from drawings provided by the consulting engineers (drawing ref; Construction Sequence, SK/001, by SOUP, dated 5 June 2017).

4.3 Sampling Strategy

The borehole and trial pit locations were specified by the consulting engineers and positioned on site by GEA whilst avoiding known buried services.

A number of samples recovered from the boreholes were submitted to a geotechnical laboratory for a programme of testing that included moisture content and Atterberg limit tests, and soluble sulphate and pH level analysis.

Three samples of the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. All three of these samples were also subject to asbestos screening analysis as a precautionary measure.

The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification. The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. Details of the MCERTs accreditation and test methods are included in the Appendix together with the analytical results.

5.0 GROUND CONDITIONS

The investigation has encountered a moderate thickness of made ground, overlying the London Clay, which has been encountered to the full depth investigated, of 15.00 m (68.20 m OD). Soils interpreted as Head Deposits locally overlie the London Clay.

5.1 Made Ground

Below the existing surfacings, the made ground generally comprised brown silty sand or brown mottled orange-brown clay with flint, rootlets, shell fragments, concrete, brick and ash, which extended to depths of between 0.82 m and 1.30 m (80.58 m OD and 81.90 m OD). A 0.20 m thickness of black silty clay with fine rootlets, decaying wood and fragments of red brick was also encountered at a depth of 0.52 m (82.88 m OD) in Borehole No 3.

With the exception of occasional fragments of extraneous material, no visual or olfactory evidence of significant contamination was observed within the made ground. However, three samples of the made ground have been subject to contamination testing as a precautionary measure and the results are presented in Section 5.5.

5.2 Head Deposits

Directly beneath the made ground in Borehole Nos 2 and 3, soils interpreted as Head Deposits were encountered and extended to depths of between 2.00 m and 2.70 m (81.40 m OD and 78.70 m OD). The material generally comprised soft orange-brown mottled grey silty clay or firm brown or brown mottled grey silty clay, with a reworked texture.

5.3 London Clay

Directly beneath the made ground in Borehole No 1 or Head Deposits in Borehole Nos 2 and 3, the London Clay was found to comprise firm becoming stiff fissured brown mottled grey silty clay with occasional fine selenite crystals, rare fine claystones and rare partings of silt and fine sand, extending to a depth of 11.0 m (72.20 m OD). Below this depth, stiff fissured grey silty clay with occasional carbonaceous material and occasional partings of light grey sand and silt was encountered and proved to a depth of 15.00 m (68.20 m OD). Live rootlets were observed to a maximum depth of 2.70 m (80.70 m OD) and decayed rootlets to a maximum depth of 4.70 m (78.50 m OD).

In Borehole No 3, grey silt was encountered between depths of 7.23 m and 7.28 m (76.17 m OD and 76.12 m OD), and, in Borehole No 2, a pocket of brown silt was encountered between depths of 6.30 m and 6.32 m (75.1 m OD and 75.08 m OD). These coincided with groundwater strikes encountered during drilling, resulting in the material being recovered as soft.

The fieldwork did not identify desiccation within any of the shallow soils sampled and subsequent laboratory testing has affirmed this.

The results of laboratory Atterberg Limit tests have indicated the clay to be of high volume change potential.

The results of undrained triaxial tests indicate shear strengths of medium strength becoming high strength.

These soils were found to be free from evidence of contamination.

5.4 Groundwater

Groundwater was encountered during drilling in Borehole Nos 2 and 3, at depths of 6.20 m and 7.20 m (75.20 m OD and 76.2 m OD) respectively. Monitoring of the standpipes installed in each of the boreholes has been carried out on five occasions over a period of roughly seven weeks since the date of the fieldwork. The results are shown in the table below.

Date	Borehole No	Depth to water (m)	Level of water (mOD)
10/05/2017	1	Not installed	
	2	3.63	77.77
	3	5.55	77.85
17/05/2017	1	3.75	79.45
	2	1.85	79.55
	3	2.64	80.76
01/06/2017	1	1.16	82.04
	2	Not monitored	
	3	3.28	80.12
14/06/2017	1	0.84	82.36
	2	1.73	79.67
	3	2.61	80.79
27/06/2017	1	1.14	82.06
	2	1.79	79.61

Date	Borehole No	Depth to water (m)	Level of water (mOD)
	3	2.27	81.13

Rising head tests were also carried out in each of the three boreholes at the time of the second monitoring visit to provide a preliminary assessment of the permeability of the nearby soils, and of potential groundwater inflows into the basement excavation. The results of the tests are appended. The testing indicated inflow rates of 7.58×10^{-6} m/s and 1.15×10^{-5} m/s in Borehole Nos 1 and 2 respectively, with no groundwater inflow recorded in Borehole No 3 over a period of 80 minutes. Despite the anticipated impermeable nature of the soils, it is inferred by the results that isolated and perched groundwater exists throughout the site, and that inflows and elevated permeability values probably arise from localised silt and sand partings within the London Clay. It is also possible that higher than anticipated readings represent reworked head material present on site.

5.5 Soil Contamination

The table below sets out the values measured within the three samples of made ground analysed; all concentrations are in mg/kg unless otherwise stated.

Determinant	BH2: 0.40 m	TP2: 0.40 m	BH3: 0.60 m
pH	9.3	8.5	8.0
Arsenic	21	11	30
Cadmium	<0.2	0.3	0.9
Chromium	32	21	30
Copper	39	31	76
Mercury	0.3	0.5	0.8
Nickel	20	16	26
Lead	**310**	97	**690**
Selenium	<1.0	<1.0	<1.0
Zinc	140	140	510
Total Cyanide	<1	<1	<1
Total Phenols	<1.0	<1.0	<1.0
Sulphide	1.4	7.2	**79**
Total PAH	12.4	17.2	37.9
Benzo(a)pyrene	1.1	1.7	3.5
Naphthalene	0.08	0.10	0.25
TPH (C8 - C10)	<0.1	<0.1	<0.1
TPH (C10 - C12)	<2.0	<2.0	8.2
TPH (C12 - C16)	<4.0	7.7	26
TPH (C16 - C21)	4.6	53	83

Determinant	BH2: 0.40 m	TP2: 0.40 m	BH3: 0.60 m
TPH (C21 - C35)	18	230	220
Total organic carbon %	1.6	0.9	3.6

5.5.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end, contaminants of concern are those that have values in excess of generic human health risk based guideline values which are either those of the CLEA[8] Soil Guideline Values where available, or are Generic Screening Values calculated using the CLEA UK Version 1.06[9] software assuming a residential end use with plant uptake, or are based on the DEFRA Category 4 Screening values[10]. The key generic assumptions for this end use are as follows;

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be young female children aged zero to six years old;
- that the exposure duration will be six years;
- that the building type equates to a two-storey small terraced house; and
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of home grown produce, consumption of soil adhering to home grown produce, skin contact with soils and dust, and inhalation of dust and vapours.

It is considered that these assumptions are considered acceptable for this generic assessment of this site, with the exception of that made on groundwater, which is considered to be a sensitive receptor at this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However, where concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or

8 *Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009* and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.
9 Contaminated Land Exposure Assessment (CLEA) Software Version 1.06 Environment Agency 2009
10 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

The contamination testing has revealed elevated concentrations of lead in Borehole Nos 2 and 3 in the made ground. In addition, asbestos screening in the laboratory under electron microscope identified asbestos in the form of Chrysotile in samples of the made ground taken from Trial Pit 2 and Borehole No 3 in the form of loose fibres and bitumen.

A single elevated concentration of sulphide was recorded within Borehole No 3. However, concentrations of sulphide are not considered a risk to human health and will therefore be discussed in Section 8.6 of this report, with regard to their impact on structures.

The significance of the contamination results is considered further in Part 2 of the report.

5.6 Existing Foundations

The trial pit findings are summarised in the table below and the trial pit records and associated site plan can be found in the appendix.

Trial Pit No	Structure	Foundation detail	Bearing Stratum
1	Western elevation of house	Concrete Base – extends to a depth of at least 0.60 m No lateral projection Pit abandoned due to drainage trench	Not known
2	Northern elevation of house Section A – A'	Concrete Base – extends to a depth of at least 0.90 m No lateral projection Pit abandoned due to numerous service pipes	Not known
	Northern elevation of house Section B – B'	Concrete Base – extends to a depth of at least 0.46 m No lateral projection Pit abandoned due to numerous service pipes	Not known
2A	Northern elevation of garage	Concrete Base 0.55 m No lateral projection	MADE GROUND
3	Eastern elevation of garage	Concrete Base 0.42 m No lateral projection	MADE GROUND
4	Northern elevation of pool house	Concrete Base – extends to a depth of at least 0.18 m No lateral projection Pit abandoned due to numerous service pipes	Not known
4A	Northern elevation of pool house	Concrete Base – extends to a depth of at least 0.10 m No lateral projection Pit abandoned due to numerous service pipes	Not known
5	Northern edge of paving slabs around pool house	Concrete Base 0.18 m Lateral projection 130 mm	TOPSOIL

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to foundation options and contamination issues.

6.0 INTRODUCTION

It is understood that it is proposed to construct a single storey extension along the northern elevation of the existing pool house building and to replace the existing garage with a two-storey structure with a single level basement, extending to a depth of roughly 2.80 m (80.84 m OD). Drawings provided by the consulting engineer, Elliott Wood, show loads for each part of the development of between 90 kN and 160 kN.

7.0 GROUND MODEL

The desk study has revealed that the site was developed with the existing house in the 1990s and prior to this was occupied by a square building in the centre of the site and a couple of outbuildings, presumably with a residential use. The site and immediate surrounding area have not had a potentially contaminative history and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- the investigation has encountered a moderate thickness of made ground overlying the London Clay, encountered to the full depth investigated of 15.00 m (68.20 m OD). The London Clay is locally overlain by Head Deposits;
- made ground extends to depths of between 0.82 m and 1.30 m (80.58 m OD and 81.90 m OD);
- directly beneath the made ground in Borehole Nos 2 and 3, Head Deposits were encountered and generally comprised soft orange-brown mottled grey silty clay or firm brown or brown mottled grey silty clay, with a reworked texture. These soils extended to depths of between 2.00 m and 2.70 m (81.40 m OD and 78.70 m OD);
- the London Clay initially comprises firm becoming stiff fissured medium strength becoming high strength brown mottled grey silty clay, to a depth of 11.0 m (72.20 m OD);
- the initial layer is underlain by stiff fissured high strength grey silty clay with occasional carbonaceous material and occasional partings of light grey sand and silt, which was proved to the maximum depth investigated of 15.00 m (68.20 m OD);
- live rootlets were observed to a maximum depth of 2.70 m (80.70 m OD) and decayed rootlets to a maximum depth of 4.70 m (78.50 m OD), although desiccated clay soils were not encountered;
- silt horizons were encountered in Borehole Nos 2 and 3 at depths of 7.23 m and 6.30 m respectively (76.17 m OD and 75.10 m OD);

- groundwater was encountered during drilling within silt horizons in Borehole Nos 2 and 3, at depths of 6.20 m and 7.20 m, (75.20 m OD and 76.2 m OD) respectively;
- monitoring of installed standpipes over a period of roughly seven weeks, has measured water in the pipes at depths of between 0.84 m and 5.55 m (82.36 m OD and 77.77 m OD);
- rising head test results undertaken within the standpipes indicate that there is localised perched groundwater within the Head Deposits and London Clay beneath the site.
- the results of the contamination testing have revealed elevated concentrations of lead and sulphide; and
- Chrysotile asbestos was detected in samples of made ground from Trial Pit 2 and Borehole No 3 in the form of loose fibres and / or bitumen fragments.

8.0 ADVICE AND RECOMMENDATIONS

It is understood that piles are proposed to support the new extensions, which would provide a suitable foundation solution.

Formation level for the proposed 2.80 m (80.84 m OD) deep basement and single storey pool house extension is likely to be within either the Head Deposits or London Clay.

Some form of groundwater control is likely to be locally required to construct the basement and inflows should be expected from within the sandier layers of the Head Deposits. However, given the results of the groundwater monitoring any inflows are anticipated to be localised.

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements.

All new foundations will need to bypass the made ground and any potentially desiccated clay soils and NHBC guidelines should be followed in this respect.

8.1 Basement Construction

It is understood that the proposed basement will extend to a depth of 2.80 m (80.84 m OD) below existing ground level. Formation level is therefore likely to be within the firm clay of the Head Deposits or London Clay.

The investigation has indicated that groundwater is likely to be encountered within the basement excavation. However, whilst monitoring should be continued, it is not possible to draw entirely meaningful conclusions from the measurements made in the standpipes, as the level of the water present within the installation is not indicative of the volume of water that may flow into the excavation. For example, a high level of water measured in a standpipe may not be significant if this represents only a small volume of water.

Inflows of perched water may be encountered from within the made ground, Head Deposits and London Clay, but the predominantly clayey nature of the shallow soils suggests that the rate of groundwater inflow is likely to be very slow and potential inflows are unlikely to be significant. Rising head tests carried out in each of the three boreholes reiterated this, indicating inflow rates of 7.58×10^{-6} m/s and 1.15×10^{-5} m/s in Borehole Nos 1 and 2 respectively, with no groundwater inflow recorded in Borehole 3 over a period of 80 minutes. These results demonstrate the localised and isolated nature of groundwater within the clay soils beneath the site.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by whether it is to be incorporated into the permanent works and have a load bearing function. The final choice will depend on the need to protect nearby structures from movements, the required overall stiffness of the support system, and the need to control groundwater movement through the wall in the temporary condition. In this respect, the stability of the existing and nearby buildings will be paramount.

It is understood that, following demolition of the existing garage, it is proposed to form the new basement in an open cut excavation. This should be feasible on the basis of the groundwater monitoring results to date, provided that localised slipping can be tolerated and that the excavations are managed to ensure that they do not have an adverse effect on the stability of the site. However, it would be prudent to undertake trial excavations to confirm the likely groundwater conditions. In any case, inflows could conceivably occur from perched water tables, particularly in the vicinity of existing foundations, but should be adequately dealt with through sump pumping. The contractor should have a contingency in place to deal with any groundwater inflows that are more significant than anticipated.

In situ retaining walls will then be constructed in front of the excavation and the area behind the walls backfilled on completion.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity and in this respect the timing of the provision of support to the wall will have an important effect on movements. The stability of the adjacent foundations will need to be ensured at all times and the retaining walls will need to be designed to support the loads from these foundations. These aspects are considered in more detail in the further ground movement assessment carried out as part of the report.

8.1.1 Basement Retaining Walls

The following parameters are suggested for the design of the permanent basement retaining walls.

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (Φ' – degrees)
Made ground	1700	Zero	27
Head Deposits / London Clay	1850	Zero	23
London Clay	1950	Zero	23

Monitoring of installed standpipes over a period of roughly seven weeks has measured water in the pipes at depths of between 0.84 m and 5.55 m (82.36 m OD and 77.77 m OD), but this represents isolated perched water. At this stage, it is therefore recommended that a design water level of two-thirds of the excavation depth is adopted, unless a fully effective drainage system can be ensured. Reference should be made to BS8102:2009[11] with regard to requirements for waterproofing and design with respect to groundwater pressures.

11 BS8102 (2009) *Code of practice for protection of below ground structures against water from the ground*

8.1.2 Basement Heave

The excavation will result in a net unloading of around 55 kN/m^2, which will result in elastic heave and long term swelling of the London Clay. The effects of the longer term swelling movement will to a certain extent be counteracted by the applied loads from the development, but further consideration is given to heave movements within the ground movement analysis in Part 3 of this report.

8.2 Spread Foundations

All new foundations should bypass the made ground, soft clay and any potentially desiccated clay soils. Groundwater may be encountered within the basement excavation as perched water.

Provided that a dry excavation can be maintained, spread foundations excavated to bear within the firm clay of the Head Deposits or London Clay may be designed to apply a net allowable bearing pressure of 120 kN/m^2 below the proposed basement. These values incorporate an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits. An allowable bearing pressure of 120 N/m^2 may be adopted for the single storey extension, at a minimum depth of 1.00 m.

The depth of new foundations is expected to be such that foundations will be placed below the depth of actual or potential desiccation, but this should be checked once the proposals have been finalised, with the survey drawing showing former and existing trees. Notwithstanding NHBC guidelines, all foundations should extend beyond the zone of any potential desiccation. In this respect, it would be prudent to have all foundation excavations inspected by a suitably experienced engineer. Due allowance should be made for future growth of existing / proposed trees. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines. High volume change potential soils should be assumed at the site. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

If for any reason spread foundations are not considered appropriate, piled foundations would provide a suitable alternative.

8.3 Piled Foundations

For the ground conditions at this site some form of bored pile is likely to be the most appropriate. A conventional rotary augered pile may be appropriate but consideration will need to be given to the possible instability and water ingress in the made ground and within any silty or sandy zones within the London Clay. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the SPT / depth graph in the appendix.

Stratum	Depths m	kN / m^2
Ultimate Skin Friction		
Made Ground	GL to 1.00 m	Ignore

Head Deposits / London Clay	1.00 m to 2.50 m	Increasing linearly from 14 to 25
London Clay	2.50 m to 15.00 m	Increasing linearly from 25 to 75
Ultimate End Bearing		
London Clay	1.00 m to 15.00 m	Increasing linearly from 252 to 1350

In the absence of pile tests, guidance from the London District Surveyors Association (LDSA)[12] suggests that a factor of safety of 2.6 should be applied to the above coefficients in the computation of safe theoretical working loads. On the basis of the above coefficients and a factor of safety of 2.6, the below table shows the estimated safe working loads for 300 mm and 450 mm piles at various depths below ground level.

Given the variation in site levels, safe working loads have been determined from two general levels. The upper driveway level is considered to indicate conditions at the level of the proposed basement excavation and two-storey structure, and the lower garden level is assumed to indicate conditions at the single-level pool house extension. The variation in ground level was estimated as 1.8 m based on plans provided.

Pile diameter mm	Depth Below Ground Level at upper driveway level (m)	Depth Below Ground Level at lower garden level (m)	Safe Working Load (kN)
300	6.0	4.2	60
	8.0	6.2	95
	10.0	-	135
	12.0	-	185
450	4.0	2.2	60
	6.0	4.2	105
	8.0	6.2	160

The above examples are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of an appropriate piling scheme and their attention should be drawn to potential groundwater inflows within the made ground and silt and sand partings within the London Clay.

Desiccation was not observed during fieldwork and this was later confirmed by laboratory testing. The pile design should however take into account of the possible effects of trees and be designed to take into account any potential loss of shaft friction due to clay shrinkage in the vicinity of trees, and the possibility of heave if any trees are removed.

The presence of obstructions within the made ground, such as cobbles of concrete, encountered in Trial Pit No 2, should be noted.

12 LDSA (2009) *Foundations No 1 – Guidance notes for the design of straight shafted bored piles in London Clay*. LDSA Publications

8.4 Ground and Basement Floor Slabs

Following the excavation of the basement, it is likely that the floor slab for the proposed basement will need to be suspended over a void to accommodate the anticipated heave, unless the slab can be suitably reinforced to cope with these movements.

Where no basement is proposed the floor slab will need to be suspended in view of the high volume change potential soils.

Further consideration is given to heave movements in Part 3 of this report.

8.5 Basement Raft Foundation

Depending on the loads and whether they can be relatively uniformly distributed, it may be feasible to adopt a basement raft foundation for the proposed development.

It is likely, as a result of the weight of the soil excavated to form the proposed basement, that a raft would be subject to a net unloading. However, further consideration will need to be given to possible movements if this foundation solution is to be considered once the loads have been finalised.

8.6 Shallow Excavations

On the basis of the borehole and trial pit findings it is considered likely that it will be feasible to form relatively shallow excavations for services extending through the made ground without the requirement for lateral support, although localised instabilities may occur. However, should deeper excavations be considered, or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Significant groundwater inflows into shallow excavations are not generally anticipated due to the clayey nature of the underlying soils, although seepages may be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations; such inflows should, however, be suitably controlled by sump pumping.

8.7 Effect of Sulphates

Chemical analyses carried out on selected samples of the made ground and underlying natural soils for water soluble sulphate have been compared with of Table C2 of BRE Special Digest 1: SD1 Third Edition (2005) in order to determine the sulphate class and are summarised in the table below. The assessment has been based on static groundwater conditions and the guidelines contained in the above digest should be followed in the design of foundation concrete.

Stratum	No of samples	pH	SO_4 (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	3	8.0 to 9.3	102 to 1750	DS-1 to DS-3	AC-1 to AC-3
Head Deposits / London Clay	3	7.70 to 7.80	590 to 3360	DS-2 to DS-4	AC-1s to AC-3s

The samples of the London Clay tested are likely to have contained selenite crystals, which probably contributed to the elevated concentrations, and it is therefore possible that the classification can be downgraded, although further testing may be advisable in this respect. The British Standard EN 206-1, which relates to the BRE Special Digest, contains a table that allows a relaxation of one DC class in some circumstances, assuming that some degree of chemical attack is acceptable. Table A.9 states that where a section thickness of greater than 450 mm is used and some surface chemical attack is acceptable, a relaxation of one step in CS-class may be applied. The advice within the guidance should be followed, and appropriate additional protective measures (APMs) incorporated, as in Table D4 from the BRE Special Digest.

8.8 Site Specific Risk Assessment

The desk study has indicated that the site has not had a contaminative history, having been occupied with the existing house in the 1990s and prior to this only by a square building in the centre of the site and a couple of outbuildings. The results of the contamination testing have revealed elevated concentrations of lead within samples from Borehole Nos 2 and 3. In addition to this, Chrysotile asbestos was detected in samples from Trial Pit 2 and Borehole 3 in the form of loose fibres and as bitumen.

The source of the metal contamination and asbestos is likely to be from extraneous fragments in the made ground. The lead is considered to be non-volatile or of a low volatility and does not thus present a significant vapour risk. In addition, the compounds are considered likely to be of low solubility and a plausible risk to groundwater has therefore not been identified.

End users will be effectively isolated from direct contact with the identified contaminants by the proposed buildings and areas of external hardstanding. No new soft landscaped areas are proposed.

Asbestos contamination was identified in two locations. Asbestos containing material may be present elsewhere within the made ground in areas that have not been investigated. Site workers should be made aware of this and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE[2] and CIRIA[3]. Any materials containing asbestos that could become airborne should, where possible, be kept damp and should be double bagged and labelled with asbestos warnings and deposited in covered locked skips.

A single elevated concentration of sulphide was also recorded within Borehole 3. However, concentrations of sulphide are not considered a risk to human health.

It is recommended that a watching brief be maintained during ground works by the contractor and any suspected contamination, especially in areas not covered by the investigation, should be brought to the attention of a geoenvironmental engineer.

8.8.1 Site Workers

Site workers should be made aware of the contamination, including the potential presence of asbestos, and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE and CIRIA and the requirements of the Local Authority Environmental Health Officer. A watching brief should also be maintained during the groundwork, and if suspicious soils are encountered then a suitably qualified engineer should inspect the soils and further testing should be carried out if required.

8.9 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[13] states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE[14] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £86.10 per tonne (about £155 per m^3) or at the lower rate of £2.70 per tonne (roughly £5 per m^3). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency it is considered likely that the soils encountered during this ground investigation, as represented by the three chemical analyses carried out, would be generally classified as follows;

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Comments
Made ground	Non-hazardous (17 05 04)	Yes	If it contains asbestos the soil may be classified as hazardous. Asbestos quantification tests are recommended at this stage, along with additional asbestos screening on made ground to be removed from the site.
Head Deposits / London Clay	Inert (17 05 04)	Should not be required but confirm with receiving landfill	-

Any soils containing asbestos may be classified as HAZARDOUS waste if the concentration is over 0.1 %. Asbestos quantification has not been undertaken to date, but it is recommended that additional sampling and testing is carried out to confirm the concentration to assist in the waste classification.

Under the requirements of the European Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[15] which states that in certain circumstances,

13 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition
14 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2
15 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

Part 3: GROUND MOVEMENT ANALYSIS

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

9.0 INTRODUCTION

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the efficiency of the various support systems employed during underpinning and the efficiency or stiffness of any support structures used.

An analysis has been carried out of the likely movements arising from the proposed excavation and the results of this analysis have been used to predict the effect of these movements on surrounding structures.

9.1 Construction Sequence

It is understood that it is proposed to construct a new basement structure, to a depth of approximately 2.8 m (80.84 m OD), beneath the footprint of the existing garage on the north-western part of the site, and that it will be formed in an open cut excavation. This should be feasible provided that localised slipping can be tolerated and that the excavations are managed to ensure that they do not have an adverse effect on the stability of the site. In situ retaining walls will then be constructed in front of the excavation and the area behind the walls backfilled on completion.

The following sequence of operations has been provided by Elliott Wood and has been used to enable analysis of the ground movements around the excavation both during and after construction. Full details of the proposed construction sequence are included within Elliott Woods Structural & Civil Engineering Planning Report (report ref 2170310, dated August 2017), which should be read in conjunction with this report.

In general, following demolition of the existing garage structure, the sequence of works for excavation and construction will comprise the following stages.

1. Excavate ground to basement level with all sides battered back.
2. Install piles at basement level.
3. Install heave protection, new RC slab suspended on piles & new RC Basement walls.
4. Install base to proposed French drains at new basement level.
5. Install drainage and construct basement slab and walls.
6. Install ground floor slab & backfill with hard core to form French drains.
7. Install superstructure on RC basement box.

Suitable angles for the battered sides of the excavation are expected to be approximately 60º for the London Clay. Care should be taken to protect the sides during periods of rainfall and any run-off from construction operations until the retaining walls have been installed. Movement of plant at the top of any open cut should be prevented and daily inspections of the cut faces should be carried out to check stability.

10.0 GROUND MOVEMENTS

An assessment of ground movements within and surrounding the excavations has been undertaken using the X-Disp and P-Disp computer programs licensed from the OASYS suite of geotechnical modelling software from Arup. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The analysis of potential ground movements, as a result of the proposed open-cut excavation and resulting unloading of the underlying soils, has been carried out using the Oasys P-Disp Version 19.2 – Build 12 software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation of soil behaviour at small strains.

The ground movements predicted by P-Disp have then been imported into the X-Disp program, which has then been used to undertake the subsequent damage assessment.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction approximately parallel with the orientation east-west, whilst the y-direction is approximately parallel with the orientation of north-south. Vertical movement is in the z-direction. Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while greater than 10 m wall lengths have been modelled as 2 m elements to reflect the greater stiffness of the longer walls.

The full outputs of all the analyses are included within the appendix.

10.1 Ground Movements – Resulting from the Excavation

10.1.1 Model Used

Unloading of the underlying soils, particularly the clay soils of the London Clay, will take place as a result of the excavation of the proposed basement and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and we have used a well-established method to provide our estimates. This relates values of E_u and E', the undrained and drained stiffness respectively, to values of undrained cohesion (Cu), as described by Padfield and Sharrock[16] and Butler[17] and more recently by O'Brien and Sharp[18]. Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young's modulus.

16 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils.* CIRIA Special Publication 27

17 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review.* Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond

18 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53

These values may be slightly conservative but are considered to provide a sensible approach for this stage in the design.

The excavation of an approximately 3.0 m thickness of soil for the proposed 2.8 m deep basement structure will result in a net unloading of around 55 kN/m^2, assuming a unit weight of 17 kN/m^3 for the made ground and an average of 19 kN/m^3 for the Head Deposits and London Clay.

The soil parameters used in this analysis are tabulated below.

Stratum	Depth Range (m)	Eu (MPa)	E'(MPa)
Made Ground	GL – 1.0	12.5	7.5
Head Deposits / London Clay	1.0 – 20.0	15.0 to 95.0	9.0 to 57.0

A rigid boundary for the analysis has been set within the London Clay at a depth of 20.0 m below ground level.

10.1.2 Results

The predicted movements are summarised in the table below; the results are presented below and in subsequent tables to the degree of accuracy required to allow predicted variations in ground movements around the structure(s) to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Location	Movement (mm)		
	Short-term Heave (Excavation Phase)	Long-term Heave (post construction)	Total Heave
Centre of excavations	5	8	13
Edge of excavations	3	5	8
At 5 m from edge of excavations	<1	<1	<1

The P-Disp analysis indicates that, by the time the basement construction is complete, up to 5 mm of heave is likely to have taken place at the centre of the proposed excavations, reducing to 2 mm at the edges. In the long term, following completion of the basement construction, a further 8 mm of heave is estimated as a result of long term swelling of the underlying London Clay.

If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect, potential heave pressures are typically taken to equate to around 40% of the total unloading pressure.

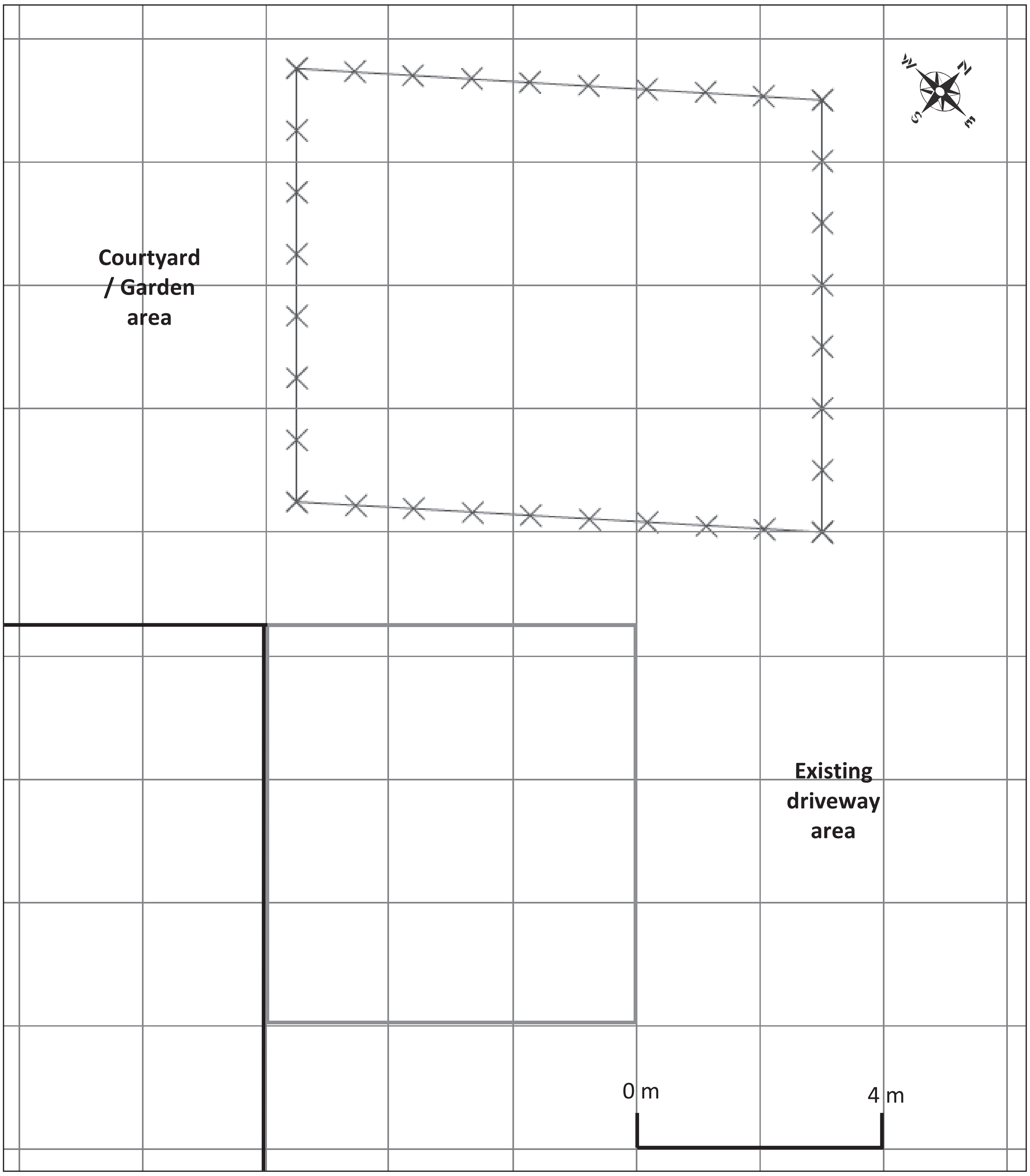
11.0 DAMAGE ASSESSMENT

In addition to the above assessment of the likely movements that will result from the proposed development, any neighbouring buildings within the zone of influence of the excavations are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of CIRIA report C760[19].

19 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design*

The sensitive structures outlined below have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. For clarity, these critical lines are shown on the plan below.

- An adjoining two-storey house, known as The Little House, located to the north of the proposed basement.



For the analyses, it has been assumed that the foundations of The Little House extend to a depth of approximately 0.5 m below existing ground level, as per the information contained within the sections provided by the consulting engineer, Elliott Wood.

All other nearby structures, such as the Fitzroy Farm Coach House, located just over 10 m from the new basement structure, have been confirmed as being at sufficient distances to not be affected by the proposed excavations and the resultant ground movements.

11.1 Damage to Neighbouring Structures

The combined movements calculated using the X-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table below, whilst the specific building damage results for all segments are included within the tabular output within the appendix.

Building Damage Assessment			
Sensitive Structure	Elevation	Max Tensile Strain (%)	Category of Damage*
The Little House (building footprint at ground level)	Southern Elevation (1)	0.04	Category 0 (Negligible)
	Eastern Elevation (2)	0.03	Category 0 (Negligible)
	Northern Elevation (3)	<0.01	Category 0 (Negligible)
	Western Elevation (4)	0.01	Category 0 (Negligible)

**From Table 2.5 of C580: Classification of visible damage to walls.*

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures would generally be Category 0 (negligible).

11.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of the adjacent properties and structures. The structures to be monitored during the construction stages should include the existing property and the neighbouring structure assessed above. Condition surveys of the above existing structures should be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage and it will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements of the adjacent structures exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.

12.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be generally ‘Negligible.

On this basis, the damage that has been predicted to occur as a result of the construction the proposed basement falls within the acceptable limits, although careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Part 4: BASEMENT IMPACT ASSESSMENT

13.0 BASEMENT IMPACT ASSESSMENT

The screening identified several potential impacts. The desk study and ground investigation information has been used below to review the potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

The table below summarises the previously identified potential impacts and the additional information that is now available from the site investigation in consideration of each impact.

Potential Impact	Site Investigation Conclusions
The nearest surface water feature is 38 m southeast of the site	Although the nearest water feature has been identified within close proximity of the site, it is inferred that groundwater encountered within the investigation correlates to perched groundwater within more granular material, and that the nature of the soil is unlikely to sustain any regional groundwater regime. It is therefore not considered that the proposed basement will impact any nearby water course and will not restrict any regional groundwater flow. It should be noted however that localised perched groundwater may affect the construction process and this should be managed appropriately.
The site exists within the Highgate Chain Catchment area	As the site is underlain directly by London Clay, any water moving to the nearby watercourse is likely to do so primarily as surface water flow, given the soils inability to support regional groundwater flow. Due to this, it is not considered that the proposals will have any significant effect on the current drainage regime, given the nature of the shallow clay soils.
The proposed extension will slightly increase the proportion of hard surfaced/paved areas to the north of the existing pool house	As the site is underlain directly by London Clay, any water moving to the nearby watercourse is likely to do so primarily as surface water flow, given the soils inability to support regional groundwater flow. Due to this, it is not considered that the proposals will have any significant effect on the current drainage regime, given the nature of the shallow clay soils.
London Clay is the shallowest stratum on the site	Despite trees existing across the site, the London Clay was not visually assessed as being desiccated, which was confirmed through the laboratory testing.

Potential Impact	Site Investigation Conclusions
The site is within an area likely to be affected by seasonal shrink-swell	The London Clay is the shallowest stratum at the site and laboratory testing has indicated a high volume change potential. Shrinkable clay is present within a depth that can be affected by tree roots, however, desiccation was not observed and in any case the foundations for the proposed basement would be expected to bypass any desiccated soils. Furthermore, the Ground Movement Assessment undertaken as Part 3 of this report considers the proposed basement excavation to fall within the acceptable damage limits.
The development is within 5 m of a pedestrian right of way	The investigation has not indicated any specific problems, such as weak or unstable ground, voids or a high water table that would make working within 5 m of public infrastructure particularly problematic at this site. In addition, although the site exists within 5 m of the highway, the proposed development is beyond this zone.
The proposed basement may increase the differential depth of foundations relative to neighbouring properties	The Ground Movement Assessment undertaken as Part 3 of this report considers the proposed basement excavation to fall within the acceptable damage limits.

The results of the site investigation and GMA have therefore been used below to review the remaining potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

London Clay is the Shallowest Stratum / Seasonal Shrink-Swell

The proposed basement will extend to a depth such that new foundations will be expected to bypass any desiccated soils.

Provided that foundations extend below the required depths in accordance with NHBC guidelines, and subject to inspection of foundation excavations in the normal way to ensure that there is not significant unexpectedly deep root growth, it is not considered that the occurrence of shrink-swell issues in the local area has any additional bearing on the proposed development.

The GMA analysis has concluded that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be generally 'Negligible'. And that the damage that has been predicted to occur as a result of the basement construction falls within the acceptable limits. Nevertheless, careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Perched Groundwater may exist

Despite the London Clay not being capable of supporting regional scale groundwater conditions, it may be that localised perched groundwater exists within granular pockets. Measures should be taken to mitigate this and any water bodies encountered during construction should be monitored and managed throughout and after the development is completed.

13.1 BIA Conclusion

A Basement Impact Assessment has been carried out following the information and guidance published by the London Borough of Camden.

Information from a Site Investigation and Ground Movement Assessment have been used to assess potential impacts identified by the screening process.

It is concluded that the proposed development is unlikely to result in any specific land or slope stability issues, groundwater or surface water issues.

14.0 NON-TECHNICAL SUMMARY

This section provides a short summary of the evidence acquired and used to form the conclusions made within the BIA.

14.1 Screening

The following table provides the evidence used to answer the surface water flow and flooding screening questions.

Question	Evidence
1. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine the changes in the proportions.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	A site walkover and review of plans.
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	
6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature?	Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 and the North London Strategic Flood Risk Assessment dated 2008.

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Question	Evidence
1a. Is the site located directly above an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
1b. Will the proposed basement extend beneath the water table surface?	Observations during the site investigations.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	Historical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine

Question	Evidence
	the changes in the proportions.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	The details of the proposed development do not indicate the use of soakaway drainage.

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Question	Evidence
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Site survey drawing and Figures 16 and 17 of the Arup report and confirmed during a site walkover
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	The details of the proposed development provided do not include the re-profiling of the site to create new slopes
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report and confirmed during a site walkover
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	
5. Is the London Clay the shallowest strata at the site?	Geological maps and Figures 3, 5 and 8 of the Arup report
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	A site walkover confirmed that there are trees on site. An arboriculturist should be consulted if any trees are to be removed from the site.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Knowledge on the ground conditions of the area was used to make an assessment of this, in addition to a visual inspection of the buildings carried out during the site walkover
8. Is the site within 100 m of a watercourse or potential spring line?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report
9. Is the site within an area of previously worked ground?	Geological maps and Figures 3, 5 and 8 of the Arup report
10. Is the site within an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
11. Is the site within 50 m of Hampstead Heath ponds?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report.
12. Is the site within 5 m of a highway or pedestrian right of way?	Site plans and the site walkover.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Camden planning portal and the site walkover confirmed the position of the proposed basement relative to the neighbouring properties.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Maps and plans of infrastructure tunnels were reviewed.

14.2 Scoping and Site Investigation

The questions in the screening stage that required further assessment, were taken forward to a scoping stage and the potential impacts discussed in Section 4.0 of this report, with reference to the possible impacts outlined in the Arup report.

A ground investigation was carried out, which has allowed an assessment of the potential impacts of the basement development on the various receptors identified from the screening and scoping stages. Principally the investigation aimed to establish the ground conditions, including the groundwater level, and the engineering properties of the underlying soils, to enable suitable design of the basement development and the configuration of existing party wall foundations. The findings of the investigation are discussed in Section 5.0 of this report and summarised in both Section 7.0 and the Executive Summary.

14.3 Impact Assessment

Section 13.0 of this report summarises whether or not, on the basis of the findings of the investigation, the potential impacts still need to be given consideration and identifies ongoing risks that will require suitable engineering mitigation. Section 8.0 of this report also provides recommendations for the design of the proposed development.

A Ground Movement Analysis including a building damage assessment has been completed and the results are presented in Part 3 of this report.

15.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work is considered to be required.

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

As discussed throughout the report, groundwater is likely to be encountered during the basement excavation although groundwater monitoring should be continued and trial excavations should be considered to assess the extent of inflows to be expected within the proposed basement excavations.

Asbestos was identified in two samples of made ground tested. It is recommended that asbestos quantification tests are undertaken on the positive asbestos results in order to assist in waste disposal costs. With this exception, the investigation has not identified the presence of any other significant contamination, and as the made ground will be removed from this site through the excavation of the proposed basement, remedial measures should not be required, other than where areas of soft landscaping are to be formed. However, as with any site there is a potential for further areas of contamination to be present within the made ground beneath parts of the site not covered by the investigation it is recommended that a watching brief is maintained during any groundworks for the proposed new foundations and that if any suspicious soils are encountered that they are inspected by a geoenvironmental engineer and further assessment may be required.

As only a limited number of samples have been tested, it would be prudent to carry out contamination testing on additional samples of made ground / topsoil recovered from the areas of the site that are to remain as soft landscaped gardens, in order to ensure the absence of any significant contamination.

The analysis has concluded that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be generally ‘Negligible.

The GMA analysis has concluded that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be generally 'Negligible'. And that the damage that has been predicted to occur as a result of the basement construction falls within the acceptable limits. Nevertheless, careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

These items should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

APPENDIX

Borehole Records

Trial Pit Records

Results of Rising Head Tests

Geotechnical Laboratory Test Results

Chemical Analyses (Soil)

Generic Risk Based Screening Values

Envirocheck Report Summary

Site Plan Over Arup Figure 16

Historical Maps

Preliminary UXO Risk Assessment

P-DISP ANALYSIS

Short Term Movement

Total Movement

BUILDING DAMAGE ASSESSMENT (X-DISP)

Tabular Output of Results

Site Plan

Geotechnical & Environmental Associates (GEA)

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
Wallace House, Fitzroy Park, London N6 6HT	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150 mm to 1.5 m	83.20	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
	On driveway	11/05/2017	Elliott Wood	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
				Tarmac (macadar)	83.05	(0.15) 0.15	MADE GROUND (macadam, 70 mm thick, overlying concrete)
0.40	D1			roadstone & concrete			MADE GROUND (greyish brown silty sandy clay with flint, coal, ash, brick and concrete)
						(1.15)	
0.80	D2						
1.20-1.65 1.20-1.65	SPT(C) N=6 B3	1.20	DRY	1,0/1,2,1,2	81.90	1.30	Firm becoming stiff fissured medium strength becoming high strength brown mottled orange-brown silty sandy CLAY with frequent pale blueish grey partings, occasional selenite, mica and carbonaceous material and dark red staining towards the base. Pockets of orange sand and selenite common around 2.60 m and 4.50 m. Rootlets noted to a depth of 4.70 m
1.80	D4			fill, brick & concrete, rubble, ashes & brown CLAY			
2.00 2.00-2.45	D5 SPT N=10	1.50	DRY	1,2/2,2,3,3			
2.60	D6						
3.00-3.45	U7						
3.50	D8						Medium subrounded claystone fragment observed at 3.50 m
3.80	D9						
4.00-4.45 4.00	SPT N=10 D10	1.50	DRY	1,2/2,2,3,3		(5.40)	
4.70	D11						
5.00-5.45	U12						
5.50	D13						
6.00-6.45 6.00	SPT N=16 D14	1.50	DRY	2,2/3,4,4,5			
					76.50	6.70	Stiff fissured high strength brownish grey silty sandy CLAY with carbonaceous material, mica, rare off-white shell fragments and occasional pale grey fine sand and silt partings
6.90	D15						
7.50-7.95	U16			Firm, stiff brown CLAY with crystals & occasional grey workings and roots noticed to 5.0m			
8.00	D17						
						(4.30)	
9.00-9.45 9.00	SPT N=19 D18	1.50	DRY	3,4/4,5,5,5			

Remarks
Hand-dug starter pit to a depth of 1.2 m (75 minutes)
Groundwater not encountered during drilling
Standpipe installed to a depth of 6.00 m
Groundwater has been measured at depths of 3.75 m on 17/05/2017, 1.26 m on 01/06/2017, 0.84 m on 14/06/2017 and 1.14 m on 27/06/2017

Scale (approx)	Logged By
1:50	CP/HD

Figure No. J17111.BH1

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Borehole Number
Wallace House, Fitzroy Park, London N6 6HT	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150 mm to 1.5 m	83.20	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
	On driveway	11/05/2017	Elliott Wood	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50	D19								
11.00	D20				72.20	11.00	Stiff fissured high strength grey silty CLAY with occasional black carbonaceous material/staining and frequent mica		
12.00-12.45 12.00	SPT N=26 D21	1.50	DRY	4,5/6,6,7,7					
						(4.00)			
13.50-13.95	U22								
14.00	D23								
14.50-14.95 14.50	SPT N=29 D24	1.50	DRY	5,6/6,7,8,8					
					68.20	15.00	Complete at 15.00m		
				Stiff grey occasionally sility CLAY					

Remarks
Hand-dug starter pit to a depth of 1.2 m (75 minutes)
Groundwater not encountered during drilling
Standpipe installed to a depth of 6.00 m
Groundwater has been measured at depths of 3.75 m on 17/05/2017, 1.26 m on 01/06/2017, 0.84 m on 14/06/2017 and 1.14 m on 27/06/2017

Scale (approx)	Logged By
1:50	CP/HD

Figure No. J17111.BH1

GEA Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Number
Wallace House, Fitzroy Park, London N6 6HT	**BH2**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler	118mm to 1.00m	81.40	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
	Southwest of pool house	09/05/2017	Elliott Wood	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Water
					(0.82)	MADE GROUND (brown silty sand with rare flint gravel, shell fragments and cobbles of concrete, brick fragments, rootlets and rare ash. Hessian bag encountered at a depth of 0.60 m)	
0.40	D1						
				80.58	0.82	Soft orange-brown mottled grey silty CLAY with dead roots and decayed rootlets - reworked texture	
					(0.33)		
				80.25	1.15	Firm brown mottled grey silty CLAY with occasional fine selenite crystals, rare fine claystones and rare partings of orange-brown fine sand and silt and rootlets. Rootlets noted to a depth of 2.40 m - reworked texture	
1.20	D2		(PP) 0.75				
1.20-1.65	SPT N=8	DRY	1,1/2,2,2,2				
1.50	D3		(PP) 1.25			...with occasional coarse selenite crystals	
1.80	D4		(PP) 2.25		(1.55)		
2.00-2.45	SPT N=13	DRY	2,1/3,3,3,4				
2.10	D5		(PP) 2.25				
2.40	D6		(PP) 2.50			...becoming siltier	
				78.70	2.70	Firm brown mottled grey silty fissured CLAY with occasional fine selenite crystals, rare fine claystones and rare partings of orange-brown fine sand and silt and decayed rootlets	
2.70	D7		(PP) 2.00		(0.70)		
3.00-3.45	SPT N=11	DRY	1,2/2,3,3,3			...pocket of yellow fine sand and silt at 3.10 m	
3.10	D8		(PP) 1.50				
3.40	D9		(PP) 2.50	78.00	3.40	Stiff brown mottled grey silty fissured CLAY with occasional selenite crystals and rare partings of orange-brown fine sand and silt. Decayed rootlets noted to a depth of 4.00 m	
3.70	D10		(PP) 3.00		(0.60)		
				77.40	4.00	Stiff brown silty fissured CLAY with selenite crystals and occasional partings of orange-brown fine sand and silt and specklings of mica. Between 6.30 m and 6.32 m, band of soft brown silt	
4.00	D11		(PP) 3.50			...pocket of bluish green and yellow fine sand and silt at 4.00 m	
4.00-4.45	SPT N=18	DRY	2,3/4,4,4,6				
4.30	D12		(PP) 2.50				
4.60	D13		(PP) 4.00				
4.90	D14		(PP) 3.00				
5.00-5.45	SPT N=19	DRY	2,3/4,5,5,5		(2.40)		
5.20	D15						
5.50	D16						
5.80	D17						
6.00-6.45	SPT N=18	DRY	2,3/4,4,5,5				
6.10	D18		Water strike(1) at 6.20m.				∇1
6.40	D19			75.00	6.40	Stiff grey silty fissured CLAY with occasional partings of light grey fine sand and silt	
6.70	D20				(1.05)		
7.00-7.45	SPT N=20	DRY	2,3/4,5,5,6				
7.00	D21						
				73.95	7.45	Complete at 7.45m	

Remarks
Standpipe installed to a depth of 5.00 m - response zone from 1.00 m to 5.00 m
PP denotes pocket penetrometer reading
Groundwater has been measured at depths of 3.63 m on 10/05/2017, 1.85 m on 17/05/2017, 1.73 m on 14/06/2017 and 1.79 m on 27/06/2017

Scale (approx)	Logged By
1:50	HD

Figure No. J17111.BH2

GEA Geotechnical & Environmental Associates	Widbury Barn, Widbury Hill, Ware, Herts, SG12 7QE	Site: Wallace House, Fitzroy Park, London N6 6HT	Number: **BH3**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler	118mm to 1.00m	83.40	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
	North of existing garage	09/05/2017	Elliott Wood	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.30	D1		
0.60	D2		
0.80	D3		
1.00-1.45	SPT N=10	DRY	1,2/2,3,2,3
1.30	D4		(PP) 1.50
1.60	D5		(PP) 1.50
1.90	D6		(PP) 2.00
2.00-2.45	SPT N=12	DRY	2,2/2,3,3,4
2.20	D7		(PP) 1.50
2.50	D8		(PP) 2.25
2.80	D9		(PP) 2.50
3.00-3.45	SPT N=13	DRY	2,3/2,3,4,4
3.10	D10		(PP) 2.00
3.40	D11		(PP) 2.50
3.70	D12		(PP) 2.50
4.00	D13		(PP) 1.75
4.00-4.45	SPT N=12	DRY	2,1/2,3,3,4
4.30	D14		(PP) 2.25
4.60	D15		(PP) 2.75
4.90	D16		(PP) 3.25
5.00-5.45	SPT N=18	DRY	2,2/4,4,4,6
5.00	D17		
5.50	D18		
6.00-6.45	SPT N=20	DRY	3,3/4,5,5,6
6.00	D19		
6.50	D20		
7.00-7.45	SPT N=23	DRY	2,3/5,5,6,7
7.00	D21		Water strike(1) at 7.20m.

Level (mOD)	Depth (m) (Thickness)	Description
83.32	0.08 (0.37)	MADE GROUND (paving slab, 50 mm thick, over sand sub-base)
82.95	0.45	MADE GROUND (brown silty sand with cobbles of concrete and brick)
82.83	0.57 (0.20)	MADE GROUND (brown mottled orange-brown clay with fine rootlets)
82.63	0.77 (0.13)	MADE GROUND (black silty clay with fine rootlets, decaying wood and fragments of red brick)
82.50	0.90	MADE GROUND (greyish brown silty clay with rare flint gravel and fragments of brick and ash)
82.40	1.00 (1.00)	MADE GROUND (orange-brown mottled light grey silty clay with fragments of brick)
81.40	2.00 (0.80)	Firm brown mottled grey silty CLAY with rootlets - reworked texture
		Firm brown mottled grey silty fissured CLAY with occasional partings of orange-brown fine sand and silt and selenite crystals. Live rootlets noted to 2.7 m
80.60	2.80 (2.40)	Stiff brown mottled grey silty fissured CLAY with occasional partinngs of orange-brown fine sand and silt and selenite crystals. Dead rootlets noted to 2.90 m
78.20	5.20 (0.50)	Stiff brown silty fissured CLAY with partings of orange-brown fine sand and silt
77.70	5.70 (1.75)	Stiff grey silty fissured CLAY with abundant partings of dark grey fine sand and silt. Soft grey silt encountered between 7.23 m and 7.28 m
75.95	7.45	Complete at 7.45m

Water: ∇1

Remarks
Standpipe installed to a depth of 6.00 m - response zone from 1.00 m to 6.00 m
PP denotes pocket penetrometer reading
Groundwater has been measured at depths of 5.55 m on 10/05/2017, 2.64 m on 17/05/2017, 3.28 m on 01/06/2017 and 2.61 m on 14/06/2017 and 2.27 m on 27/06/2017

Scale (approx)	Logged By
1:50	HD

Figure No. J17111.BH3

Geotechnical & Environmental Associates
Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Standard Penetration Test Results

Site : 86a Chiltern Street, London W1U 5AL

Client : Starbright W1 Limited

Engineer : Price & Myers

Job Number J17126

Sheet 1 / 1

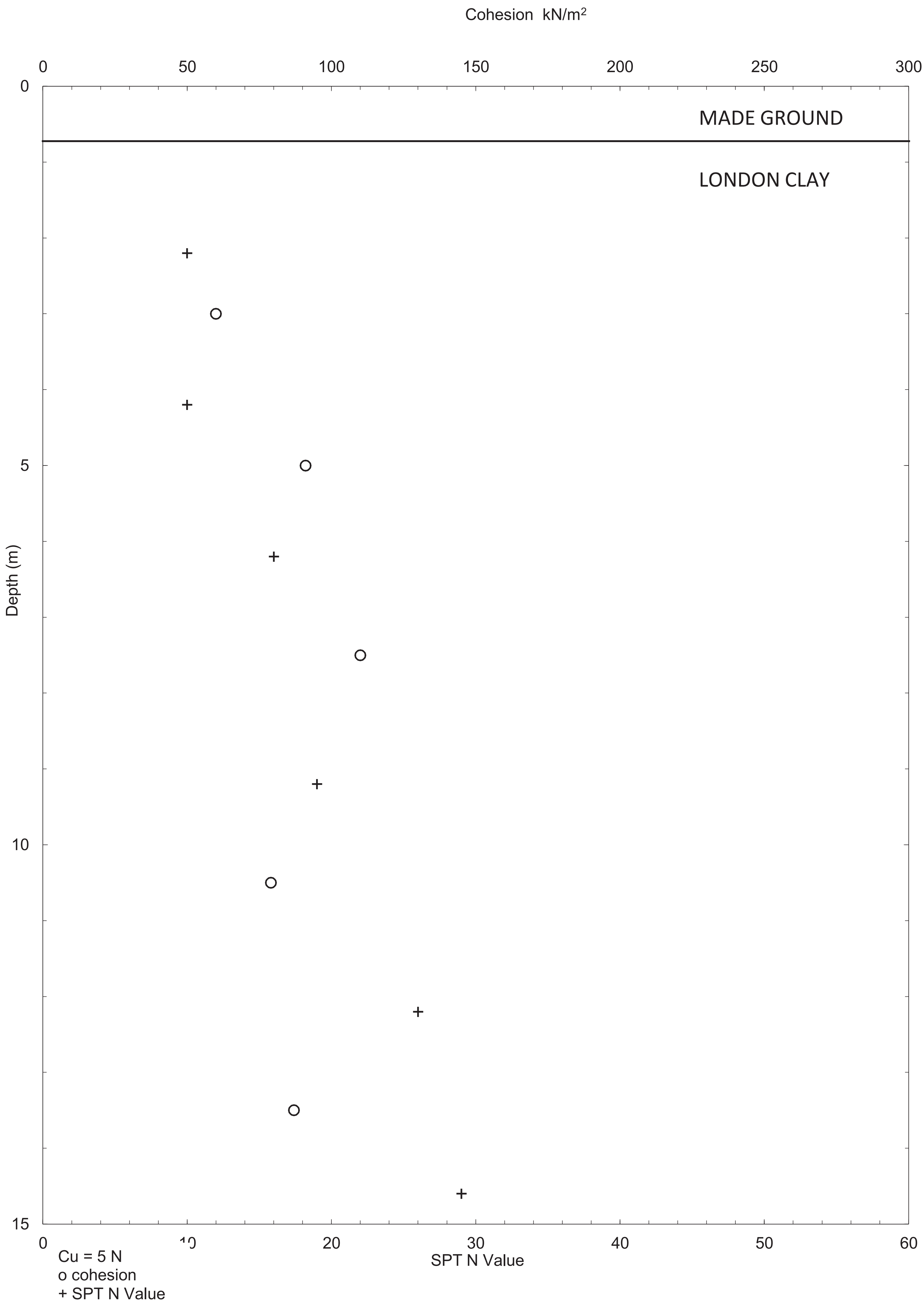
Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
BH1	1.20	1.35	1.65	CPT	2	5	3	1	5	3	N=12	
BH1	2.00	2.15	2.45	CPT	2	1	3	2	3	2	N=10	
BH1	3.00	3.15	3.45	CPT	1	3	1	2	2	4	N=9	
BH1	4.00	4.15	4.45	CPT	5	4	5	6	8	11	N=30	
BH1	5.00	5.15	5.45	CPT	6	6	8	8	7	7	N=30	
BH1	6.50	6.65	6.95	CPT	6	7	6	6	7	7	N=26	
BH1	8.00	8.15	8.45	CPT	5	4	4	3	5	6	N=18	
BH1	11.00	11.15	11.45	SPT	3	5	6	6	6	7	N=25	
BH1	14.00	14.15	14.45	CPT	10	10	7	6	7	7	N=27	
BH1	17.00	17.15	17.45	SPT	3	6	7	8	8	9	N=32	
BH1	19.55	19.70	20.00	SPT	6	7	7	8	8	9	N=32	

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

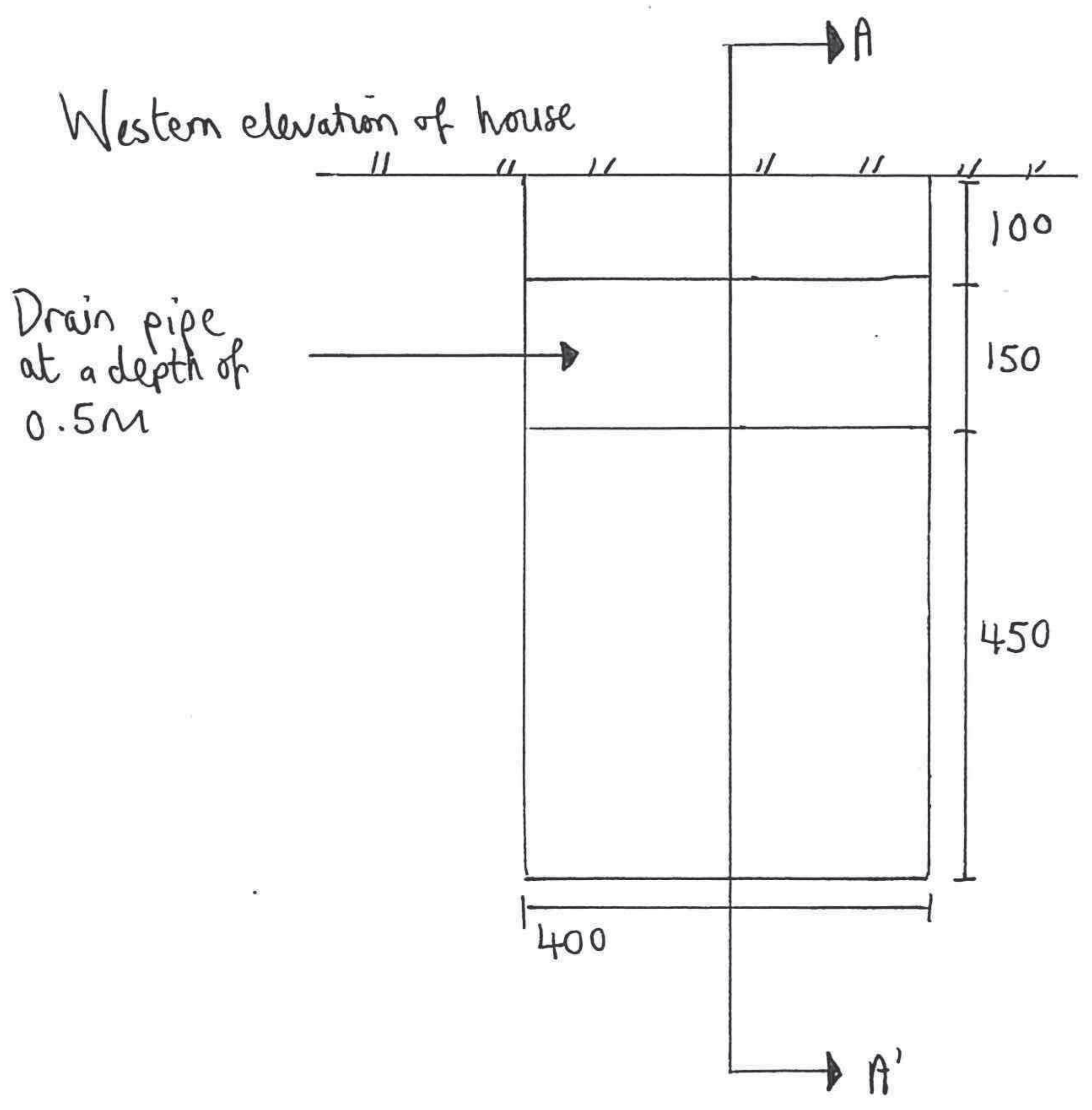
SPT & Cohesion / Depth Graph

Site	Wallace House, Fitzroy Park, London N6 6HT	**Job Number**	J17111
Client	Derrick & Claire Dale	**Sheet**	1/1
Engineer	Elliott Wood		



Geotechnical & Environmental Associates Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			Site Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number 1
Excavation Method Manual	**Dimensions** 400 x 700 x 700	**Ground Level (mOD)** 81.47	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

PLAN



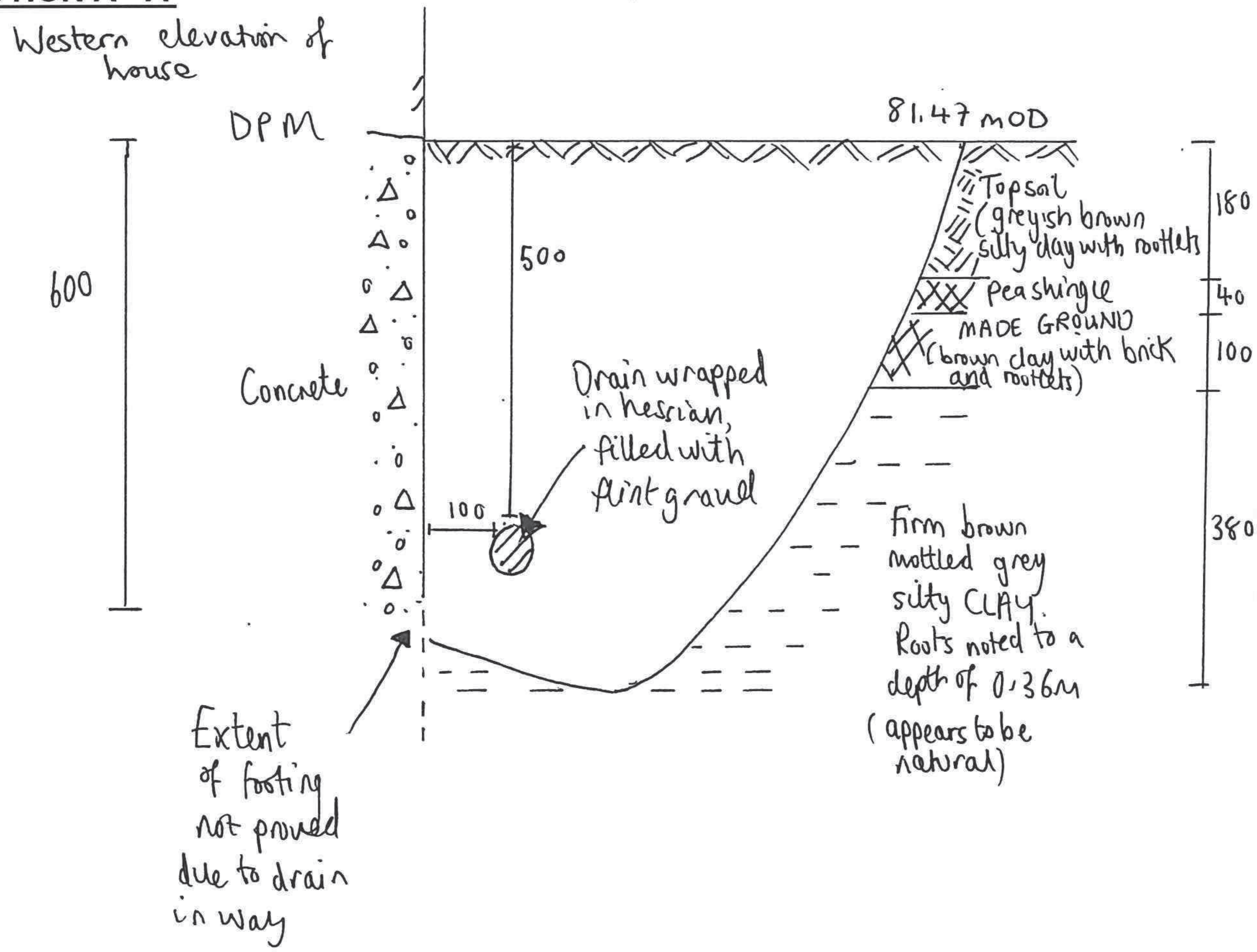
Drain wrapped in hessian, filled with coarse flint gravel which keeps collapsing

Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD

Geotechnical & Environmental Associates (GEA)	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number 1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual	400 x 700 x 700	81.47	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
		10/05/2017	Elliott Wood	

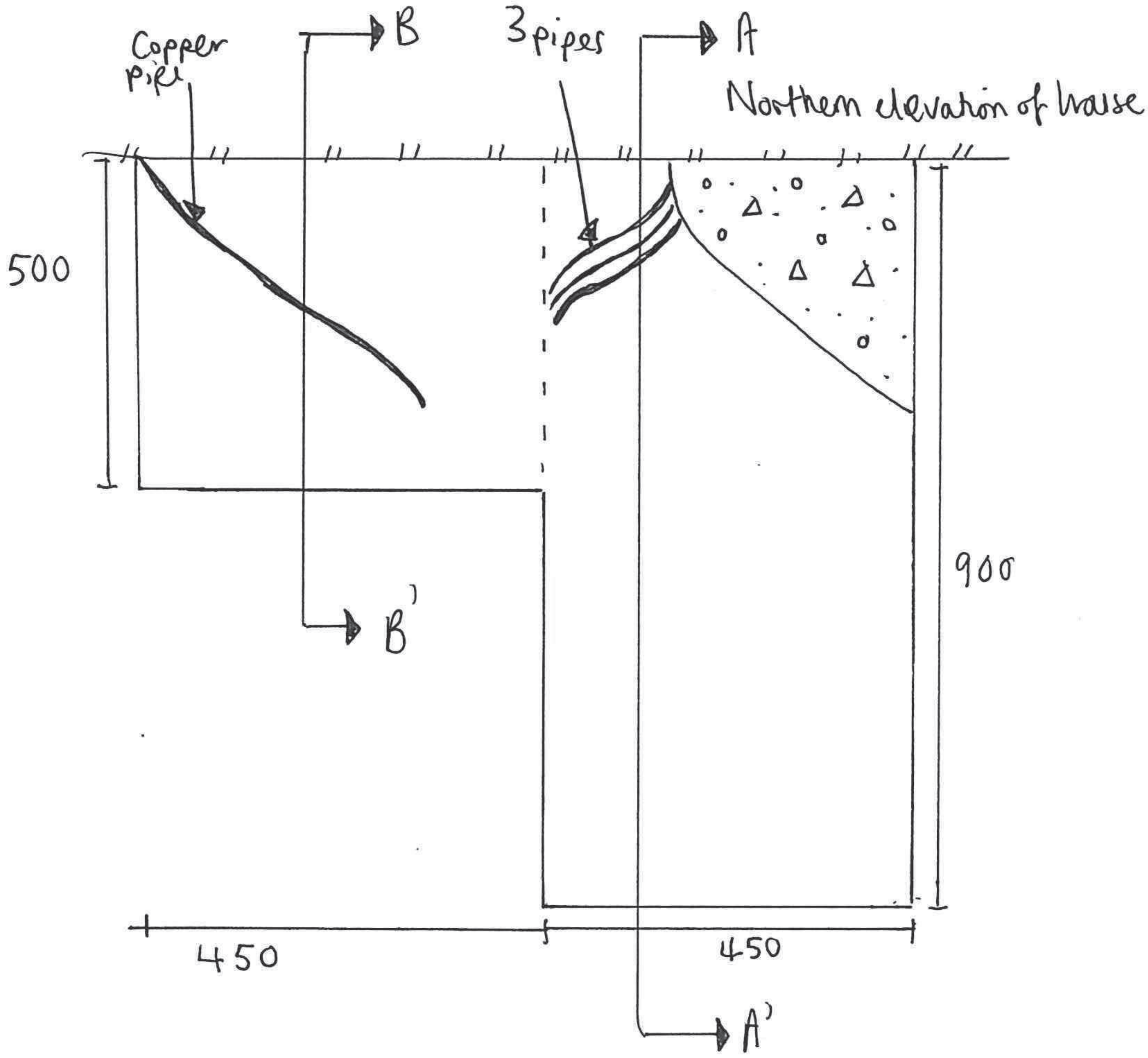
SECTION A - A'



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** Wallace House, Fitzroy Park, London, N6 6HT	**Trial Pit Number** 2
Excavation Method Manual	**Dimensions** 900 x 1000 x 920	**Ground Level (mOD)** 83.195	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

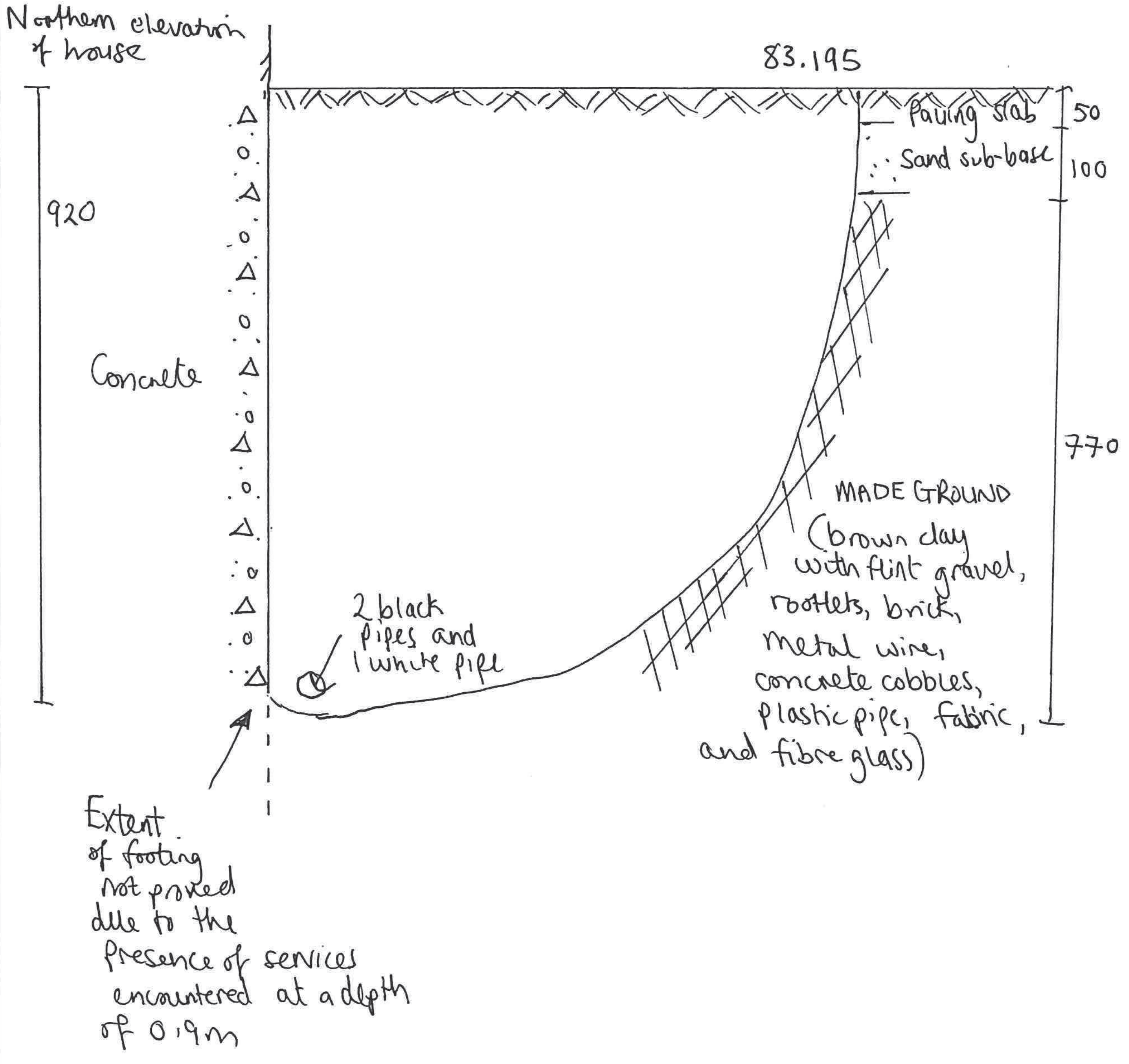
PLAN



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD

GEA Geotechnical & Environmental Associates		Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** Wallace House, Fitzroy Park, London, N6 6HT	**Trial Pit Number** 2
Excavation Method Manual	**Dimensions** 900 x 1000 x 920	**Ground Level (mOD)** 83.195	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

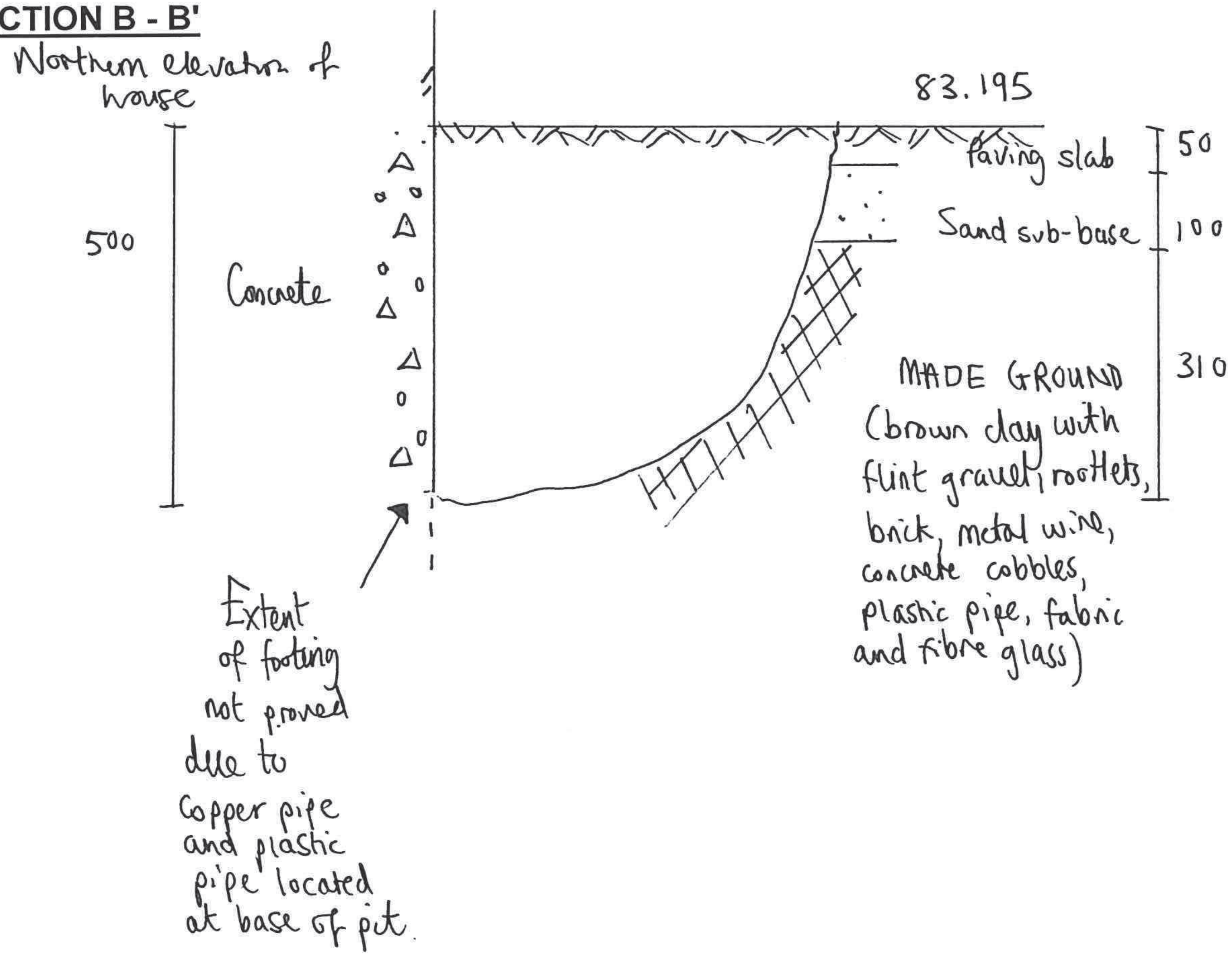
SECTION A - A'



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD

GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			Site Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number 2
Excavation Method Manual	Dimensions 900 x 1000 x 920	Ground Level (mOD) 83.195	Client Derrick and Claire Dale	Job Number J17111
	Location	Dates 10/05/2017	Engineer Elliott Wood	Sheet

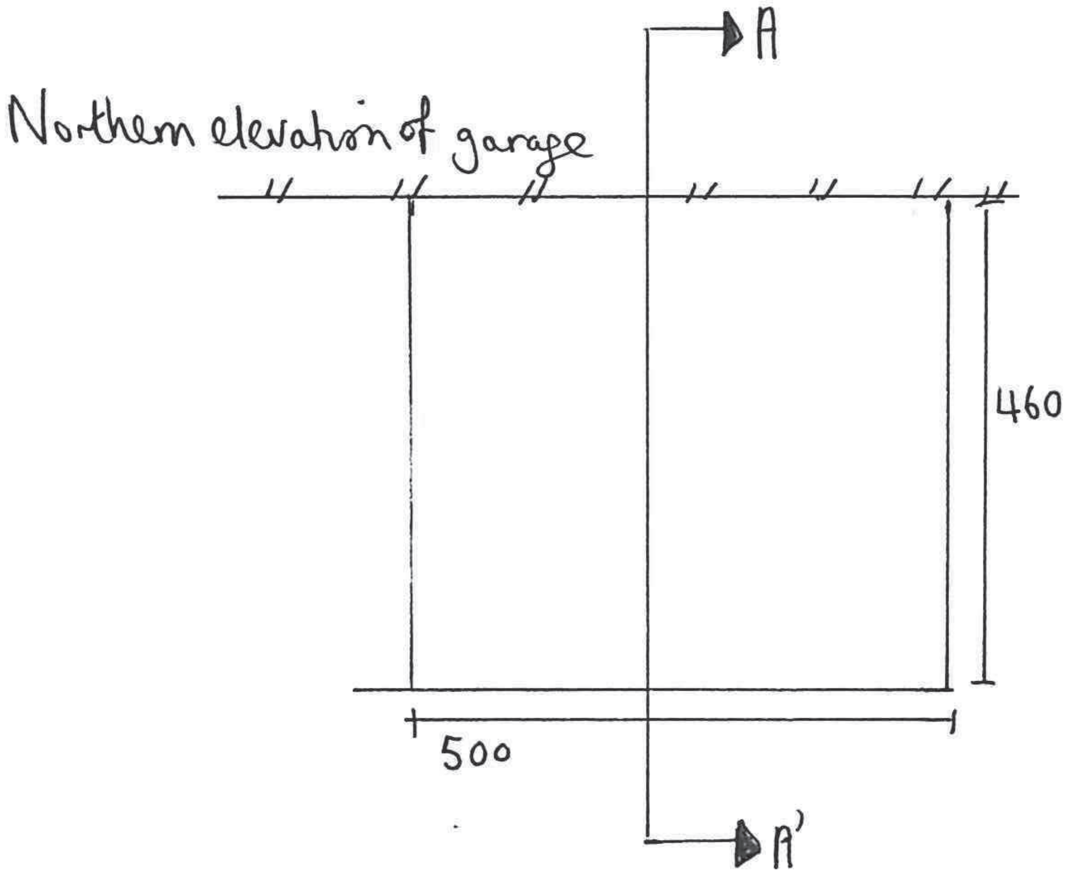
SECTION B - B'



Remarks:	Scale: 1:10
All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Logged by: HD

Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site: Wallace House, Fitzroy Park, London, N6 6HT		Trial Pit Number: 2A
Excavation Method Manual	**Dimensions** 500 x 460 x 690	**Ground Level (mOD)** 83.195	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

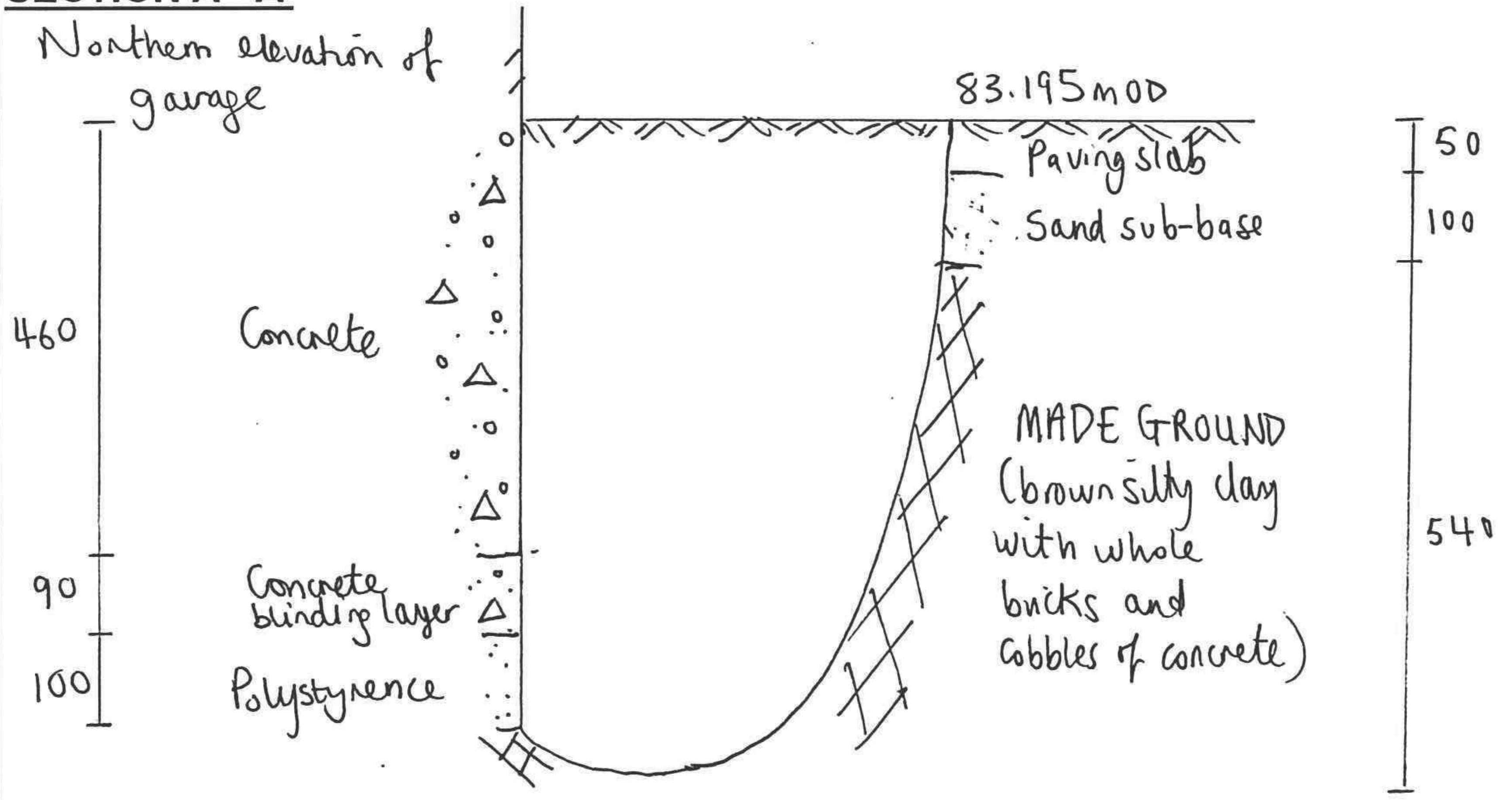
PLAN



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD

GEA Geotechnical & Environmental Associates	Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE	Site: Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number: 2A
Excavation Method: Manual	Dimensions: 500 x 460 x 690	Ground Level (mOD): 83.195	Client: Derrick and Claire Dale	Job Number: J17111
	Location:	Dates: 10/05/2017	Engineer: Elliott Wood	Sheet:

SECTION A - A'

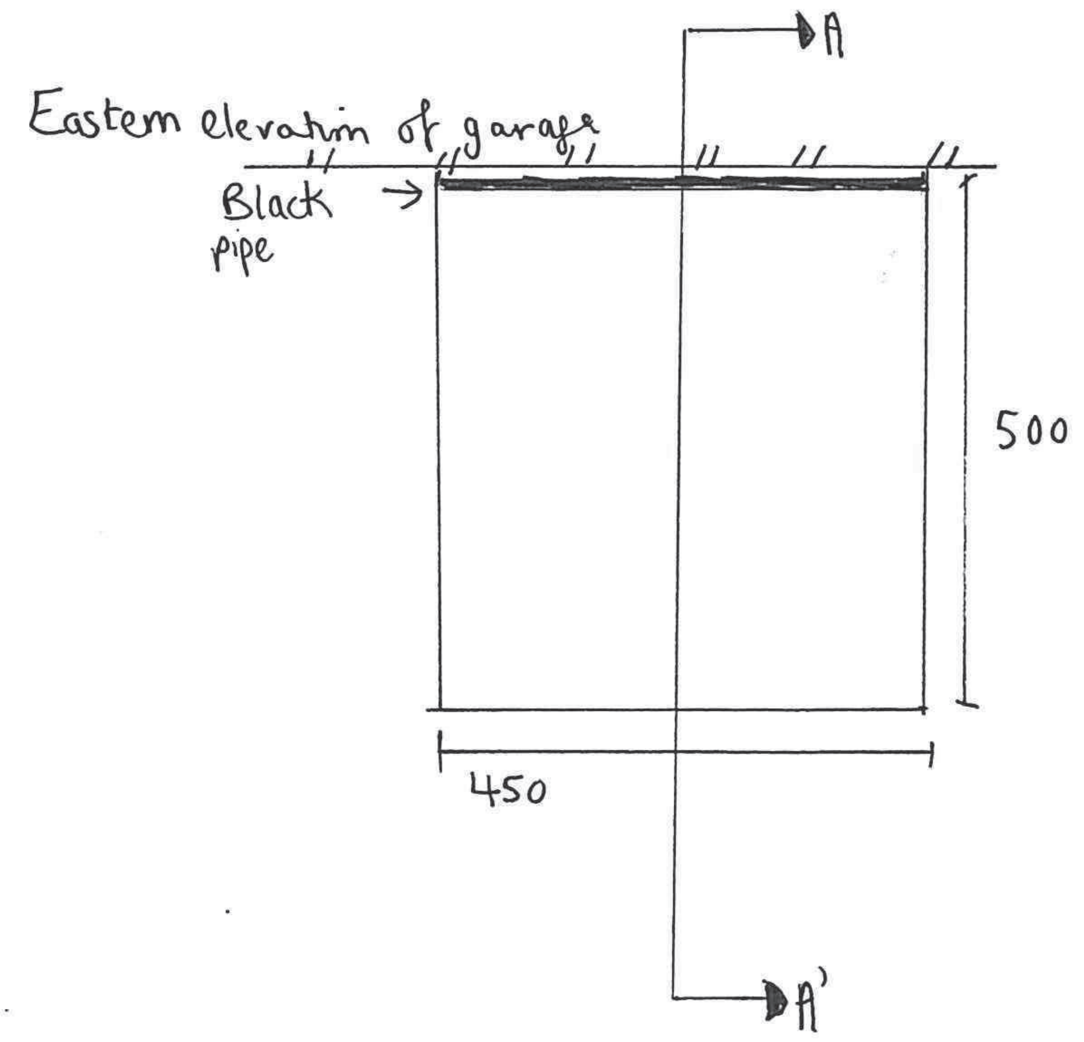


Remarks:	Scale: 1:10
All dimensions in millimetres	
Sides of trial pit remained stable during excavation	Logged by: HD
Groundwater: Not encountered	

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** Wallace House, Fitzroy Park, London, N6 6HT	**Trial Pit Number** 3

Excavation Method	**Dimensions**	**Ground Level (mOD)**	**Client**	**Job Number**
Manual	500 x 450 x 1000	83.415	Derrick and Claire Dale	J17111
	Location	**Dates**	**Engineer**	**Sheet**
		10/05/2017	Elliott Wood	

PLAN



Remarks:

All dimensions in millimetres

Sides of trial pit remained stable during excavation

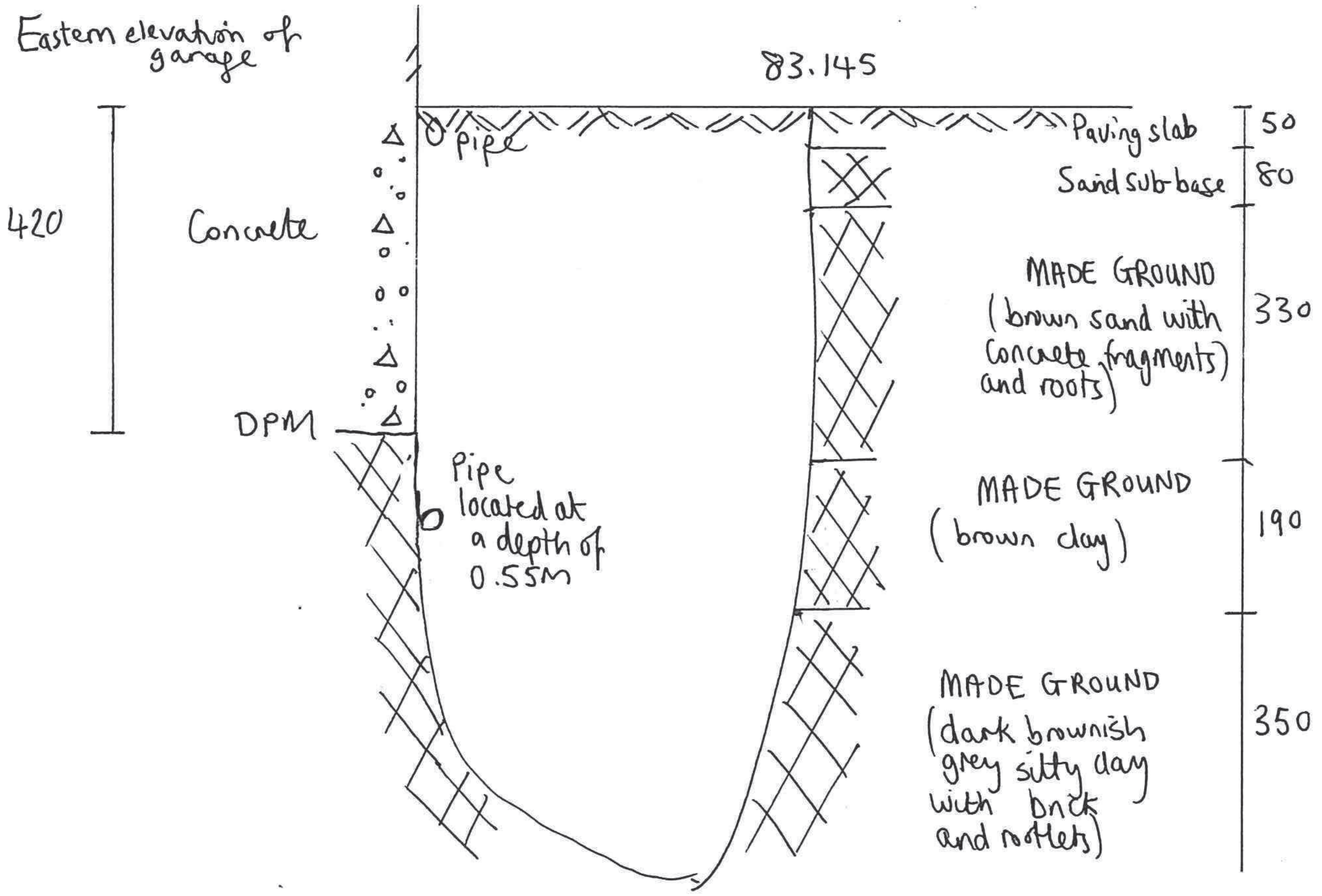
Groundwater: Not encountered

Scale: 1:10

Logged by: HD

GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			Site Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number 3
Excavation Method Manual	**Dimensions** 500 x 450 x 1000	**Ground Level (mOD)** 83.145	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

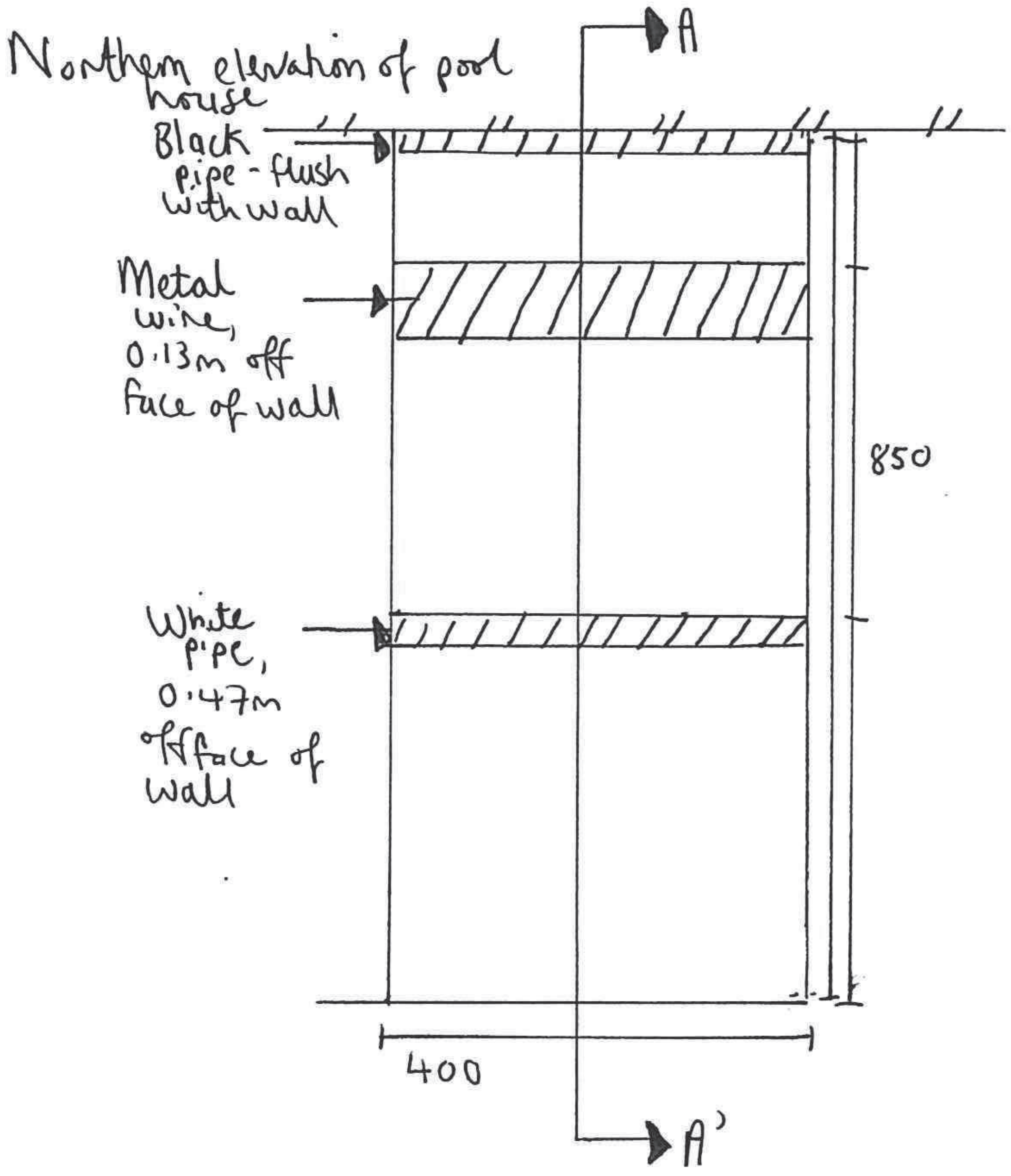
SECTION A - A'



Remarks: All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Scale: 1:10 Logged by: HD

Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			Site Wallace House, Fitzroy Park, London, N6 6HT	Trial Pit Number 4
Excavation Method Manual	**Dimensions** 400 x 850 x 320	**Ground Level (mOD)** 81.47	**Client** Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

PLAN

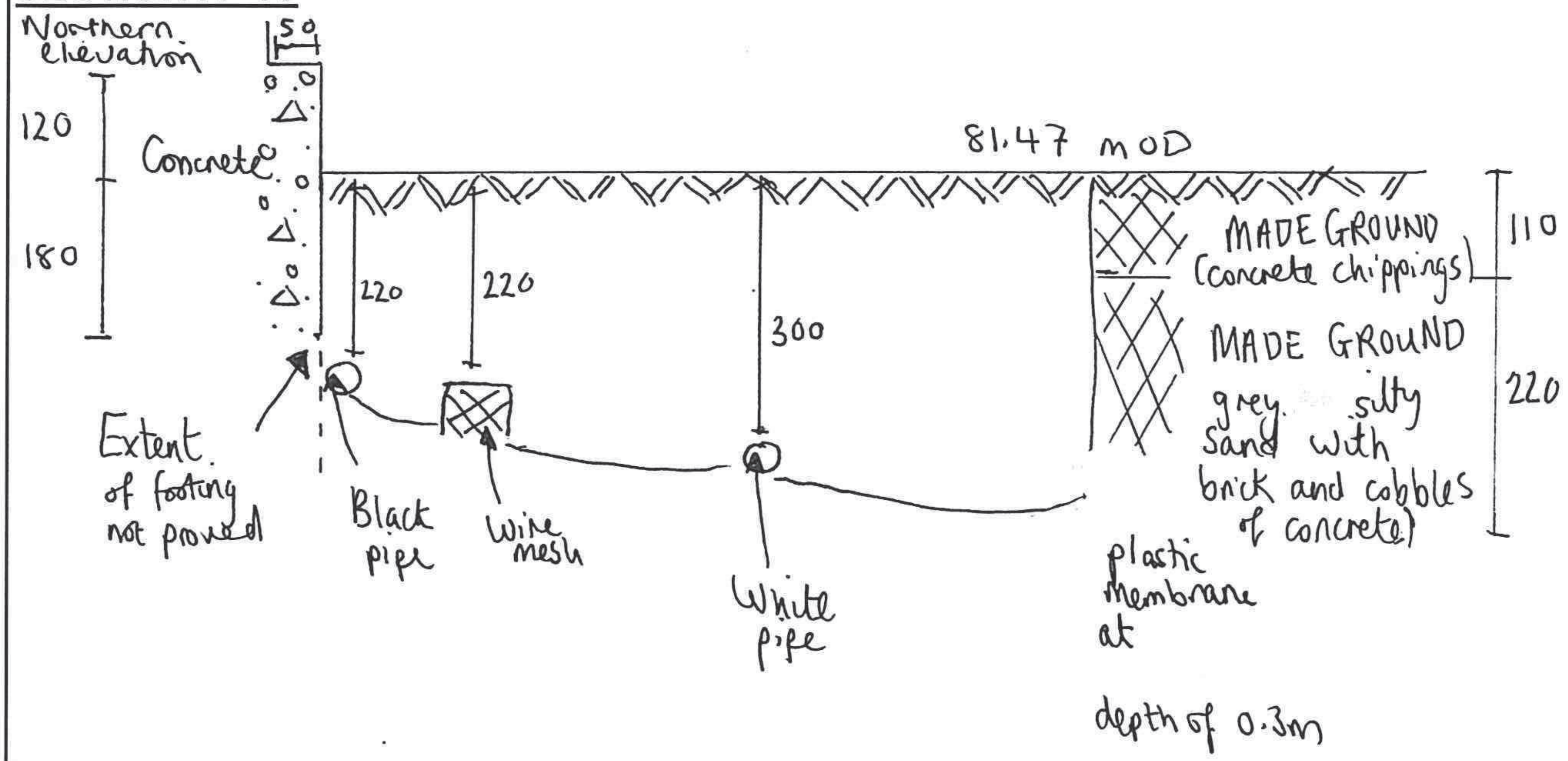


Remarks:	Scale: 1:10
All dimensions in millimetres	Logged by: HD
Sides of trial pit remained stable during excavation	
Groundwater: Not encountered	

Geotechnical & Environmental Associates
Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Excavation Method Manual	**Dimensions** 400 x 850 x 320	**Ground Level (mOD)** 81.47	**Site** Wallace House, Fitzroy Park, London, N6 6HT	**Trial Pit Number** 4
			Client Derrick and Claire Dale	**Job Number** J17111
	Location	**Dates** 10/05/2017	**Engineer** Elliott Wood	**Sheet**

SECTION A - A'



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	HD