The groundwater encountered may represent perched water that has seeped down from the surface and gathered above more impermeable layers within the encountered formations.

Groundwater levels may vary seasonally and with variations in rainfall. Water may also become perched upon cohesive strata or around features such as foundations, and may also occur from leaking drains and water mains etc.

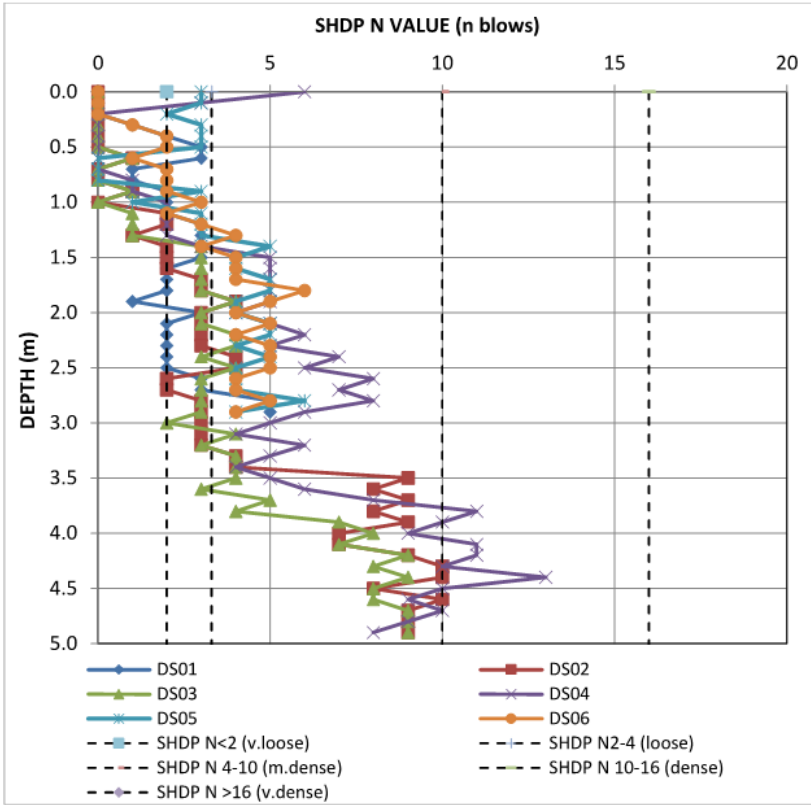
8.8 Stability and Casing

No instability encountered. No casing used.

9 GEOTECHNICAL FIELD TESTING

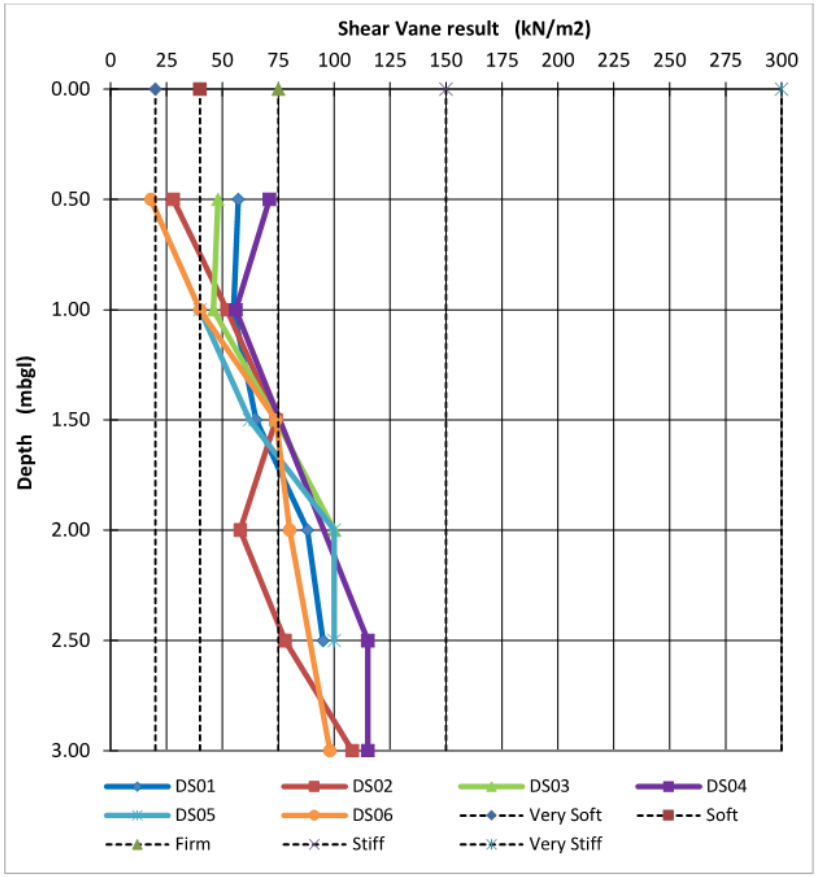
9.1 Dynamic probing (SHDP)

A super heavy dynamic probe (SHDP) was undertaken at all positions. The test is used as a measure of the relative density of granular soils (as defined in BS5930:1999). The test provides limited data in cohesive soils but may be used to illustrate changes in consistency with depth. A typical range of results is summarised below.



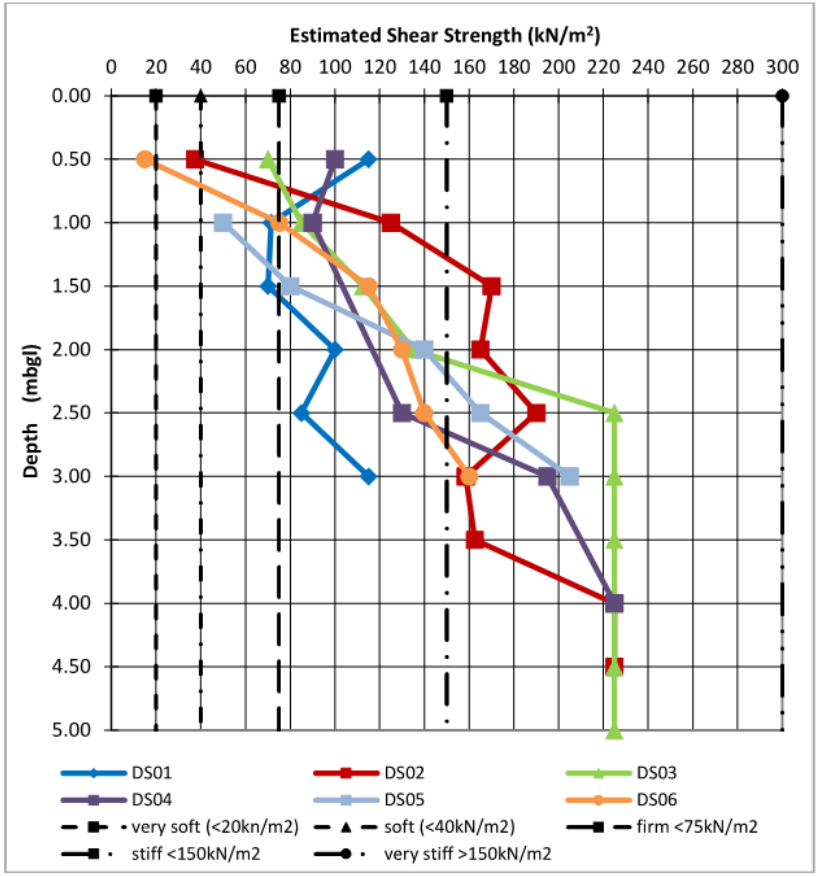
9.2 Shear Vanes

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.



9.3 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.



10 GEOTECHNICAL LABORATORY TESTING

10.1 General

Samples of soil were sent for laboratory geotechnical testing; copies of the results are appended, and summaries are given in the following tables. The testing was undertaken in accordance with the relevant British Standards in BS1377 following documented quality procedures.

10.2 Particle Size Distribution

Particle Size Distribution analysis was performed on representative samples of more granular materials.

Strata	No. of tests	% Clay/Silt	% Sand	% Gravel	% Cobbles
River Terrace Deposits	1	19.9	48.6	31.6	0.0

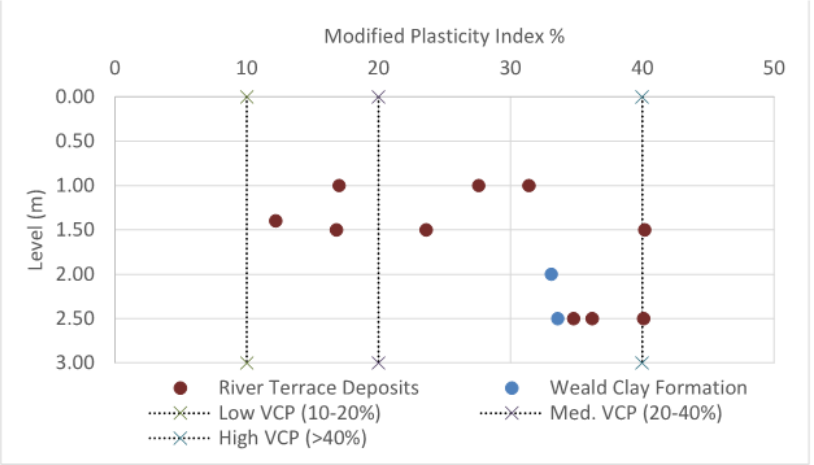
10.3 Plasticity Indexes (Atterberg Limits)

Atterberg Limit tests were undertaken on selected samples of cohesive soils, as summarised below.

Strata	No. of tests	Plasticity Index %		
		Minimum	Maximum	Average
River Terrace Deposits	10	18.6	43.3	30.9
Weald Clay Formation	2	36.5	37.2	36.9

A modified plasticity index (PI') was calculated following the NHBC methodology, to account for any non-shrinkable percentage not passing the 425µm sieve:

Strata	No. of tests	Modified Plasticity Index %		
		Minimum	Maximum	Average
River Terrace Deposits	10	12.2	40.2	28.0
Weald Clay Formation	2	33.1	33.6	33.4



10.4 pH and Sulphate

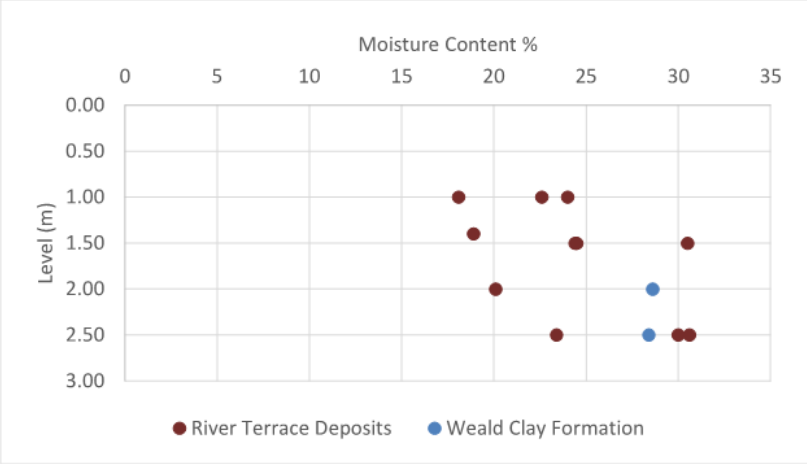
Geochemical testing for water soluble Sulphate and pH were undertaken, and the results are summarised on the following table.

Strata	No. of tests	Water soluble Sulphate (SO_4 g/l)	pH (value)
Made Ground	2	0.12-0.23	7.5-8.0
River Terrace Deposits	3	0.011-0.019	7.9-8.3

10.5 Water Content

Water content determinations (formerly known as *moisture content*) were undertaken in combination with various classification tests, and the results are summarised on the following page.

Strata	No. of tests	Moisture content %		
		Minimum	Maximum	Average
River Terrace Deposits	11	18.1	30.6	24.3
Weald Clay Formation	2	28.4	28.6	28.5



11 GEOTECHNICAL ASSESSMENT

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

11.1 General Foundation Design

The proposed development was understood to comprise the construction of two detached dwellings with garages.

Shrinkable soils were identified, which may be susceptible to seasonal heave and shrinkage movements caused by changes in moisture content caused by the action of tree roots and rootlets. Trees were noted along the boundaries of the site. An assessment of tree heights and species will need to be carried out in order to calculate minimum foundation depths in accordance with Section 4.2 of NHBC Standards.

A shallow water table standing at approximately 0.28mbgl to 4.45mbgl was encountered. The groundwater encountered may represent perched water that has seeped down from the surface and gathered above more impermeable layers within the encountered formations. Groundwater levels may rise further during prolonged periods of wet climatic conditions. It is considered prudent to confirm groundwater levels and trench stability parameters by means of excavating a series of trial pits across the site immediately prior to construction.

Subject to confirming groundwater can be controlled, it is expected that traditional strip foundations with light reinforcement would be appropriate for the proposed development.

11.2 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
River Terrace Deposits	-	20-40%	Medium volume change potential
Weald Clay Formation			

Specifications for heave precautions on medium 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		Medium
Minimum depth for traditional foundations outside zone of influence of trees (m) *		0.90m
No tree planting zone required for minimum depth foundations above (m)		0.5 x mature tree height
Minimum depth for traditional foundations but allowing for restricted new planting (m) *		1.25m
Minimum void dimension	Against side of traditional foundations and ground beams etc.	25mm
	Beneath ground beam and suspended in-situ concrete ground floors etc.	100mm
	Beneath suspended precast concrete or timber floors etc.	250mm
Minimum allowance for potential ground movement for new drains		100mm

All foundations should extend below any major root zones or desiccated soil encountered, and trenches should be carefully inspected accordingly. Void former will be required for foundations deeper than 1.50m and within the influence of trees.

11.3 Traditional Shallow Foundations

The following recommendations are made where traditional foundations are to be used.

The primary design parameter for shallow foundations is maximum net allowable bearing pressure, which takes into account a tolerable degree of settlement, and is dependent not only on soil conditions but also the foundation dimensions, ground levels, sloping ground, and the symmetry of loading, amongst others.

All traditional shallow foundations should be taken through any Made Ground, soft or loose zones, disturbed soils, major root zones, or desiccated materials and taken wholly into or onto the firm sandy, silty, gravelly clay of the River Terrace Deposits.

A long narrow strip foundation, as described above, symmetrically loaded and up to a width of 1.00m, may be designed based on a maximum allowable net bearing pressure of 110 kN/m^2 at a minimum depth of 1.50mbgl.

This assessment includes an appropriate factor of safety against shear failure, and settlements should remain within appropriate limits. This figure should be sufficient for the type of construction proposed.

Given the variability in engineering characteristics of the River Terrace Deposits at the anticipated formation level, it is recommended that all foundations are lightly reinforced to account for potential differential settlements.

The River Terrace Deposits will soften rapidly when exposed to free water. The final 50mm of any foundation trench should not be excavated until immediately before concreting, unless blinded or otherwise protected immediately after excavation. Special care should be taken to ensure foundation trenches remain dry.

11.4 Ground Floor Slabs

Given the presence of soils susceptible to volume change potential (i.e. shrinkable) it is recommended that all ground floor slabs should be fully suspended, with a suitable minimum void space.

Ground bearing floor slabs may be considered for other structures such as garages or outbuildings. The formation should be appropriately treated, and the design should allow potential future movements.

11.5 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.

Strata	Stability
Made Ground	Generally unstable. May be battered back to a safe angle. Deeper excavations may require trench support.
River Terrace Deposits & Weald Clay Formation	Generally stable in the short to medium term.

Excavations which are to remain open for prolonged periods will require trench support.

All excavations taken beneath the water table are likely to become highly unstable. Significant collapse and over-dig expected. Consideration should be given to the use of dewatering and full-trench support.

It is considered that normal-rated plant and machinery will be sufficient for undertaking excavations.

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 generally not be used as backfill.

11.6 Pavements

The design of pavements will depend on the performance requirements and specification, as well as the ground conditions and finished levels etc. The suitability of shallow soils encountered as a formation level for pavements is summarised as follows:

Strata	Depth range	Suitability
Made Ground	0.15 to 0.45m	Only suitable for pavements with low performance requirements. A CBR value for these materials will not reflect the possible settlements that may occur. The materials will be frost susceptible so a minimum pavement thickness of 450mm will be required, and the formation will need to be adequately proof-rolled and treated
River Terrace Deposits	3.00 to 3.80m	These materials are generally a suitable formation level. Based on the Atterberg Limit test results, the formation materials should be considered as being non-frost susceptible for pavement design purposes.

With reference to Transport Road Research Laboratory Report LR1132 "The Structural Design of Bituminous Roads", a CBR index of 3% is considered appropriate for the sandy, silty, gravelly clay of the River Terrace Deposits assuming poor construction conditions and a shallow groundwater table.

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. Cohesive formations will degrade rapidly if exposed to standing water for even short periods. All engineering fill should be granular and non-frost susceptible (i.e. <10% fine material passing 425µm sieve).

11.7 Building Materials

Based on BS8500-1:2015+A1:2016, the results of the Sulphate and pH analyses fell into Class DS-1 and an ACEC class AC-1 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 not require any special specification in order to resist chemical contamination. No pipework should be laid where there is evidence of hydrocarbons.

12 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.

12.1 General

The intrusive investigation included 6no dynamic sampler boreholes and super heavy dynamic probes. The site comprised a roughly rectangular shaped parcel of land covered in a thin layer of demolition rubble with a large mound of rubble to the south of the site following the recent demolition of the commercial units on site. The proposed development comprised the demolition of commercial buildings and construction of two detached dwellings with garages.

12.2 Soils Encountered

Strata	Depth m	Summary
Made Ground	0.15-0.45	Brown grey very sandy clayey GRAVEL. Sand is fine to coarse. Gravels are fine to coarse brick and concrete fragments.
River Terrace Deposits	3.00-3.80	Orange grey mottled very sandy silty gravelly CLAY. Sand is fine to medium. Gravels are fine to medium sub-angular claystone fragments.
Weald Clay Formation	5.00+	Dark grey slightly clayey slightly sandy SILT. Sand is fine to coarse.

12.3 Groundwater

Groundwater was recorded during drilling standing at levels of between 0.28mbgl to 4.45mbgl. The groundwater encountered may represent perched water that has seeped down from the surface and gathered above more impermeable layers within the encountered formations.

12.4 Foundations

Traditional foundations may be suitable depending on the groundwater conditions, and design parameters are given. The formation should be treated as being medium volume change potential. Light reinforcement and a minimum foundation depth of 1.50m will be required due to the poor engineering characteristics of the soils above this depth.

12.5 Excavations

Generally likely to remain stable. Excavations below the water table may become highly unstable. Risk assessments should be prepared, and appropriate safety measures provided.

12.6 Pavements

CBR value of 3% recommended for the River Terrace Deposits, which are not classified as being frost susceptible.

12.7 Building Materials

DS-1 and AC-1 in accordance with BS8500.

12.8 Further Action

It is considered prudent to confirm groundwater levels and trench stability parameters by means of excavating a series of trial pits across the site immediately prior to construction. This report should be submitted to relevant regulatory bodies and warranty providers in good time for approval.

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