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51 CALTHORPE STREET, LONDON, WC1X 0HH

Basement Impact Assessment – Revision C Version 2 – Volume 3 of 5

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APPENDIX I

A REPORT ON A 2ND PHASE GROUND INVESTIGATION AT 51 CALTHORPE STREET, LONDON WC1X 0HH

CLIENT: Mr Simon Firth

ENGINEER: Create Consulting Engineers Limited

Date: 18 January 2016

Reference: AFH/15.116/Phs2

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1. INTRODUCTION

It is proposed to undertake structural modifications to the existing property at 51 Calthorpe Street, London (Drawing 15.116/Phs2/01).

Following a ground investigation carried out by A F Howland Associates Limited (AFHA) that provided an assessment of the potential contamination aspects at the site (AFHA, 2015), a second phase investigation was undertaken to provide information on the geotechnical parameters needed for design purposes by Create Consulting Engineers Limited, Engineer for the project, and to provide data to address certain conditions attached to the planning consent for the proposal.

This report provides the factual details of the fieldwork and laboratory testing undertaken during the second phase investigation, and discusses the findings with respect to issues raised by the local planning authority and the design requirements of the Engineer.

2. FIELDWORK

The fieldwork related to the second phase of investigation was carried out on 16, 17, 19, 20 and 23 November 2015. No work was undertaken on 18 November at the instruction of the Client.

The fieldwork comprised two boreholes, referenced BH102 and BH103, undertaken by a demountable cable percussive rig and three hand dug trial pits, referenced TP101 to TP103.

The exploratory holes were set out in general accordance with the requirements of the Engineer, as shown approximately on Drawing 15.116/Phs2/02. The National Grid reference of the positions, and the elevation relative to Ordnance Datum, were measured using a Hemisphere S320 VRS GPS (RTK) system by AFHA.

A cable avoidance tool (CAT) was used to sweep the location and the immediate surrounding area to locate any potential underground services and the position adjusted as necessary. Also, at the borehole locations a starter pit was excavated by hand to a depth of 1.20 m to provide direct inspection for services or obstructions.

Sampling and *in situ* testing were carried out in general accordance with the recommendations of BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930:2015 (BSI, 2015a), and as specified by the Engineer. Open tube drive samples (U100) were taken in cohesive materials to allow laboratory testing of undisturbed material. Further disturbed samples were taken for laboratory testing and to allow later inspection of the materials encountered and facilitate accurate logging.

Standard penetration tests (SPT) were carried out using a split barrel sampler or a solid cone, as appropriate, to obtain complementary strength information in cohesive material and made ground, and to assess the condition of granular strata. The N value was taken as the number of blows for 300 mm of penetration, following a seating drive of 150 mm or 25 blows.

Borehole BH103 was sited at ground level on the frontage of the property and BH102 in a light well/access way to the rear and on the west side of the property. They were taken to a maximum depth of 20 m, albeit that BH103 was extended then to 22.25 m by continuous standard penetration tests following further advancement by boring techniques not being possible.

The boreholes were monitored for groundwater ingress during advance. Upon encountering inflow, drilling was temporarily stopped to allow the level to stabilise, recording the water level at five minute intervals for a period of twenty minutes. Samples of groundwater were also taken for possible laboratory analysis.

However, groundwater observations are affected by the permeability of the ground, the rate of progress of the hole and the boring technique in operation. The general procedures used do not allow precise measurements of the groundwater conditions, but give only a general guide to the overall situation. Fluctuations in any groundwater table can also occur as a result of seasonal or climatic effects, as well as other outside influences.

To allow a longer term assessment of the groundwater condition, a standpipe piezometer was installed in each of the boreholes. These comprised a slotted uPVC access tube, surrounded by a granular filter, and sealed at the top by bentonite. Both AFHA and the Engineer returned to site to carry out subsequent groundwater monitoring.

The trial pits, were located adjacent to the property walls and were excavated by hand to a depth adequate to expose the foundation at each location. Samples were taken from the trial pits for subsequent logging.

TP101 and TP102 were located in the light well that was adjacent to No 49 Calthorpe Street. TP01 was excavated along the front elevation of No 51 Calthorpe Street and TP102 adjacent to the party wall with No 49. TP03 was excavated inside the basement of No 51 adjacent to the party wall with No 49 and a pillar of structural interest to the Engineer.

Details of the strata encountered, the sampling, *in situ* and laboratory testing are shown on records appended to this report.

For ease of reference, the borehole from the previous investigation (AFHA, 2015), and a window sample probe hole carried out by others (HGE, 2013) are appended.

3. LABORATORY TESTING

3.1 GENERAL

Subsequent to the fieldwork a programme of laboratory testing was carried out to provide additional quantitative data on the materials encountered. The tests were completed in accordance with the procedures laid down in BS1377: 1990 unless stated otherwise and consisted of:

- Natural moisture content
- Atterberg limits
- Particle size distribution
- Undrained shear strength in triaxial compression without measurement of pore pressure
- One dimensional consolidation
- Sulphate content and pH value
- Total sulphur

3.2 TEST PROCEDURES

3.2.1 Natural Moisture Content

The natural moisture content is determined according to BS1377: Part 2: 1990: clause 3.2. This represents the mass of moisture content retained by the soil in its natural state as a percentage of its dry mass. For organic soils and peats care should be taken to avoid heating the sample above 50°C to prevent irreversible physical changes to the material.

3.2.2 Atterberg Limits

The Atterberg limits are determined in the laboratory by the procedures given in BS1377: Part 2: 1990. The liquid limit (LL) is the moisture content of the soil at the point that its behaviour passes from that of a plastic solid to that of a liquid. The test procedure given as clause 4.4 was used based on the cone penetrometer in which the penetration of a free-fall cone into moistened and cured samples of the soil is measured. The plastic limit (PL) is the moisture content of the soil at the point that its behaviour passes from a plastic solid to a brittle solid. This point is measured according to clause 5.3 and is the point at which a thread of the soil rolled to 3 mm diameter begins to crumble.

Together the Atterberg limits can be used to define the plastic range of the soil. The plasticity index (PI) is the difference between the liquid and plastic limit and is broadly correlated to the engineering behaviour of the soil. When used with the natural moisture content of the soil they can also give an indication of its *in situ* condition.

3.2.3 Particle Size Distribution

A quantitative assessment of the particle size distribution of the soil down to the fine grained sand size is made according to BS 1377: Part 2: 1990: clause 9. In this the percentage of certain sized fractions of the soil are found by determining the weight retained on a variety of sieve sizes through which the material is allowed to pass. The combined silt and clay fraction is determined by the difference between the sum of the retained weights and the original sample weight. Variations of the test procedure allow the silt and clay fraction to be removed from the coarser fraction by wet sieving during which the fine material is washed from the surface of the coarser material.

3.2.4 Determination of the Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure

The undrained shear strength of the soil was measured, as stated in BS 1377: Part 7: 1990: clause 8, by axial compression of 100mm diameter cylindrical specimens cut from U100 undisturbed samples. The nature of the test is such that no change in moisture content of the specimen is allowed during shear.

The theory of behaviour of saturated clay materials in undrained shear failure gives that the strength will not be influenced by the confining pressure such that the measured angle of internal friction for the material will apparently be equal to zero. Experience has shown that this is true only for samples of unweathered heavily overconsolidated pure clays. Where the material is weathered or it contains a significant granular content a plastic rather than a brittle failure develops which produces a strain hardening during shear. In this situation measurable apparent undrained angle of internal friction is produced. A similar situation develops in partially saturated materials. The test results are also influenced by sample variation, and in particular the presence of natural fissures or inclusions within the sample.

The use of large diameter specimens is preferred as this compensates for the scale effects of random features in smaller specimens. One of two tests are carried out according to the soil characteristic. Unweathered specimens of heavily overconsolidated clays which have a brittle failure in shear are tested in a single stage. The confining pressure is taken as the total overburden pressure of the sample *in situ*. It is then failed by axial compression and the measured deviator stress reported as the apparent undrained cohesion. Specimens of weathered clay or the clays with granular contents are tested in a multistage manner according to BS 1377: Part 7: 1990: clause 9.

The test procedure is similar to the single stage but at the point that failure begins the confining pressure is increased and the specimen compressed for a further 2% of vertical strain at which point the confining pressure is again increased and held for a further 2% strain. The deviator stresses at each of the confining pressures are used to plot the Mohr envelope and the apparent undrained cohesion and if appropriate the undrained angle of internal friction.

3.2.5 One Dimensional Consolidation Test

This determines the rate and magnitude of the consolidation of a saturated specimen of the soil in the form of a disc, confined laterally and subjected to a vertical axial pressure and which is allowed to drain freely from the top and bottom surfaces. The procedure is carried out according to BS 1377: Part 5: 1990: clause 3.5 in which the total load is applied incrementally.

In this instance the loading sequence was modified to provide a measure of the response of the soil to reduction and re-application of the vertical load.

3.2.6 Sulphate Content and pH Value

In order to aid the evaluation of any aggressive tendency of the subsoil or groundwater to buried concrete the pH and soluble sulphate of a number of samples were determined using in-house procedures based on British Standard methods. The pH of a groundwater sample, or a soil suspension was determined electrometrically according to BS 1377: Part 3: 1990: clause 9.5. The water soluble sulphate content was undertaken using a procedure based on BS 1377: Part 3: 1990: clause 5.5 in which the sulphate is analysed by ICP-OES in a distilled water filtrate from the soil or a groundwater sample. The total sulphate of a soil was measured on a filtrate following digestion of the soil by 10% hydrochloric acid.

3.2.7 Total Sulphur Content

To aid the evaluation of aggressive tendency of the subsoil to buried concrete as a result of its pyritic potential, the total potential sulphate content can be determined from the relationship between the total (acid soluble) sulphate content and the amount of total sulphur present. The total sulphur content is determined by a laboratory in-house method based on the Methods for the Examination of Waters and Associated Materials (Environment Agency, 2006).

A dried portion of the soil is extracted at 115 °C for 75 minutes using 100% aqua regia and potassium bromate/bromide oxidizing mixture. The principle of this digest is to oxidize all sulphur to sulphate, and use the aqua regia acid mixture to digest the sample. The resultant digest solution is then filtered and analysed by ICP-OES. The results are expressed as % S, and include water soluble and acid soluble sulphates and total reduced sulphur, as well as insoluble sulphates and organic sulphur.

4. DISCUSSION AND ENGINEERING INTERPRETATION

4.1 GENERAL

The purpose of the further investigation was to satisfy certain conditions attached to the planning consent for a change of use for the existing building from offices to 17 number flats, to include an additional storey, the incorporation of a mezzanine floor and the excavation of a lower basement.

The particular conditions to be addressed required:

- confirmation of the order of strata below ground level. In particular, to relate to an apparent discrepancy between mapped regional geology and the previous borehole record[1];
- confirmation of the direction of groundwater flow and how the basement would effect this considering that the neighbouring property also has a deep basement;
- to confirm the possible influence of a scour feature of the former River Fleet; and to
- confirm foundation depth and type of the neighbouring property.

In addition, the investigation was required to allow the determination of certain design parameters to assist the Engineer with the structural design of the scheme. These included:

- Stratum thicknesses;
- Bulk weight of each stratum;
- Stratum type :
  - Cohesive/Cohesionless;
  - Normal/Over consolidated;
  - Drained/Undrained;
- Coefficient of earth pressure at rest, Ko;
- Soil friction angle;
- Cohesion :
  - Drained;
  - Undrained;
- Young's modulus;
- Poisson ratio; and
- Water table elevation.

[1] BH01 reported by AFHA, 2015

It is understood that the design concept was for the basement to form a watertight mini-piled (secant piled) retaining wall box in which a two storey basement could be excavated whilst keeping water out (assuming that the basement excavation level was within or very close to the ground water table level). However, the findings indicated the presence of a thick layer of made ground and sand/gravels to be present which was at variance with an expected presence of the London Clay.

The comments and recommendations contained in the report address the issues raised by the planning consent and the design requirements as understood, and are based on the data obtained from the site investigation. Extrapolation between and to other parts of the site is considered within the light of the geological setting as interpreted, but no responsibility can be accepted for varying geological and geotechnical conditions from those on which the report is based. It should be noted that the solutions discussed reflect the design proposals and information supplied at the time of reporting and must be subject to re-assessment if changes are made at a later date.

4.2 GENERAL GEOLOGY

The geology as mapped for the area by the British Geological Survey (BGS, 2016) indicated a solid geology at about the contact of the Lambeth Group and overlying London Clay Formation with the solid geology being overlain by superficial soils termed the Hackney Gravel Member (dwg 15.116/Phs2/03).

The **Lambeth Group** is of Eocene Age and comprise the laterally contemporaneous beds of the Woolwich and Reading Formations which together comprise a variable sequence of very heavily overconsolidated clays and shelly clays, with occasional beds of limestone interbedded with sand and gravel units, generally becoming more sandy and gravelly towards the base. These sediments are interpreted to have been deposited in a back lagoon environment, behind a marine bar, through which periodic marine incursions occurred; therefore the deposits are both laterally and vertically variable.

The more easterly soils associated with the **Woolwich Formation** include a variety of lithologies, thought to have been laid down in a lagoon or estuarine environment. Most widespread is an overconsolidated shelly clay, the 'Woolwich Shell Beds.' The formation is also characterised by grey-brown and grey, thinly bedded, interlaminated sands, silts and clays. Other lithologies include ferruginous or lignitic sands (locally cemented by silica) and occasional beds of limestone.

The more westerly **Reading Formation** predominantly comprises an overconsolidated multicoloured mottled clay, typically shades of red, brown and blue-grey, with subordinate silts and fine sands. These sediments are believed to represent the deposits of an alluvial mudflat, subjected to subaerial exposure during dry periods. The formation also contains beds of medium grained sand, which may include silica and iron concretions and are interpreted as the deposits of river channels crossing the mudflats.

The **London Clay Formation** is a heavily overconsolidated clay of the Eocene Series. It contains varying amounts of silt and fine sand, with silt generally more abundant at the base and the top of the formation. In its unweathered state the London Clay is typically very stiff, fissured to a varying degree and dark grey or purplish grey in colour. Beds of calcareous concretions, some of which are septarian, are found intermittently throughout the formation. Phosphatic and pyritic nodules also occur, selenite crystals are characteristic. The clay weathers to brown and the more sandy beds to an orange-brown colour, deteriorating in consistency to firm or even soft.

The London Clay is the most widespread of the Palaeogene deposits and is stratigraphically of significant thickness. At the scale of most sites it is often regarded as homogeneous for much of this thickness with any variation generally related to the development of a weathering profile.

Stratigraphically, the **Harwich Formation** exists at the base of the London Clay lying unconformably over the Lambeth Group and below the marine transgression marking the base of the London Clay Formation. However, it is more evident in the northeast of the London Basin and East Anglia where it comprises a sequence of silty clays and sandy, clayey silts with subordinate locally glauconitic silts and sands.

The **Hackney Gravel Member** is one of a series of river terrace deposits of the River Thames. These were derived from the chalk and younger Eocene deposits during the Pleistocene and laid down while the river was flowing with a greater discharge than its does today. Subsequent readjustment of the river level has left the deposits as terraces along its valley sides and as lag deposits along the floor of the present day valley and its tributaries.

They terrace deposits comprise flint sand and gravel, locally displaying vertical sorting. Some terraces may be capped by finer alluvium, but often this has been removed by later erosion. Towards the edges of the terraces the material has often been reworked and transported so that it may be found draped over lower levels than those at which it was originally deposited.

The particular morphology of the site and its geology is such that the natural sequence and expected stratigraphic levels have been prone to disturbance by particular periglacial processes, and also to fluvial scour. The consequence being that the natural sequence can be disrupted and the materials weakened. Also, it causes the over-lying superficial soils to extend to greater depths than the regional stratigraphy would suggest to be the case. A particular incidence has been recorded in the vicinity of the site where published work suggests that the course of the former River Fleet probably crosses the site and that a substantial fluvial scour is present within the vicinity (Berry, 1979; Banks *et al*, 2015). The work by Berry, which is based on the ground conditions encountered during the construction of a post office tunnel that lies below Calthorpe Street where it runs adjacent to the site, and to a number of boreholes in the vicinity, suggests a complex and variable sequence to be present at anything down to elevation of – 20 m OD[2]. The removal of the London Clay by the scour action is evident by the elliptical shaped exposure of the underlying Lambeth Group in the vicinity of the site as shown on drawing 15.115/Phs2/03.

4.3 SITE GEOLOGY

The boreholes proved an overall similarity of sequence in that all the boreholes, including those from the earlier investigations showed made ground to be present to up to 8 m below road level and that this overlay over a sequence of natural materials. However, the character and condition of the natural soils differed significantly both within and between boreholes (Dwg 15.116/Phs2/04).

The **made ground** comprised a variable sandy clay that contained gravel and occasional cobble size pieces of brick, flint, concrete, chalk, charcoal and slate. Organic odours were noted locally below about 5 m depth. The materials were assessed as very soft or soft and this was supported by *in situ* standard penetration testing that gave N-values that ranged between 2 and

[2] See Appendix F of the report for pertinent extracts from Berry (1979)

10 with one anomalous higher value that is likely to have influenced by an obstruction (Dwg 15.116/Phs2/05).

The initial borehole, BH01 proved a natural **cohesive deposit** immediately below the made ground at a depth of 8.0 m (approx 10.2 mOD) from street level. This consisted of dark brown clay; it was also organic and included rootlets. At 8.4 m it became firm, brown and grey, and variably silty and sandy, and included sand partings. Atterberg limits determinations indicated a clay of intermediate to high plasticity, with a plasticity index ranging between 17 and 25%. A single undrained triaxial test result from an undisturbed sample gave an apparent cohesion value of 52 kNm^{-2}, while the assessed strength was also confirmed by an N-value of 17.

The clay gave way to **granular deposits** at 10.9 m that comprised brown slightly silty sand containing flint gravel. Standard penetration tests indicated a medium dense condition, albeit that some blowing conditions developed during boring.

At borehole BH103 from the current phase of investigation the natural sequence was broadly similar to that at BH01. Initially, sandy gravelly clay was recorded to 9.5 m but which changed at about 9.0 m from a firm to a soft consistency. Other than for a thin gravel band at 9.5 m, this continued to about 12.0 m, albeit that it improved in consistency again to firm. The upper levels of the cohesive material were similarly organic to that found in BH01. The presence of brick and ceramic material within the material at BH103 was interpreted to be due the action of drilling, rather than represent a locally deeper development of the made ground. Testing of a sample of the clay suggested a soft condition, although the sample may have suffered some water softening during boring. An Atterberg limit determination indicated a clay of intermediate plasticity with a plasticity index of 23% and as such suggested the material was comparable to that in BH01.

At 12.0 m, the clay in BH103 gave way to granular material. This extended to a depth of 22.05 m. However, the borehole was advanced only to 20.0 m with the findings below that being based on the results and recovery from continuous SPTs. Therefore, the lower level data and interpretation should be treated with some caution. Variation was also present within the granular sequence at BH103 with the upper and probable lower sections being dominated by the fine and medium sand fraction and an intermediate section by more coarse sandy gravel.

At BH102, the natural soils showed some initial similarity in that a sandy clay of intermediate plasticity was also present immediately below the made ground and proved to be in a soft to firm, improving to a firm condition, based on the results of an SPT and a single undrained triaxial compressive test.

This initial clay was less thick in BH102 and although it gave way to a granular soil, this also was more thinly developed than was the case in BH01 and BH103.

Below the granular material, a more persistent clay was proved to the base of BH102. This was slightly silty, locally sandy in places and was initially of a firm to stiff consistency and became stiff with depth. It was initially grey in colour and contained fine sand sized selenite crystals. However, from a depth of 13.0 m, it became very stiff and mottled grey and brown with occasional red mottling, and an absence of selenite crystals. Atterberg limit determinations of the upper grey clay showed this to be of high and very high plasticity and otherwise characteristic of that expected of the London Clay. However, the mottling of the underlying clay was characteristic of that associated with the underlying Lambeth Group and it is possible that the borehole crossed the geological contact between the two. If so, no evidence for the Harwich Formation was identified.

4.4 GROUNDWATER

At each borehole **groundwater** inflow took place as a sub-artesian strike on entering the granular soils below the made ground, although an earlier strike was also recorded in the made ground at BH01. In each instance, the water rose during a break in boring. Groundwater monitoring instrumentation installed in each borehole were monitored subsequent to their installation and suggested a groundwater level of 10.85 mOD[3]. A higher level recorded in the previous window sample hole was considered anomalous and to reflect a residual influence at the base of the instrument (dwg 15.116/Phs2/06).

4.5 GROUND CHEMISTRY

Selected samples of the made ground, clay and groundwater were subject to pH and sulphate testing, with sulphur determinations made to complement the sulphate testing according to

[3] This is based on two readings taken within a few weeks of each other, albeit that the results are supported by an earlier reading of the instrument in BH01 taken in April 2015. In view of the sensitivity of many construction procedures to groundwater further monitoring of the instruments would be prudent to confirm a longer term persistency of groundwater regime.

the recommendations of Building Research Special Digest 1 (BRE, 2005). Combining the results from BH01, they can be summarised as follows:

- pH values in soil between 7.2 and 8.4, while values of 6.8 and 7.2 were recorded in groundwater
- sulphate (SO_3) concentration of 0.13, 0.17 and 0.37 gl^{-1} in groundwater
- water soluble sulphate (SO_3) concentrations in soil from 0.04 to 0.77 gl^{-1}
- acid soluble sulphate (SO_4) between 0.02 and 0.21%
- total sulphur concentrations from 0.01 to 0.83

The sulphur determinations were made to complement the sulphate testing according to the recommendations of Building Research Special Digest 1 (BRE, 2005). This establishes if a material is pyritic and uses a relationship between total sulphur, acid soluble and water soluble sulphate, and Total Potential Sulphate (TPS), to determine whether it is necessary to increase the Design Sulphate (DS) class. This produced oxidisable sulphides above the 0.3% trigger concentration, suggesting that certain of the soils may contain pyrites.

4.6 EXISTING FOUNDATIONS

A review of historical Ordnance Survey maps suggests that the building was built as a school, later became a drill hall and more recently took on its present use as an office block.

The foundation pits along the external walls exposed a corbelled brick lower wall acting onto a concrete footing. However, it was not possible to establish whether this was a common foundation with No 49 as the option also to excavate within No 49 was not available. The likelihood, or otherwise that they have a common foundation would need to be inferred from the structural arrangement and integrity of the superstructure of the buildings[4].

TP103 that was excavated internal to the building at basement level on the boundary between the two properties and showed a founding level for the base of concrete slab of approximately 14.1 m OD. The founding levels at the other two pits that were located in the light well on the front elevation differed from this, but in each instance, the foundations were found to be acting onto the made ground.

[4] This aspect is outside of the remit of this report.

Made ground is generally considered to be an unsuitable founding strata in view of its heterogeneous nature and an associated weak and compressible character, unless it is an engineered fill with more certain properties.

It is understood that properties in the vicinity, and No 49 in particular, have experienced movement in the more recent past, which suggests that the founding soils remain subject to influences other than those of soil consolidation alone.

Subject to an understanding of those additional influences, which is unlikely to be possible, but which may include vibration from increased traffic, local engineering works and ground water level changes, the allowable bearing capacity, qa, of the made ground, if taken to be largely cohesive in character can be determined by:

$$qa = \frac{1}{F} (Nc \times Cu)$$

where;

Nc is a bearing capacity factor related to footing geometry
Cu is the undrained shear strength of the stressed soil , and
F is a factor of safety against bearing capacity failure

If an undrained shear strength of 20 kNm^{-2} is taken for the made ground, being the lower bound value for soft soil, the allowable bearing stress increase, qa, for a factor of safety of 3 is:

$$qa = \frac{1}{3} (6.1 \times 20)$$

$$= 40.67\ kNm^{-2}$$

It should be noted that a conservative value for the bearing capacity factor Nc has been adopted in this approach.

4.7 PROPOSED SUBSTRUCTURE WORKS

4.7.1 Excavations

The excavation for the new basement is anticipated to be taken to an elevation of approximately 12.5 mOD. This will be contained within the made ground and above the regional groundwater table[5] albeit that some perched water may be present above (dwg 15.116/Phs2/04).

The made ground is heterogeneous but generally cohesive in character, although coarser bands may be present. In view of the consequences of sidewall failure, the made ground should be regarded as being incapable of self-support and the construction system should be devised accordingly. In particular, the concept for a proposed watertight mini-piled (secant piled) retaining wall box would need to ensure that it is adequate to prevent any lateral displacement of the retained soil in both the permanent and temporary conditions.

Excavations that remain above the groundwater will, in essence, remain dry and would not be expected to affect the groundwater, or be affected by it. However, as the water level is approached it is generally the case that the soils become more soft. Excavations that need to be taken below the water table will encounter more adverse conditions that would need additional consideration.

4.7.2 Retaining Structures

Although the walls of the new basement excavation will extend some 2 to 3 m below the existing basement, they will need to be capable of accommodating the stresses induced by the full depth of soil; subject to the precise detail of the existing soil/structure interaction. In the worst case this will be the depth of soil from street, or ground floor level plus the surcharge load of any foundations acting at a higher level than the base of the excavation. In addition, as the water pressure acting on a retaining structure requires only the presence of water on the back wall, and in the absence of drainage measures in the wall, this can develop irrespective of the regional groundwater table. Consequently, the system should also assume water loading over the full depth from street, or ground floor level.

4.7.3 Characteristic Soil Parameters

The soil parameters that have been indicated by the Engineer as necessary to assist with the assessment of the temporary and permanent works aspect of the construction proposal are listed in Section 4.1 above and values for each are given in Table 1, below.

[5] See footnote 3, page 13

Parameter	Made Ground	Natural cohesive soils (not LC)	Natural granular soils	London Clay (LC)
Stratum thickness[1]	8 m from street level (base approx 10.5 mOD)	Variable (has the potential to be present to the full depth investigated)	Variable (has the potential to be present to the full depth investigated)	Variable (has the potential to be to be present to the full depth investigated)
Stratum Type[1]	Cohesive	Cohesive	Cohesionless	Cohesive
State of Consolidation[2]	Not applicable	Over-consolidated, unless fully softened by disturbance	Not applicable	Over-consolidated
Bulk weight, γ_k (weight density)[3]	17.5 to 20	19.0 to 20.0	17.0 to 20.0	20.0
Undrained strength, kNm^{-2}[4]	20.0	20.0 increasing to 40.0 where the strata is thicker	Not applicable	40.0 increasing to 150.0 with depth
Drained strength, c' kNm^{-2} / φ' degrees[3]	0 / 25	0 / 25	0 / 30	0 / 20
Coefficient of earth pressure at rest, Ko[5]	0.75	0.75	0.40 (loose or medium dense 0.80 (dense)	1.00
Poisson's ratio[5]	0.2 to 0.3	0.4 to 0.5	0.20	0.4 to 0.5
Young's Modulus, MNm^{-2}[6]	0.5 to 5 (very soft to soft)	5 (soft) 5 to 8 (firm)	30 to 80 (loose) 80 to 160 (medium dense 160 to 320 (dense)	4 to 7 (firm) 7 to 20 (stiff/very stiff)
Water table elevation, mOD[1]	10.85	10.85	10.85	10.85

Table 1 : Soil Parameters

NB. Data source:
1 – Borehole records; **2 – Geological provenance derived from geological setting;**
3 – BS 8002 (BSI, 2015b); **4 – Derived from SI data;**
5 - Tomlinson (1996); **6 - www.geotechdata.info/parameter/soil-young's-modulus.html.**

Natural materials are variable in character and condition. This is notably the case at the site as a result of the particular geological processes that have been active in the area. Thus, the parameters provided in Table 1 should not be taken to represent an innate property of the soil and the values will vary not only as result of the variability of the soils but also by the context in which the parameter will apply. Any analysis would be enhanced by a sensitivity analysis for the parameters as a means to determine the impact of the uncertainty of each.

4.7.4 Underpin piled foundations

It is understood that the proposed secant piles that will be used to support the excavation are intended also to underpin and accommodate the structural loads of the building. Unless individual piles are extended below the level that is required to support the sidewalls of the basement extension, the pile group will act as a deep strip foundation, with the benefit of the friction developed along the internal and external faces of the pile group.

Although the soils have been found to have a significant variability, the structural integrity of the construction system in such loads will be distributed to some degree within the group. However, the potential exists for differing behaviour as some of the variability in the soils is at a large scale. For example, a pile system acting into the London Clay from below the made ground would have a differing response to that where the granular soils of the over-deepened superficial soils are present. It would seem prudent therefore that the design approach focussed on the settlement response of the system acting into each soil type in order to ensure that differential movements were of an acceptable level, rather than the load capacity alone.

4.7.5 Buried Concrete

Specific chemical analysis were undertaken in order to evaluate the aggressive tendency of the ground to buried concrete. Considering the results together with those from the previous investigation (AFHA, 2015), the pH results indicated slightly alkaline conditions, with one sample of made ground showing a more positive alkaline value. The soluble sulphate results correspond with a design sulphate class of **DS-1** and **DS-2** (BRE, 2005).

The digest identifies a number of different site categories, which include those with natural soil conditions, those that have been subject to brownfield development and also those sites that contain pyrite bearing ground that would be subject to future disturbance and could result in pyritic oxidation. Based on the presence of made ground to depth, a brownfield character should be adopted. It is also necessary to take into account other factors related to the environment into which the concrete is placed i.e. the pH of the material and the mobility of the groundwater table. An ACEC (aggressive chemical environment for concrete) class can then be assigned. Given that the piles will need to be taken below the groundwater and that significant thicknesses of granular soils are present, a mobile groundwater condition has been adopted. As the pH is higher than 6.5, in a natural ground setting the guidelines indicate that ACEC classification of **AC-2** would be appropriate for buried concrete in contact with **undisturbed** deposits. This assumes that any concrete is cast according to good construction practices, in direct contact with the ground, and where the soils have not been allowed to deteriorate beforehand. That is the pyritic soils that are locally present would not be disturbed such that oxidation of the pyrite might occur which would require a greater level of protection to the buried concrete.

5. SUMMARY

1. The investigation sought to address a number of issues raised by the planners and required to assist with the structural aspects of the proposed development.

2. In response to the particular planning conditions;

   - The additional investigation confirmed the ground profile and proved it to be variable in character and condition as a result of a particular geological phenomenon associated with localised enhanced fluvial scouring which created a deepening to the base of the superficial granular terrace deposits and significant disruption and weakening of the underlying materials of the solid geology. This accounts for the discrepancy with the sequence expected from the mapped regional geology;
   - For the period monitored the groundwater level is consistent in the area of the site at about 10.85 m. This suggests that groundwater is hydrostatic and that no significant flow is taking place, although an overriding regional flow pattern could not be determined from the evidence of a limited area. In view of the significant permeability of the soils that would be present below the property, the presence of the properties are not likely to impact on the groundwater regime;
   - Further to the comment above, the additional boreholes confirmed the presence of a probable scour feature of the former River Fleet and discussed its possible influence on the proposals;
   - The external wall of No 51 adjacent to No 49 had a foundation that comprised a corbelled footing acting onto a probable concrete raft with a formation level to the concrete of about 14.1 mOD.

3. The significant variability of the soils, both vertically and laterally will need to be taken in account within the design process and consequent construction procedures. Notably:

   - Soils varied from fully cohesive to fully cohesionless;
   - Cohesive soils varied from soft to firm, and cohesionless soils from medium dense to dense with no clear logical pattern to the variation in either case;
   - Groundwater was present below the formation level of the basement extension, but perched water may exist above that;
   - Parameters for the soils have been tabled for use in analysis, but they are not innate properties and sensitivity assessments should be included in the design process;
   - Water pressure should be assumed to act on any retaining structure.

4. An ACEC classification of AC-2 is considered appropriate for buried concrete in contact with undisturbed ground.

K P Blanke
BSc (Hons)

Dr A F Howland
MSc PhD DIC CEng FIMMM CGeol FGS

A F HOWLAND ASSOCIATES
18 January 2016

APPENDIX A: REFERENCES

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APPENDIX B: CABLE PERCUSSIVE BOREHOLE RECORDS

Borehole BH01 from previous investigation (AFHA, 2015)

Borehole BH102 and BH103 from the current investigation

B	Bulk disturbed sample
D	Small disturbed sample
W	Water sample
U	Nominal 100 mm diameter undisturbed open tube sample
ES	Environmental sample
X blows	The associated figure 'X' is the number of blows to drive the sample tube over the given depth range
XF	Undisturbed sample not recovered after 'X' number of blows to drive the sample tube
SPT	Standard penetration test using a split spoon sampler. N Value is uncorrected, but the hammer energy ratio is given in the remarks.
SPT(C)	Cone penetration test using a solid cone
X,X/X,X,X,X	Blows per increment during the standard penetration test. The initial value relates to the seating drive (150 mm) and the remaining four to the 75 mm increments of the test length
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300 mm)
X*/Y	Incomplete standard penetration test where the seating drive could not be completed. The blows 'X' represent the total blows for the given length of seating drive 'Y' (mm)
X/Z	Incomplete standard penetration test where the seating drive was achieved but the full test length was not. The blows 'X' represent the total blows for the given test length 'Z' (mm)
<u>dd/mm/yy: 1.0</u> **dd/mm/yy: dry**	Date, water level at the borehole depth at the end of shift and the start of the following shift

Each sample type is numbered sequentially with depth and relates to the depth range quoted

All depths and measurements are given in metres, except as noted

Strata descriptions complied by visual examination of samples obtained during boring, after BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930: 2015 and modified in accordance with laboratory test results where applicable

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Geotechnical Engineers

Site	51 CALTHORPE STREET, LONDON WC1X 0HH			**Borehole Number** BH01
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 14.50m open hole to 15.00m	**Ground Level (mOD)** 18.19	**Client** Mr Simon Firth	**Job Number** 15.116
	Location 530932 E 182459 N	**Dates** 16/04/2015	**Engineer** Create Consulting Engineers Limited	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records
0.30-0.50	B1			
0.70	ES1			
0.70-0.90	B2			
1.00-1.20	B3			
1.20-1.65	SPT(C) N=2		DRY	1/1,,1
1.20-1.70	B4			
2.00-2.45	SPT(C) N=3	1.50	DRY	1/1,,1,1
2.00-2.50	B5			
3.00-3.45	SPT(C) N=3	3.00	DRY	1,2/1,,1,1
3.00	D1			
3.00	ES2			
4.00-4.45	SPT(C) N=3	3.00	DRY	1/1,,1,1
4.00-5.00	B6			
5.00-5.45	SPT(C) N=5	4.50	DRY	1,2/1,2,1,1
5.00-6.00	B7			
5.62	W1			
6.00-6.45	SPT(C) N=7	6.00	DRY	2,3/3,2,1,1
6.00-7.00	B8			
6.70	ES3			
				Medium(1) at 6.85m, rose to 5.62m in 20 mins, sealed at 7.50m.
7.50-7.95	SPT N=6	7.50	DRY	1,2/1,2,1,2
7.50-7.95	D2			
8.00-8.20	D3			
8.40-8.65	D4			
9.00-9.45	U1	9.50	DRY	33 blows
9.45	D5			
9.50	W2			

Level (mOD)	Depth (m) (Thickness)	Description	Water
17.99	(0.20) 0.20	CONCRETE	
16.99	(1.00) 1.20	MADE GROUND (Soft brown and grey very sandy very gravelly clay with occasional angular cobble sized brick fragments. Gravel is angular to subrounded fine to coarse flint, brick, chalk and concrete)	
14.19	(2.80) 4.00	MADE GROUND (Very soft brown with occasional orange brown mottling sandy gravelly clay. Gravel is angular to subrounded fine to coarse flint, brick, chalk, concrete and charcoal)	
11.59	(2.60) 6.60	MADE GROUND (Brown sandy gravelly clay, recovered in a very soft condition. Gravel is angular to subrounded fine to coarse flint, brick, concrete, slate and rare chalk)	▼1
11.34	(0.25) 6.85	MADE GROUND (Black slightly silty slightly sandy slightly gravelly clay with a weak organic odour. Gravel is angular to subrounded fine to coarse flint and brick)	▽1
10.69	(0.65) 7.50	MADE GROUND (Brown with black mottling slightly silty slightly sandy slightly gravelly clay with occasional angular cobble sized brick fragments and a weak organic odour, recovered in a very soft condition. Gravel is angular to rounded fine to coarse flint, brick and concrete)	
10.19	(0.50) 8.00	MADE GROUND (Greyish brown silty slightly sandy slightly gravelly clay with a weak organic odour, recovered in a very soft condition. Gravel is fine occasionally medium flint and brick)	▼2
9.79	(0.40) 8.40	Soft to firm dark brown slightly silty slightly sandy CLAY with numerous infilled rootlets and an organic odour	
9.19	(0.60) 9.00	Firm greyish brown with occasional orange brown and blue grey mottling very silty sandy CLAY. Rare flint gravel	
		Firm greyish brown to grey with occasional orange brown mottling silty slightly sandy becoming sandy CLAY with occasional orange brown fine to medium sand partings	

Remarks
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 1.20 m.
3. Groundwater struck at 6.85 m and rose to 5.85 m in 5 mins., 5.62 m in 10 mins. and 15 mins. and 20 mins.
4. Groundwater struck at 10.90 m and rose to 8.63 m in 5 mins., 8.27 m in 10 mins., 8.22 m in 15 mins. and 20 mins.
5. Piezometer installed to 11.80 m.
6. SPT Hammer Energy Ratio = 67.66%

Scale (approx)	Logged By
1:50	KPB

Figure No. 15.116.BH01

A F Howland Associates Geotechnical Engineers			Site 51 CALTHORPE STREET, LONDON WC1X 0HH	Borehole Number **BH01**
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 14.50m open hole to 15.00m	**Ground Level (mOD)** 18.19	**Client** Mr Simon Firth	**Job Number** 15.116
	Location 530932 E 182459 N	**Dates** 16/04/2015	**Engineer** Create Consulting Engineers Limited	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(1.90)	.... CLAY becomes brown		
10.50-10.95 10.50-10.95	SPT N=17 D6	7.50	DRY	1,2/2,4,5,6					
				Quick(2) at 10.90m, rose to 8.22m in 20 mins, not sealed.	7.29	10.90 (0.20)	Orange brown slightly clayey medium to coarse SAND		∇2
					7.09	11.10	Light brown slightly silty gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse flint (blowing conditions)		
13.00-13.50	B9					(3.90)			
14.00-14.50	B10								
14.50-14.95	SPT(C) N=12	14.50		1,1/2,2,3,5			.... medium dense		
				16/04/2015:8.50m	3.19	15.00	Complete at 15.00m		

Remarks	Scale (approx)	Logged By
7. Unable to take SPT at 12.00 m and 13.50 m due to blowing sand.	1:50	KPB
	Figure No. 15.116.BH01	

A F Howland Associates
Geotechnical Engineers

Site	51 CALTHORPE STREET, LONDON WC1X 0HH
Borehole Number	BH01
Installation Type	Single Installation
Dimensions	Internal Diameter of Tube [A] = 19 mm Diameter of Filter Zone = 150 mm
Client	Mr Simon Firth
Job Number	15.116
Location	530932 E 182459 N
Ground Level (mOD)	18.19
Engineer	Create Consulting Engineers Limited
Sheet	1/1

Water	Level (mOD)	Depth (m)	Description
	17.99	0.20	Concrete
	17.19	1.00	Bentonite Seal
▼1, ∇1, ▼2			Topfill
	7.79	10.40	Bentonite Seal
∇2	7.29	10.90	Gravel Filter
	6.69	11.50	Piezometer Tip
	6.39	11.80	Gravel Filter
	6.19	12.00	General Backfill
	3.19	15.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
16/04/15		6.85	6.00	Medium	5.85	5.62	5.62	5.62	7.50
16/04/15		10.90	7.50	Quick	8.63	8.27	8.22	8.22	NOT

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
16/04/15							15.00	14.50	8.50	9.69

Instrument Groundwater Observations

Inst. [A] Type : Standpipe Piezometer

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
30/04/15	13:30	7.36	10.83	
20/11/15	11:35	7.33	10.86	
08/12/15		7.40	10.79	Taken by Create Consulting

Remarks
1. Water sample taken 30/04/2015

A F Howland Associates Geotechnical Engineers	Site	Borehole Number
	51 CALTHORPE STREET, LONDON WC1X 0HH	BH102

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Demountable Cable Percussion Drilling Rig	200mm cased to 8.00m 150mm cased to 9.00m open hole to 17.00m	15.39	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530923 E 182477 N	16/11/2015-17/11/2015	Create Consulting Engineers Limited	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					15.33	0.06	MADE GROUND (Concrete)		
						(0.19)			
0.30-0.50	B1				15.14	0.25	MADE GROUND (Brown sandy clay and angular brick fill)		
					15.09	0.30	MADE GROUND (Beige weak mix concrete)		
0.50-1.00	B2					(1.20)	MADE GROUND (Brown very sandy very gravelly clay fill. Gravel is angular to sub angular fine to course flint, brick, concrete, charcoal, and occasional clinker. Occasional angular coble sized brick fragments)		
1.50-1.95 1.50-2.00	SPT(C) N=4 B3	1.50	DRY	1,1/1,1,1,1	13.89	1.50	MADE GROUND (Soft brown sandy gravelly clay fill. Gravel is angular to subangular fine to coarse brick, concrete, charcoal, clinker and rare chalk)		
						(1.50)			
2.50-2.80 2.50-3.00	SPT(C) 50/150 B4	2.50	DRY	1,1/1,49					
3.00-3.45 3.00	SPT(C) N=3 D1	3.00	DRY	0,1/1,1,0,1	12.39	3.00	MADE GROUND (Very soft brown and dark brown to black mottled slightly silty slight sandy slightly gravelly clay. Gravel is angular to subangular fine medium flint and brick)		
3.50-4.00	B5								
4.00-4.45 4.00-4.50	SPT(C) N=9 B6	4.00	DRY	1,1/2,2,2,3		(2.10)			▼1
4.50	W1								
5.00-5.45 5.00-5.50	SPT(C) N=10 D2	5.00	DRY	1,1/1,3,3,3	10.29	5.10	Soft to firm greyish green with brown speckling silty slightly sandy CLAY		
5.50-6.00	B7					(1.30)			
6.00-6.45	U1	6.00	4.25	30 blows			... becoming stiff		
6.50-7.00	B8			Medium(1) at 6.40m, rose to 4.20m in 20 mins, not sealed. 16/11/2015:4.25m	8.99	6.40	Medium dense brown grey sandy angular to rounded fine to coarse flint GRAVEL		∇1
						(0.60)			
				17/11/2015:4.25m	8.39	7.00	Medium dense brown very gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse flint		
						(0.90)			
7.50-7.95 7.50-8.00	SPT(C) N=10 B9	7.50	4.20	1,1/2,2,3,3					
					7.49	7.90	Firm brown with occasional orange brown mottling silty slightly sandy CLAY		
8.00	D3					(0.20)			
					7.29	8.10	Firm to stiff grey with occasional light grey veins silty CLAY with fine sand sized selenite crystals		
8.20	D4								
9.00-9.45	U2	9.00	DRY	35 blows		(1.90)			
9.50	D5								
10.00-10.45	SPT N=14	9.00		1,2/2,3,4,5					

Remarks
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 1.20 m.
3. Groundwater struck at 6.40 m and rose to 6.40 m in 5 mins., 5.80 m in 10 mins., 4.90 m in 15 mins. and 4.20 m in 20 mins.
4. Chiselling Required from 2.50 m to 2.70 m for 0.5 hr
5. Slotted Standpipe installed to 8.00 m.
6. SPT Hammer Energy Ratio = 72 %

Scale (approx)	Logged By
1:50	KPB

Figure No. 15.116.BH102

A F Howland Associates
Geotechnical Engineers

Site	Borehole Number
51 CALTHORPE STREET, LONDON WC1X 0HH	**BH102**

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Demountable Cable Percussion Drilling Rig	200mm cased to 8.00m 150mm cased to 9.00m open hole to 17.00m	15.39	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530923 E 182477 N	16/11/2015-17/11/2015	Create Consulting Engineers Limited	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					5.39	10.00			
10.00-10.50	D6						Stiff grey silty CLAY with occasional light grey veins and fine sand sized selenite crystals. Slightly sandy in places		
11.00	D7								
11.00-11.45	U3 No Recovery	9.00	DRY	50 blows					
						(3.00)			
11.50-12.00	B10								
12.50	D8								
					2.39	13.00	Stiff blue grey and brown mottled slightly silty CLAY		
13.00-13.45	U4	9.00		81 blows					
						(0.50)			
					1.89	13.50	Very stiff brown blue grey and occasional red mottled slightly silty CLAY		
13.50-13.95	SPT N=21	9.00		2,2/4,5,5,7					
13.50	D9								
13.50-14.00	D10								
15.00-15.45	U5	9.00		100 blows					
						(3.50)			
15.50	D11								
16.00	D12								
16.50-16.95	SPT N=29	9.00		2,3/6,7,8,8					
16.50-17.00	D13								
				17/11/2015:	-1.61	17.00	Complete at 17.00m		

Remarks	Scale (approx)	Logged By
	1:50	KPB
	Figure No. 15.116.BH102	

A F Howland Associates
Geotechnical Engineers

Site	51 CALTHORPE STREET, LONDON WC1X 0HH	**Borehole Number**	**BH102**
Installation Type Single Installation	**Dimensions** Internal Diameter of Tube [A] = 50 mm	**Client** Mr Simon Firth	**Job Number** 15.116
Location 530923 E 182477 N	**Ground Level (mOD)** 15.39	**Engineer** Create Consulting Engineers Limited	**Sheet** 1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
			15.19	0.20	Concrete
					Bentonite Seal
			14.39	1.00	
	▼1				Topfill
			9.39	6.00	
	∇1				Bentonite Seal
			8.39	7.00	
					Slotted Standpipe
			7.39	8.00	
					Bentonite Seal
			6.39	9.00	
					General Backfill
			-1.61	17.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
16/11/15	1600	6.40	6.00	Medium	6.40	5.80	4.90	4.20	NOT

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
16/11/15							6.45	6.00	4.25	11.14
17/11/15		6.45	6.00	4.25	11.14		17.00	9.00		

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
23/11/15	14:00	4.52	10.87	
08/12/15		4.56	10.83	Taken by Create Consullting

Remarks

A F Howland Associates
Geotechnical Engineers

Site	Borehole Number
51 CALTHORPE STREET, LONDON WC1X 0HH	BH103

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Demountable Cable Percussion Drilling Rig	200mm cased to 9.00m 150mm cased to 20.00m open hole to 22.52m	18.27	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530942 E 182465 N	19/11/2015- 23/11/2015	Create Consulting Engineers Limited	1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(0.30)	MADE GROUND (Dark brown very sandy very gravelly clayey fill. Angular to subangular fine to coarse flint, brick,, concrete, charcoal and ceramic. Occasional angular cobble sized brick fragments)		
0.30-0.50	B1				17.97	0.30			
0.50-1.20	B2					(1.00)	MADE GROUND (Dark brown very sandy very gravelly clayey fill. Angular to subangular fine to coarse flint, brick,, concrete, charcoal and ceramic. Occasional angular cobble sized brick fragments)		
1.20-1.65 1.20-1.70	SPT(C) N=6 B3	1.20	DRY	1,1/1,1,2,2	16.97	1.30	MADE GROUND (Very soft brown sandy very gravelly clay fill. Gravel is angular to subangular fine to coarse flint, brick, concrete, charcoal and clinker)		
2.00-2.45 2.00-2.50	SPT(C) N=3 B4	2.00	DRY	1,0/1,0,1,1					
						(2.80)			
3.00-3.45 3.00-3.50	SPT(C) N=7 B5	3.00	DRY	1,1/1,2,2,2					
4.00-4.45 4.00-4.50	SPT(C) N=7 B6	4.00	DRY	1,1/1,2,2,2	14.17	4.10	MADE GROUND (Very soft brown and greyish brown mottled sandy gravelly clay. Gravel is angular to rounded fine to coarse flint, chalk, concrete, brick and charcoal)		
						(0.90)			
5.00-5.50	B7			19/11/2015:	13.27	5.00	MADE GROUND (Very soft brown grey and green mottled silty slightly gravelly clay. Gravel is angular to subangular fine to medium brick, flint and concrete. Organic odour possible reworked Alluvium?)		
5.00-5.45	SPT(C) N=2	5.00	DRY	20/11/2015: 1,0/1,0,0,1		(0.80)			
					12.47	5.80 (0.20)	MADE GROUND (very soft black silty slightly sandy very gravelly clay. Gravel is angular to subangular fine to coarse brick and flint)		
6.00-6.45 6.00-6.50	SPT(C) N=3 B8	6.00	DRY	1,1/1,0,1,1	12.27	6.00	MADE GROUND (Very soft black slightly silty slightly sandy slightly gravelly clay with an organic odour. Gravel is angular to subangular fine to coarse flint and brick)		
						(1.50)			
7.50-7.95 7.50-8.00	SPT(C) N=10 B9	7.50	DRY	1,1/2,2,3,3	10.77	7.50	Firm black and grey mottled slightly silty slightly sandy slightly gravelly CLAY with an organic odour. Gravel is angular to sub angular fine to coarse flint, brick and ceramic) (possible that brick and ceramic could be present due to drilling action)		
						(1.50)			
9.00-9.45 9.00-9.50	SPT(C) N=10 B10	9.00	DRY	1,1/2,2,3,3	9.27	9.00 (0.50)	Firm greyish brown and black mottled silty very sandy slightly gravelly CLAY with thin layers of soft to firm brown and black mottled slightly silty CLAY. Gravel is angular to rounded fine to coarse flint and rare brick (possible made ground - rare brick may have been pushed down from above)		
9.50-9.80	B11				8.77	9.50 (0.30)			
9.80	D1				8.47	9.80	Black slightly sandy angular to rounded flint GRAVEL		

Remarks
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 1.20 m.
3. Groundwater struck at 11.80 m and rose to 11.80 m in 5 mins., 11.70 m in 10 mins., 11.60 m in 15 mins. and 20 mins.
4. Water added from 13.00 m to 15.70 m approx 2000 litres, 15.70 m to 20.00 m approx 2000 litres
5. Slotted Standpipe installed to 19.00 m.
6. SPT Hammer Energy Ratio = 72%
7. BH progressed by continuous CPT from 20.00 m to 22.52 m.
8. On extraction of continuous CPT Grey Clay was observed on the CPT shaft.

Scale (approx)	Logged By
1:50	KPB
Figure No.	
15.116.BH103	

A F Howland Associates Geotechnical Engineers	Site: 51 CALTHORPE STREET, LONDON WC1X 0HH	Borehole Number: BH103

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Demountable Cable Percussion Drilling Rig	200mm cased to 9.00m 150mm cased to 20.00m open hole to 22.52m	18.27	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530942 E 182465 N	19/11/2015-23/11/2015	Create Consulting Engineers Limited	2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Water
10.00-10.45	U1	10.00	DRY	32 blows			Firm grey and green grey mottled silty very sandy CLAY with occasional roots and rare angular to subangular fine to coarse flint gravel	
10.50-10.95 10.50 10.50-11.00	SPT N=7 D2 D3	10.00	DRY	1,1/1,2,2,2		(2.00)		
11.80	D4			Slow(1) at 11.80m, rose to 11.60m in 20 mins, not sealed.	6.47	11.80 (0.20)	Firm orange brown and brown mottled silty very sandy CLAY	▼1 ▽1
12.00 12.00-12.50 12.00-12.45	D5 B12 SPT N=11	12.00	11.60	0,1/2,2,3,4	6.27	12.00	Medium dense orange brown silty fine to coarse SAND with occasional angular to subangular fine to medium flint gravel	
						(2.00)		
13.50-13.95 13.50 13.50-14.00	SPT N=37 D6 B13	13.50	10.10	2,3/5,9,11,12				
					4.27	14.00	Medium dense brown slightly silty slightly gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse flint	
						(2.00)		
				20/11/2015:4.50m 23/11/2015:7.03m	2.27	16.00	Medium dense brown sandy angular to rounded fine to coarse flint GRAVEL	
16.50-17.00	B14							
						(1.80)		
17.00-17.45 17.00-17.50	SPT(C) N=6 B18	17.00	4.00	0,1/1,1,2,2				
					0.47	17.80	Medium dense brown fine to coarse SAND with rare angular to rounded fine to coarse flint gravel. Occasional thin gravel bands	
18.50-18.95 18.50-1.95	SPT N=15 D7	18.50	4.00	1,1/2,3,4,6				
19.80-20.30 20.00-20.45	B16 SPT(C) N=11	20.00	4.00	0,0/2,3,2,4				

Remarks
Water added from 13.00m to 15.70m. Water added from 15.70m to 20.00m.

Scale (approx)	Logged By
1:50	KPB

Figure No. 15.116.BH103

A F Howland Associates Geotechnical Engineers			Site 51 CALTHORPE STREET, LONDON WC1X 0HH	Borehole Number BH103
Boring Method Demountable Cable Percussion Drilling Rig	Casing Diameter 200mm cased to 9.00m 150mm cased to 20.00m open hole to 22.52m	Ground Level (mOD) 18.27	Client Mr Simon Firth	Job Number 15.116
	Location 530942 E 182465 N	Dates 19/11/2015-23/11/2015	Engineer Create Consulting Engineers Limited	Sheet 3/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(4.25)			
20.45-20.90	SPT(C) N=32	20.00	4.00	5,7/9,9,7,7					
20.90-21.35	SPT(C) N=49	20.00	4.00	7,6/10,10,15,14					
21.35-21.80	SPT(C) N=77	20.00	4.00	14,16/24,18,19,16					
21.80-22.25	SPT(C) N=113	20.00	4.00	15,21/23,25,33,32					
22.05-22.50	D8				-3.78	22.05 (0.47)	Grey slightly silty slightly sandy CLAY		
				23/11/2015:4.00m	-4.25	22.52	Complete at 22.52m		

Remarks	Scale (approx)	Logged By
	1:50	KPB
	Figure No. 15.116.BH103	

A F Howland Associates
Geotechnical Engineers

Site	Borehole Number
51 CALTHORPE STREET, LONDON WC1X 0HH	BH103

Installation Type	Dimensions	Client	Job Number
Single Installation	Internal Diameter of Tube [A] = 50 mm	Mr Simon Firth	15.116

Location	Ground Level (mOD)	Engineer	Sheet
530942 E 182465 N	18.27	Create Consulting Engineers Limited	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
			18.07	0.20	Concrete
					Bentonite Seal
			17.27	1.00	
					Topfill
			7.27	11.00	
	▼1 ▽1				Bentonite Seal
			6.27	12.00	
					Slotted Standpipe
			-0.73	19.00	
					Gravel Filter
			-1.73	20.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
20/11/15		11.80	11.50	Slow	11.80	11.70	11.60	11.60	NOT

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
19/11/15							5.00	4.50		
20/11/15		5.00	4.50				15.70	15.50	4.50	13.77
23/11/15		15.70		7.03	11.24		22.52	20.00	4.00	14.27

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	
24/11/15	11:35	7.30	10.97	
08/12/15		7.42	10.85	Taken by Create Consulting

Remarks

APPENDIX C: TRIAL PIT RECORDS

Trial Pits TP101 to TP103 from the current investigation

B	Bulk disturbed sample
D	Small disturbed sample
W	Water sample
U	Nominal 38mm diameter undisturbed driven open tube sample
P	Hand penetrometer test
V	Pilcon hand vane test (results in kPa)

Each sample type is numbered sequentially with depth and relates to the depth range quoted

All depths and measurements are given in metres

Strata descriptions complied by visual examination of samples obtained during excavation, after BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930: 2015 and modified in accordance with laboratory test results where applicable

A F Howland Associates Geotechnical Engineers			Site 51 CALTHORPE STREET, LONDON WC1X 0HH	Trial Pit Number **TP101**
Excavation Method Hand dug inspection pit	**Dimensions** 0.75m x 0.40 m x 0.85 m	**Ground Level (mOD)** 15.18	**Client** Mr Simon Firth	**Job Number** 15.116
	Location 530926 E 182461 N	**Dates** 16/11/2015	**Engineer** Create Consulting Engineers Limited	**Sheet** 1/1

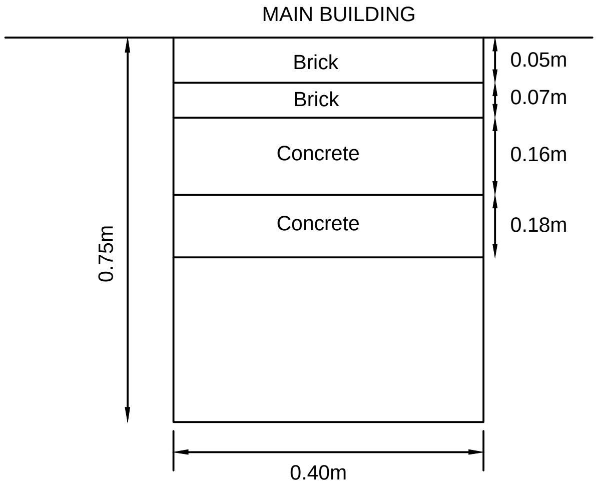
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				15.13	0.05	MADE GROUND (Concrete slab)		
				15.08	0.10	MADE GROUND (Weak mix concrete base)		
0.20-0.30	D1					MADE GROUND (Brown very clayey very sandy very gravelly mixed fill. Gravel is angular to subangular fine to coarse brick, concrete, clinker and flint. Occasional angular cobble sized brick fragments)		
					(0.75)			
0.70-0.85	B1							
				14.33	0.85	Complete at 0.85m		

Remarks

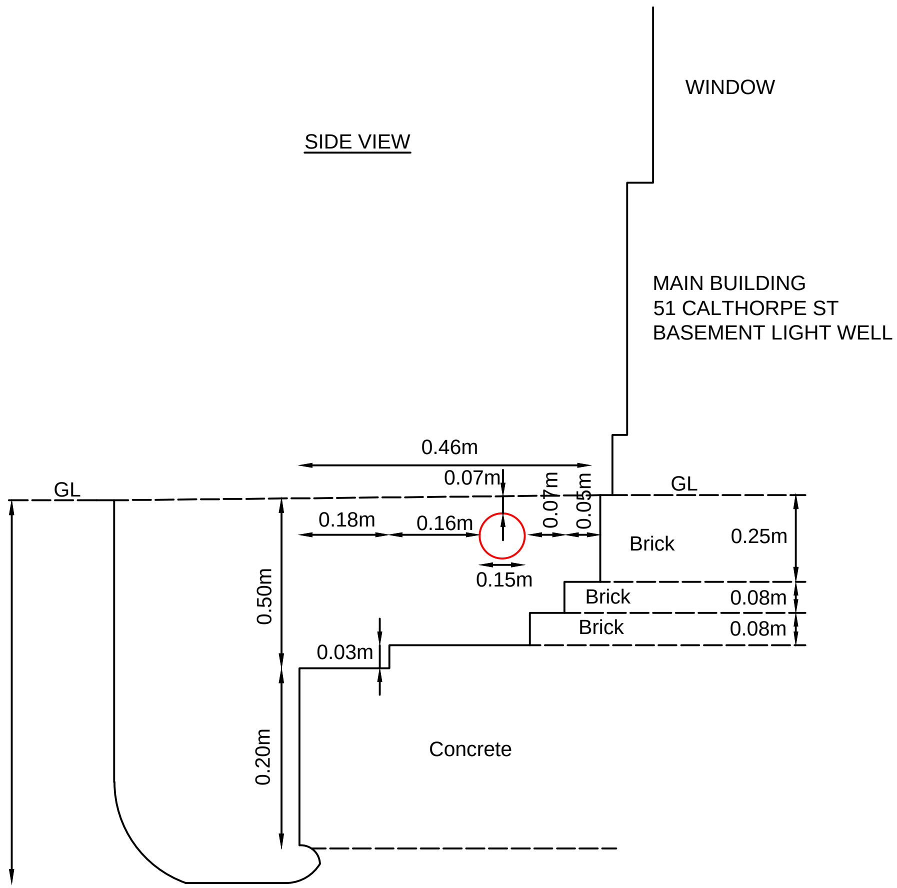
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 0.85 m.
3. No groundwater encountered
4. 150mm diameter clay pipe encountered at 0.07 mbgl

Scale (approx)	Logged By	Figure No.
1:20	KPB	15.116.TP101

PLAN VIEW



SIDE VIEW



KEY

150mm dia clay pipe

Not to Scale at A4

A F Howland Associates
Geotechnical Engineers

Site:	51 CALTHORPE STREET, LONDON WC1X 0HH
	FOUNDATION PIT (TP101)
Client :	Mr Simon Firth
Date :	January 2016
Dwg :	15.116/TP101

A F Howland Associates
Geotechnical Engineers

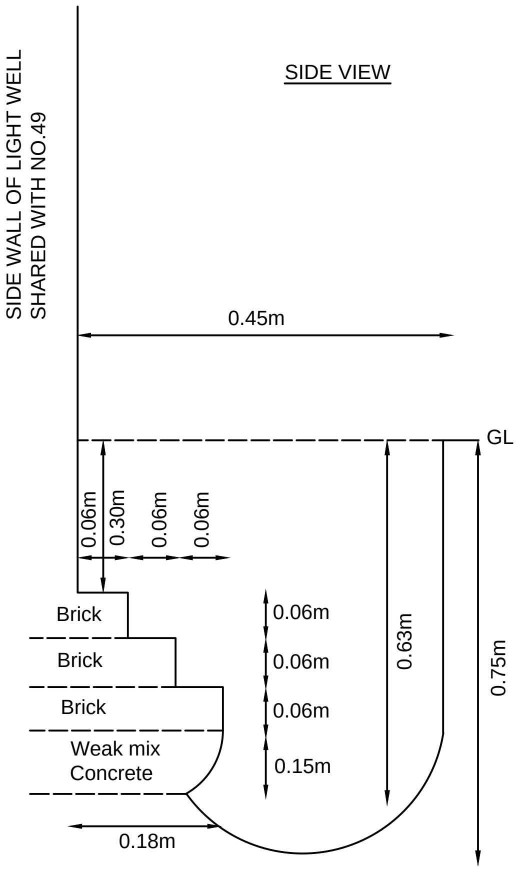
Site	Trial Pit Number
51 CALTHORPE STREET, LONDON WC1X 0HH	TP102

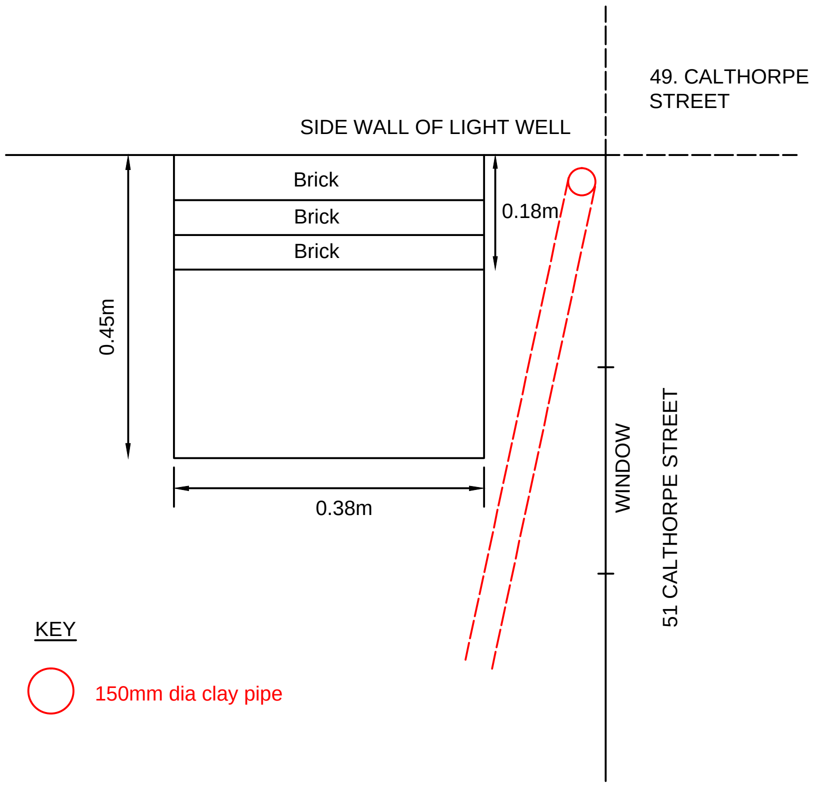
Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Hand dug inspection pit	0.45 m x 0.38 m x 0.75 m	15.18	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530925 E 182461 N	16/11/2015	Create Consulting Engineers Limited	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				15.13	0.05	MADE GROUND (Concrete slab)		
					(0.70)	MADE GROUND (Brown very clayey very sandy very gravelly mixed fill. Gravel is angular to rounded fine to coarse flint, brick, concrete and occasional charcoal and clinker. Occasional angular cobble sized brick fragments)		
0.63-0.75	D1			14.43	0.75			
						Complete at 0.75m		

Remarks

Scale (approx)	Logged By	Figure No.
1:25	KPB	15.116.TP102





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A F Howland Associates
Geotechnical Engineers

Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

FOUNDATION PIT (TP102)

Client : Mr Simon Firth

Date : January 2016 **Dwg :** 15.116/TP102

A F Howland Associates
Geotechnical Engineers

Site	Trial Pit Number
51 CALTHORPE STREET, LONDON WC1X 0HH	TP103

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Hand dug inspection pit	0.60 m x 0.85 m x 1.21 m		Mr Simon Firth	15.116
	Location	**Dates** 19/11/2015	**Engineer** Create Consulting Engineers Limited	**Sheet** 1/1

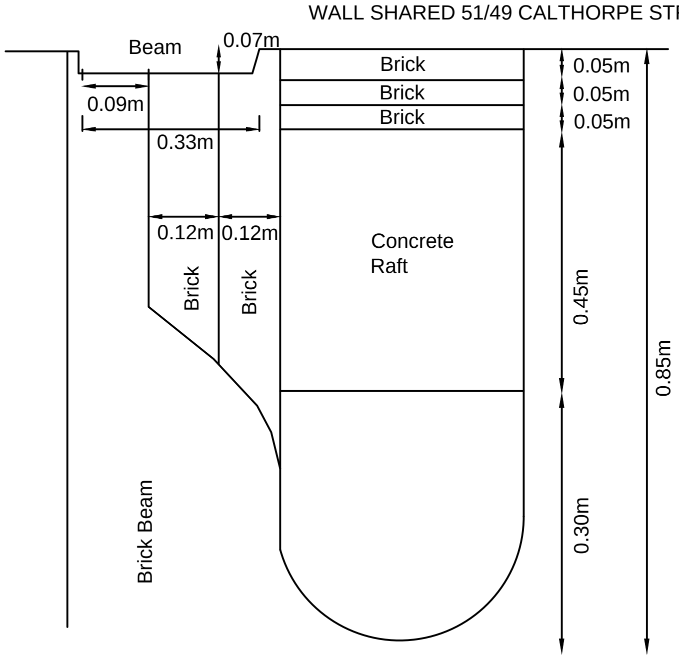
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.03	MADE GROUND (Screed concrete)		
					(0.12) 0.15	MADE GROUND (Concrete)		
0.30-0.50	D1				(1.06)	MADE GROUND (Dark brown clayey sandy gravelly mixed fill. Gravel is angular to subrounded fine to coarse flint, concrete, brick, charcoal, ceramic and glass. Occasional angular cobbles sized brick fragments)		
1.10-1.20	D2							
					1.21	Complete at 1.21m		

Remarks

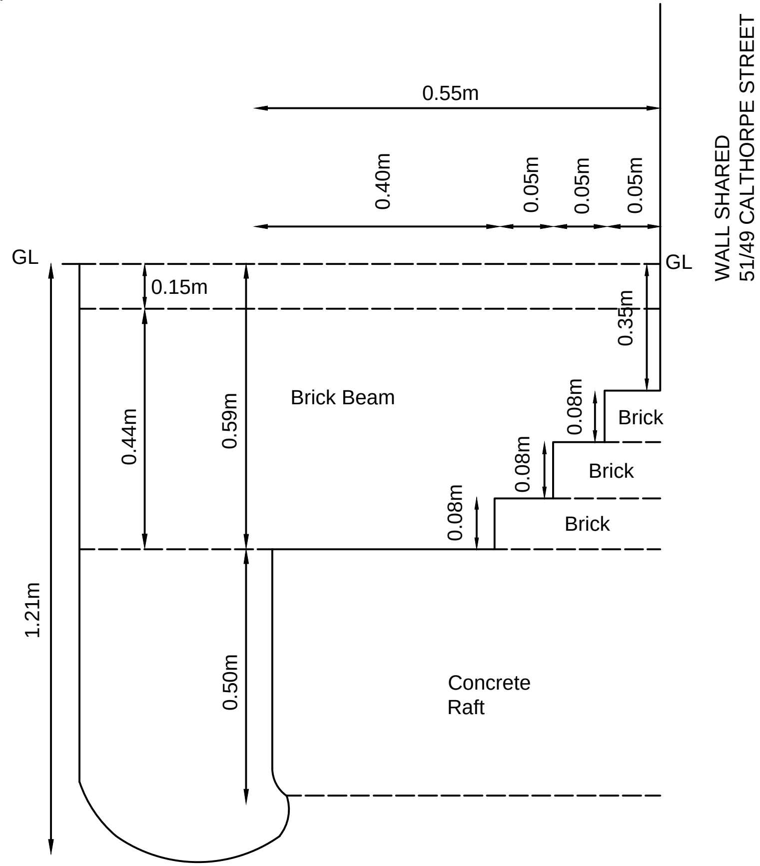
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 1.21 m.
3. No groundwater encountered

Scale (approx)	Logged By	Figure No.
1:25	KPB	15.116.TP103

PLAN VIEW



SIDE VIEW



Not to Scale at A4

A F Howland Associates
Geotechnical Engineers

Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

FOUNDATION PIT (TP103)

Client : Mr Simon Firth

Date : January 2016 **Dwg :** 15.116/TP103

APPENDIX D: WINDOW SAMPLE PROBE HOLE RECORD

Window sample probe WS1 undertaken previously (HGE, 2013)

Groundwater monitored at 4.82 m bgl by Create Consulting Engineers Limited on 8 December 2015 harrisongroup

Window Sample Record

WS1
Sheet 1 of 1

Project: 51 Calthorpe Street

Project ID: GL17050

Coordinates:

Ground Level:

Description	Legend	Depth (m)	O.D. Level (m)	Sample Test Type	Sample Test Depth (m)	Remarks and Test Results	Installations
CONCRETE		0.05					
MADE GROUND. Brown and dark grey mottled grey and red slightly clayey gravelly SAND with low cobble content. Gravel is very angular to subangular brick, concrete, flint, clay pipe, chalk, glass and wood.				B1	0.20-0.50		0.20
				ES1	0.25		
				B2	0.50-1.00		
				ES2	1.00		
At 1.20m: brick cobble							
				ES3	1.50		
				D1	2.00		2.00
From 2.30m to 2.60m: pocket of grey clay with brick fragments				ES4	2.50		
				D2	3.00		
At 3.30m: rare concrete cobble							
From 3.50m to 4.00m: light grey greyish brown clay pockets				ES5	3.50		
MADE GROUND. Dark grey slightly gravelly silty SAND. Gravel is angular to subangular fine and medium flint and brick.		4.00		D3	4.00		
				ES6	4.50		
Window Sample Complete at 5.00 m		5.00		D4	5.00		5.00

Drive Records

Diameter (mm)	From (m)	To (m)	Recovery (%)
87	1.20	2.00	100
75	2.00	3.00	70
65	3.00	4.00	50
55	4.00	5.00	50

Water Level Observations

Date	Water Strike (m)	Standing Time (Mins)	Standing Level (m)	Casing Depth (m)	Depth Sealed (m)

Client: Create Consulting Engineers Limited
Engineer: Harrison Group Environmental Limited
Contractor: Harrison Group Environmental Limited
Date: 11/12/2012
Plant: Premier Window Sampling Rig
Drilled By: P. Kirnig
Logged By: G. Pursey
Checked By: J. Keay

Remarks:
1. Inspection pit excavated from GL to 1.20mbgl.
2. Groundwater was not encountered.
3. Installation details: 50mm diameter HDPE standpipe installed from 5.00mbgl to GL. Slotted from 5.00mbgl to 2.00mbgl, plain from 2.00mbgl to GL. Finished with gas tap, end cap and flush fitting cover.
4. Backfill details: Gravel filter packs from 5.00mbgl to 2.00mbgl, bentonite pellets from 2.00mbgl to 0.20mbgl and concrete from 0.20mbgl to GL.

A F Howland Associates
Geotechnical Engineers

Site	Borehole Number
51 CALTHORPE STREET, LONDON WC1X 0HH	WS1(HARRISON

Installation Type	Dimensions	Client	Job Number
Standpipe		Mr Simon Firth	15.116

Location	Ground Level (mOD)	Engineer	Sheet
	18.19	Create Consulting Engineers Limited	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
			17.99	0.20	Concrete
			16.19	2.00	Bentonite Seal
			13.19	5.00	Slotted Standpipe

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type :

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
08/12/15		4.82	13.37	

Remarks

APPENDIX E: LABORATORY TESTING

Natural moisture content

Atterberg limits

Particle size distribution

Undrained shear strength in triaxial compression without measurement of pore pressure

One dimensional consolidation

Sulphate content, sulphur content and pH value

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

Engineer : Create Consulting Engineers Limited

Job Number 15.116

Sheet 1 / 1

DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX

Borehole/ Trial Pit	Depth (m)	Sample	Natural Moisture Content %	Sample Passing 425µm Sieve Percentage %	Sample Passing 425µm Sieve Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Group Symbol	Laboratory Description
BH102	4.00	B6	29	85	34	39	21	18	0.72	CI	Very soft brownish grey and very dark grey organic slightly gravelly slightly sandy silty CLAY with occasional red brick fragments. Gravel is black and brown fine to coarse angular and subangular flint
BH102	5.50	B7	27	90	30	40	18	22	0.55	CI	Very soft mottled bluish grey and olive slightly gravelly slightly sandy silty CLAY with dark grey organic pockets and rare recently active roots. Gravel is brown, black and white fine to coarse angular and subangular flint
BH102	6.00	U1	21	98	22	43	14	29	0.28	CI	Stiff mottled greyish brown, yellowish brown and light grey gravelly sandy CLAY
BH102	9.00	U2	30	100	30	72	23	49	0.14	CV	Stiff grey CLAY
BH102	11.50	B10	30	100	30	58	21	37	0.24	CH	Grey clay.
BH102	13.00	U4	23	100	23	63	22	41	0.02	CH	Stiff greyish brown CLAY
BH102	15.00	U5	25	100	25	65	26	39	-0.03	CH	Very stiff greyish brown with light grey mottling CLAY
BH103	10.00	U1	27	100	27	36	13	23	0.61	CI	Soft to firm brownish grey CLAY with rare fine sand. Water softening to most of the surface

Method of Preparation : BS 1377:PART 1:1990:7.4 Preparation of samples for classification tests BS 1377:PART 2:1990:4.2 & 5.2 Sample preparations

Method of Test : BS 1377:PART 2:1990:3 Determination of moisture content 1990:4 Determination of the liquid limit BS 1377:PART 2:1990:5 Determination of the plastic limit and plasticity index

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

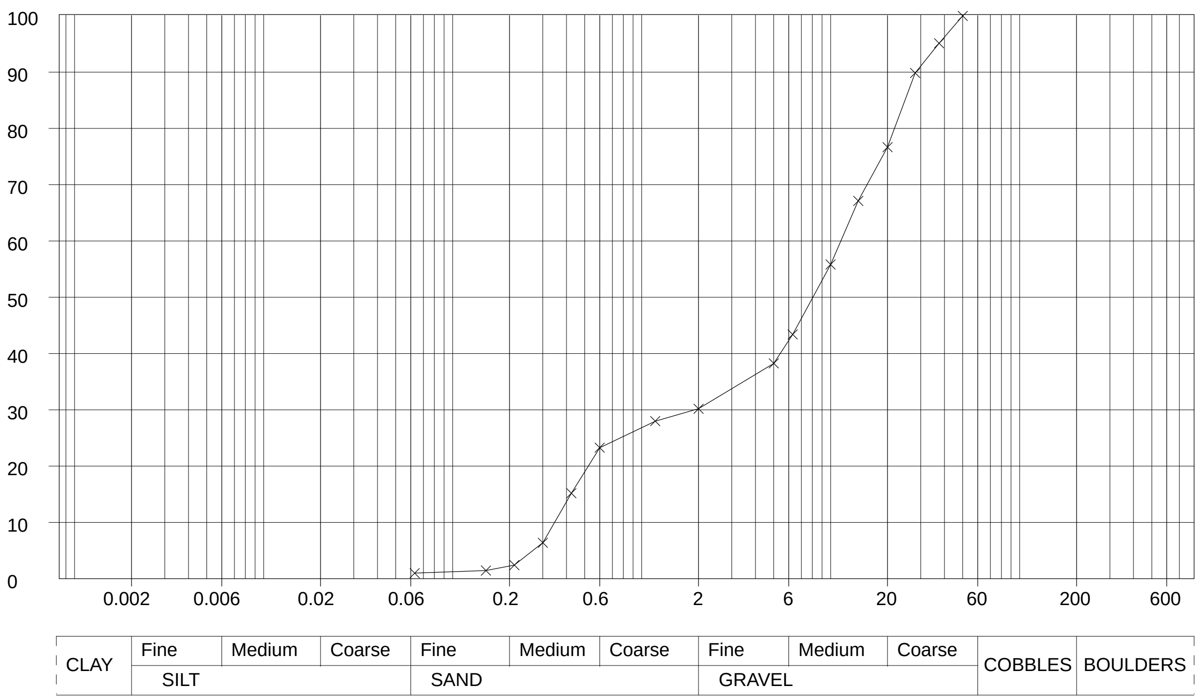
Engineer : Create Consulting Engineers Limited

Job Number 15.116

Sheet 1/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH102	6.50 - 7.00	B8	Black, brown and white slightly silty very sandy angular to rounded flint GRAVEL. Sand is brown



Sieve / Particle Size	% Passing
50 mm	100.0
37.5 mm	95.1
28 mm	89.9
20 mm	76.7
14 mm	67.1
10 mm	55.8
6.3 mm	43.4
5 mm	38.2
2 mm	30.2
1.18 mm	28.0
600 µm	23.3
425 µm	15.2
300 µm	6.4
212 µm	2.4
150 µm	1.4
63 µm	1.0

Grading Analysis	
D85	25.1 mm
D60	11.5 mm
D10	351.4 µm
Uniformity Coefficient	32.7

Particle Proportions	
Cobbles + Boulders	-
Gravel	69.8%
Sand	29.2%
Silt	-
Clay	-

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

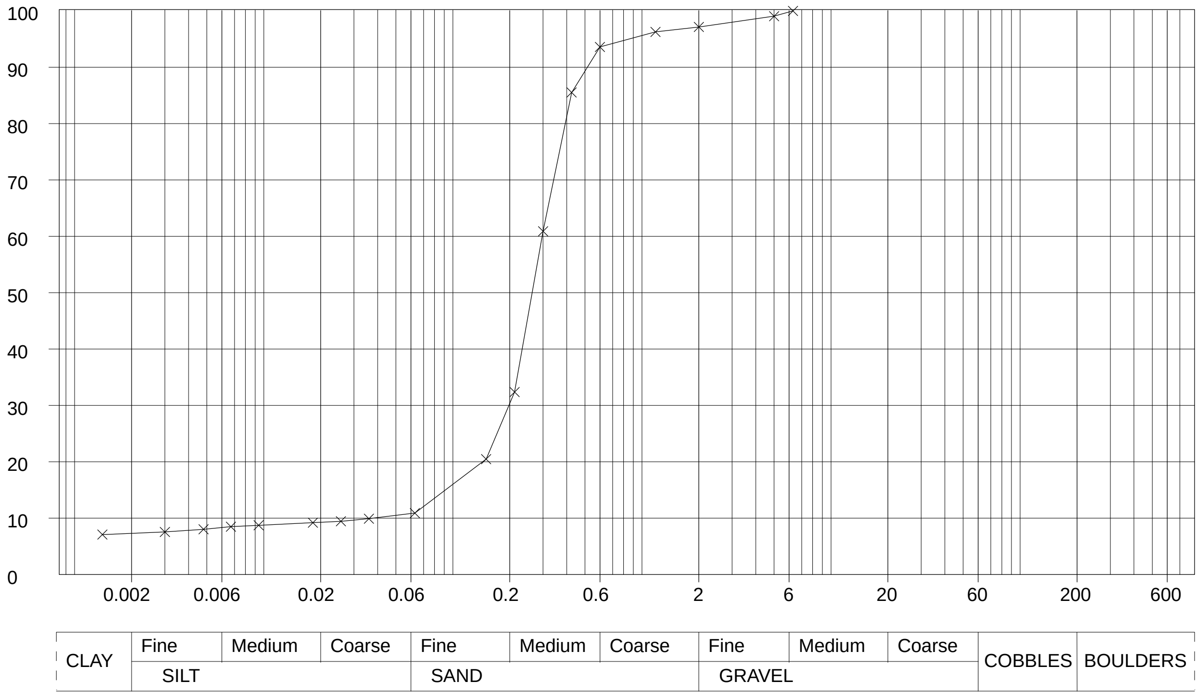
A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH	**Job Number** 15.116
Client : Mr Simon Firth	
Engineer : Create Consulting Engineers Limited	**Sheet** 2/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH103	12.00	B12	Yellowish brown slightly gravelly clayey fine and medium SAND. Gravel is white, brown and grey fine and medium subangular and subrounded



Sieve / Particle Size	% Passing
6.3 mm	100.0
5 mm	99.1
2 mm	97.1
1.18 mm	96.3
600 µm	93.6
425 µm	85.5
300 µm	60.9
212 µm	32.4
150 µm	20.5
63 µm	10.9
36 µm	9.9
25.6 µm	9.4
18.2 µm	9.2
9.4 µm	8.7
6.7 µm	8.5
4.8 µm	8.0
3 µm	7.5
1.4 µm	7.1

Grading Analysis	
D85	422.3 µm
D60	297.2 µm
D10	38.5 µm
Uniformity Coefficient	7.7

Particle Proportions	
Cobbles + Boulders	-
Gravel	2.9%
Sand	86.3%
Silt	3.5%
Clay	7.3%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

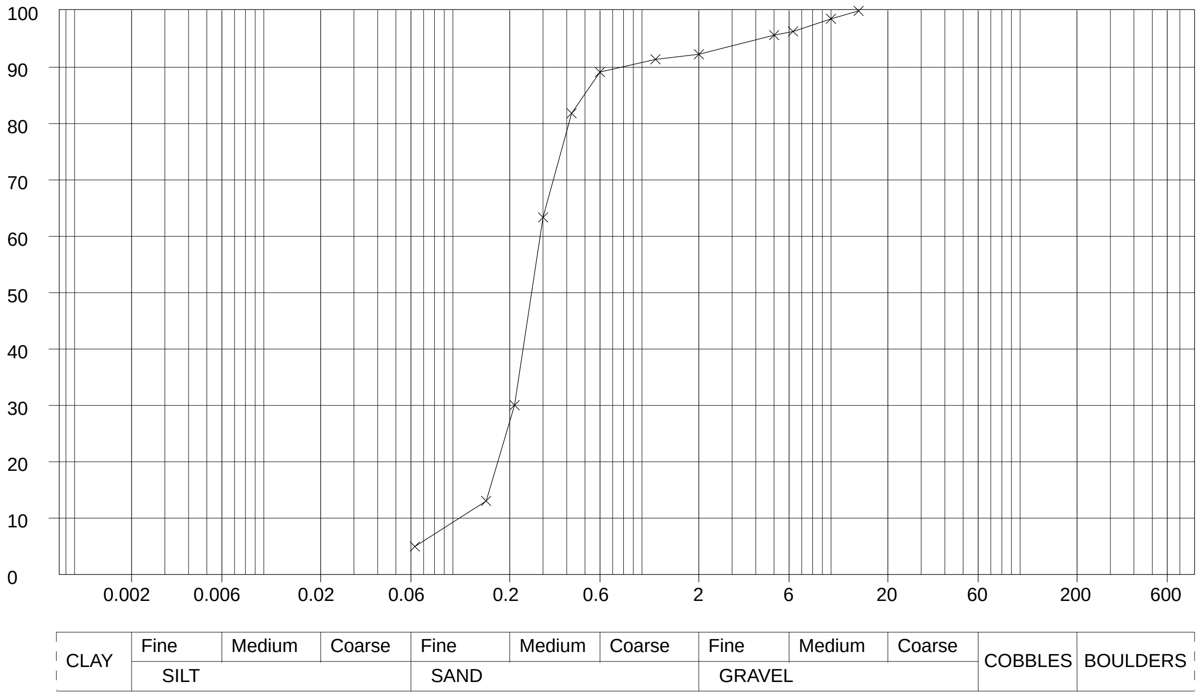
Remarks :

A F Howland Associates Geotechnical Engineers	Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH	**Job Number** 15.116
Client : Mr Simon Firth	**Sheet** 3/5
Engineer : Create Consulting Engineers Limited	

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH103	13.50 - 14.00	B13	Yellowish brown slightly silty gravelly fine and medium SAND with rare soft and firm grey clay lumps. Gravel is black, white and brown fine and medium angular to subrounded



Sieve / Particle Size	% Passing
14 mm	100.0
10 mm	98.6
6.3 mm	96.4
5 mm	95.7
2 mm	92.3
1.18 mm	91.4
600 µm	89.1
425 µm	81.8
300 µm	63.4
212 µm	30.0
150 µm	13.1
63 µm	5.0

Grading Analysis	
D85	500.7 µm
D60	291.1 µm
D10	117.2 µm
Uniformity Coefficient	2.5

Particle Proportions	
Cobbles + Boulders	-
Gravel	7.7%
Sand	87.3%
Silt	-
Clay	-

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

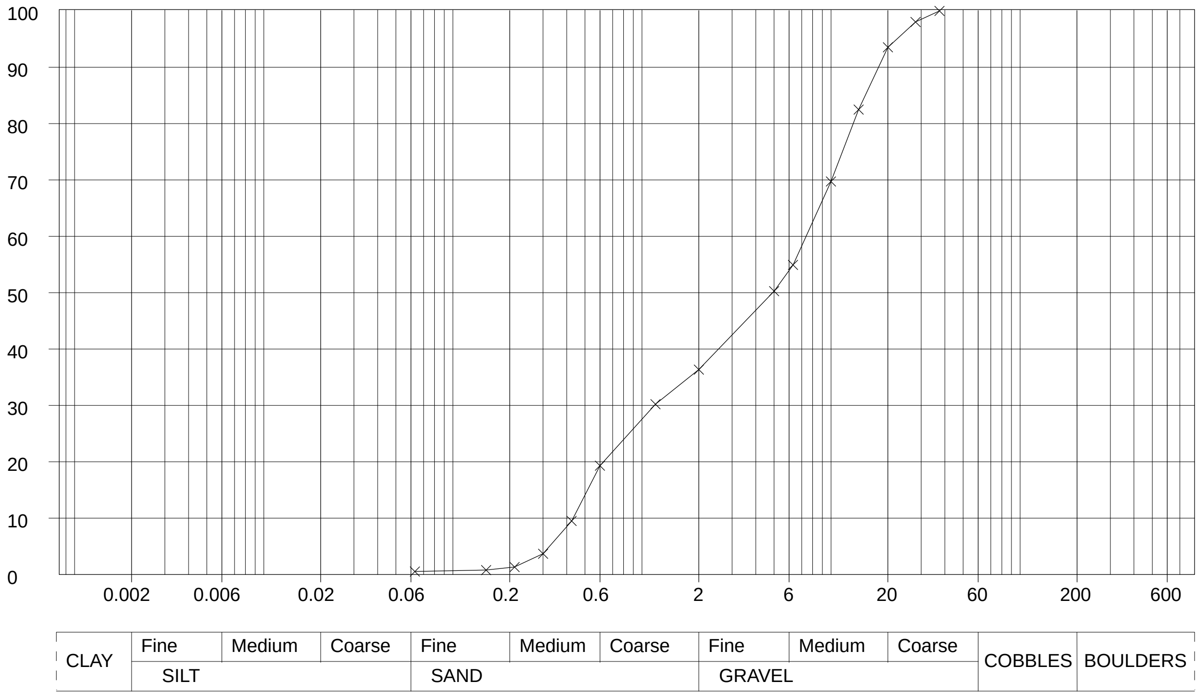
A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH	**Job Number** 15.116
Client : Mr Simon Firth	**Sheet** 4/5
Engineer : Create Consulting Engineers Limited	

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH103	16.50 - 17.00	B14	Black, brown, grey and white very sandy fine to coarse angular to subrounded GRAVEL. Sand is orangey brown medium and coarse



Sieve / Particle Size	% Passing
37.5 mm	100.0
28 mm	98.0
20 mm	93.5
14 mm	82.5
10 mm	69.7
6.3 mm	54.9
5 mm	50.3
2 mm	36.4
1.18 mm	30.2
600 µm	19.3
425 µm	9.5
300 µm	3.7
212 µm	1.3
150 µm	0.8
63 µm	0.5

Grading Analysis	
D85	15.4 mm
D60	7.6 mm
D10	433.9 µm
Uniformity Coefficient	17.4

Particle Proportions	
Cobbles + Boulders	-
Gravel	63.6%
Sand	35.8%
Silt	-
Clay	-

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

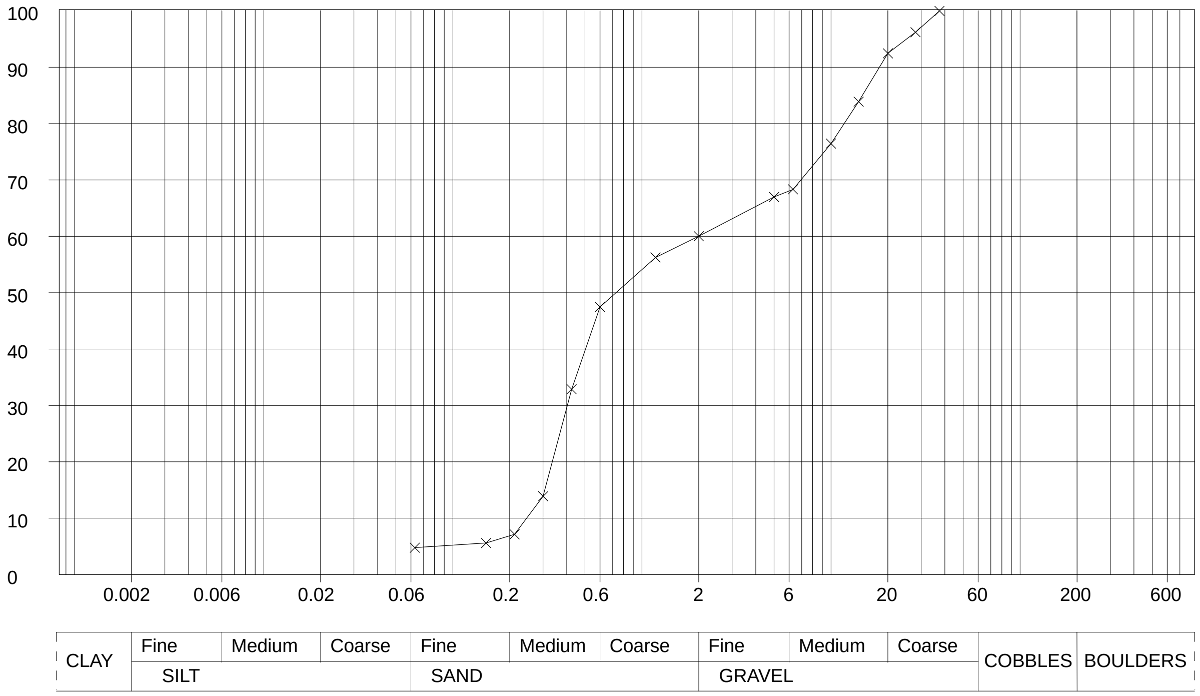
A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH	**Job Number** 15.116
Client : Mr Simon Firth	**Sheet** 5/5
Engineer : Create Consulting Engineers Limited	

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH103	19.80 - 20.00	B16	Brown slightly silty very gravelly SAND with occasional soft brown clay lumps. Gravel is black, brown, grey and white fine to coarse angular to rounded



Sieve / Particle Size	% Passing
37.5 mm	100.0
28 mm	96.2
20 mm	92.5
14 mm	83.9
10 mm	76.5
6.3 mm	68.3
5 mm	67.0
2 mm	60.0
1.18 mm	56.3
600 µm	47.5
425 µm	32.9
300 µm	13.9
212 µm	7.1
150 µm	5.6
63 µm	4.8

Grading Analysis	
D85	14.8 mm
D60	2.0 mm
D10	249.5 µm
Uniformity Coefficient	8.0

Particle Proportions	
Cobbles + Boulders	-
Gravel	40.0%
Sand	55.3%
Silt	-
Clay	-

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

Engineer : Create Consulting Engineers Limited

Job Number 15.116

Sheet 1 / 1

DETERMINATION OF DENSITY, MOISTURE CONTENT AND UNDRAINED SHEAR STRENGTH IN TRIAXIAL COMPRESSION WITHOUT MEASUREMENT OF PORE PRESSURE

Borehole/ Trial Pit	Depth (m)	Sample	Moisture Content %	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Cell Pressure (kN/m^2)	Deviator Stress (kN/m^2)	Apparent Cohesion (kN/m^2)	Angle of Shearing Resistance (degrees)	Laboratory Description
BH102	6.00	U1	21	2.02	1.66	60 120	115 121	51	2.7	Stiff mottled greyish brown, yellowish brown and light grey gravelly sandy CLAY
BH102	13.00	U4	23	2.12	1.73	130 260 520	184 187 190	90	0.5	Stiff greyish brown CLAY
BH102	15.00	U5	25	2.06	1.64	150 300 600	182 191 226	78	3.8	Very stiff greyish brown with light grey mottling CLAY
BH103	10.00	U1	27	2.08	1.63	100	21	10		Soft to firm brownish grey CLAY with rare fine sand. Water softening to most of the surface

Method of Preparation : BS 1377:PART 1:1990:7.4.2 Moisture content 1990: Preparation of undisturbed samples for testing BS 1377:PART 2:1990:7.2

Method of Test : BS 1377:PART 2:1990:3 Determination of moisture content 1990:7 Determination of density BS 1377:PART 7:1990:8 Undrained shear strength 1990:9 Multistage loading

Remarks :

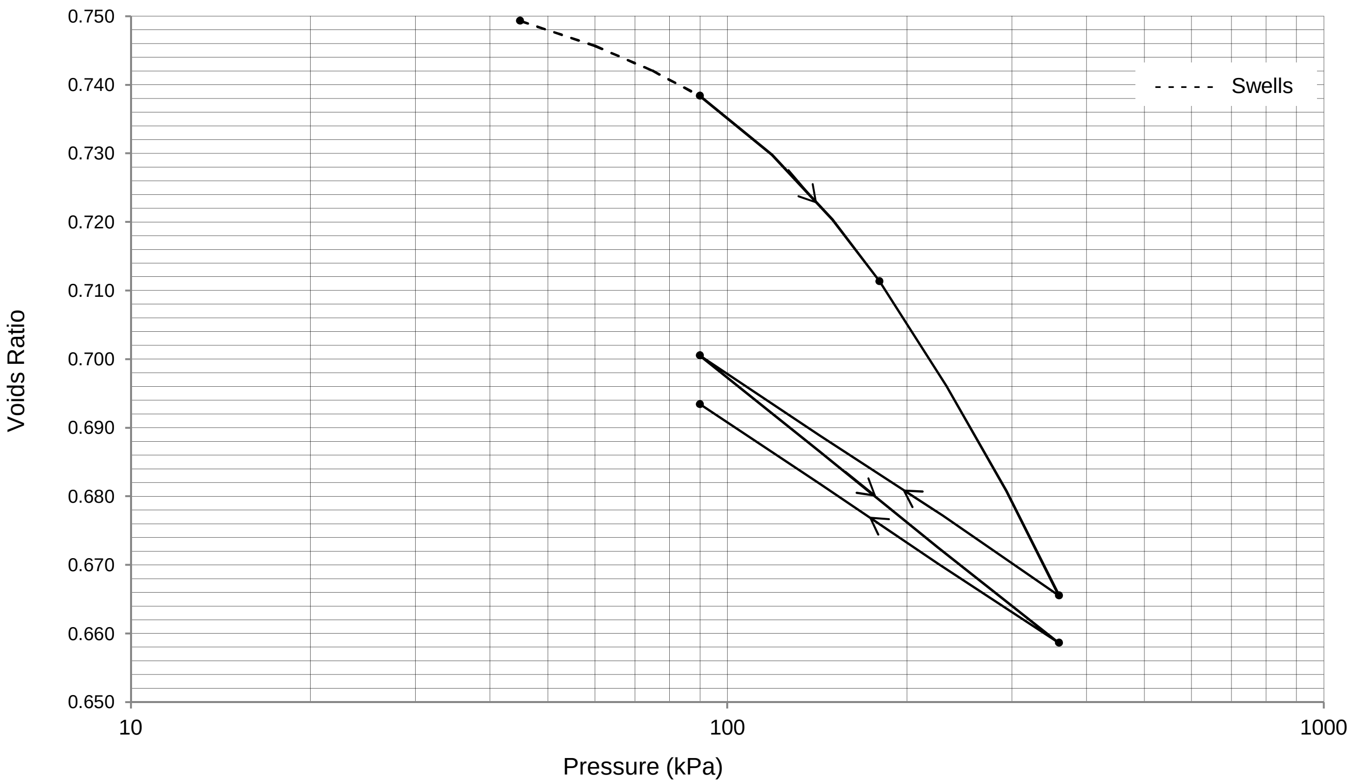
BS1377 : Part 5 : Clause 3 : 1990

Determination of One Dimensional Consolidation Properties of Soil

Borehole No.:	BH102
Sample Ref.:	U2
Depth (m):	9.00
Depth within original:	9.15
Orientation within original:	Vertical
Specimen preparation:	Undisturbed

Description:

Stiff grey CLAY



Initial Conditions:

						Initial
Height	(mm)	18.3	Moisture Content	(%)		30
Diameter	(mm)	76.2	Voids Ratio			0.754
Area	(mm²)	4556.8	Bulk Density	(Mg/m³)		2.00
Volume	(cm³)	83.4	Dry Density	(Mg/m³)		1.54
Laboratory Temperature	(ºC)	20	Particle density	(Mg/m³)		2.7 (Assumed)

Pressure Range (kPa)	m_v (m²/MN)	c_v (m²/year)	Time Fitting Method	Void Ratio
0 - 45	-	Specimen swelled	-	0.749
45 - 90	0.14	1.2	t50	0.738
90 - 180	0.17	0.40	t50	0.711
180 - 360	0.15	0.33	t50	0.666
360 - 90	0.078	0.32 (Sv)	t50	0.701
90 - 360	0.091	0.57	t50	0.659
360 - 90	0.078	0.32 (Sv)	t50	0.693

Checked and Approved by

JS

J Sturges (Ops Mgr)

Date: 21/12/2015

Project Number:

GEO / 23461

Project Name:

51 Calthorpe Street, London WC1X 0HH

Project Ref.: 15.118

GEOLABS®

UKAS TESTING 1982

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

Engineer : Create Consulting Engineers Limited

Job Number 15.116

Sheet 1 / 1

DETERMINATION OF pH, SULPHATE CONTENT AND TOTAL SULPHUR OF SOIL AND GROUNDWATER

Borehole/ Trial Pit	Depth (m)	Sample	Concentration of Soluble Sulphate			Total Sulphur %	Percentage of sample passing 2mm Sieve %	pH	Classification	Laboratory Description
			Soil		Groundwater g /l					
			Total S04 %	S03 in 2:1 water:soil g /l						
BH102	3.50	B5		0.33		0.38		7.2	DS-1	Brown loam and clay.
BH102	4.50	W1			0.13			7.2	DS-1	Water Sample
BH102	5.50	B7	0.04	0.15		0.03		7.5	DS-1	Very soft mottled bluish grey and olive slightly gravelly slightly sandy silty CLAY with dark grey organic pockets and rare recently active roots. Gravel is brown, black and white fine to coarse angular and subangular flint
BH102	9.50	D5	0.14	0.77		0.83		7.7	DS-2	Grey clay and sand.
BH102	11.50	B10	0.09	0.69		0.42		7.7	DS-2	Grey clay.
BH102	15.50	D11	0.03	0.16		0.03		8.4	DS-1	Brown clay.
BH103	5.00	B7	0.15	0.67		0.14		7.3	DS-2	Grey clay and loam.
BH103	6.00	B8	0.21	0.61		0.40		7.3	DS-2	Grey loam and clay.
BH103	10.50	D3	0.06	0.38		0.26		7.5	DS-1	Grey clay and sand.

Method of Preparation : BS 1377:PART 1:1990:7.5 Preparation of soil for chemical tests BS 1377:PART 3:1990:5.2, 5.3, 5.4 & 9.4

Method of Test : Laboratory in-house methods based on BS1377: Part 3 for contents of water soluble sulphate, total sulphate and pH. Laboratory in-house method based on MEWAM (Environment Agency, 2006) for total sulphur

Remarks : Classification relates to Design Sulphate Class of BRE Special Digest 1 (2005)

APPENDIX F: PERTINENT EXTRACT FROM BERRY (1979)

was probably formed before the diminutive drainage line of the historical river was established.

5*a* *Gray's Inn Road, Calthorpe Street.* (Fig. 16; Anonymous, 1928; IGS Internal Report PD 69/9, 1969; Wakeling & Jennings 1976; TWA Drawings XH17.) This hollow was discovered during tunnelling works for the Post Office railway beneath Mount Pleasant sorting office and Calthorpe Street in 1915–16, when disturbed solid strata (Reading Beds) and water-saturated gravels were encountered, leading to a run-in. The hollow was not apparent from the line surveys. It is bisected by a ridge or pinnacle of solid strata, through which one access shaft (Shaft 4) was sunk. Three separate records refer to the strata encountered here as 'mottled clay', 'brown clay', or 'blue clay', but the deposit is likely to be entirely Reading Beds. Two separate records of the tunnel have been combined to produce the annexed section of the hollow (Fig. 17).

This large feature was encountered again during site investigation for the 'Times' new building, (known as 'New Printing House Square') from 1969 to 1971, on the south side of Calthorpe Street, where trial holes showed the extent of the hollow and later excavations for a deep basement provided extensive sections and opportunities for sampling.

Contouring suggests a major hollow about 305 m across from north-east to south-west. The feature obviously extends to the north-western side of Calthorpe Street, but there is no data available in that area. The hollow lies within a slight channel-like depression, apparently cut into the western margin of the well-developed bench at about 13.5 m OD which extends across Islington and Hackney towards the Lee Valley. The Fleet and a smaller tributary have re-excavated some of this sub-drift topography in more recent times.

There are marked differences in fill between the two lobes of the hollow. In the western half, a gravel layer

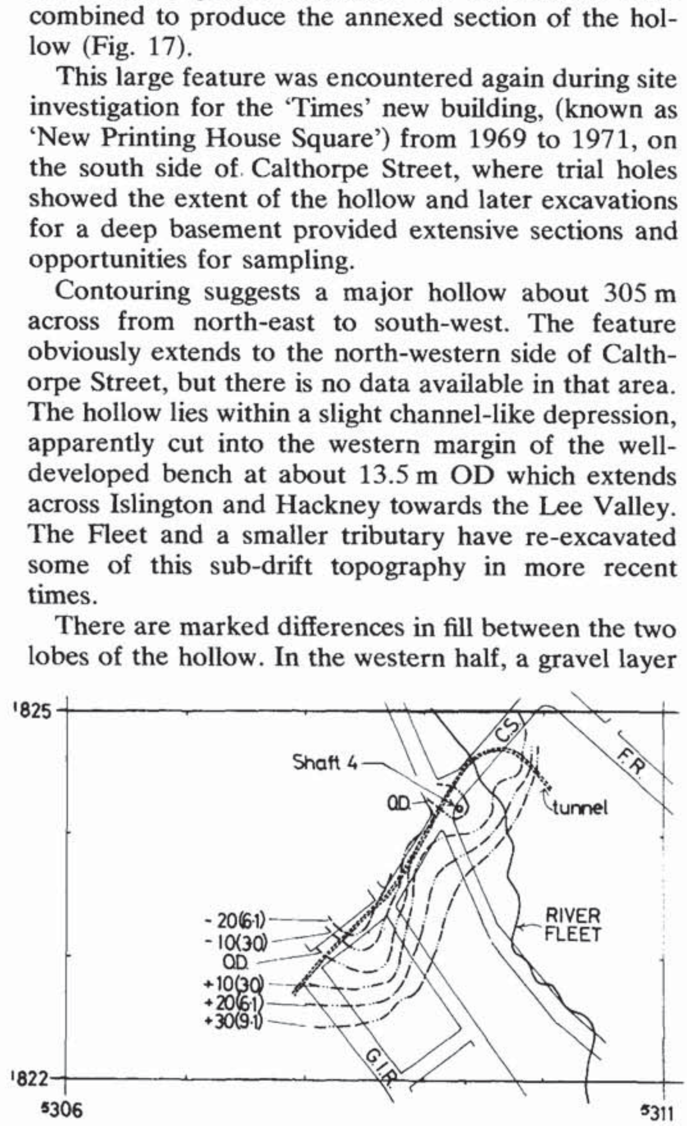


FIG. 16. Grey's Inn Road–Calthorpe Street (5*a*) GIR = Grey's Inn Road; CS = Calthorpe Street; FR = Farringdon Road. Based on 25 borehole records and numerous tunnel levels.

of variable thickness underlies a thick lens of well laminated, silty, fine-grained deposits (the 'black deposit' of the TWA drawing) which form the basal lining of the hollow, and gravels lie within or above this material. The historical course of the Fleet crosses the eastern lobe and it might be thought that the differences were due to stream development of more recent times. However, the Fleet is known to be graded in this stretch to a base level of about 5.2 m OD and seems unlikely to have achieved the capacity for extensive vertical scour.

Samples from the laminated clayey silts obtained from the 'Times' building excavations were found to contain a freshwater fauna of Mollusca and Ostracoda, also fragmentary mosses and seeds of aquatic and marsh-frequenting angiosperms and the oogonia of a freshwater alga (*Chara*). The matrix was found to be heavily over-consolidated and much fissured, generally resembling, in both hand-specimen and thin section, some parts of the London Clay. It also contained derived London Clay and Chalk foraminifers. Therefore it is not, perhaps, surprising that the deposits have been variously attributed in unpublished accounts and communications to the Tertiary system, the underlying beds of gravel being thought of as Blackheath Beds; they have also been classified, rather loosely, as Fleet River deposits and, from the testimony of the rather catholic species of Ostracoda present, as Recent. At one stage, the whole feature was regarded as a 'land slip', although the nature and location of the material supposed to be slipping were not defined. Among the Mollusca, however, are two species of small bivalves or 'pea-mussel' now extinct in Britain (*Pisidium vincentianum* Woodward, *and P. obtusale lapponicum* Clessin) which are characteristic of the older Pleistocene and generally colder conditions. There can be no doubt that the sediments aggrading the hollow are of Pleistocene age and, as they are unlikely to be younger than the adjacent and next lower terrace bench (Upper Floodplain Terrace), are probably pre-Devensian, and earlier than Last Interglacial.

The levels of the London Clay/Woolwich & Reading Beds junction are locally rather variable, but rise towards the eastern margin of the hollow. Scouring has removed the London Clay over much of the area of the hollow and it marks a local and unmapped inlier of Reading Beds.

6 Ravensbourne

The rock-head features and the erosional history of the lower part of the Ravensbourne valley are not at all well known. The broad tract of drift above Catford conceals two bench features, but there is no evidence that these are dissected by the kind of extended channels or scoops which mark some of the principal terraces in central London. Channels however, begin to appear further downstream at Rushey Green, but

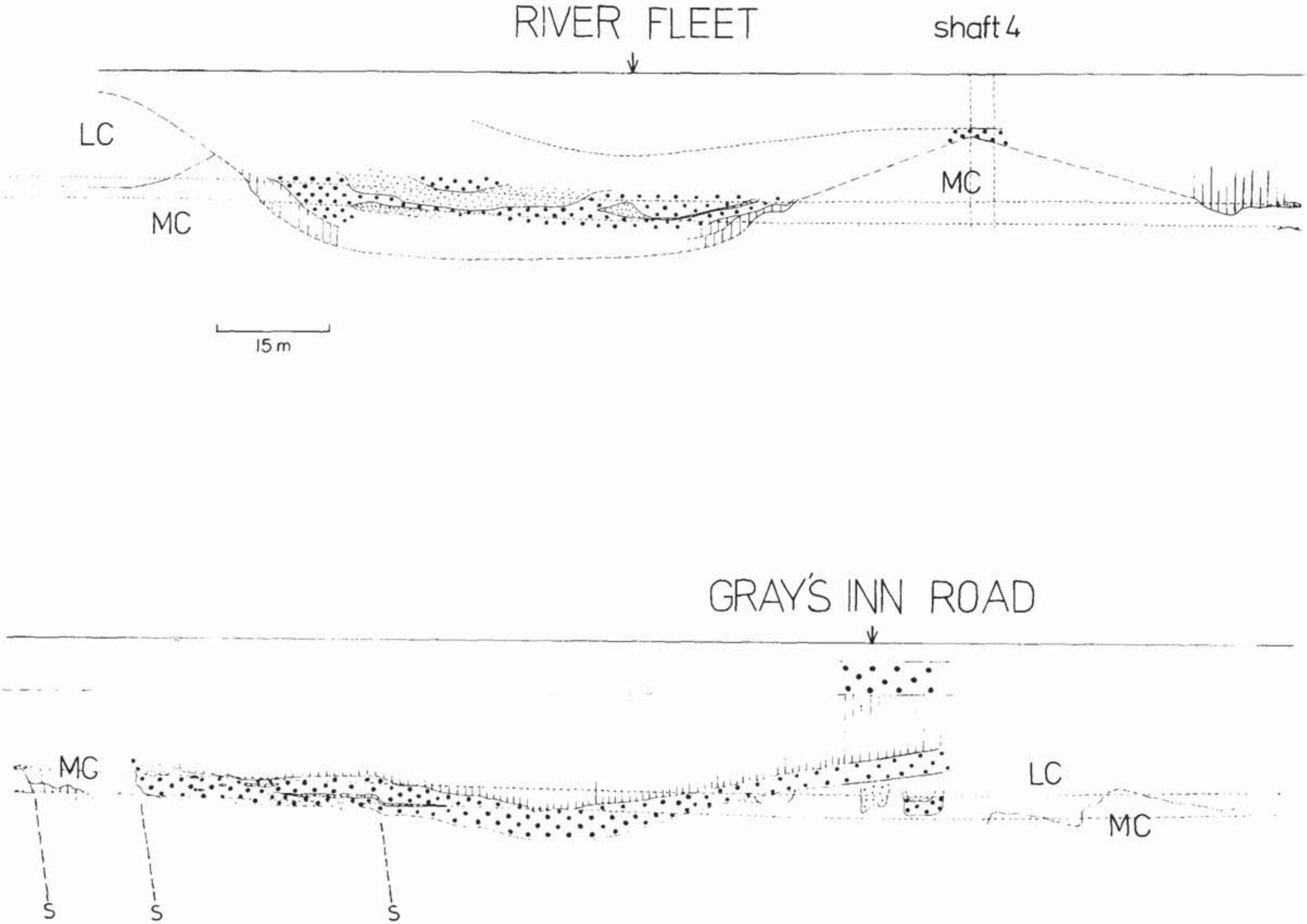
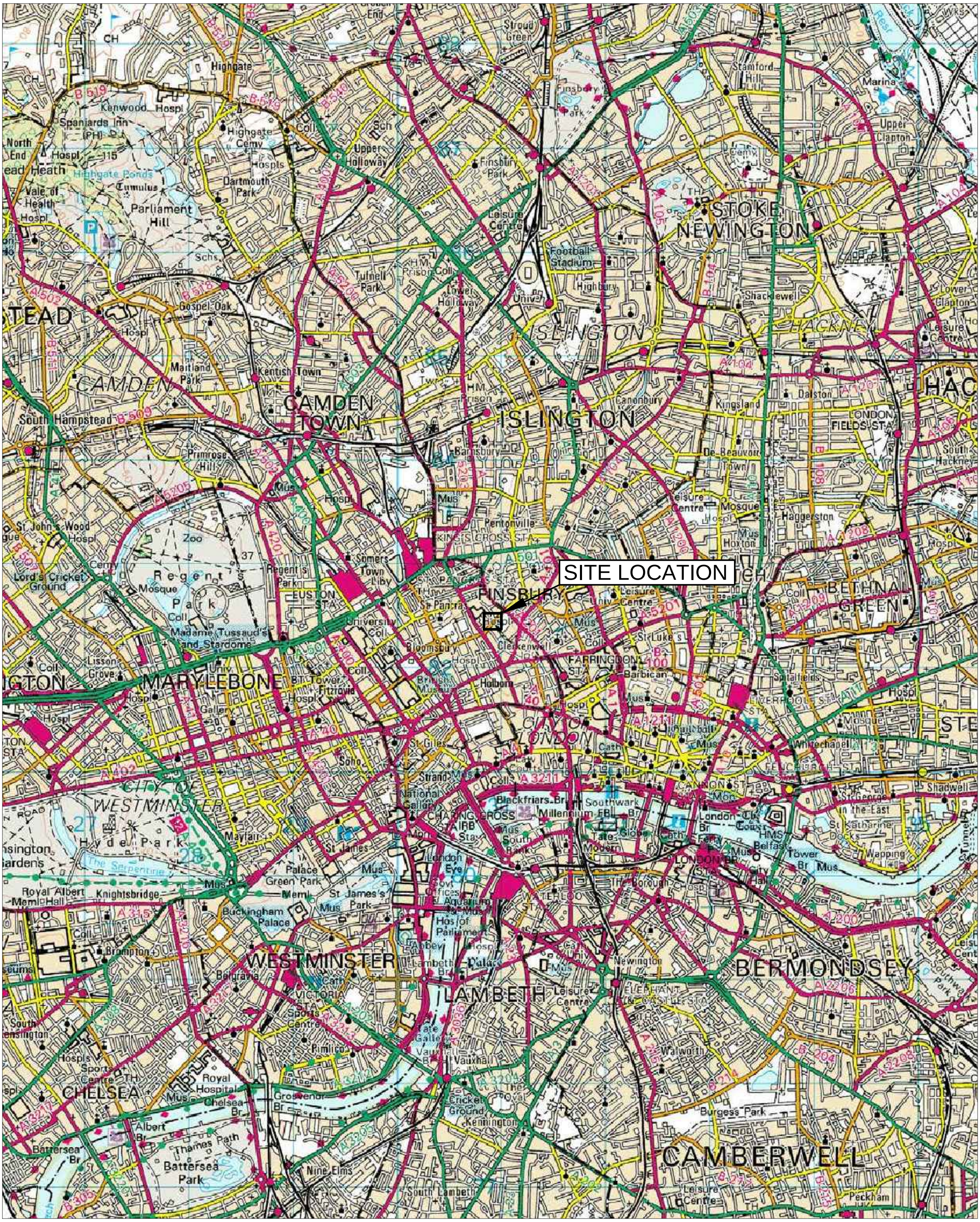


Fig. 17. Grey's Inn Road–Calthorpe Street anomaly (5*a*) based on TWA Drawing XH17 and Anonymous, 1928; true-scale vertical section along tunnel alignment. MC = mottled clay (Reading Beds); LC = London Clay; coarse stipple = gravels; fine stipple = sands; vertical bars = fine-grained alluvium. Base of made ground (fill) in course of Fleet shown by pecked line. S = slip plane.

APPENDIX G: DRAWINGS

Drawing 15.116/Phs2/01	Site Location Plan
Drawing 15.116/Phs2/02	Exploratory Location Plan
Drawing 15.116/Phs2/03	Geology Plan
Drawing 15.116/Phs2/04	Nominal Section
Drawing 15.116/Phs2/05	SPT vs Reduced Level (mOD)
Drawing 15.116/Phs2/06	Water level (mOD) vs Time Plot



North

Box indicates approximate position of drawing 15.116/Phs2/02

Scale 1: 50,000 @ A4

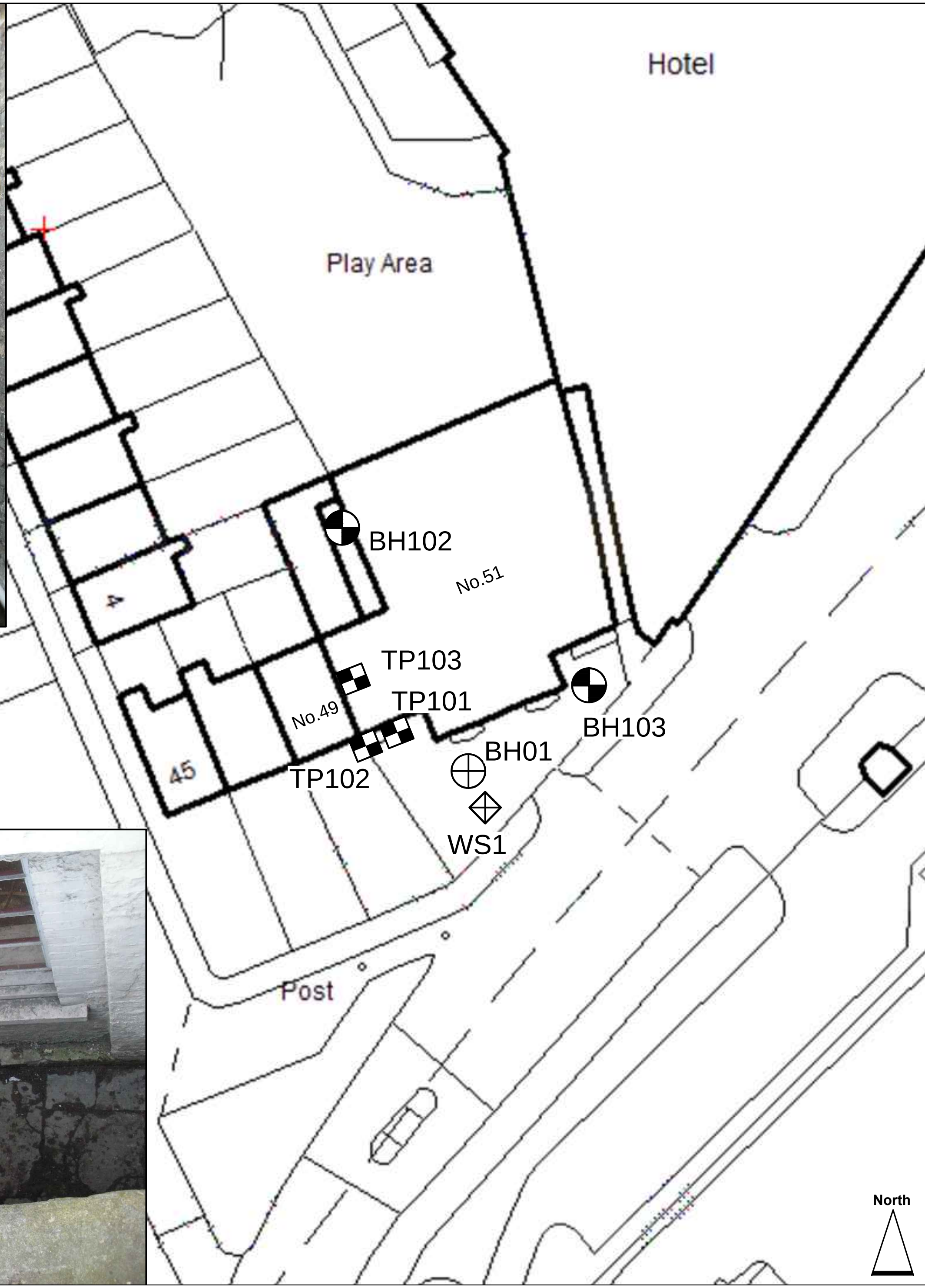
A F Howland Associates
Geotechnical Engineers

Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

SITE LOCATION PLAN

Client : Mr Simon Firth

Date : January 2016 **Dwg :** 15.116/Phs2/01



North

Key:

Borehole location and reference

Trial pit location and reference

Borehole location and reference (AFHA, 2015)

Window sample location and reference (HEG, 2013)

Rev	Date	Revision Description	Drwn	Chkd

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web: www.howland.co.uk
mail: admin@howland.co.uk

Client: Mr Simon Firth

Site:
51 CALTHORPE STREET, LONDON WC1X 0HH

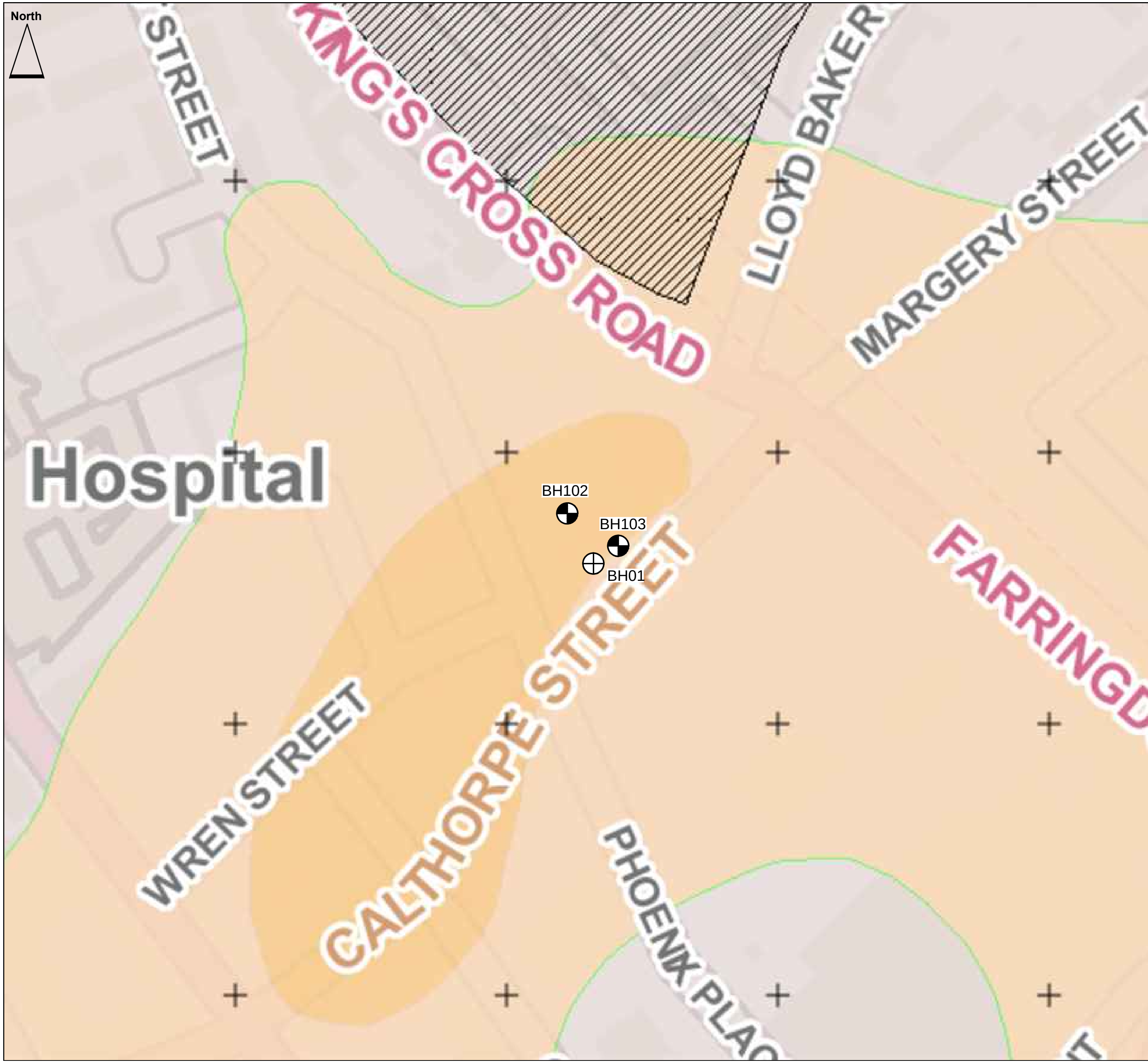
Job No.: 15.116

Drawing Title:
EXPLORATORY HOLE LOCATION PLAN

Date: January 2016

Drawing No: 15.116/Phs2/02

Scale: 1:500 @ A4



Key:

Borehole location and reference	
Borehole location and reference (AFHA,2015)	

SUPERFICIAL GEOLOGY

- HACKNEY GRAVEL MEMBER - SAND AND GRAVEL
- WORKED GROUND (UNDIVIDED) - VOID

SOLID GEOLOGY

- LONDON CLAY FORMATION - CLAY, SILT AND SAND
- LAMBETH GROUP - CLAY, SILT AND SAND

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Client: Mr Simon Firth

Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

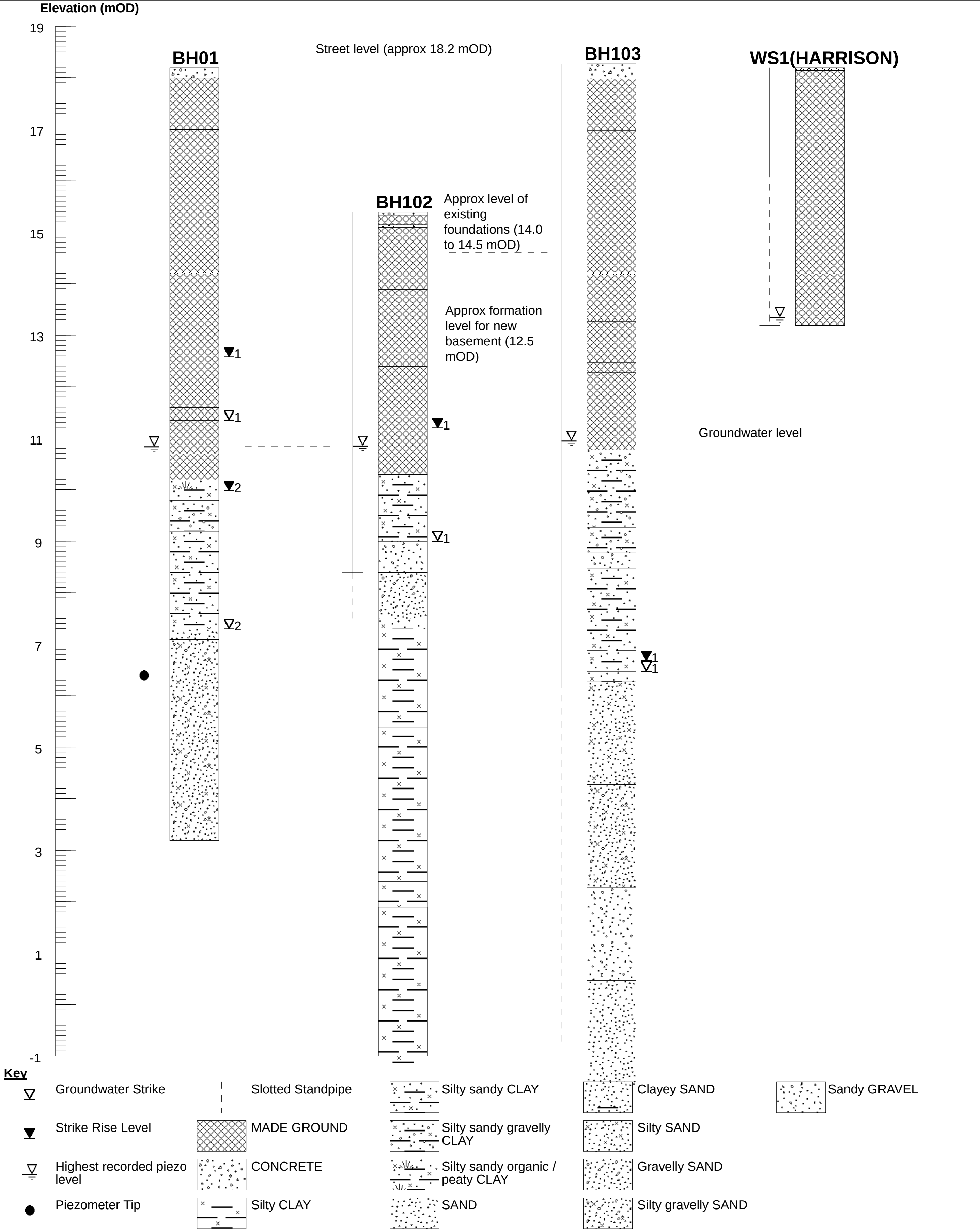
Job No.: 15.116

Drawing Title: GEOLOGY PLAN

Date: January 2016

Drawing No: 15.116/Phs2/03

Scale: 1:2000 @ A4



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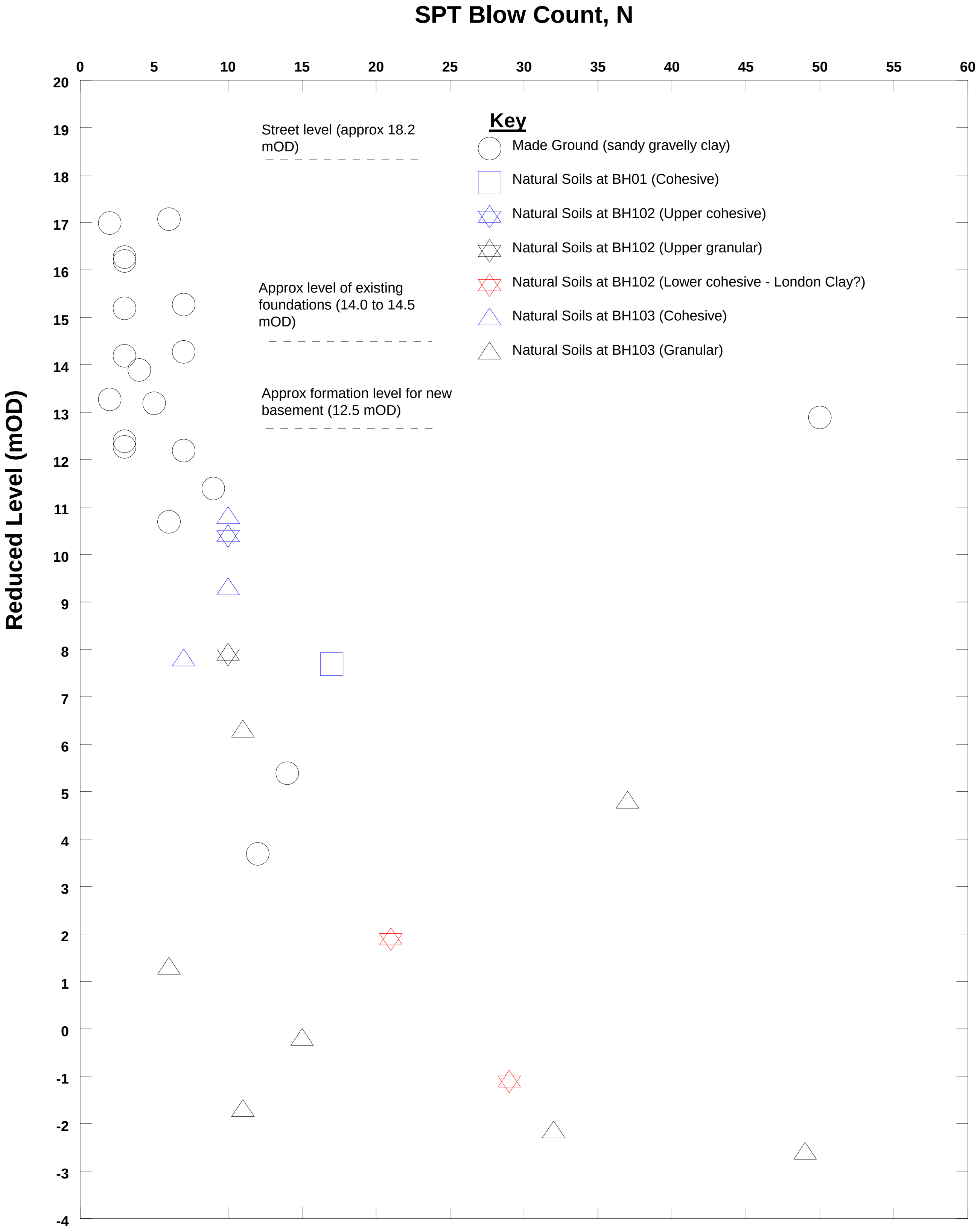
Nominal Section

Site	Date Drawn	Date Checked	Sheet	Job Number
51 CALTHORPE STREET, LONDON WC1X 0HH	11/12/2015		1/1	15.116
Client	**Drawn By**	**Checked By**	**Scale**	**Figure No.**
Mr Simon Firth			1:100[V]	15.116/Phs2/04



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Title				
SPT vs Reduced Level (mOD)				
Site	**Date Drawn**	**Date Checked**	**Sheet**	**Job Number**
51 CALTHORPE STREET, LONDON WC1X 0HH	13/01/2016			15.116
Client	**Drawn By**	**Checked By**	**Scale**	**Figure No.**
Mr Simon Firth				15.116/Phs2/05

Key

BH/WS
BH01
BH102
BH103
WS1(HARRISON)

A F Howland Associates
Geotechnical Engineers

Site 51 CALTHORPE STREET, LONDON WC1X 0HH			
Title Water Level (mOD) vs Time Plot			
Drawn	**Checked**	**Approved**	**Job No.** 15.116
Date 15/01/2016	**Date**	**Date**	**Figure No.** 15.116/Phs2/06

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A REPORT ON A GROUND INVESTIGATION AT 51 CALTHORPE STREET, LONDON WC1X 0HH

CLIENT: Mr Simon Firth

ENGINEER: Create Consulting Engineers Limited

Date: 20 May 2015

Reference: GNB/15.116

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A F Howland Associates

CONTENTS

CLIENT: Mr Simon Firth

ENGINEEER: Create Consulting Engineers Limited

A REPORT ON A GROUND INVESTIGATION AT 51 CALTHORPE STREET, LONDON WC1X 0HH

Reference: GNB/15.116

Date: 20 May 2015

1. INTRODUCTION

It is proposed to redevelop an existing property at 51 Calthorpe Street in the London Borough of Camden (Drawing 15.116/1). This will include the construction of an additional basement.

At the instruction of Mr Simon Firth, an investigation was carried out to provide information on the subsoil conditions and relevant geotechnical parameters for design purposes, to install groundwater monitoring equipment, and to assess potential contamination in the ground.

This report provides the factual details of the fieldwork and laboratory testing undertaken during the investigation, and discusses the findings with respect to possible contamination risks to construction workers and end users, as well as providing information for waste disposal.

2. FIELDWORK

Fieldwork was carried out on 16 April 2015 and comprised a single borehole set out in general accordance with the requirements of the Consulting Engineers for the project (Create Consulting), as shown approximately on Drawing 15.116/2. The National Grid reference and the elevation of the hole position relative to Ordnance Datum were measured using a Hemisphere S320 VRS GPS (RTK) system by A F Howland Associates.

A cable avoidance tool (CAT) was used to sweep the location and the immediate surrounding area to locate any potential underground services and the position adjusted as necessary. A starter pit was also excavated by hand to a depth of 1.20 m to provide direct inspection for services or obstructions.

The **borehole** was taken to a depth of 15m using conventional cable percussive techniques ('shell and auger') in 150 mm diameter casing. Sampling and in situ testing were carried out in general accordance with the recommendations of BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930:1999+A2:2010, and as specified by the Client. An open tube drive sample (U100) was taken in cohesive material to allow laboratory testing of undisturbed material. Further disturbed samples were taken for laboratory testing and to allow later inspection of the materials encountered and facilitate accurate logging.

Standard penetration tests (SPT) were carried out using a split barrel sampler or a solid cone, as appropriate, to obtain additional strength information in cohesive material and the made ground, and to assess the condition of granular strata. The N value was taken as the number of blows for 300 mm of penetration, following a seating drive of 150 mm or 25 blows.

Specialist **environmental samples** were taken during fieldwork. They were placed in dedicated containers, stored temporarily in cool boxes and delivered to a UKAS accredited facility for analysis of potentially contaminating substances.

The borehole was monitored for **groundwater** ingress during advance. Upon encountering inflow, drilling was temporarily stopped to allow the level to stabilise, recording the water level at five minute intervals for a period of twenty minutes. Samples of groundwater were also taken for possible laboratory analysis.

However, such observations are affected by the permeability of the ground, the rate of progress of the hole and the excavation techniques in operation. The general procedures used do not allow precise measurements of the groundwater conditions, but give only a general guide to the overall situation. Fluctuations in any groundwater table will occur as a result of seasonal or climatic effects, as well as other outside influences.

To allow a longer term assessment of the groundwater condition, a piezometer was installed upon completion of the borehole. This comprised PVC access tubing fitted with a porous tip, surrounded by a granular filter, and sealed at the top by bentonite. AFHA returned to site to carry out groundwater monitoring on one occasion, but it is understood that Create Consulting have continued and taken further readings.

Details of the strata encountered, the sampling, in situ and laboratory testing are shown on records appended to this report.

3. LABORATORY TESTING

3.1 GENERAL

Subsequent to the fieldwork a programme of laboratory testing was carried out to provide additional quantitative data on the materials encountered. The tests were completed in accordance with the procedures laid down in BS1377: 1990 unless stated otherwise and consisted of:

- Natural moisture content
- Atterberg limits
- Particle size distribution
- Undrained shear strength in triaxial compression without measurement of pore pressure
- Sulphate content and pH value
- Total sulphur
- Contamination testing
- Waste Acceptance Criteria (WAC) testing

3.2 TEST PROCEDURES

3.2.1 Natural Moisture Content

The natural moisture content is determined according to BS1377: Part 2: 1990: clause 3.2. This represents the mass of moisture content retained by the soil in its natural state as a percentage of its dry mass. For organic soils and peats care should be taken to avoid heating the sample above 50°C to prevent irreversible physical changes to the material.

3.2.2 Atterberg Limits

The Atterberg limits are determined in the laboratory by the procedures given in BS1377: Part 2: 1990. The liquid limit (LL) is the moisture content of the soil at the point that its behaviour passes from that of a plastic solid to that of a liquid. The test procedure given as clause 4.4 was used based on the cone penetrometer in which the penetration of a free-fall cone into moistened and cured samples of the soil is measured. The plastic limit (PL) is the moisture content of the soil at the point that its behaviour passes from a plastic solid to a brittle solid. This point is measured according to clause 5.3 and is the point at which a thread of the soil rolled to 3 mm diameter begins to crumble.

Together the Atterberg limits can be used to define the plastic range of the soil. The plasticity index (PI) is the difference between the liquid and plastic limit and is broadly correlated to the engineering behaviour of the soil. When used with the natural moisture content of the soil they can also give an indication of its *in situ* condition.

3.2.3 Particle Size Distribution

A quantitative assessment of the particle size distribution of the soil down to the fine grained sand size is made according to BS 1377: Part 2: 1990: clause 9. In this the percentage of certain sized fractions of the soil are found by determining the weight retained on a variety of sieve sizes through which the material is allowed to pass. The combined silt and clay fraction is determined by the difference between the sum of the retained weights and the original sample weight. Variations of the test procedure allow the silt and clay fraction to be removed from the coarser fraction by wet sieving during which the fine material is washed from the surface of the coarser material.

3.2.4 Determination of the Undrained Shear Strength in Triaxial Compression without measurement of Pore Pressure

The undrained shear strength of the soil was measured, as stated in BS 1377: Part 7: 1990: clause 8, by axial compression of 100mm diameter cylindrical specimens cut from U100 undisturbed samples. The nature of the test is such that no change in moisture content of the specimen is allowed during shear.

The theory of behaviour of saturated clay materials in undrained shear failure gives that the strength will not be influenced by the confining pressure such that the measured angle of internal friction for the material will apparently be equal to zero. Experience has shown that this is true only for samples of unweathered heavily overconsolidated pure clays. Where the material is weathered or it contains a significant granular content a plastic rather than a brittle failure develops which produces a strain hardening during shear. In this situation measurable apparent undrained angle of internal friction is produced. A similar situation develops in partially saturated materials. The test results are also influenced by sample variation, and in particular the presence of natural fissures or inclusions within the sample.

The use of large diameter specimens is preferred as this compensates for the scale effects of random features in smaller specimens. One of two tests are carried out according to the soil characteristic. Unweathered specimens of heavily overconsolidated clays which have a brittle failure in shear are tested in a single stage. The confining pressure is taken as the total overburden pressure of the sample *in situ*. It is then failed by axial compression and the measured deviator stress reported as the apparent undrained cohesion. Specimens of weathered clay or the clays with granular contents are tested in a multistage manner according to BS 1377: Part 7: 1990: clause 9.

The test procedure is similar to the single stage but at the point that failure begins the confining pressure is increased and the specimen compressed for a further 2% of vertical strain at which point the confining pressure is again increased and held for a further 2% strain. The deviator stresses at each of the confining pressures are used to plot the Mohr envelope and the apparent undrained cohesion and if appropriate the undrained angle of internal friction.

3.2.5 Sulphate Content and pH Value

In order to aid the evaluation of any aggressive tendency of the subsoil or groundwater to buried concrete the pH and soluble sulphate of a number of samples were determined using in-house procedures based on British Standard methods. The pH of a groundwater sample, or a soil suspension was determined electrometrically according to BS 1377: Part 3: 1990: clause 9.5. The water soluble sulphate content was undertaken using a procedure based on BS 1377: Part 3: 1990: clause 5.5 in which the sulphate is analysed by ICP-OES in a distilled water filtrate from the soil or a groundwater sample. The total sulphate of a soil was measured on a filtrate following digestion of the soil by 10% hydrochloric acid.

3.2.6 Total Sulphur Content

To aid the evaluation of aggressive tendency of the subsoil to buried concrete as a result of its pyritic potential, the total potential sulphate content can be determined from the relationship between the total (acid soluble) sulphate content and the amount of total sulphur present. The total sulphur content is determined by a laboratory in-house method based on the Methods for the Examination of Waters and Associated Materials (MEWAM Environment Agency, 2006).

A dried portion of the soil is extracted at 115 °C for 75 minutes using 100% aqua regia and potassium bromate/bromide oxidizing mixture. The principle of this digest is to oxidize all sulphur to sulphate, and use the aqua regia acid mixture to digest the sample. The resultant digest solution is then filtered and analysed by ICP-OES. The results are expressed as % S, and include water soluble and acid soluble sulphates and total reduced sulphur, as well as insoluble sulphates and organic sulphur.

3.2.7 Contamination Testing

In order to determine the presence of other chemical contamination not otherwise naturally present in the ground, a signature suite of tests was undertaken to provide data on a broad mix of inorganic and organic potential contaminants. This comprised the total content of antimony, arsenic, beryllium, cadmium, chromium, chromium VI, lead, mercury, selenium, copper, nickel, vanadium, zinc and cyanide, together with speciated polycyclic aromatic hydrocarbons (PAH), pH, phenols and the organic matter content.

The presence of asbestos was also screened, while specific hydrocarbon analysis in the form of total petroleum hydrocarbons using the Criteria Working Group (CWG) suite took place in both samples. This provides the split between the aliphatic and aromatic fractions in the C5 to C35 ranges. It also includes specified hydrocarbons: benzene, toluene, ethylbenzene, xylenes (collectively known as BTEX) and methyl tertiary butyl ether (MTBE).

"Product identification" was also carried out by extraction/dilution with dichloromethane followed, with analysis by gas chromatography mass-spectrometry. The chromatogram can then be compared against a library of known chromatograms

The samples were tested using a variety of analytical techniques, and carried out to MCERTS accredited methods, where applicable, or to UKAS accredited or other acceptable methodologies, which are fully listed in the relevant appended test report.

3.2.8 Waste Acceptance Criteria Testing

Waste Acceptance Criteria (WAC) assessment was undertaken to assist with disposal of excavated material. Waste materials fall into three categories, namely 'inert', 'non-hazardous' and 'hazardous', with each category defined by leaching limit values for acceptance at the relevant landfill site. Leaching is carried out with a liquid/solid ratio of 2:1 and 8:1 and then the 10:1 is determined. The components analysed are arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, lead, antimony, selenium, zinc, chloride, fluoride, sulphate, together with dissolved organic carbon and total dissolved solids; phenols are only relevant to the inert waste category.

Additionally, the inert classification requires the determination of BTEX (a combination of the volatile organic hydrocarbons defined above), polychlorinated biphenyls (total of the EC7 PCBs), mineral oil (in the C_{10} to C_{40} range), and polycyclic aromatic hydrocarbons. These suites of tests are not required for the non-hazardous and hazardous categories. pH is determined for non-hazardous waste acceptance and loss on ignition for the hazardous class, while the acid neutralisation capacity is measured for both, and total organic carbon for all three.

4. CONTAMINATION ASSESSMENT

4.1 BOREHOLE FINDINGS

The borehole proved a sequence of made ground over natural clay strata in turn underlain by granular deposits.

The **made ground** extended to a depth of approximately 8.0 m and comprised variably sandy clay layers that contained gravel and occasional cobble size pieces of brick, flint, concrete, chalk, charcoal and slate. Organic odours were noted below about 6.6 m depth. The materials were assessed as very soft or soft and this was supported by in situ standard penetration testing that gave N-values between 2 and 7.

The upper natural **cohesive deposits** consisted initially of dark brown clay that was also organic, and included rootlets. By 8.4 m it became firm brown and grey variably silty sandy clay that included sand partings. Atterberg limits results from laboratory testing indicated clays of intermediate to high plasticity, with a plasticity index between 17 and 25%. A single undrained triaxial test result from the undisturbed sample gave an apparent cohesion value of 52 kNm^{-2}, while the assessed strength was also confirmed by an N-value of 17.

These materials overlay **granular deposits** at 10.9 m depth that comprised brown slightly silty sand containing flint gravel. The typical grading was indicated by the particle size distribution during laboratory testing. In situ standard penetration testing was disrupted initially by blowing conditions, but a successful test at 14.5 m depth suggested a medium dense condition. The granular material continued to the limit of the investigation at 15 m depth.

Groundwater inflow took place initially within the made ground, with a short-term standing level at 5.6 m depth. A further water strike took place at the top of the sand at 10.9 m and rose rapidly to 8.2 m.

Selected samples of the deeper made ground, clay and groundwater were subject to pH and sulphate testing, with sulphur determinations made to complement the sulphate testing according to the recommendations of Building Research Special Digest 1 (BRE, 2005). The results can be summarised as follows:

- pH values in soil between 7.2 and 8.0, while values of 6.8 and 7.2 were recorded in groundwater
- sulphate (SO_3) concentration of 0.17 and 0.37 gl^{-1} in groundwater
- water soluble sulphate (SO_3) concentrations in soil from 0.04 to 0.52 gl^{-1}
- acid soluble sulphate (SO_4) between 0.02 and 0.13%
- total sulphur concentrations from 0.01 to 0.37

4.2 GROUND CONTAMINATION

4.2.1 Background and Assessment Methodology

As part of the current investigation two samples of made ground were analysed to determine the concentrations of a range of potential contaminants to establish whether there are implications with regard to human health and to aid the disposal of any surplus soils.

For human health, the results were assessed using methods based on the CLEA software version 1.04 or 1.06. Where available, results were compared to generic Soil Guideline Values (SGVs), for residential end-use with gardens (Environment Agency, 2009). When relevant SGVs were unavailable, results were compared to ATRISK^{soil} Soil Screening Values (SSVs) derived from WS Atkins Consultants Limited (Atkins, 2011). These SSVs have been based on 2009 guidance (Final SC050021/SR2 (the TOX report) and Final SC050021/SR3 (the CLEA Report)) for categories which include commercial, residential and other land uses (Environment Agency, 2009a and 2009b).

It should be noted that the SSVs for chromium V1 and lead have been temporarily suspended from ATRISK^{soil} on the basis that recent toxicological information indicates that these compounds are more toxic than previously considered. In these instances, the concentrations have been compared to the Category 4 Screening Values given by Contaminated Land: Applications in Real Environments (CL:AIRE, 2013), which has also been developed using the CLEA software. The derivation of C4SLs uses the concept of a low level of toxicological concern (LLTC), which represents the estimated concentration of a contaminant that would pose an 'acceptably low' risk to human health. They also use a range of values which are based partly on exposure limits and conditions; in this case the lowest most conservative LLTCs have been used for comparison purposes.

Furthermore, the SGVs and SSVs are formulated from research into long-term chronic exposure pathways, and are not directly applicable to short-term contact such as that experienced by construction workers. Nevertheless, without any current UK guidelines that allow an assessment of the potential risk to workers from contaminated soils the CLEA software and Atkins ATRISK^{soil} (2011) approach provide the most applicable assessment criteria.

4.2.2 Results and Implications of Contamination

A conservative approach has been taken and a residential end-use assumed with plant up-take, while a soil organic matter content has been taken to be about 1% on average. Comparison with the relevant assessment criteria shows that most of the metals and inorganic compounds did not exceed guideline values for females with lifetime exposure via all exposure routes or were below the limits of detection. The only exception was **lead**, where values of 280 and 770 mg/kg exceeded the C4SL upper and lower bound values of 82 and 210 mg/kg.

Similarly, both samples analysed for organic compounds contained levels of phenol, polyaromatic hydrocarbon (PAH) compounds, oil/fuel compounds (aliphatic and aromatic CWG banding) and the monoaromatics (BTEX and MTBE) below the relevant guideline values. The attempts to undertake an identification of hydrocarbon product confirmed that none was present.

No asbestos was detected.

Overall, concentrations of contamination in the soil were found to be generally below levels of concern, which indicates that no special measures are necessary with respect to the long-term human residential end users. Although elevated lead concentrations were identified the made ground will be separated from contact with residents by the construction materials of the new basement. It may be a potential problem if garden areas are proposed.

The test results also suggest that short-term contact with spoil during the construction period would not pose a hazard. Nevertheless, in view of the need for partial demolition during redevelopment of the building, it would be prudent to make construction and other workers on site aware of the possible hazard of contact with 'contaminated' ground, and to ensure that the minimum precautions are implemented through 'toolbox talks' and site inductions.

During the process of development, workers coming into contact with potentially contaminated soil should be equipped with appropriate protective equipment and should always adopt good hygiene procedures when handling excavated soils. As long as standard hygiene rules and procedures are followed on-site such as wearing gloves, overalls and provision of suitable welfare facilities then the material will not prove a hazard to the construction workforce.

4.2.3 Waste Management and Disposal

The legislative regime on waste seeks to minimise the amount of material taken to landfill by actively requiring re-use, or improving it by further processing. Where spoil is to be disposed of from site, the waste generator is required to establish the nature and character of the materials to the satisfaction of the waste receiver, although the practicalities of this are not firmly established. The situation is mitigated if the material has value, in which case it does not constitute waste, *per se*. Consequently, where the soils are suitable for a purpose such as earthworks, landscaping or backfill, an assessment of risk necessary to demonstrate adequate duty of care may be all that is required.

The proposed scheme may generate a quantity of excavated material that will be need to be addressed in terms of waste management. The 'waste' could be re-used on site, used elsewhere or sent to landfill.

The ground conditions encountered at the borehole position indicate that the materials that could arise from the construction process, will comprise made ground which was essentially cohesive in nature, often very soft and became organic at depth. It contained extraneous materials such as brick and concrete and in practical terms it is more likely that excavated soils will require disposal.

Waste Acceptance Criteria (WAC) assessment of the made ground were made to assist with the disposal of excavated soil. The main categories for disposal are 'inert waste landfill', 'stable non-reactive hazardous waste in non-hazardous landfill', and 'hazardous waste landfill'. The regulations dictate that to be classified in the lowest category as 'inert', the waste must meet all of the following criteria:

- it will not undergo any significant physical, chemical or biological transformations
- it will not dissolve
- it will not burn

- it will not physically or chemically react
- it will not biodegrade
- it will not adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or to harm human health
- it has insignificant total leachability and pollutant content
- it produces a leachate with an insignificant ecotoxicity (if it produces a leachate).

The tested samples appear to conform with most of the factors listed above, with the WAC analyses showing that the concentrations of all the determinands were generally below the leaching limits for waste acceptance at landfill for 'inert waste'. Total organic carbon, BTEX (benzene, toluene, ethyl benzene and xylenes), polychlorinated biphenyls, mineral oil (as total petroleum hydrocarbons in the C10 to C40 range) and the polycyclic aromatic hydrocarbons also fell into this category. pH is within the acceptable limit for 'non hazardous waste', while loss on ignition is within its acceptability range. However, the exceptions were the leaching limits for sulphate within the made ground at 3 m and antimony within the deeper made ground at 6.7 m.

The **sulphate** concentration of 1500 mg/kg exceeded the inert waste landfill limit of 1000 mg/kg, while the **antimony** value of 0.22 mg/kg exceeded the inert waste limit of 0.06 mg/kg. However, both results are within the acceptance levels for stable non-reactive hazardous waste in non-hazardous landfill and may still be acceptable as inert waste, as it is ultimately the decision of the landfill operator to make the judgement based on all the test results. It may be noted that although lead had been identified as an elevated total concentration for risks to human health, its leachate concentration did not exceed the inert waste limit for lead.

Furthermore, the complete assessment of waste should be made in the context of current legislation that governs usage, handling and movement of the materials (Environment Agency, 2015). The management of waste partly depends on the classification and coding within the European Waste Catalogue (EWC) codes. The made ground may classify as 17 05 04 i.e. 'soils and stones' as a result of construction, but could require further analyses in order to prove that it does not classify as code 17 05 03 which relates to 'soils and stones that contain dangerous substances'. It may be more practical to analyse the actual spoil taken during construction as it would be mixed state and more representative.

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20 May 2015

APPENDIX A: REFERENCES

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[1] SSVs for lead and chromium VI have been withdrawn temporarily as of 29 January 2015

APPENDIX B: CABLE PERCUSSIVE BOREHOLE RECORD

B	Bulk disturbed sample
D	Small disturbed sample
W	Water sample
U	Nominal 100 mm diameter undisturbed open tube sample
ES	Environmental sample
X blows	The associated figure 'X' is the number of blows to drive the sample tube over the given depth range
XF	Undisturbed sample not recovered after 'X' number of blows to drive the sample tube
SPT	Standard penetration test using a split spoon sampler. N Value is uncorrected, but the hammer energy ratio is given in the remarks.
SPT(C)	Cone penetration test using a solid cone
X,X/X,X,X,X	Blows per increment during the standard penetration test. The initial value relates to the seating drive (150 mm) and the remaining four to the 75 mm increments of the test length
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300 mm)
X*/Y	Incomplete standard penetration test where the seating drive could not be completed. The blows 'X' represent the total blows for the given length of seating drive 'Y' (mm)
X/Z	Incomplete standard penetration test where the seating drive was achieved but the full test length was not. The blows 'X' represent the total blows for the given test length 'Z' (mm)
<u>dd/mm/yy: 1.0</u> **dd/mm/yy: dry**	Date, water level at the borehole depth at the end of shift and the start of the following shift

Each sample type is numbered sequentially with depth and relates to the depth range quoted

All depths and measurements are given in metres, except as noted

Strata descriptions complied by visual examination of samples obtained during boring, after BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930:1999+A2:2010 and modified in accordance with laboratory test results where applicable

A F Howland Associates Geotechnical Engineers	Site: 51 CALTHORPE STREET, LONDON WC1X 0HH	Borehole Number: BH01

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 14.50m open hole to 15.00m	18.19	Mr Simon Firth	15.116
	Location	**Dates**	**Engineer**	**Sheet**
	530932 E 182459 N	16/04/2015	Create Consulting Engineers Limited	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					17.99	(0.20) 0.20	CONCRETE		
0.30-0.50	B1					(1.00)	MADE GROUND (Soft brown and grey very sandy very gravelly clay with occasional angular cobble sized brick fragments. Gravel is angular to subrounded fine to coarse flint, brick, chalk and concrete)		
0.70	ES1								
0.70-0.90	B2								
1.00-1.20	B3								
1.20-1.65	SPT(C) N=2		DRY	1/1,,1	16.99	1.20	MADE GROUND (Very soft brown with occasional orange brown mottling sandy gravelly clay. Gravel is angular to subrounded fine to coarse flint, brick, chalk, concrete and charcoal)		
1.20-1.70	B4								
2.00-2.45	SPT(C) N=3	1.50	DRY	1/1,,1,1					
2.00-2.50	B5								
						(2.80)			
3.00-3.45	SPT(C) N=3	3.00	DRY	1,2/1,,1,1					
3.00	D1								
3.00	ES2								
4.00-4.45	SPT(C) N=3	3.00	DRY	1/1,,1,1	14.19	4.00	MADE GROUND (Brown sandy gravelly clay, recovered in a very soft condition. Gravel is angular to subrounded fine to coarse flint, brick, concrete, slate and rare chalk)		
4.00-5.00	B6								
5.00-5.45	SPT(C) N=5	4.50	DRY	1,2/1,2,1,1					
5.00-6.00	B7					(2.60)			
5.62	W1								▼1
6.00-6.45	SPT(C) N=7	6.00	DRY	2,3/3,2,1,1					
6.00-7.00	B8								
					11.59	6.60 (0.25)	MADE GROUND (Black slightly silty slightly sandy slightly gravelly clay with a weak organic odour. Gravel is angular to subrounded fine to coarse flint and brick)		
6.70	ES3			Medium(1) at 6.85m, rose to 5.62m in 20 mins, sealed at 7.50m.	11.34	6.85 (0.65)	MADE GROUND (Brown with black mottling slightly silty slightly sandy slightly gravelly clay with occasional angular cobble sized brick fragments and a weak organic odour, recovered in a very soft condition. Gravel is angular to rounded fine to coarse flint, brick and concrete)		∇1
7.50-7.95	SPT N=6	7.50	DRY	1,2/1,2,1,2	10.69	7.50 (0.50)	MADE GROUND (Greyish brown silty slightly sandy slightly gravelly clay with a weak organic odour, recovered in a very soft condition. Gravel is fine occasionally medium flint and brick)		
7.50-7.95	D2								
8.00-8.20	D3				10.19	8.00 (0.40)	Soft to firm dark brown slightly silty slightly sandy CLAY with numerous infilled rootlets and an organic odour		▼2
8.40-8.65	D4				9.79	8.40 (0.60)	Firm greyish brown with occasional orange brown and blue grey mottling very silty sandy CLAY. Rare flint gravel		
9.00-9.45	U1	9.50	DRY	33 blows	9.19	9.00	Firm greyish brown to grey with occasional orange brown mottling silty slightly sandy becoming sandy CLAY with occasional orange brown fine to medium sand partings		
9.45	D5								
9.50	W2								

Remarks
1. Location CAT scanned prior to excavation.
2. Hand dug inspection pit to 1.20 m.
3. Groundwater struck at 6.85 m and rose to 5.85 m in 5 mins., 5.62 m in 10 mins. and 15 mins. and 20 mins.
4. Groundwater struck at 10.90 m and rose to 8.63 m in 5 mins., 8.27 m in 10 mins., 8.22 m in 15 mins. and 20 mins.
5. Piezometer installed to 11.80 m.
6. SPT Hammer Energy Ratio = 67.66%

Scale (approx)	Logged By
1:50	KPB

Figure No. 15.116.BH01

A F Howland Associates
Geotechnical Engineers

Site 51 CALTHORPE STREET, LONDON WC1X 0HH				**Borehole Number** BH01
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 14.50m open hole to 15.00m	**Ground Level (mOD)** 18.19	**Client** Mr Simon Firth	**Job Number** 15.116
	Location 530932 E 182459 N	**Dates** 16/04/2015	**Engineer** Create Consulting Engineers Limited	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(1.90)	.... CLAY becomes brown		
10.50-10.95 10.50-10.95	SPT N=17 D6	7.50	DRY	1,2/2,4,5,6					
				Quick(2) at 10.90m, rose to 8.22m in 20 mins, not sealed.	7.29	10.90 (0.20)	Orange brown slightly clayey medium to coarse SAND		∇2
					7.09	11.10	Light brown slightly silty gravelly fine to coarse SAND. Gravel is angular to rounded fine to coarse flint (blowing conditions)		
13.00-13.50	B9					(3.90)			
14.00-14.50	B10								
14.50-14.95	SPT(C) N=12	14.50		1,1/2,2,3,5			.... medium dense		
				16/04/2015:8.50m	3.19	15.00	Complete at 15.00m		

Remarks
7. Unable to take SPT at 12.00 m and 13.50 m due to blowing sand.

Scale (approx)	**Logged By**
1:50	KPB
Figure No. 15.116.BH01	

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Installation Type Single Installation	**Dimensions** Internal Diameter of Tube [A] = 19 mm; Diameter of Filter Zone = 150 mm		**Site** 51 CALTHORPE STREET, LONDON WC1X 0HH; **Client** Mr Simon Firth	**Borehole Number** BH01; **Job Number** 15.116
	Location 530932 E 182459 N	**Ground Level (mOD)** 18.19	**Engineer** Create Consulting Engineers Limited	**Sheet** 1/1

Level (mOD)	Depth (m)	Description
17.99	0.20	Concrete
		Bentonite Seal
17.19	1.00	Topfill
7.79	10.40	Bentonite Seal
7.29	10.90	Gravel Filter
6.69	11.50	Piezometer Tip
6.39	11.80	Gravel Filter
6.19	12.00	General Backfill
3.19	15.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
16/04/15		6.85	6.00	Medium	5.85	5.62	5.62	5.62	7.50
16/04/15		10.90	7.50	Quick	8.63	8.27	8.22	8.22	NOT

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
16/04/15							15.00	14.50	8.50	9.69

Instrument Groundwater Observations

Inst. [A] Type : Standpipe Piezometer

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
30/04/15	13:30	7.36	10.83	

Remarks
1. Water sample taken 30/04/2015

APPENDIX C: LABORATORY TESTING

Natural moisture content

Atterberg limits

Particle size distribution

Undrained shear strength in triaxial compression without measurement of pore pressure

Sulphate content, sulphur content and pH value

Contamination testing

WAC testing

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Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH		**Job Number** 15.116
Client : Mr Simon Firth		
Engineer : Create Consulting Engineers Limited		**Sheet** 1 / 1

DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX

Borehole/ Trial Pit	Depth (m)	Sample	Natural Moisture Content %	Sample Passing 425µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Group Symbol	Laboratory Description
				Percentage %	Moisture Content %						
BH01	8.00	D3	36	100	36	53	28	25	0.32	CH	Firm dark greyish brown organic slightly sandy CLAY with rare fine flint gravel
BH01	8.40	D4	24	100	24	40	19	21	0.24	CI	Firm olive grey slightly sandy silty CLAY with occasional yellowish brown mottling and rare fine and medium flint gravel
BH01	9.45	D5	24	100	24	39	18	21	0.29	CI	Firm olive grey sandy silty CLAY
BH01	10.50	D6	24	100	24	38	21	17	0.18	CI	Firm yellowish brown slightly sandy silty CLAY with occasional orange mottling

Method of Preparation : BS 1377:PART 1:1990:7.4 Preparation of samples for classification tests BS 1377:PART 2:1990:4.2 & 5.2 Sample preparations

Method of Test : BS 1377:PART 2:1990:3 Determination of moisture content 1990:4 Determination of the liquid limit BS 1377:PART 2:1990:5 Determination of the plastic limit and plasticity index

Remarks :

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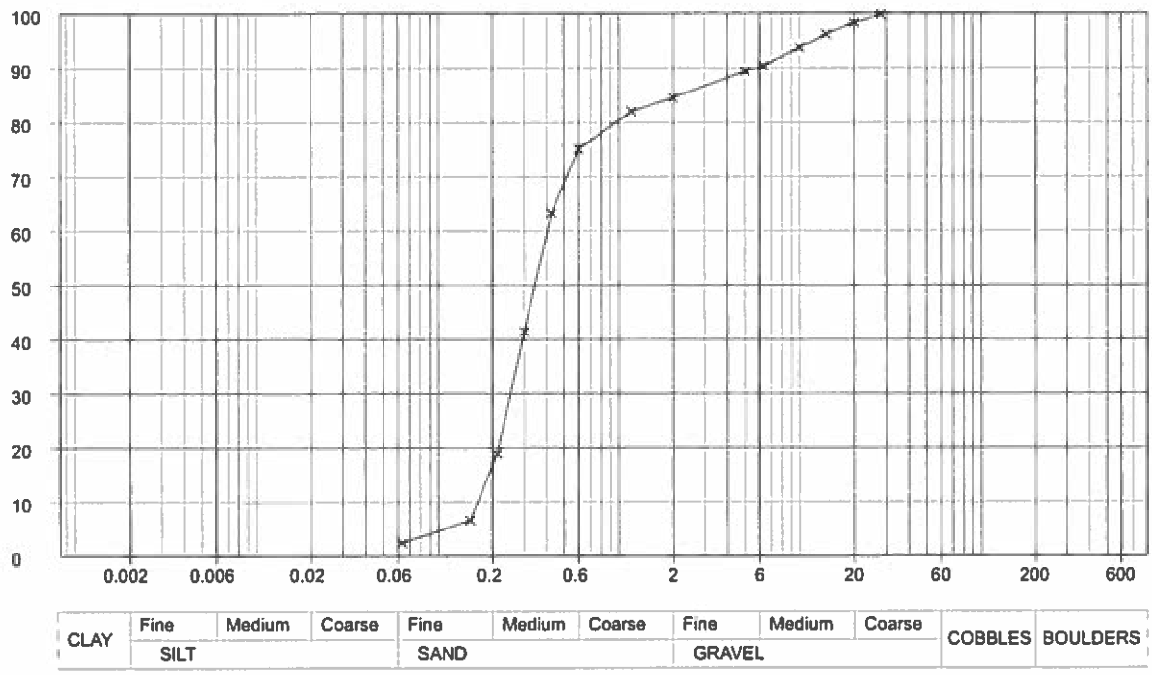
Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH	**Job Number** 15.116
Client : Mr Simon Firth	**Sheet** 1/1
Engineer: Create Consulting Engineers Limited	

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
BH01	13.00 - 13.50	B9	Yellowish brown slightly silty gravelly SAND. Gravel is brown, white and black angular and subangular



Sieve / Particle Size	% Passing
28 mm	100.0
20 mm	98.4
14 mm	96.4
10 mm	93.8
6.3 mm	90.4
5 mm	89.5
2 mm	84.6
1.18 mm	82.1
600 µm	75.1
425 µm	63.3
300 µm	41.4
212 µm	18.8
150 µm	6.6
63 µm	2.4

Grading Analysis	
D85	2.3 mm
D60	406.2 µm
D10	167.3 µm
Uniformity Coefficient	2.4

Particle Proportions	
Cobbles + Boulders	-
Gravel	15.4%
Sand	82.2%
Silt	-
Clay	-

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

Engineer : Create Consulting Engineers Limited

Job Number 15.116

Sheet 1 / 1

DETERMINATION OF DENSITY, MOISTURE CONTENT AND UNDRAINED SHEAR STRENGTH IN TRIAXIAL COMPRESSION WITHOUT MEASUREMENT OF PORE PRESSURE

Borehole/ Trial Pit	Depth (m)	Sample	Moisture Content %	Bulk Density (Mg/m³)	Dry Density (Mg/m³)	Cell Pressure (kN/m²)	Deviator Stress (kN/m²)	Apparent Cohesion (kN/m²)	Angle of Shearing Resistance (degrees)	Laboratory Description
BH01	9.00	U1	21	2.04	1.69	182 362 720	107 109 113	52	0.5	Firm dark greyish brown slightly sandy silty CLAY

Method of Preparation : BS 1377:PART 1:1990:7.4.2 Moisture content 1990: Preparation of undisturbed samples for testing BS 1377:PART 2:1990:7.2

Method of Test : BS 1377:PART 2:1990:3 Determination of moisture content 1990:7 Determination of density BS 1377:PART 7:1990:8 Undrained shear strength 1990:9 Multistage loading

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : 51 CALTHORPE STREET, LONDON WC1X 0HH

Client : Mr Simon Firth

Engineer : Create Consulting Engineers Limited

Job Number: 15.116

Sheet: 1 / 1

DETERMINATION OF pH, SULPHATE CONTENT AND TOTAL SULPHUR OF SOIL AND GROUNDWATER

Borehole/ Trial Pit	Depth (m)	Sample	Concentration of Soluble Sulphate			Total Sulphur %	Percentage of sample passing 2mm Sieve %	pH	Laboratory Description
			Soil		Groundwater g /l				
			Total S04 %	S03 in 2:1 water:soil g /l					
BH01	5.62	W1			0.37			7.2	Water Sample
BH01	6.70	ES3	0.13	0.52		0.37		7.5	Black clay and sand
BH01	8.00	D3	0.06	0.46		0.11		7.2	Brown CLAY and sand
BH01	9.45	D5	0.02	0.04		0.01		8.0	Light brown CLAY and sand
BH01	9.50	W2			0.17			6.8	Water Sample

Method of Preparation : BS 1377:PART 1:1990:7.5 Preparation of soil for chemical tests BS 1377:PART 3:1990:5.2, 5.3, 5.4 & 9.4

Method of Test : Laboratory in-house methods based on BS1377: Part 3 for contents of water soluble sulphate, total sulphate and pH. Laboratory in-house method based on MEWAM (Environment Agency, 2006) for total sulphur

Remarks :

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Analytical Report Number : 15-70368

Project / Site name:	51 Calthorpe Street, London WC1X 0HH	**Samples received on:**	23/04/2015
Your job number:	15.116	**Samples instructed on:**	23/04/2015
Your order number:	GNB/15.116/00/01	**Analysis completed by:**	05/05/2015
Report Issue Number:	1	**Report issued on:**	05/05/2015
Samples Analysed:	2 soil samples		

Signed: CCStone

Dr Claire Stone
Quality Manager
For & on behalf of i2 Analytical Ltd.

Signed:

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Other office located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

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Analytical Report Number: 15-70368

Project / Site name: 51 Calthorpe Street, London WC1X 0HH
Your Order No: GNB/15.116/00/01

Lab Sample Number				436919	436920			
Sample Reference				BH01	BH01			
Sample Number				ES2	ES3			
Depth (m)				3.00	6.70			
Date Sampled				16/04/2015	16/04/2015			
Time Taken				None Supplied	None Supplied			
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	18	< 0.1			
Moisture Content	%	N/A	NONE	14	20			
Total mass of sample received	kg	0.001	NONE	1.6	1.5			
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected			
General Inorganics								
pH	pH Units	N/A	MCERTS	7.5	7.5			
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1			
Organic Matter	%	0.1	MCERTS	0.9	2.6			
Total Phenols								
Total Phenols (monohydric)	mg/kg	1	MCERTS	< 1.0	< 1.0			
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05			
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Benzo(a)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Chrysene	mg/kg	0.05	MCERTS	< 0.05	< 0.05			
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Benzo(a)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05			
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	< 1.60	< 1.60			
Heavy Metals / Metalloids								
Antimony (aqua regia extractable)	mg/kg	1	ISO 17025	1.5	8.2			
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	11	15			
Beryllium (aqua regia extractable)	mg/kg	0.06	MCERTS	0.6	0.8			
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2			
Chromium (hexavalent)	mg/kg	4	MCERTS	< 4.0	< 4.0			
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	21	23			
Copper (aqua regia extractable)	mg/kg	1	MCERTS	63	1300			
Lead (aqua regia extractable)	mg/kg	1	MCERTS	280	770			
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	0.6	2.9			
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	18	22			
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0			
Vanadium (aqua regia extractable)	mg/kg	1	MCERTS	31	40			
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	58	120			

Iss No 15-70368-1

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Analytical Environmental Science

Analytical Report Number: 15-70368

Project / Site name: 51 Calthorpe Street, London WC1X 0HH
Your Order No: GNB/15.116/00/01

Lab Sample Number				436919	436920			
Sample Reference				BH01	BH01			
Sample Number				ES2	ES3			
Depth (m)				3.00	6.70			
Date Sampled				16/04/2015	16/04/2015			
Time Taken				None Supplied	None Supplied			
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0			
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0			
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0			
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0			
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0			
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0			
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0			
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0			
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0			
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	8.5			
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10			
TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0			
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0			
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	< 10	< 10			
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	< 10	< 10			
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10			
Miscellaneous Organics								
Product ID		N/A	NONE	See Attached	See Attached			

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Analytical Environmental Science

Analytical Report Number : 15-70368

Project / Site name: 51 Calthorpe Street, London WC1X 0HH

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and topsoil/loam soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
436919	BH01	ES2	3.00	Light brown clay and sand with stones.
436920	BH01	ES3	6.70	Black clay and sand.

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Analytical Environmental Science

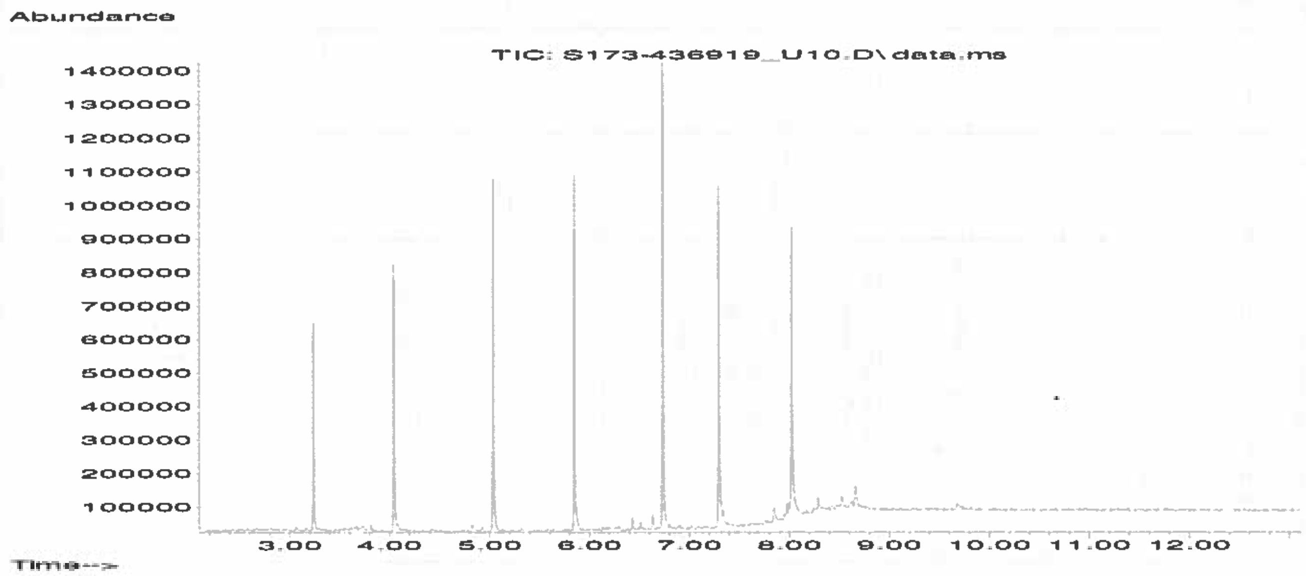
Analytical Report Number : 15-70368

Project / Site name: 51 Calthorpe Street, London WC1X 0HH

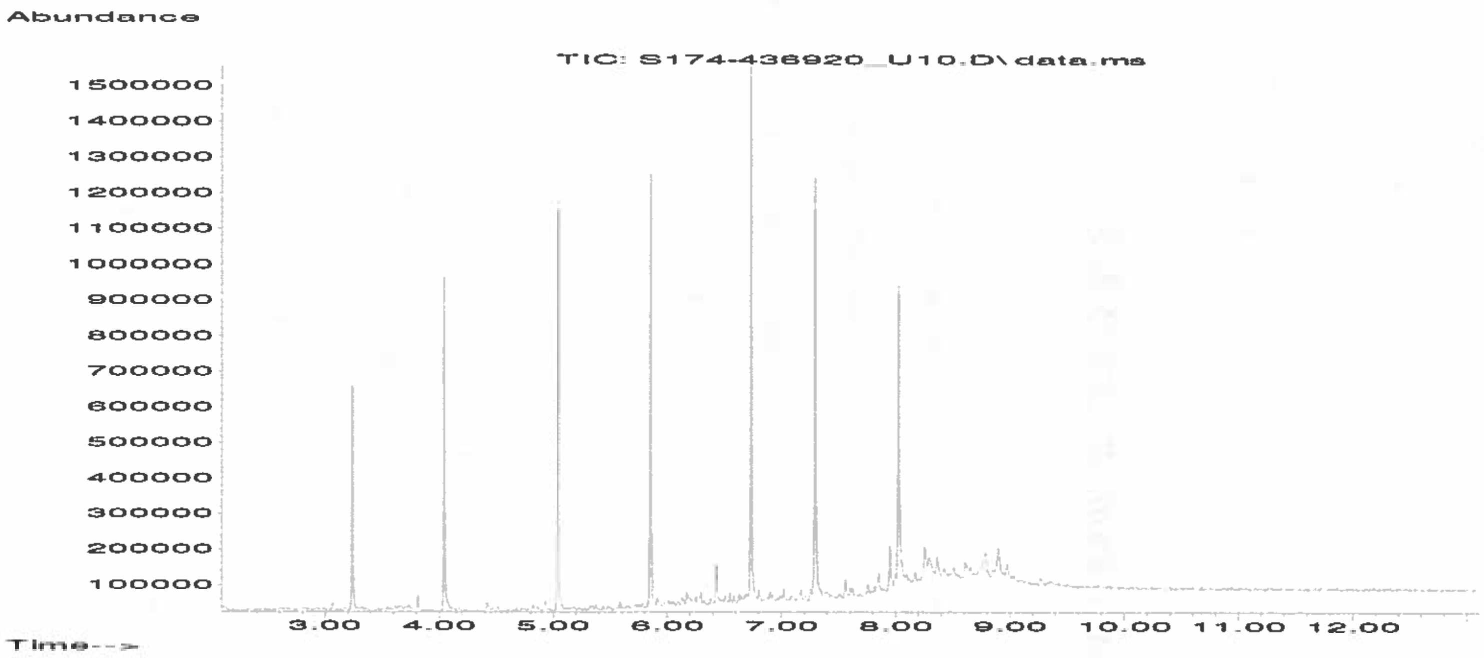
Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with disperion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
BTEX and MTBE in soil	Determination of BTEX in soil by headspace GC-MS.	In-house method based on USEPA8260	L073S-PL	W	MCERTS
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method	L080-PL	W	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	MCERTS
Organic matter in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L023-PL	D	MCERTS
pH in soil (automated)	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L099-PL	D	MCERTS
Product ID	Determination against standard chromatograms.	In-house method	L064-PL	W	NONE
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight. Sample results are not corrected for the stone content of the sample.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
TPHCWG (Soil)	Determination of hexane extractable hydrocarbons in soil by GC-MS/GC-FID.	In-house method	L076-PL	W	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.



The sample is clean and there is no hydrocarbon product to identify.



The sample is clean and there is no hydrocarbon product to identify.

4041 mCERTS

Environmental Science

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Analytical Report Number : 15-70369

Project / Site name:	51 Calthorpe Street, London WC1X 0HH	**Samples received on:**	23/04/2015
Your job number:	15.116	**Samples instructed on:**	23/04/2015
Your order number:	GNB/15.116/00/01	**Analysis completed by:**	05/05/2015
Report Issue Number:	1	**Report issued on:**	05/05/2015
Samples Analysed:	2 wac multi samples		

Signed: CCStone

Dr Claire Stone
Quality Manager
For & on behalf of i2 Analytical Ltd.

Signed:

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Other office located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

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Waste Acceptance Criteria Analytical Results							
Report No:	15-70369						
					Client: AFHOWLAND		
Location	51 Calthorpe Street, London WC1X 0HH						
Lab Reference (Sample Number)	436921				Landfill Waste Acceptance Criteria Limits		
Sampling Date	16/04/2015				Inert Waste Landfill	Stable Non-reactive HAZARDOUS waste in non-hazardous Landfill	Hazardous Waste Landfill
Sample ID	BH01 ES2						
Depth (m)	3.00						
Solid Waste Analysis							
TOC (%)**	0.5				3%	5%	6%
Loss on Ignition (%) **	4.1				--	--	10%
BTEX (µg/kg) **	< 10				6000	--	--
Sum of PCBs (mg/kg) **	< 0.30				1	--	--
Mineral Oil (mg/kg)	< 10				500	--	--
Total PAH (WAC-17) (mg/kg)	< 1.6				100	--	--
pH (units)**	7.5				--	>6	--
Acid Neutralisation Capacity (mol / kg)	3.4				--	To be evaluated	To be evaluated
Eluate Analysis	2:1	8:1		Cumulative 10:1	Limit values for compliance leaching test		
(BS EN 12457 - 3 preparation utilising end over end leaching procedure)	mg/l	mg/l		mg/kg	using BS EN 12457-3 at L/S 10 l/kg (mg/kg)		
Arsenic *	< 0.010	< 0.010		0.053	0.5	2	25
Barium *	0.11	0.026		0.36	20	100	300
Cadmium *	< 0.0005	< 0.0005		< 0.0020	0.04	1	5
Chromium *	0.0012	0.0011		0.011	0.5	10	70
Copper *	0.0037	0.0034		0.035	2	50	100
Mercury *	< 0.0015	< 0.0015		< 0.010	0.01	0.2	2
Molybdenum *	0.053	0.017		0.22	0.5	10	30
Nickel *	0.0012	0.0012		0.012	0.4	10	40
Lead *	0.0077	< 0.0050		0.032	0.5	10	50
Antimony *	0.0070	< 0.0050		0.048	0.06	0.7	5
Selenium *	< 0.010	< 0.010		< 0.040	0.1	0.5	7
Zinc *	0.0044	0.0023		0.026	4	50	200
Chloride *	< 4.0	< 4.0		< 15	800	4000	25000
Fluoride	< 0.050	< 0.050		0.42	10	150	500
Sulphate *	670	75		1500	1000	20000	50000
TDS	680	140		2100	4000	60000	100000
Phenol Index (Monhydric Phenols) *	< 0.13	< 0.13		< 0.50	1	-	-
DOC	3.8	2.3		25	500	800	1000
Leach Test Information							
Stone Content (%)	18						
Sample Mass (kg)	1.6						
Dry Matter (%)	86						
Moisture (%)	14						
Stage 1							
Volume Eluate L2 (litres)	0.33						
Filtered Eluate VE1 (litres)	0.23						

Results are expressed on a dry weight basis, after correction for moisture content where applicable
Stated limits are for guidance only and i2 cannot be held responsible for any discrepancies with current legislation

*= UKAS accredited (liquid eluate analysis only)
** = MCERTS accrediited

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Waste Acceptance Criteria Analytical Results

Report No:	15-70369						
					Client: AFHOWLAND		
Location	51 Calthorpe Street, London WC1X 0HH						
Lab Reference (Sample Number)	436922				Landfill Waste Acceptance Criteria Limits		
Sampling Date	16/04/2015				Inert Waste Landfill	Stable Non-reactive HAZARDOUS waste in non-hazardous Landfill	Hazardous Waste Landfill
Sample ID	BH01 ES3						
Depth (m)	6.70						
Solid Waste Analysis							
TOC (%)**	1.5				3%	5%	6%
Loss on Ignition (%) **	6.3				--	--	10%
BTEX (µg/kg) **	< 10				6000	--	--
Sum of PCBs (mg/kg) **	< 0.30				1	--	--
Mineral Oil (mg/kg)	< 10				500	--	--
Total PAH (WAC-17) (mg/kg)	< 1.6				100	--	--
pH (units)**	7.5				--	>6	--
Acid Neutralisation Capacity (mol / kg)	4.8				--	To be evaluated	To be evaluated
Eluate Analysis	2:1	8:1		Cumulative 10:1	Limit values for compliance leaching test using BS EN 12457-3 at L/S 10 l/kg (mg/kg)		
(BS EN 12457 - 3 preparation utilising end over end leaching procedure)	mg/l	mg/l		mg/kg			
Arsenic *	0.011	< 0.010		0.069	0.5	2	25
Barium *	0.10	0.039		0.46	20	100	300
Cadmium *	< 0.0005	< 0.0005		< 0.0020	0.04	1	5
Chromium *	< 0.0010	< 0.0010		0.0063	0.5	10	70
Copper *	0.0094	0.0070		0.072	2	50	100
Mercury *	< 0.0015	< 0.0015		< 0.010	0.01	0.2	2
Molybdenum *	0.085	0.019		0.26	0.5	10	30
Nickel *	0.0044	0.0026		0.028	0.4	10	40
Lead *	0.0093	< 0.0050		0.050	0.5	10	50
Antimony *	0.031	0.021		0.22	0.06	0.7	5
Selenium *	< 0.010	< 0.010		< 0.040	0.1	0.5	7
Zinc *	0.0049	0.0038		0.039	4	50	200
Chloride *	12	< 4.0		24	800	4000	25000
Fluoride	< 0.050	< 0.050		0.47	10	150	500
Sulphate *	180	56		690	1000	20000	50000
TDS	200	100		1100	4000	60000	100000
Phenol Index (Monhydric Phenols) *	< 0.13	< 0.13		< 0.50	1	-	-
DOC	30	9.2		110	500	800	1000
Leach Test Information							
Stone Content (%)	< 0.1						
Sample Mass (kg)	1.5						
Dry Matter (%)	80						
Moisture (%)	20						
Stage 1							
Volume Eluate L2 (litres)	0.31						
Filtered Eluate VE1 (litres)	0.18						

Results are expressed on a dry weight basis, after correction for moisture content where applicable
Stated limits are for guidance only and i2 cannot be held responsible for any discrepancies with current legislation

*= UKAS accredited (liquid eluate analysis only)
** = MCERTS accredited

4041 MCERTS

Environmental Science

Analytical Report Number : 15-70369

Project / Site name: 51 Calthorpe Street, London WC1X 0HH

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and topsoil/loam soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
436921	BH01	ES2	3.00	Light brown clay and sand with stones.
436922	BH01	ES3	6.70	Black clay and sand.

4041 MCERTS

Environmental Science

Analytical Report Number : 15-70369

Project / Site name: 51 Calthorpe Street, London WC1X 0HH

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Acid neutralisation capacity of soil	Determination of acid neutralisation capacity by addition of acid or alkali followed by electronic probe.	In-house method based on Guidance an Sampling and Testing of Wastes to Meet Landfill Waste Acceptance	L046-PL	W	NONE
BTEX (Sum of BTEX compounds) in soil	Determination of BTEX in soil by headspace GC-MS. Individual components MCERTS accredited	In-house method based on USEPA8260	L073S-PL	W	MCERTS
Chloride in WAC leachate (BS EN 12457-3 Prep)	Determination of chloride in leachate by Gallery discrete analyser.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L082-PL	W	ISO 17025
DOC in WAC leachate (BS EN 12457-3 Prep)	Determination of dissolved organic carbon in leachate by the measurement on a non-dispersive infrared analyser of carbon dioxide released by acidification.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L037-PL	W	NONE
Fluoride in WAC leachate (BS EN 12457-3 Prep)	Determination of fluoride in leachate by 1:1ratio with a buffer solution followed by Ion Selective Electrode.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L033-PL	W	NONE
Loss on ignition of soil @ 450oC	Determination of loss on ignition in soil by gravimetrically with the sample being ignited in a muffle furnace.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L047-PL	D	MCERTS
Metals in WAC leachate (BS EN 12457 3 Prep)	Determination of metals in leachate by acidification followed by ICP-OES.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L039-PL	W	ISO 17025
Mineral Oil in Soil	Determination of dichloromethane/hexane extractable hydrocarbons in soil by GC-MS.	In-house method based on USEPA 8270	L064-PL	D	NONE
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
PCB's by GC-MS in soil	Determination of PCB by extraction with acetone and hexane followed by GC-MS.	In-house method based on USEPA 8082	L027-PL	D	NONE
pH in soil	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	MCERTS
Phenol Index in WAC leachate (BS EN 12457-3 Prep)	Determination of monohydric phenols in leachate by continuous flow analyser.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	ISO 17025
Seciated WAC-17 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	NONE
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight. Sample results are not corrected for the stone content of the sample.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Sulphate in WAC leachate (BS EN 12457-3 Prep)	Determination of sulphate in leachate by acidification followed by ICP-OES.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L039-PL	W	ISO 17025
TDS in WAC leachate (BS EN 12457-3 Prep)	Determination of total dissolved solids in leachate by electrometric measurement.	In-house method based on Standard Methods for the Examination of Water and Waste Water, 21st Ed.	L004-PL	W	NONE

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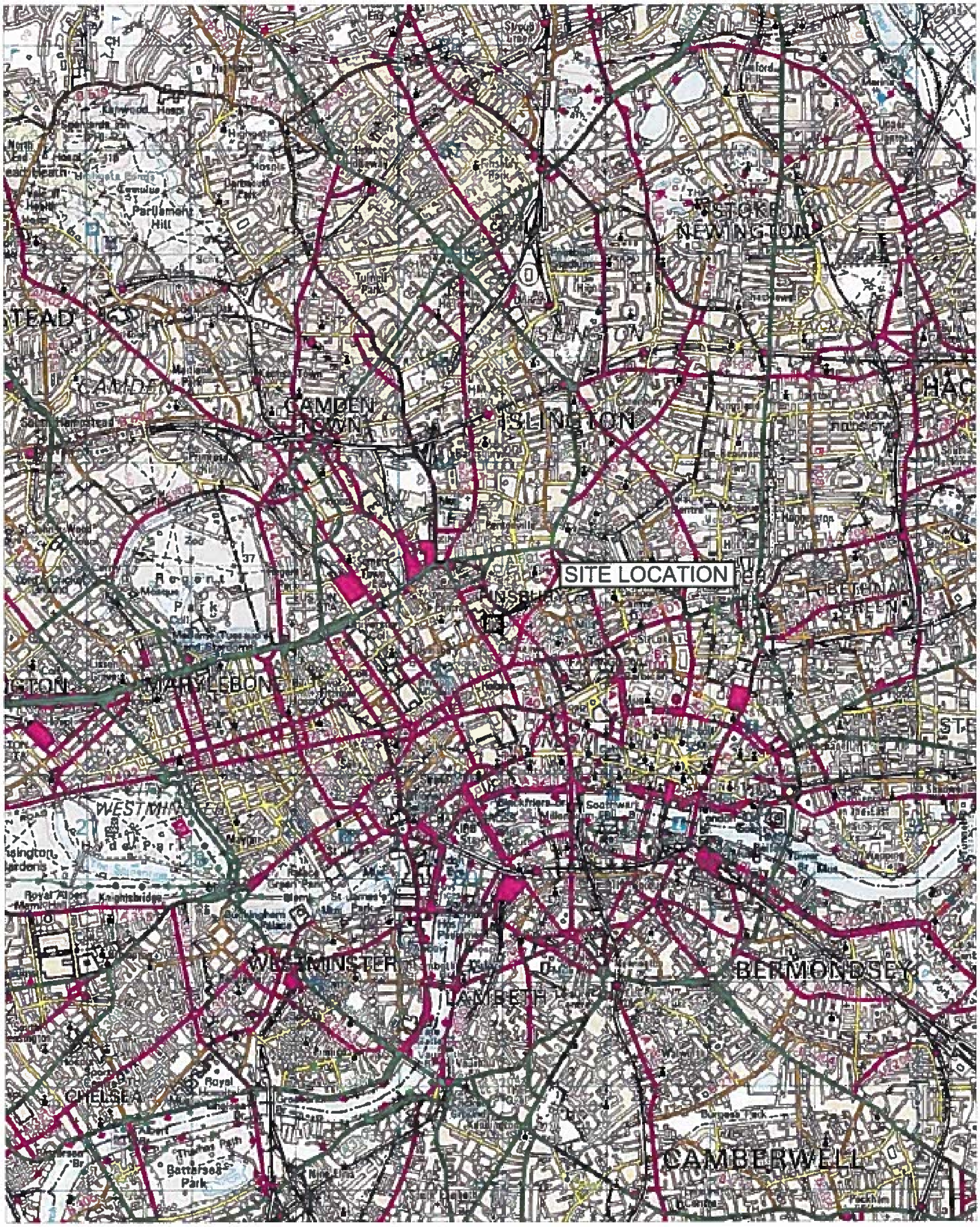
Analytical Report Number : 15-70369

Project / Site name: 51 Calthorpe Street, London WC1X 0HH

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Total organic carbon in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L023-PL	D	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.



North

Box indicates approximate position of drawing 15.116/2

Scale 1: 50,000 @ A4

A F Howland Associates
Geotechnical Engineers

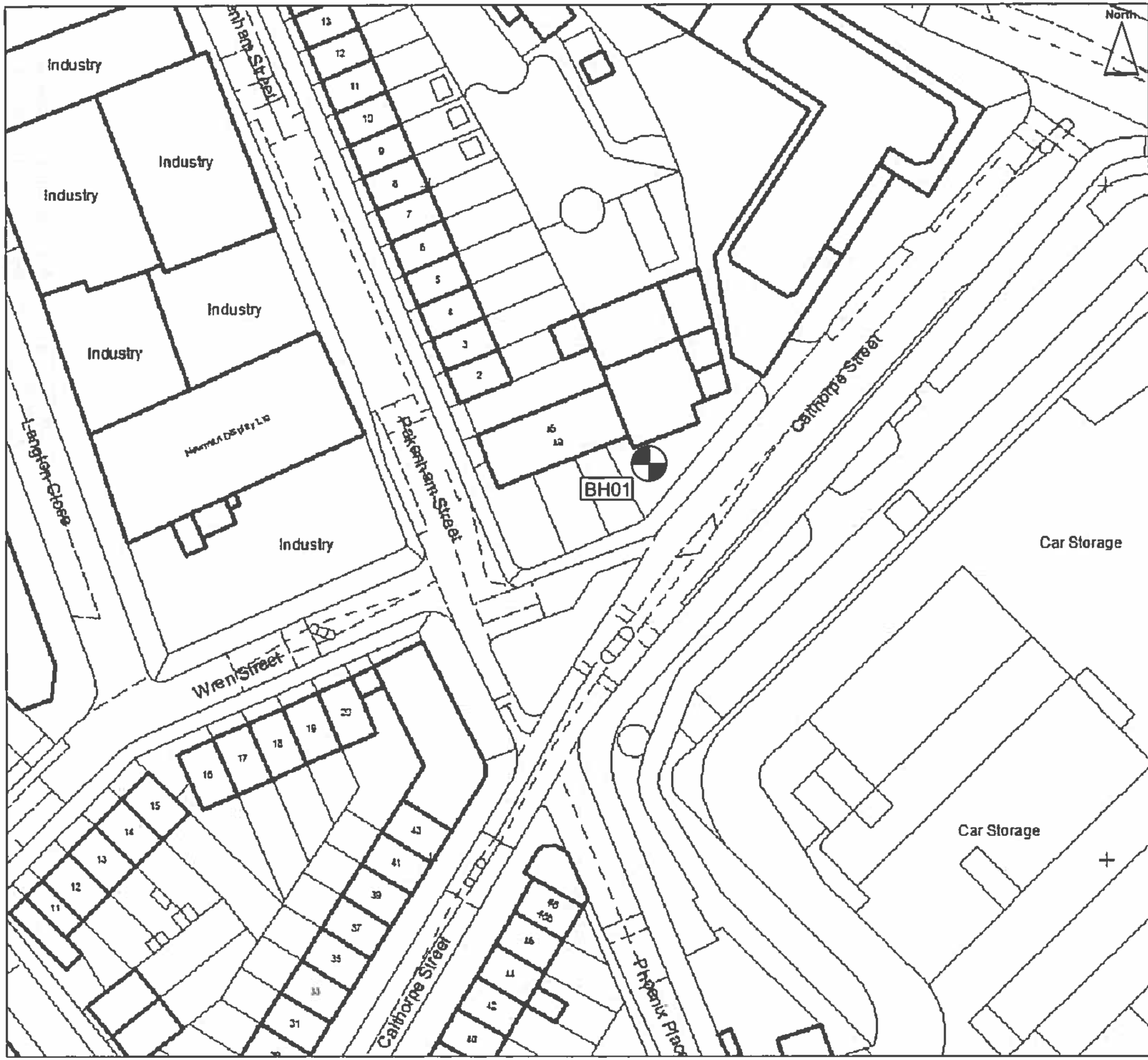
Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

SITE LOCATION PLAN

Client : Mr Simon Firth

Date : May 2015 **Dwg :** 15.116/1

APPENDIX D: DRAWINGS



Key:

Borehole location and reference

Rev	Date	Revision Description	Drwn	Chkd

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Client: Mr Simon Firth

Site: 51 CALTHORPE STREET, LONDON WC1X 0HH

Job No.: 15.116

Drawing Title: BOREHOLE LOCATION PLAN

Date: May 2015

Drawing No: 15.116/2

Scale: 1:800 @ A4

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