20 Appendix D – GEA Report J16180

DESK STUDY & GROUND INVESTIGATION REPORT

Land to rear of
159-163 King's Cross Road
London
WC1X 9BN

Client: Balcap RE

Engineer: Parmarbrook

J16180

November 2016




Geotechnical & Environmental Associates

Document Control

Project title	Land to rear of 159–163 King's Cross Road, London WC1X 9BN	**Project ref**	J16180
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Issue No	Status	Amendment Details	Date	Approved for Issue
1	Final		4 November 2016	
2	Final (revised)		15 November 2016	SN

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This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

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Part 3: GROUND MOVEMENT ASSESSMENT

Part 4: BASEMENT IMPACT ASSESSMENT

EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Parmarbrook, on behalf of Balcap Re Limited, with respect to the demolition of the existing building and subsequent construction of a new two-storey and three-storey commercial building with a single level basement. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions, to assess the extent of any contamination and to provide information to assist with the design of retaining walls and spread foundations. The report also includes information required to comply with London Borough of Camden (LBC) Planning Guidance CPG4, relating to the requirement for a Basement Impact Assessment (BIA), including a ground movement assessment.

SITE HISTORY

The earliest map studied, dated 1851, shows King's Cross Road and Britannia Street in their present-day orientations. By the time of the next map, dated 1874, the site is depicted as having been developed. At some time between 1946 and 1953, the building on the site had been reconfigured to comprise a single building and a large building to the west is annotated as an engineering works. The 1951 to 1967 insurance plans indicate the site to have been a confectionery warehouse and garage, presumable for vehicle maintenance, with an asbestos roof. By 1992, a small building, presumably the existing building that houses gas assets, had been constructed adjacent to the southwestern corner of the site. The site has most recently been used as a mirror and architectural glass shop, although the date that the business was established at this address is not known. The site and surrounding area have since remained essentially unchanged.

GROUND CONDITIONS

Below a significant thickness of made ground, the London Clay Formation was encountered to the full depth of the investigation, of 15.00 m. The made ground generally comprised dark brown and grey very silty sandy gravelly clay, sand and silt with cobbles, fragments of brick, concrete and pockets of ash, and extended to depths of 1.90 m and 3.80 m. The London Clay initially comprised firm fissured medium strength silty clay which extended to a depth of 4.90 m, over firm becoming stiff fissured medium to high strength silty clay. Groundwater was encountered during drilling in Borehole No 2, at a depth of 3.0 m, and subsequent monitoring has measured the groundwater at depths of 2.6 m and 5.0 m. Contamination testing has not indicated the presence of elevated concentrations of contaminants within any of the samples of made ground tested.

RECOMMENDATIONS

The excavation of the proposed 4.4 m deep basement will result in a formation level in the firm medium strength silty clay of the London Clay and occasional groundwater seepages may be encountered in the excavation. Spread foundations or underpins may be designed to apply a net allowable bearing pressure of 120 kN/m² below the level of the proposed basement floor. Care should be taken at all times to ensure the stability of neighbouring properties and the existing party wall foundations will need to be underpinned prior to basement excavation or supported by new retaining walls. The contamination testing has not indicated that remedial works are required.

BASEMENT IMPACT ASSESSMENT

The BIA has not indicated any concerns with regard to the effects of the proposed basement construction on the site and surrounding area. A flood risk assessment may however need to be carried out. It has been concluded that the impacts identified can be mitigated by appropriate design and standard construction practice.

GROUND MOVEMENT ASSESSMENT CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties from the installation of the proposed underpin construction and basement excavation would be 'Negligible' to 'Very Slight', whilst three walls of sensitive structures may result in Category 2 'slight' damage. A monitoring strategy is recommended for the proposed construction and the horizontal limits outlined in this report should be incorporated into the strategy in order to limit the predicted movement to Category 1, Very Slight. It is recommended that movement monitoring is carried out on all structures prior to and during the proposed basement construction.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2, while the Ground Movement Assessment and Basement Impact Assessment are presented in Parts 3 and 4 respectively.

1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Parmarbrook, on behalf of Balcap Re Limited, to carry out a desk study and ground investigation at land to the Land to rear of Nos 159-163 King's Cross Road, London WC1X 9BN. This report also includes a Basement Impact Assessment (BIA) and a ground movement assessment, which has been carried out in support of a planning application.

1.1 Proposed Development

It is understood that it is proposed to demolish the existing building and subsequently construct a new two-storey and three-storey commercial building with a single level basement.

This report is specific to the proposed development and the advice herein should be reviewed once the development proposals are finalised.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- to check the history of the site and surrounding areas with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to assess the possible impact of the proposed development on the local hydrogeology and nearby sensitive structures;
- to provide information about the existing foundations;
- to provide advice with respect to design of suitable foundations and retaining walls;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out followed by a ground investigation. The desk study comprised:

- a review of historical Ordnance Survey (OS) maps, aerial photographs, Post Office maps and environmental searches sourced from the Envirocheck database;

- a review of readily available geology maps; and
- a walkover survey of the site carried out in conjunction with the fieldwork.

In the light of this desk study, an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- a single borehole advanced to a depth of 15.00 m by cable percussive methods;
- a single window sampler borehole advanced to a depth of 6.00 m;
- installation of a standpipe within each of the boreholes to a depth of 6.00 m and a single subsequent monitoring visit;
- a series of 14 trial pits advanced to investigate the existing foundations and neighbouring basement depths;
- testing of selected soil samples for contamination and geotechnical purposes; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The report includes a contaminated land assessment which has been undertaken in accordance with the methodology presented in Contaminated Land Report (CLR) 11[1] and involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. The risk assessment is thus divided into three stages comprising Preliminary Risk Assessment, Generic Quantitative Risk Assessment, and Site-Specific Risk Assessment.

The exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon GEA's engineering experience, local precedent where applicable and relevant published information.

1.3.1 Basement Impact Assessment

The work carried out also includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), all of which form part of the BIA procedure specified in the London Borough of Camden (LBC) Planning Guidance CPG4[2] and their Guidance for Subterranean Development[3] prepared by Arup. The aim of the work is to provide information on surface water, land stability and groundwater and in particular to assess whether the development will affect neighbouring properties or groundwater movements and whether any identified impacts can be appropriately mitigated by the design of the development.

1.3.2 Qualifications

The land stability element of the Basement Impact Assessment (BIA) has been carried out by Martin Cooper, a BEng in Civil Engineering, a chartered engineer (CEng), member of the Institution of Civil Engineers (MICE), and Fellow of the Geological Society (FGS) who has over 20 years' specialist experience in ground engineering. The subterranean (groundwater)

1 *Model Procedures for the Management of Land Contamination* issued jointly by the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) Sept 2004
2 London Borough of Camden Planning Guidance CPG4 *Basements and lightwells*
3 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

flow assessment has been carried out by John Evans, MSc in Hydrogeology, Chartered Geologist (CGeol) and Fellow of the Geological Society of London (FGS). The surface water and flooding assessment has been carried out by Rupert Evans, a hydrologist with more than ten years consultancy experience in flood risk assessment, surface water drainage schemes and hydrology / hydraulic modelling. Rupert Evans is a Chartered Environmentalist, Chartered Water and Environmental Manager and a Member of CIWEM. The assessments have been made in conjunction with Steve Branch, a BSc in Engineering Geology and Geotechnics, MSc in Geotechnical Engineering, a chartered geologist (CGeol) and Fellow of the Geological Society (FGS) with some 30 years' experience in geotechnical engineering and engineering geology.

All assessors meet the qualification requirements of the Council guidance.

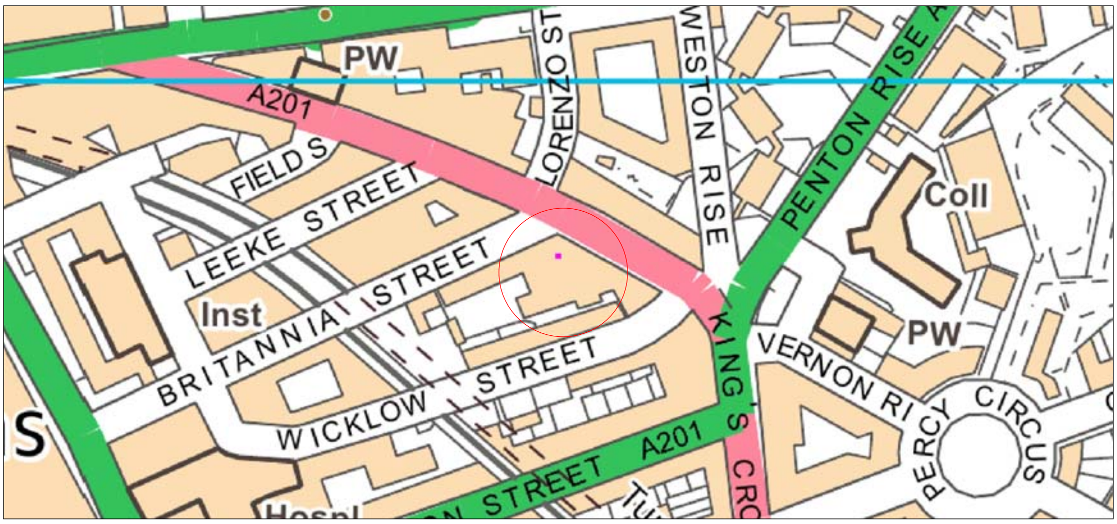
1.4 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted and the number of locations where the ground was sampled. No liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located in the London Borough of Camden, approximately 340 m east of King's Cross St Pancras Railway and London Underground stations and 860 m west of Angel London Underground station. The site is located behind properties that front on to King's Cross Road to the northeast and Britannia Street to the northwest and it is bounded by a communal courtyard area that is accessed by apartments that front on to the aforementioned roads and Wicklow Street to the south. The site may be additionally located by National Grid Reference 530720, 182908 and is shown on the map extract below.



A walkover of the site was carried out by a geotechnical engineer from GEA at the time of the fieldwork. The site is accessed from a vehicular access gate between Nos 1 and 3 Britannia Street in the northeast; there is also a pedestrian fire exit that leads to the communal courtyard to the south.

The site is entirely covered by a single storey double height building; including a temporary mezzanine level that occupies the southern half of the building, and an office and WC in the northwest and northeast respectively. There are two-storeys above the access to site on Britannia Street and these are not accessible from, and do not form part of the site. At the time of the walkover, the majority of the site was in use as a mirror and architectural glass shop, while the southeastern corner of the site was occupied by a cluster of rooms that has recently been used as accommodation and was accessed only from the mirror shop via an internal door.

Photographs: Mezzanine floor looking southeast (left); Entrance to site looking northwest (right)

An online search[4] indicates that the site is used for the manufacture and etching of glass and screen printing, although there was no evidence of the manufacture of glass on the site. The site contained equipment to repair and alter glass and the south of the site was predominantly used to store large quantities of mirrors, glass and decorative frames. A number of pots and

4 http://www.2kmirror.co.uk/

containers that appeared to contain resins and greases, some of which were leaking, were noted during the walkover, as were a number of broken mirrors, with shards of glass on the floor of the building. During the initial visit to site the engineer from GEA was warned that a container of acid was on the premises, although the location of this was never determined. Adjacent to the southwestern corner of the site is an outbuilding that houses gas assets. The site is essentially level and is devoid of vegetation.

2.2 Site History

The site history has been researched by reference to internet sources and historical Ordnance Survey (OS) maps obtained from the Envirocheck database.

The earliest map studied, dated 1851, shows King's Cross Road and Britannia Street in their present-day orientations, with a road to the south of the site named George Street and King's Cross station to the northwest, with the Metropolitan Railway orientated northwest-southeast to the west of the site. By the time of the next map, dated 1874, the site is depicted as developed with a U-shaped building including a central courtyard, whilst terraced houses annotated as industrial dwellings are shown to the northwest, northeast and south and George Street to the south had been renamed Wicklow Street. A mineral water facility is shown on the site on the 1892 Insurances Plan. The 1896 map indicates that the central courtyard area had been developed with a number of rooms; whilst a public house and a Tramway Depot were located to the northwest and north respectively. Also at that time, a large cluster of terraced houses to the northeast of the site on the opposite side of King's Cross Road had been redeveloped into a single large building that was later used as a bottling depot and a warehouse.

The Bomb Damage Maps of London[5] indicate the site to have sustained minor blast damage during World War II (WWII), whilst the building immediately north of the site had sustained general non-structural blast damage. By the time of the aerial photograph taken in 1946, a cluster of terraced houses that had fronted onto Britannia Street to the northwest had been redeveloped into an iron works and the Bomb Damage Maps of London indicate the buildings in this area had been damaged beyond repair during the war.

At some time between 1946 and 1953, the building on the site had been reconfigured to comprise a single building, and a large building to the west is annotated as an engineering works. The 1951 to 1967 insurance plans indicate the site to have been a confectionery warehouse and garage, presumably for vehicle maintenance, with an asbestos roof, and the site and surrounding buildings had been renamed the Derby Buildings. By 1976, the engineering works to the west had been cleared and by 1982, the iron works to the northwest is annotated as a post office depot. The map dated 1992 shows that a small building, presumably the existing building that houses gas assets, had been constructed adjacent to the southwestern corner of the site and what appears to have been a small structure or raised flower bed had been positioned within the courtyard area of the Derby Buildings. By 1996 the area to the west; formerly an engineering works, is annotated as a car park and by 1999 the former bottling depot had been redeveloped into townhouses.

The site has most recently been used as a mirror and architectural glass shop, although the date that the business was established at this address is not known. The site and surrounding area have since remained essentially unchanged.

5 Laurence Ward (2015) *The London County Council Bomb Damage Maps 1939-1945*. Thames & Hudson

2.3 Other Information

A search of public registers and databases has been made via the Envirocheck database and relevant extracts from the search are appended. Full results of the search can be provided if required.

The Envirocheck report has indicated no historic landfill sites, waste management, waste transfer or Control of Major Accident Hazards (COMAH) sites are located within 500 m of the site.

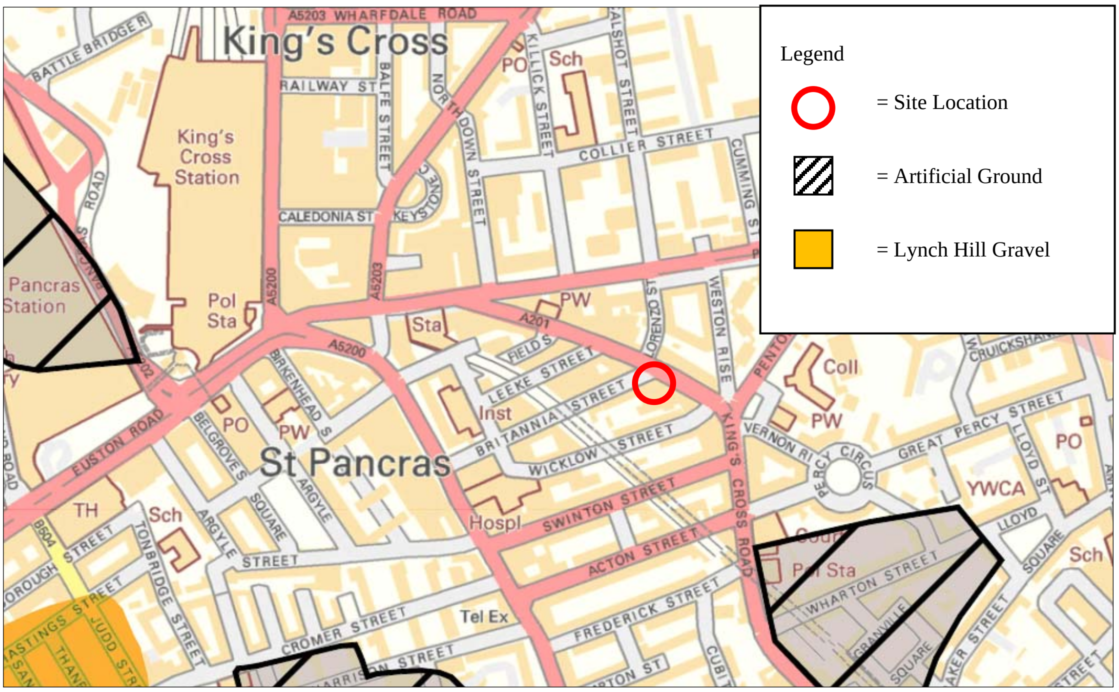
No pollution incidents to controlled waters have been recorded within 250 m of the site. The site is located within the King's Cross Conservation area, specifically the Gray's Inn Road Sub Area 4.

Reference to records compiled by the Health Protection Agency (formerly the National Radiological Protection Board) indicates that the site falls within an area where less than 1% of homes are affected by radon emissions and therefore radon protective measures will not be necessary.

2.4 Geology

The British Geological Survey (BGS) map of the area (Sheet 256) indicates that the site is directly underlain by London Clay.

According to the BGS Sheet 256, dated 2006, the site is shown in an area of "Head Propensity". Head propensity is shown on the BGS map as areas denoted as most likely to be covered by Quaternary Head Deposits as interpreted from digital slope analysis and confirmed by borehole data. These deposits are not mapped and have not been verified by fieldwork; they are noted as having properties similar to that of the London Clay and are shown to occur close to the boundary with the overlying Claygate Member.



Geological Map Extract: Superficial Deposits

According to the BGS memoir, the London Clay is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine grained sand.

The geological map on the previous page indicates that the site is located roughly 270 m northwest of an area of artificial ground. The origin of the artificial ground is unclear and is not shown on the historical or sensitivity maps, although it is likely to be attributable to the Metropolitan Railway that runs through the area of artificial ground. The area of artificial ground is likely to have occurred prior to the earliest historical map, dated 1851 and as such is highly unlikely to pose a risk to the site from migrating soil gas.

2.5 Hydrology and Hydrogeology

The London Clay is classified as an Unproductive Stratum, which refers to rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow, as defined by the Environment Agency (EA).

Any groundwater flow within the London Clay will be at a very slow rate, due to its negligible permeability. The permeability will be predominantly secondary, through fissures in the clay. Published data indicates the horizontal permeability of the London Clay to generally range between 1×10^{-11} m/s and 1×10^{-9} m/s.

The nearest surface water feature appears to be a private pond within the grounds of a school, which is located 471 m to the northeast of the site. The Regent's Canal is located beyond this, at a distance of roughly 425 m to the north of the site and flows in an easterly direction, before flowing southeast towards Limehouse in east London.

Reference to the Lost Rivers of London[6] indicates that the River Fleet previously flowed along King's Cross Road from Pentonville Road in the northwest. It is shown to have flowed in an easterly and then southeasterly direction towards Clerkenwell, before flowing south along Farringdon Road, to join the River Thames at Blackfriars. The Fleet is considered to rise from springs and seepages from the Bagshot Formation sands on Hampstead Heath and is perched on the London Clay over most of its lenght. The Fleet is now entirely covered and culverted and plans of the nearby sewer system, which indicate a major sewer to follow the line of King's Cross Road, presumably represents the course of the former river. It is likely that any groundwater flow beneath the site within the London Clay Formation would follow topographic contours, although the site is located within a topographical basin, with an Ordnance Datum level of between 10 m OD and 15 m OD.

The site is not at risk of flooding from rivers or sea, as defined by the Environment Agency and is shown as being within an area at low risk of surface water flooding, although King's Cross Road is indicated a being at high risk. The site is also not indicated as having a potential for groundwater flooding for surface or below ground property.

2.6 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach, which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

6 Nicholas Barton & Stephen Myers (2016) *The Lost Rivers of London.* Historical Publications Ltd

2.6.1 Source

The desk study findings indicate that the site has previously been use as a mineral water facility, a confectionery warehouse, a garage and a mirror and architectural glass shop. The Post Office directories also indicate that the site has had an asbestos roof and is it not known if the existing roof is the original asbestos roof. The previous use of the site as a garage may represent a potential contaminative source and localised spillages of fuels and oils may have occurred. Similarly, evidence of leaking containers of resins and greases during the walkover may represent potential sources of contamination, albeit localised. The asbestos roof may represent a potential source of contamination, had the roof become damaged or been removed without due care.

2.6.2 Receptor

The proposed redevelopment of the site for commercial purposes will result in the end users representing relatively high sensitivity receptors. The occupiers of neighbouring properties are also considered to be a moderately sensitive receptor.

Groundwater is considered to be a moderately sensitive receptor and the deep chalk aquifer if considered to be a highly sensitive receptor.

2.6.3 Pathway

The negligibly permeable London Clay expected beneath the site would prevent the migration of contaminated groundwater to surrounding sites and limit the potential for groundwater percolation into the underlying chalk, and thus a pathway is not considered likely to exist to the major aquifer. Within the site, end users will be isolated from direct contact with any contaminants present within the made ground by the presence of the building and the extent of the hardstanding. Only in areas of proposed soft landscaping will a pathway to end users exist through direct contact, although it is understood that this does not form part of the proposed development.

Buried services may be exposed to any contaminants present within the soil through direct contact and site workers will come into contact with the soils during construction works. There is thus considered to be a low potential for a contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.

2.6.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a LOW risk of there being a significant contaminant linkage at this site which would result in a requirement for major remediation work. In addition, the site is not considered to be at risk from hazardous ground gas.

3.0 SCREENING

The London Borough of Camden guidance suggests that any development proposal that includes a subterranean basement should be screened to determine whether or not a full Basement Impact Assessment (BIA) is required.

3.1 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to Appendix E which includes a series of questions within a screening flowchart for three categories; groundwater flow; land stability; and surface water flow. Responses to the questions are tabulated on the following pages.

3.1.1 Subterranean (groundwater) Screening Assessment

Question	Response for Land to rear of 159-163 King's Cross Road
1a. Is the site located directly above an aquifer?	No. The site is located above an unproductive stratum.
1b. Will the proposed basement extend beneath the water table surface?	Unlikely. The London Clay cannot support a water table and is classified as an unproductive stratum, however if an upper weathered layer is present, this may have a higher permeability and could have the potential to collect groundwater if the stratum has a predominantly granular matrix, which is unlikely in this setting.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. The nearest surface water feature is a small private pond, which is located 471 m to the northeast of the site.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The proposed development will not extend beyond the existing footprint as shown on proposed drawings provided by the consulting engineers.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No, it is anticipated that the ground would not be sufficiently permeable to allow for a soakaway discharge design.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	No. There are no local ponds or spring lines and the London Clay is not able to support groundwater flow to these features.

The above assessment has not identified any potential issues that need to be assessed.

3.1.2 Stability Screening Assessment

Question	Response for Land to rear of 159-163 King's Cross Road
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No, as indicated on the Slope Angle Map Fig 16 of the Arup report.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. The site is not to be significantly re-profiled as part of the development.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No. As indicated on the Slope Angle Map Fig 16 of the Arup report.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No. As indicated on the Slope Angle Map Fig 16 of the Arup report.
5. Is the London Clay the shallowest stratum at the site?	*Yes.*
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	No. There are no trees on the site.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	*Yes. The area is prone to these effects as a result of the presence of shrinkable London Clay.*
8. Is the site within 100 m of a watercourse or potential spring line?	No. The nearest surface water feature is a small private pond, which is located 471 m to the northeast of the site.
9. Is the site within an area of previously worked ground?	No. According to the BGS geological map the site is not within an area of previously worked ground.
10a. Is the site within an aquifer?	No. The site is located above an unproductive stratum.

Question	Response for Land to rear of 159-163 King's Cross Road
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No. The London Clay cannot support a water table and is classified as an unproductive stratum.
11. Is the site within 50 m of Hampstead Heath ponds?	No.
12. Is the site within 5 m of a highway or pedestrian right of way?	*Yes - the site is accessed from Britannia Street in the north, although it is understood that the proposed basement will be constructed in the southern two-thirds of the site.*
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Yes - The development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent.*
14. Is the site over (or within the exclusion zone of) any tunnels, eg railway lines?	No.

The above assessment has identified the following potential issues that need to be assessed:

Q5 London Clay is the shallowest stratum at the site.
Q7 The site is in an area likely to be affected by seasonal shrink-swell.
Q12 The site is within 5 m of Britannia Street in the north.
Q13 The development will increase the foundation depths relative to the neighbouring properties.

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for Land to rear of 159-163 King's Cross Road
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the footprint of the building/hardstanding (ie both existing and proposed), therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. There will not be an increase in impermeable area across the ground surface above the basement. There will be no surface expression of the basement development.

Question	Response for Land to rear of 159-163 King's Cross Road
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the footprint of the building/hardstanding (i.e. both existing and proposed), therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposed basement is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses as the surface water drainage regime will be unchanged and the land uses will remain the same.
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	*Yes.* *The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013, and Figures 3i, 4e, 5a and 5b of the SFRA dated 2014, and Environment Agency online flood maps show that the site has a low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses.* *The Environment Agency surface water flooding map indicates that the flood depth across the site during low risk events would be below 0.3m.* *It is possible that granular fill around the basement may become saturated as the London Clay would effectively prevent it from draining and the recommendations outlined in the BIA with regards to water-proofing and tanking of the basement will reduce the risk to acceptable levels.* *In accordance with paragraph 5.11 of the CPG a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding.* *The site is located within the Critical Drainage Area number GROUP3-003, and is in a Local Flood Risk Zone (North Swinton Street), as identified in the Camden SWMP and Updated SFRA Figure 6/Rev 2.*

The above assessment has identified the following potential issues that need to be further assessed:

Q6. The site is in an area identified to have surface water flood risk.

4.0 SCOPING AND SITE INVESTIGATION

The purpose of scoping is to assess in more detail the factors to be investigated in the impact assessment. Potential impacts are assessed for each of the identified potential impact factors.

The potential impacts of the proposed development on surface flow and flooding and subterranean flow will need to be dealt with in separate assessments, such that the following section focuses on the potential impacts that may have an impact on slope stability.

4.1 Potential Impacts

The following potential impacts have been identified.

Potential Impact	Consequence
London Clay is the shallowest stratum at the site.	The London Clay is prone to seasonal shrink-swell (subsidence and heave).
Seasonal shrink-swell can result in foundation movements.	Multiple potential impacts depending on the specific setting of the basement development. For example, in terraced properties, the implications of a deepened basement/foundation system on neighbouring properties should be considered.
The site is located within 5 m of a highway or pedestrian right of way	Excavation of a basement may result in structural damage to the road or footway.
Founding depths relative to neighbours.	If not designed and constructed appropriately, the excavation of a basement may result in structural damage to neighbouring buildings and structures.
The site in an area identified to have surface water flood risk.	The proposed basement may be at risk of flooding.

These potential impacts have been investigated through the site investigation, as detailed in Section 9.0.

4.2 Exploratory Work

In order to meet the objectives described in Section 1.2, a single borehole was advanced to a depth of 15.00 m by means of a dismantlable cable percussion rig. In addition, a single window sampler borehole was advanced to a depth of 6.00 m and a series of 14 trial pits were hand excavated to a maximum depth of 1.90 m.

SPTs were carried out at regular intervals within the cable percussion boreholes to provide quantitative information about the strength of the soils and both undisturbed and disturbed samples were recovered for subsequent laboratory examination and testing.

A groundwater monitoring standpipe was installed in each of the boreholes to a depth of 6.0 m to facilitate groundwater monitoring, which has been carried out on a single occasion approximately four weeks after installation.

A selection of the samples recovered from the boreholes was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

All of the above work was carried out under the supervision of a geotechnical engineer from GEA.

The borehole and trial pit records and results of the laboratory testing are appended, together with a site plan indicating the exploratory positions.

4.3 Sampling Strategy

The boreholes and trial pits were specified by the consulting engineer and positioned on site by GEA, whilst avoiding areas of buried services.

Four samples of the made ground have been tested for the presence of contamination. The analytical suite of testing was selected to identify hydrocarbon contamination resulting from the former use of the site and a range of typical industrial contaminants for the purposes of general coverage. For this investigation the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. The samples were also submitted for asbestos identification.

The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. A summary of the MCERTs accreditation and test methods are included with the attached results and further details are available upon request.

5.0 GROUND CONDITIONS

The investigation encountered a generally significant thickness of made ground, overlying the London Clay Formation, which was proved to the full depth of the investigation, of 15.00 m.

5.1 Made Ground

Beneath a slab surface, the made ground generally comprised dark brown and grey very silty sandy gravelly clay, sand and silt with cobbles, fragments of brick, concrete and pockets of ash, and extended to depths of 1.90 m and 3.80 m in the centre and north of the site respectively.

Apart from the presence of fragments of extraneous material noted above, no visual or olfactory evidence of contamination was observed during the fieldwork. Four samples of the made ground have however been analysed for a range of contaminants as a precautionary measure and the results are summarised in Section 5.4.

5.2 London Clay

The London Clay comprised an initial weathered horizon of firm fissured medium strength brown and pale grey mottled silty clay with orange-brown sand partings, occasional coarse selenite and pockets of bluish grey sand and silt, and extended to depths of 4.90 m and to the maximum depth of Borehole No 2, of 6.0 m. In Borehole No 2, this stratum was noted as soft between 4.0 m and 5.9 m, becoming stiff from 5.9 m depth.

Below the initial weathered zone, the London Clay comprised firm becoming stiff fissured medium to high strength pale grey and brown mottled silty clay with fine selenite, becoming very silty at 9.0 m and 12.9 m depth, and was encountered to the full depth investigated, of 15.00 m.

Laboratory plasticity index test results indicate the clay to be of high volume change potential. The results from the laboratory undrained triaxial compression tests, which are plotted against depth on a graph in the appendix, indicate the clay to generally increase in strength with depth from high strength to very high strength with undrained shear strength increasing from 56 kN/m^2 to 115 kN/m^2.

No evidence of contamination was noted in these soils.

5.3 Groundwater

Groundwater was encountered during drilling in Borehole No 2 only, at a depth of 3.0 m towards the base of the made ground, which extended to a depth of 3.8 m. Monitoring of the standpipes has indicated the groundwater to be at depths of 5.0 m and 2.6 m in Borehole Nos 1 and 2 respectively, four weeks after completion of the boreholes.

5.4 Soil Contamination

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

Determinant	TP7 0.80 m	TP8 1.10 m	TP4 0.60 m	TP5 0.50 m
pH	8.6	11.4	8.4	8.4
Arsenic	24	17	34	17
Cadmium	< 0.2	< 0.2	< 0.2	< 0.2
Chromium	23	19	26	14
Copper	110	420	150	89
Mercury	2.8	1.4	3.0	2.1
Nickel	22	16	26	16
Lead	700	430	700	500
Selenium	< 1.0	< 1.0	< 1.0	< 1.0
Zinc	100	310	220	140
Total Cyanide	< 1	< 1	< 1	< 1
Total Phenols	< 1.0	< 1.0	< 1.0	< 1.0
Sulphide	1.1	< 1.0	< 1.0	< 1.0
Total PAH	< 1.60	< 1.60	26.1	3.68
Benzo(a)pyrene	< 0.10	< 0.10	3.0	0.26
Naphthalene	< 0.05	< 0.05	< 0.05	< 0.05
TPH (C8 – C10)	< 0.1	< 0.1	< 0.1	< 0.1
TPH (C10 – C12)	< 2.0	< 2.0	< 2.0	< 2.0
TPH (C12 – C16)	< 4.0	< 4.0	< 4.0	< 4.0
TPH (C16 – C21)	< 1.0	< 1.0	10	1.9
TPH (C21 – C35)	< 1.0	< 1.0	28	9.3
Total Organic Carbon %	0.9	0.4	1.5	1.1
Note: Figure in **bold** indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report				

The results of the contamination testing have indicated no elevated concentrations of contaminants within any of the four samples tested.

5.4.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end the table below indicates those contaminants of concern that have values in excess of a generic human health risk based guideline values which are either that of the CLEA[7] Soil Guideline Value where available, or is a Generic Screening Value calculated using the CLEA UK Version 1.06[8] software assuming a commercial use, or is based on the DEFRA Category 4 Screening values[9]. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be working female adults aged 16 to 65 years old;
- that young children will not have prolonged exposure to the site;
- that the exposure duration will be a working lifetime of 49 years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, skin contact with soils and dust, and inhalation of dust and vapours; and
- that the building type equates to a three storey office.

It is considered that these assumptions are suitable for this generic first assessment of this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

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

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

The results of the chemical analyses have indicated typical concentrations of contaminants to be present within the made ground, all of which are below the generic screening values adopted for a commercial end use. The significance of these results is considered further in Part 2 of the report.

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

5.5 Existing Foundations

Fourteen trial pits were excavated to expose the existing foundations and the findings are summarised below. Full records of the trial pits are appended to this report.

Trial Pit No	Foundation detail	Bearing stratum
1 / 1a	Footing inconclusive; not proved, probed to 4.0 m from ground level	N/A
2 / 2a	*Section A-A':* Concrete footing Depth to top of footing 240 mm from GL Depth to underside of footing 650 mm from GL Lateral projection 250 mm *Section B-B':* Brick footing Depth to top of footing 1600 mm from GL Depth to underside of footing 1900 mm from GL Lateral projection 140 mm	MADE GROUND (dark brown very silty sandy gravelly clay with brick and concrete fragments and pockets of ash)
3	*Section A-A':* Brick corbel Depth to top of footing 700 mm from GL Depth to underside of footing 900 mm from GL Lateral projection 130 mm *Section B-B':* Brick corbel Depth to top of footing 610 mm from GL Depth to underside of footing 685 mm from GL Lateral projection 60 mm	MADE GROUND (brown very clayey silty gravelly sand with fragments of brick, concrete, coal, occasional shell fragments and ceramic fragments)
4	*Section A-A':* Concrete footing Depth to top of footing 1140 mm from GL Depth to underside of footing 1420 mm from GL Lateral projection 300 mm *Section B-B':* Two brick corbels and a brick footing Depth to top of footing 1100 mm from GL Depth to underside of footing 1460 mm from GL Lateral projection 300 mm	MADE GROUND (brown very clayey silty gravelly sand with fragments of brick, concrete, coal and occasional shell fragments)
5	*Section A-A':* Concrete footing Depth to top of footing 1120 mm from GL Depth to underside of footing 1430 mm from GL Lateral projection 260 mm *Section B-B':* Concrete footing Depth to top of footing 1020 mm from GL Depth to underside of footing 1400 mm from GL Lateral projection 90 mm	MADE GROUND (brown silty sandy gravelly clay with fragments of brick, concrete, occasional whole brick and occasional pockets of ash)
6	*Section A-A':* Brick footing Depth to top of footing 1120 mm from GL Depth to underside of footing 1300 mm from GL Lateral projection 150 mm	MADE GROUND (brown silty sandy gravelly clay with fragments of brick, concrete, occasional whole brick and pockets of ash)

Trial Pit No	Foundation detail	Bearing stratum
7	*Section A-A':* Brick footing Depth to top of footing 1000 mm from GL Depth to underside of footing 1460 mm from GL Lateral Projection 60 mm *Section B-B':* Brick footing Depth to top of footing 980 mm from GL Depth to underside of footing 1460 mm from GL Lateral Projection Varies linearly up to 150 mm	MADE GROUND
8	*Section A-A':* Concrete footing Depth to top of footing 280 mm from GL Depth to underside of footing 1400 mm from GL Lateral Projection 120 mm *Section B-B'*: Concrete footing Depth to top of footing 640 mm from GL Depth to underside of footing 840 mm from GL Lateral Projection Varies linearly up to 220 mm	MADE GROUND (brown silty very sandy gravelly clay with frequent fragments of brick, concrete and coal)
9	*Section A-A'* Footing inconclusive; not proved.	N/A
9A	*Section A-A':* Footing type not proved due to probed beyond maximum extent of trial pit reached Depth to top of footing 1700 mm from GL Depth to underside of footing not proved Lateral Projection approximately 200 mm	MADE GROUND (brown silty sandy clay with fragments of brick, ceramic, concrete, coal and pockets of ash)
10	*Section A-A'* Footing inconclusive; not proved.	N/A
10A	*Section A-A':* Concrete footing Depth to top of footing 1500 mm from GL Depth to underside of footing 1850 mm from GL Lateral Projection approximately 350 mm	MADE GROUND (dark brown silty sandy gravelly clay with fragments of brick, concrete, pipe fragments and ash)

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to the basement excavation and the potential impact on the hydrogeology, which is discussed in greater detail in the Basement Impact Assessment within Part 4.

6.0 INTRODUCTION

It is understood that it is proposed to demolish the existing building and subsequently construct a new two-storey and three-storey commercial building with a single level basement that will extend to a depth of 4.4 m.

7.0 GROUND MODEL

The desk study has indicated that the site has had a potentially contaminative historical use as a garage, and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- Below a significant thickness of made ground the London Clay was encountered to the full depth of the investigation, of 15.00 m;
- beneath an initial concrete slab surface, the made ground comprises dark brown and grey very silty sandy gravelly clay, sand and silt with cobbles, fragments of brick, concrete and pockets of ash, and extends to depths of 1.90 m and 3.80 m in the centre and north of the site respectively;
- the London Clay comprises an initial weathered horizon of firm fissured medium strength brown and pale grey mottled silty clay to a depth of 4.90 m and to the maximum depth of Borehole No 2, of 6.0 m.
- in the north of the site, this stratum was noted as soft between 4.0 m and 5.9 m;
- below the weathered horizon, the London Clay comprises firm becoming stiff fissured medium to high strength pale grey and brown mottled silty clay to the full depth of the investigation;
- groundwater was encountered during drilling within the made ground in the north of the site at a depth of 3.0 m;
- subsequent monitoring has indicated the groundwater at depths of 2.6 m in the north and 5.0 m in the centre of the site, although the latter may represent a build-up of water from the made ground; and
- elevated concentrations of contamination have not been measured within any of the samples of made ground tested.

8.0 ADVICE AND RECOMMENDATIONS

It is understood that it is proposed to demolish the existing building and subsequently construct a new two-storey and three-storey commercial building with a single level basement, to a maximum depth of roughly 4.40 m below ground level. Formation level for the proposed basement will therefore be within the firm medium strength silty clay of the London Clay.

On the basis of the fieldwork and subsequent monitoring, groundwater may be encountered within the basement excavation in the form of seepages, and inflows may be encountered from within the made ground.

Proposed loads are not currently known, although they are anticipated to be light to moderate.

8.1 Basement Construction

The formation level for the basement is likely to be within the London Clay at a depth of about 4.40 m below ground level. Groundwater inflows were encountered during drilling in Borehole No 2 to the north of the site at a depth of 3.0 m. Groundwater has subsequently been measured at depths of between 2.6 m and 5.5 m within monitoring standpipes, although these are considered likely to reflect inflows of perched water from within the made ground. Additionally, it is not possible to draw meaningful conclusions from the measurements made in the standpipes, as the monitored water levels are not as significant as the volume of water that may flow into the excavation. For example, a high level of water measured in a standpipe may not be significant if this represents only a small localised volume of water. On this basis significant inflows of groundwater are not anticipated to be encountered within the basement excavation, although monitoring of the standpipes should be continued to confirm water levels. Shallow inflows of localised perched water are likely to be encountered from within the made ground which should be adequately controlled through sump pumping. It would be prudent, once access is available, to carry out a number of trial excavations, to depths as close to the full basement depth as possible, to provide an indication of the likely groundwater conditions.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by the requirement to prevent groundwater inflows and whether it is to be incorporated into the permanent works and have a load bearing function.

Consideration may be given to the use of a bored pile retaining wall, which would have the advantage of being incorporated into the permanent works and will be able to provide support for structural loads. It should be possible to adopt a contiguous bored pile wall, with the use of localised grouting and / or pumping if necessary, in order to deal with any groundwater inflows. Alternatively, a secant bored pile wall would be a suitable solution.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity. In this respect the timing of the provision of support to the wall will have an important effect on the movements.

8.1.1 Basement Retaining Walls

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

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

Monitoring of the standpipe should be continued, including carrying out simple rising head tests, to assess the design water level. Groundwater is likely to be encountered within the excavation and, at this stage, it is recommended that the basement is designed with a water level assumed to be 1.0 m below ground level. It may however be possible to review this requirement following additional investigation by means of trial excavations and further monitoring and the advice in BS8102:2009[10] should be followed in this respect.

8.1.2 Basement Heave

The proposed excavation, to a depth of 4.40 m, will result in an unloading of approximately 90 kN/m^2 at formation level. This will lead to heave movements, which will comprise immediate elastic movement that will account for approximately 50 % of the total movement and be expected to be complete during the construction period, and long term movements, which will theoretically take many years to complete. A ground movement assessment is included in Part 3.0 of this report.

8.2 Spread Foundations

It is assumed that the new basement will extend to a depth of about 4.40 m below ground level, into the London Clay, which would provide a suitable bearing stratum for lightly loaded spread foundations. Moderate width pad or strip foundations bearing within the stiff brown fissured clay at proposed basement depth, may be designed to apply a net allowable bearing pressure of 120 kN/m^2. This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

8.3 Basement Raft Foundation

Given the ground conditions at this site, a raft foundation would also be an appropriate solution, although the suitability of a raft foundation will depend on the resultant net pressure applied by the slab, taking into account the removal of overburden associated with the basement excavation. The raft would need to be designed to be rigid to resist any variation in upwards and downwards forces, in order to prevent differential movements and should bypass the made ground.

8.4 Piled Foundations

For the ground conditions at this site, a bored pile is likely to be the most appropriate type. A conventional rotary augered pile could be utilised but consideration will need to be given to the possible instability and water ingress within the made ground and sandy horizons or pockets within the London Clay. Bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate solution.

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

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

Stratum	Depth Below Ground Level (m)	kN / m^2
Ultimate Skin Friction		
Basement Excavation	GL to 4.40	Ignore (basement excavation)
London Clay	4.40 to 14.00	Increasing linearly from 30 to 90
Ultimate End Bearing		
London Clay	10.00 to 14.00	Increasing linearly from 900 to 1170

In the absence of pile tests, guidance from the London District Surveyors Association (LDSA)[11] suggests that a factor of safety of 2.6 should be applied to the above coefficients in the computation of safe theoretical working loads. On the basis of the above coefficients, the following pile capacities have been estimated.

On the basis of the above coefficients, applying a factor of safety of 2.6, it has been estimated that 450 mm diameter piles extending to depths of 10.0 m or 14.0 m, should provide safe working loads of about 170 kN or 315 kN respectively.

The above examples are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of a suitable piling scheme.

8.5 Shallow Excavations

On the basis of the borehole findings it is considered that it will be generally feasible to form relatively shallow excavations terminating within the made ground or the London Clay without the requirement for lateral support, although localised instabilities may occur where more granular material or groundwater is encountered.

Significant inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from localised perched water within the made ground, although such inflows should be suitably controlled by sump pumping.

If deeper excavations are considered or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

8.6 Basement Floor Slab

Following the excavation of the basement, it is likely that the floor slab for the proposed basement will need to be suspended over a void or layer of suitable compressible material to accommodate the anticipated heave unless the slab can be suitably reinforced to cope with these movements. In addition, consideration may also need to be given to designing the basement to cope with water pressure below the slab. Further consideration will need to be given to these issues once the levels and magnitude of any slab loading are known.

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

8.7 Effect of Sulphates

Chemical analyses have revealed relatively low concentrations of soluble sulphate and near-neutral to slightly alkaline pH in accordance with Class DS-2 conditions of Table C2 of BRE Special Digest 1:SD Third Edition (2005). The measured pH values of the samples show that an ACEC class of AC-2 would be appropriate for the site. This assumes a mobile water condition at the site. The highest level of soluble sulphate recorded during the investigation is at the maximum limit for the DS-2 class and adoption of class DS-3 may be more appropriate. The additional guidelines contained in the digest should be followed in the design of the foundation concrete.

8.8 Contamination Risk Assessment

The desk study findings indicate that the site has had a potentially contaminative history by means of the previous use as a garage. In addition, the results of the chemical analyses have indicated the made ground to be free from elevated concentrations of the contaminants tested for and will be excavated and removed as part of the proposed basement excavation. As a result no risk is envisaged to groundwater, adjacent sites, end users, site workers or buried services and no remediation works are considered to be required.

8.9 Waste Disposal

Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[12] states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE[13] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £84.40 per tonne (about £150 per m^3) or at the lower rate of £2.65 per tonne (roughly £5 per m^3). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

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

12 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition
13 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Comments
Made ground	Non-hazardous (17 05 04)	No	
London Clay	Inert (17 05 04)	Should not be required but confirm with receiving landfill	

Under the requirements of the European Waste Directive all waste needs to be pre-treated prior to disposal. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[14] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated on site prior to excavation by sufficiently characterising the soils insitu prior to excavation.

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

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

14 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

Part 3: GROUND MOVEMENT ASSESSMENT

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

9.0 INTRODUCTION

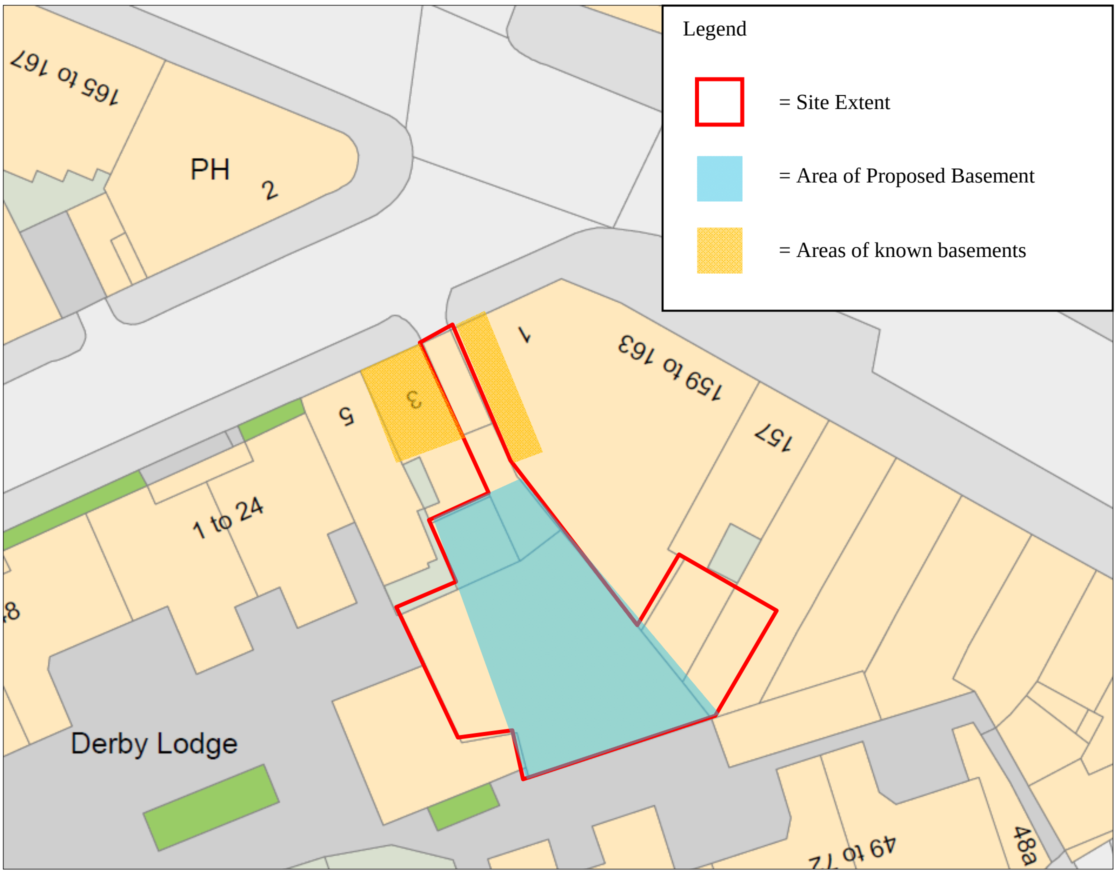
It is understood that it is proposed to construct the proposed single level basement to a depth of 4.4 m and the retaining walls will be constructed by means of traditional underpinning.

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

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

9.1 Basis of Ground Movement Assessment

9.1.1 Nearby Sensitive Structures



Section: Proposed Basement

A number of trial pits were excavated as part of the ground investigation in order to determine the depth of the existing walls and this information has been used within the ground movement assessment.

The heights of neighbouring houses have been estimated from observation. Where the depths of foundations or the heights of buildings are not known due to restricted access, these dimensions have been assumed.

The heights and basement depths of each of the nearby sensitive structures are summarised in the table below. All building foundation depths that have not been proved by means of trial pitting are assumed to be 0.5 m deep.

Sensitive Structure	Depth below existing ground floor level of basement / foundations (m)	Height of building above ground level (m)
Three storey townhouses fronting on to Britannia Street	0.5	15.0 / 3.0
Two storey townhouses fronting on to Britannia Street (front / rear)	0.5	8.0
Townhouses fronting on to King's Cross Road (front / rear / two storey extensions)	0.5	8.0 / 3.0 / 6.0
Townhouses fronting on to Wicklow Street	0.5	15.0
Gas asset building	0.5	2.6

The table below shows the walls where dimensions are known through trial pitting confirmation.

Sensitive Structure	Depth below existing ground floor level of basement / foundations (m)
Wall M	1.5
Wall N	4.0
Wall O	0.68
Wall P	1.85

Sensitive Structure	Depth below existing ground floor level of basement / foundations (m)
Wall Q	0.65
Wall W	1.7
Wall Y, AA	1.4
Wall AD, AF	1.46

The following drawings have been referred to, where relevant, to model the sensitive structures and proposed excavation.

Drawing Reference	Drawing Title
16038/P_02/P1, September 2016	Proposed Basement Plan (Draft)
16038/P_01/P1, September 2016	Proposed Ground Floor Plan
16038/P_21/P1, September 2016	Proposed Section AA

9.1.2 Construction Sequence

It is assumed that the proposed basement walls will be constructed by means of traditional underpinning, to a depth of 4.4 m from ground level.

The following sequence of operations has been assumed to enable analysis of the ground movements around the proposed basement both during and after construction.

In general, the sequence of works for basement construction will comprise the following stages.

1. Construct underpinned retaining walls. These are commonly formed in a 'hit and miss' sequence using a trench box excavation, commonly sheet lined, shored and strutted; all temporary shoring and propping to be inspected by a suitably qualified person; and

2. excavate new basement and temporarily retain and strengthen, with sufficient propping and walling beams, the new retaining walls. Construct new ground slab.

The underpins will be adequately laterally propped and sufficiently dowelled together, and the concrete will be cast and adequately cured prior to excavation of the basement and removal of the formwork and supports. It is assumed that the corners of the excavation will be locally stiffened by cross-bracing or similar and that the new retaining walls will not be cantilevered at any stage during the construction process.

The detail of the support provided to adjacent walls is beyond the scope of this report at this stage and the structural engineer will be best placed to agree a methodology with the underpinning contractor once appointed.

When the final excavation depths have been reached the permanent works will be formed, which are likely to comprise reinforced concrete walls with a drained cavity lining the inside of the underpinned walls. Reinforced concrete will be used for the floor slabs and it is anticipated that heave protection may be installed beneath the basement slab. Following this, the floor slab will be constructed at basement depth and the temporary props will be removed.

9.2 Ground Movements

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

The X-Disp program has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement).

The analysis of potential ground movements within the excavation, as a result of unloading of the underlying soils, has been carried out using the Oasys P-Disp Version 19.3 – Build 12 software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at small strains. For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction parallel with the orientation southwest-northeast, whilst the y-direction is parallel with the orientation of northwest-southeast. Vertical movement is in the z-direction. Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while walls greater than 10 m in length have been modelled as 2 m elements to reflect their greater stiffness. The full outputs of all the analyses can be provided on request and samples of the output movement contour plots are included within the appendix.

9.2.1 Ground Movements – Surrounding the Basement

Model Used

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580[15], which were derived from a number of historic case studies. The analysis has adopted the values for 'installation of a planar diaphragm wall' to most closely represent the installation of the underpinned and reinforced concrete retaining walls. The ground movement curves for 'excavations in front of a stiff wall in stiff clay' have been adopted as being considered most appropriate for the proposed excavation.

Results

The predicted movements are based on the worst case of the individually analysed segments of 'hogging' and 'sagging' and these are summarised in the tables overleaf. It should be noted that the combined effect of segments acting together typically improves the resultant movements and the values below are therefore deemed to be conservative. The diagram on the previous page details the relevant sensitive structures in relation to the proposed excavations.

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

Wall Installation Phase:

Sensitive Structure	Substructure	Structure Reference	Vertical Movement (Settlement) (mm)	Horizontal Movement (mm)
Three storey townhouses fronting on to Britannia Street	N/A	A to I	< 1	< 1
Two storey townhouses fronting on to Britannia Street	Front	J to N	< 1	< 1
	Rear	O to R	3	3
Townhouses fronting on to King's Cross Road	Front	S, T, U, X, Z, AB	< 1	2
	Rear	AC to AG	3	2
	Two storey extensions	V, W, Y, AA	< 1	< 1
Townhouses fronting on to Wicklow Street	N/A	AH t o AT	< 1	< 1
Gas asset building	N/A	AU to AW	2	3

15 Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design.* CIRIA Report C580.

Wall Installation and Excavation Phases Combined:

Sensitive Structure	Substructure	Structure Reference	Vertical Movement (Settlement) (mm)	Horizontal Movement (mm)
Three storey townhouses fronting on to Britannia Street	N/A	A to I	3	5
Two storey townhouses fronting on to Britannia Street (front / rear)	Front	J to N	4	6
	Rear	O to R	5	9
Townhouses fronting on to King's Cross Road	Front	S, T, U, X, Z, AB	4	7
	Rear	AC to AG	5	9
	Two storey rear extensions	V, W, Y, AA	4	5
Townhouses fronting on to Wicklow Street	N/A	AH t o AT	4	6
Gas asset building	N/A	AU to AW	5	9

The analysis has indicated that the maximum vertical settlements and horizontal movements that will result from the new retaining wall construction are less than 5 mm. Furthermore, the analysis has indicated that the maximum vertical settlements and horizontal movements that will result from the combined effect of the retaining wall installation and excavation are around 10 mm or less.

9.2.2 Movements within the Excavation (Heave)

Model Used

At this site, unloading of the London Clay will take place as a result of the proposed basement excavation and the reduction in vertical stress in the short term will cause heave to take place. Undrained soil parameters have been used to estimate the potential short term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total movement, which includes long term swelling that will continue for a number of years.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and we have used a well-established method to provide our estimates. This relates values of E_u and E', the drained and undrained stiffness respectively, to values of undrained cohesion, as described by Padfield and Sharrock[16] and Butler[17] and more recently by O'Brien and Sharp[18]. Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young's modulus. More recent published data[19] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Eu of 0.75, and it is considered that the use of the more conservative values provides a sensible approach for this stage in the design. The profile of the underlying London Clay has been interpolated from the ground investigation.

16 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils*. CIRIA Special Publication 27
17 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review*. Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond
18 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53
19 Burland JB, Standing, JR, and Jardine, FM (2001) *Building response to tunnelling, case studies from construction of the Jubilee Line Extension* CIRIA Special Publication 200

The proposed basement excavation will result in a net unloading of around 90 kN/m^2 which is assumed to act at a maximum excavation depth of 4.4 m below existing ground floor level. The predicted heave pressure at basement level is likely to be of the order of between 30 % and 40 % of the net unloading. Once the basement is complete it is understood that a new pressure of 60 kN/m^2 will apply as a uniformly distributed load at the proposed basement level.

The soil parameters used in this assessment are tabulated below.

Stratum	Depth range (m)	Eu (MPa)	E' (MPa)
Made Ground	GL to 2.0	20.0	20.0
London Clay	2.0 to 11.0	20.0 to 54.0	12.0 to 32.0

A rigid boundary for the analysis has been set at the base of the London Clay and underlying clay of the Lambeth Group, at a depth of 38 m below existing ground level, where nearby BGS records indicate that the base of this formation is likely to be present.

Results

The P-Disp analysis indicates that, by the time the basement construction is complete, between around 10 mm to 15 mm of heave is likely to have taken place at the centre of the proposed excavation, reducing to around 5 mm to 10 mm at the edges. An additional 10 mm to 15 mm of long term heave may theoretically occur at the centre of the proposed excavation following construction, following the application of the new loading at basement level.

The results of the P-Disp analysis can be used to indicate the likely impact of the proposed basement construction beyond the site boundaries; about 5 m away from the excavation a total movement of less than 5 mm is predicted. Movements outside the excavation will be constrained to a certain extent by the presence of the new retaining walls.

A void or layer of compressible material may need to be incorporated into the design to accommodate these potential long term movements. If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 30 % to 40 % of the total unloading pressure.

9.3 Building Damage Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, the neighbouring buildings are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 2.5 of C580[1].

All structures are shown on the plan in Section 9.1.1.

9.3.1 Damage to Neighbouring Structures

The movements resulting from the wall installation phase and the combined retaining wall installation and basement excavation phases, have been estimated using the X-Disp modelling software to carry out an assessment of the likely damage to adjacent properties and the results are summarised for the combined wall installation and basement excavation in the table below.

The potential heave movements predicted by P-Disp have not been included in the first assessment of damage category, which can therefore be considered as conservative, as these movements are likely to have a mitigating effect on the downward settlement predicted by X-Disp.

Sensitive Structure	Substructure	Structure Reference	Maximum Category of Damage*
Three storey townhouses fronting on to Britannia Street	N/A	A to I	Category 0 – Negligible
Two storey townhouses fronting on to Britannia Street (front / rear)	Front	J to N	Category 1 – Very Slight
	Rear	O to R	Category 2 – Slight
Townhouses fronting on to King's Cross Road	Front	S, T, U, X, Z, AB	Category 0 – Negligible
	Rear	AC to AG	Category 1 – Very Slight
	Two storey rear extensions	V, W, Y, AA	Category 1 – Very Slight
Townhouses fronting on to Wicklow Street	N/A	AH t o AT	Category 1 – Very Slight
Gas asset building	N/A	AU to AW	Category 2 – Slight

**From Table 2.5 of C580[1]: Classification of visible damage to walls.*

The analysis has predicted that the proposed installation of the retaining wall and underpins and excavation of the proposed basement may generally result in the building damage for sensitive structures of between Category 0 (negligible) and Category 1 (very slight); three walls of sensitive structures have however been assessed as Category 2 (Slight).

The Camden Planning Guidance notes that 'The design and construction methodology should aim to limit damage to the existing building on the site and to all adjoining buildings to Category 1 … and should never be more than Category 2', such that the damage categories above fall within acceptable limits. However, additional consideration has been given to the walls with the highest damage categories as discussed below.

Notwithstanding the above, there is a wealth of experience with respect to the construction of underpinned retaining walls, which suggests that horizontal ground movements should remain typically within the range of 2 mm to 5 mm following completion of the works, provided that they are installed by a reputable and experienced contractor in accordance with the guidelines published by the Association of Specialist Underpinning Contractors[20], which indicates that the predicted movements represent a conservative assessment of the likely movements.

A manual assessment has been carried out for sensitive structures that have been assigned Damage Category 2, Slight. Within the industry it is recognised that the assessment of an underpinned retaining wall using XDisp provides a conservative approach and, for walls where high damage categories are attained, a hand calculation of the likely damage category would be more appropriate. This method considers the total heave movements at foundation level due to the basement excavation, which is assessed using PDisp, combined with the length and height of each 'Slight' sensitive structure. For this assessment, the total heave movements including the excavation of the new basement and application of a new pressure of 60 kN/m^2 at basement level.

20 Haslam S, O'Connor L (2013) *Guidelines on safe and efficient basement construction directly below or near to existing structures* ASUC

The additional analyses have indicated that the magnitude of horizontal movement is the controlling factor in determining the damage category. For each of the sensitive walls the maximum allowable value of horizontal movement, beyond which Category 2 damage is predicted is shown in the table overleaf.

The full manual calculations for Walls P, Q and AW are appended.

Elevation	Maximum Horizontal Movement in order to achieve a Damage Category of 1, Very Slight (mm)
P	3.5
Q	2.0
AW	5.0

In order to achieve the limiting horizontal movements, the magnitudes of movement could form part of the construction monitoring strategy, as discussed below.

9.3.2 Monitoring of Ground Movements

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

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

9.4 Ground Movement Assessment Conclusions

The analysis has concluded that the predicted damage to the neighbouring properties from the installation of the proposed underpin construction and basement excavation would be 'Negligible' to 'Very Slight', whilst three walls of sensitive structures may result in Category 2 (slight) for which the damage that would occur would fall within the acceptable limits. A monitoring strategy is recommended for the proposed construction and the horizontal limits outlined in Section 7.5.1 should be incorporated into the strategy in order to limit the predicted movement to Category 1, Very Slight. It is recommended that movement monitoring is carried out on all structures prior to and during the proposed basement construction.

The separate phases of work, including excavation of the proposed basement, will in practice be separated by a number of weeks, during which time construction of permanent supports, basement slab and underpin curing will take place. This will provide an opportunity for the ground movements during and immediately after underpin construction to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

Part 4: BASEMENT IMPACT ASSESSMENT

This section of the report evaluates the direct and indirect implications of the proposed project, based on the findings of the previous screening and scoping, site investigation and ground movement assessment.

10.0 INTRODUCTION

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

10.1 Potential Impacts

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

The ground investigation has indicated that the site is directly underlain by the London Clay, which is classified as an unproductive stratum.

Potential Impact	Site Investigation Conclusions
London Clay is the shallowest stratum at the site.	The London Clay is prone to seasonal shrink-swell (subsidence and heave).
Seasonal shrink-swell can result in foundation movements.	The London Clay is prone to seasonal shrink-swell and can cause structural damage. Desiccation was not noted during the fieldwork.
The site is located within 5 m of a highway or pedestrian right of way	The proposed basement will not extend to within 5 m of Britannia Street in the north.
Founding depths relative to neighbours.	The retention system will ensure the stability of the excavation and neighbouring properties at all times.
The site is in an area identified to have surface water flood risk.	The proposed basement is set back behind the buildings that front on to Britannia Street and King's Cross Road, such that the basement is likely to be at a sufficient distance from any such surface water flooding.

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

Seasonal Shrink-Swell
The proposed basement is not located close to any existing trees and proposed planting of new trees does not form part of the proposals, such that the effect of shrink-swell of the London Clay is not envisaged.

The proposed basement will significantly increase differential depth of foundations to neighbouring properties
As part of the investigation, the depth of a number of neighbouring foundations has been determined and has been included in the ground movement assessment. The proposed basement will extend to a significant depth relative to the existing foundations of the neighbouring properties and will need to be designed to ensure the stability of the site and any potentially sensitive structures that are in close proximity to the site.

Appropriate propping and temporary works installed during basement construction may limit the effect of ground movements to the surrounding properties.

The results of a ground movement assessment by GMA to predict the likely movements as a result of the proposed development is shown in Part 3 of this report.

10.2 Non-Technical Summary of Evidence

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

10.2.1 Screening

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

Question	Response for Land to rear of 159-163 King's Cross Road
1a. Is the site located directly above an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
1b. Will the proposed basement extend beneath the water table surface?	The proposals provided by the consulting engineers assessed against the standpipe monitoring levels.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	Figures 11 and 12 of the Arup report.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	Site walkover and the proposals provided by the consulting engineers.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	The proposals provided by the consulting engineers.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	The proposals provided by the consulting engineers assessed against the standpipe monitoring levels.

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

Question	Evidence
1. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	A site walkover confirmed the proportions of hardstanding, which has been compared to the proposals to work out any proposed changes in hardstanding.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	

Question	Evidence
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 together with Figures 3iv, 4e, 5a and 5b of the Strategic Flood Risk Assessment dated 2014.

The following table provides the evidence used to answer the slope stability screening questions.

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

10.2.2 **Scoping and Site Investigation**

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

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

10.2.3 Impact Assessment

Section 9.0 of this report summarises whether or not, on the basis of the findings of the investigation, the potential impacts still need to be given consideration and identifies ongoing risks that will require suitable engineering mitigation. Section 8.0 of this report also provides recommendations for the design of the proposed development, whilst Section 9.0 makes reference to the outcomes of a ground movement analysis and building damage assessment included as an appendix to this report, which has also been used to provide a conclusion on any potential impacts from the proposed basement development.

10.3 BIA Conclusion

A Basement Impact Assessment has been carried out following the information and guidance published by the London Borough of Camden. Information from a Site Investigation and Ground Movement Assessment has been used to assess potential impacts identified by the screening process.

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

11.0 OUTSTANDING RISKS AND ISSUES

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

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

Monitoring of the standpipe should be continued to determine equilibrium groundwater levels and to establish any seasonal fluctuations. Ideally, trial excavations extending to as close to the full depth of the proposed basement as possible should be carried out to determine likely groundwater inflows into the basement excavation.

APPENDIX

Borehole Records

Laboratory Geotechnical Test Results

SPT & Cohesion/Depth Graph

Chemical Analyses (soil)

Risk-based Generic Guideline Values

Envirocheck Extracts

Historical Maps

X-DISP ANALYSIS:

Wall Installation

Contour Plots of Vertical Movements and Horizontal Movements

Wall Installation and Basement Excavation combined

Contour Plots of Combined Vertical Movements and Horizontal Movements

Tabular Output of Results

P-DISP ANALYSIS

Short Term Movement Contour Plots

Total Movement Contour Plots

DAMAGE CATEGORY MANUAL CALCULATIONS

Site Plan

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	Site 159-163 Kings Cross Road, London WC1X 9BN	Borehole Number BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 2.50m		Balcap RE	J16180
	Location	**Dates** 12/09/2016- 14/09/2016	**Engineer** Parmarbrook	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	CONCRETE		
0.30	B1					(0.85)	MADE GROUND (dark brown silty very clayey gravelly sand with fragments of brick, occasional ceramic fragments, concrete fragments, cobbles and ash)		
1.00-1.45 1.00	SPT(C) N60=7 B2	1.00	DRY	1,1/1,1,2,2		0.95 (0.45)	MADE GROUND (brownish grey silty, sandy gravelly clay with fagments of brick and ash)		
1.40	D3					1.40 (0.50)	MADE GROUND (grey clayey silt with occasional fragments of brick and gravel)		
1.90 2.00-2.45	D4 U5					1.90	Firm fissured medium strength brown and pale grey mottled silty CLAY with orange-brown sand partings, occasional coarse selenite, pockets of blue-grey sand and silt		
2.45	D6								
2.70	D7								
3.00-3.45 3.00	SPT N60=8 D8	2.50	DRY	1,1/1,2,2,2		(3.00)			
3.70	D9								
4.00-4.45	U10								
4.45	D11								
4.70 4.90 5.00-5.45 5.00	D12 D13 SPT N60=13 D14	2.50	DRY	1,2/2,3,3,3		4.90	Firm becoming stiff fissured medium to high strength pale grey and brown mottled silty CLAY with fine selenite, becoming very silty at 9.0 m and 12.9 m depth		
6.00	D15								
6.50-6.95	U16			12/09/2016:DRY 13/09/2016:DRY					
6.95	D17								
7.50	D18								
8.00-8.45 8.00	SPT N60=17 D19	2.50	DRY	2,2/3,3,4,4					
9.00	D20								
9.50-9.95	U21								

Remarks
Groundwater monitoring standpipe installed to 6.0 m
1 hr chiselling from ground level to 1 m depth
1 hr cleaning glass and debris away from working area
2 hr dismantling rig and demobilising from site - delays due to unknown road closure for nearby construction site on Britannia Street
Chiselling from 0.00m to 1.00m for 1 hour.

Scale (approx)	Logged By
1:50	CA

Figure No. J16180.BH1

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware,Herts SG12 7QE	Site 159-163 Kings Cross Road, London WC1X 9BN	Borehole Number BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 2.50m		Balcap RE	J16180
	Location	**Dates** 12/09/2016- 14/09/2016	**Engineer** Parmarbrook	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(10.10)			
9.95	D22								
10.50	D23								
11.00-11.45 11.00	SPT N60=21 D24	2.50	DRY	2,2/3,4,5,6					
12.00	D25								
12.50-12.95	U26								
12.95	D27								
13.50	D28								
14.00-14.45 14.00	SPT N60=28 D29	2.50	DRY	2,3/4,5,7,8					
15.00	D30			13/09/2016:DRY		15.00	Complete at 15.00m		

Remarks
Groundwater monitoring standpipe installed to 6.0 m
1 hr chiselling from ground level to 1 m depth
1 hr cleaning glass and debris away from working area
2 hr dismantling rig and demobilising from site - delays due to unknown road closure for nearby construction site on Britannia Street

Scale (approx)	Logged By
1:50	CA

Figure No. J16180.BH1

Geotechnical & Environmental Associates (GEA)

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Site	Number
159-163 Kings Cross Road, London WC1X 9BN	BH2

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Windowless Sampler			Balcap RE	J16180
	Location	**Dates**	**Engineer**	**Sheet**
		31/08/2016	Parmarbrook	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(3.80)	MADE GROUND (40 mm tarmac over 40 mm concrete over dark brown very silty sandy gravelly clay with fragments of brick, concrete and pockets of ash)		
1.00-1.45	SPT		0,0/1,1,0,1					
2.00-2.45	SPT		0,0/0,0,0,1					
3.00-3.45	SPT		0,0/1,0,1,1					
					3.80 (2.20)	Firm dark grey and pale brown silty CLAY becoming stif from 5.9 m, soft between 4.0 m and 5.9 m, becoming dark grey from 5.0 m depth		
4.00-4.45	SPT		9,4/3,1,0,1					
5.00-5.45	SPT		0,0/0,1,0,1					
6.00-6.45	SPT		3,2/2,3,4,3		6.00	Complete at 6.00m		

Remarks
Groundwater encountered at 3.0 m during drilling
Groundwater monitoring standpipe installed to 6.0 m depth

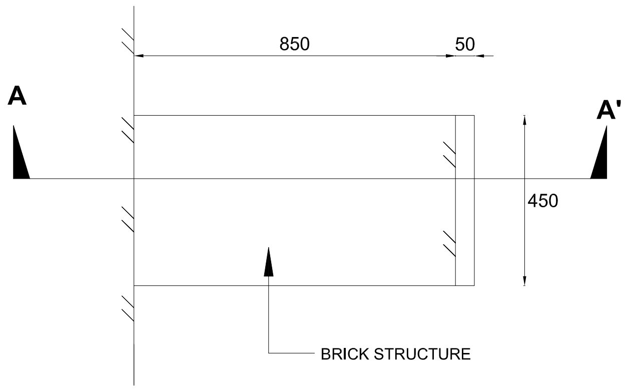
Scale (approx)	Logged By
1:50	CA

Figure No. J16180.BH2

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 900 x 450 x 1500 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

TP1

Plan



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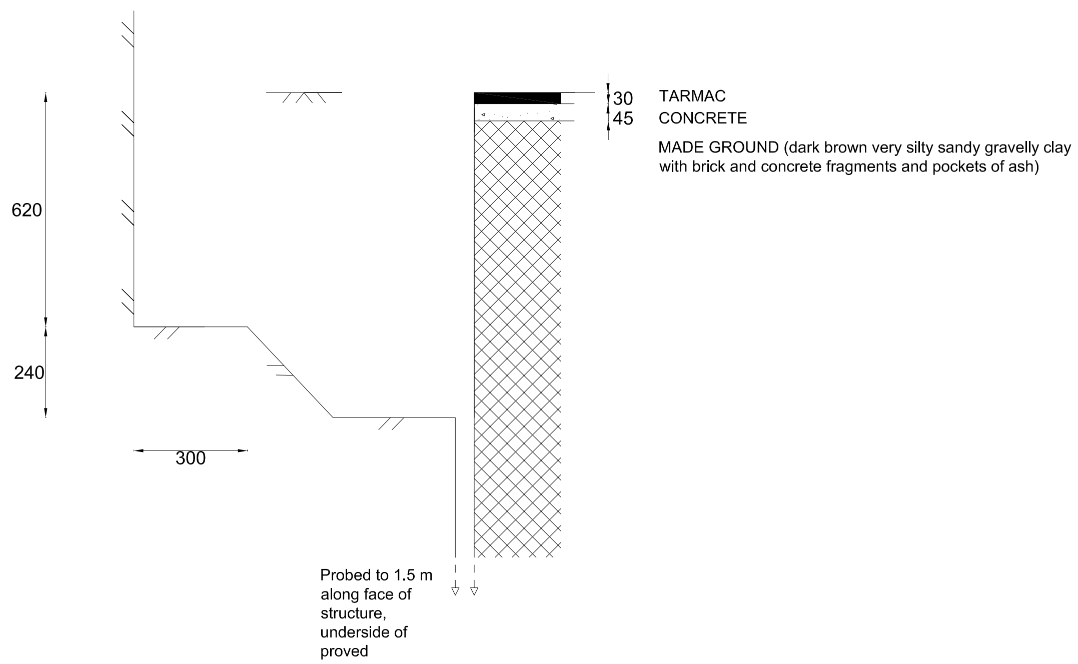


Notes:
Groundwater not encountered
Trial pit obstructed by brick structure

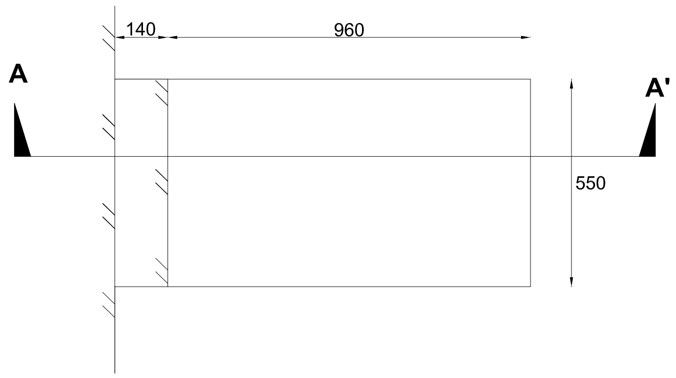
Scale
1 : 20

Logged By
CA

GEA Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 1100 x 550 x 1800 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

TP1A

Plan



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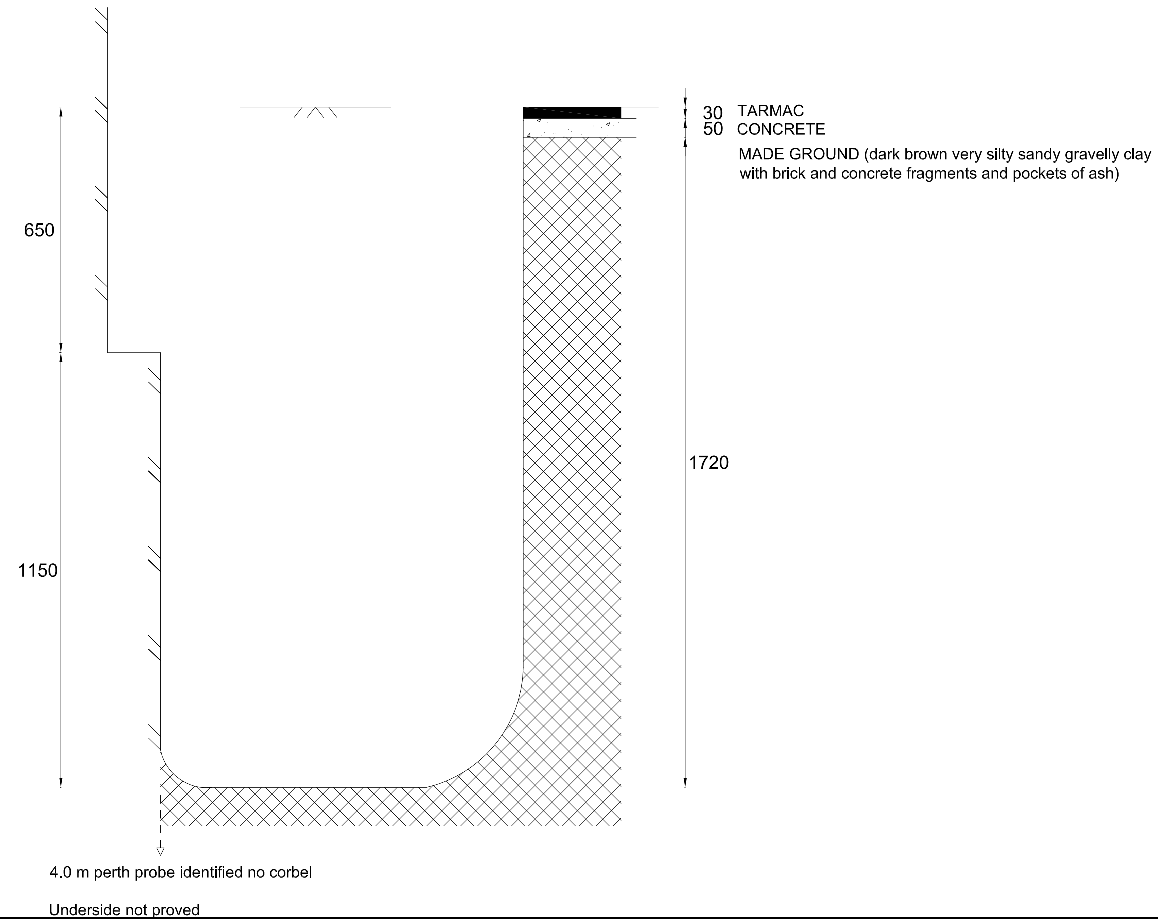
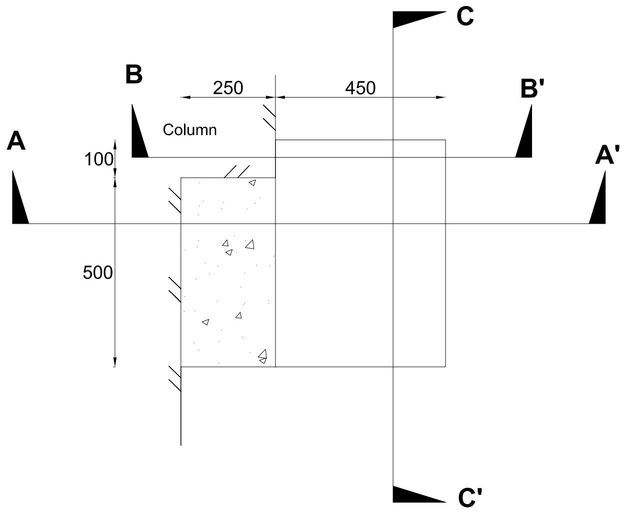


Notes: Groundwater not encountered	**Scale** 1 : 20
	Logged By CA

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

Site 159-163 Kings Cross Road, London WC1X 9BN				**Trial Pit Number** TP2
Excavation Method Manual	**Dimensions** 700 x 600 x 1550 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

Plan



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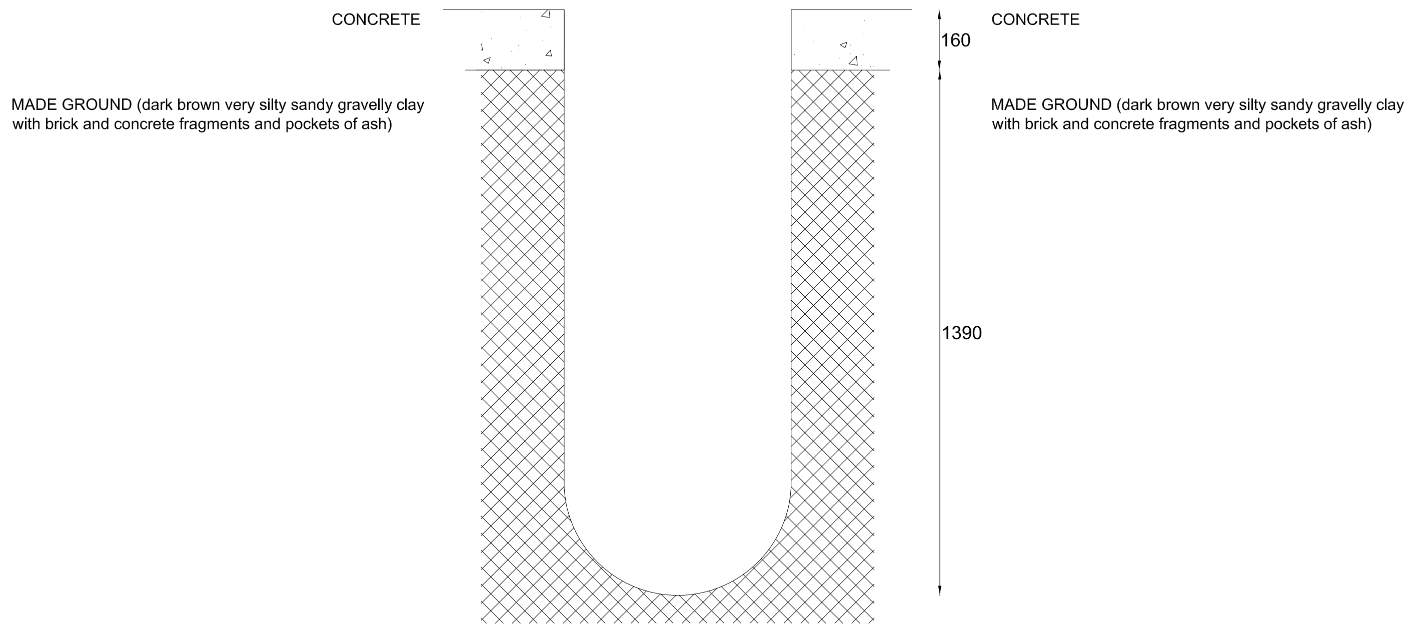

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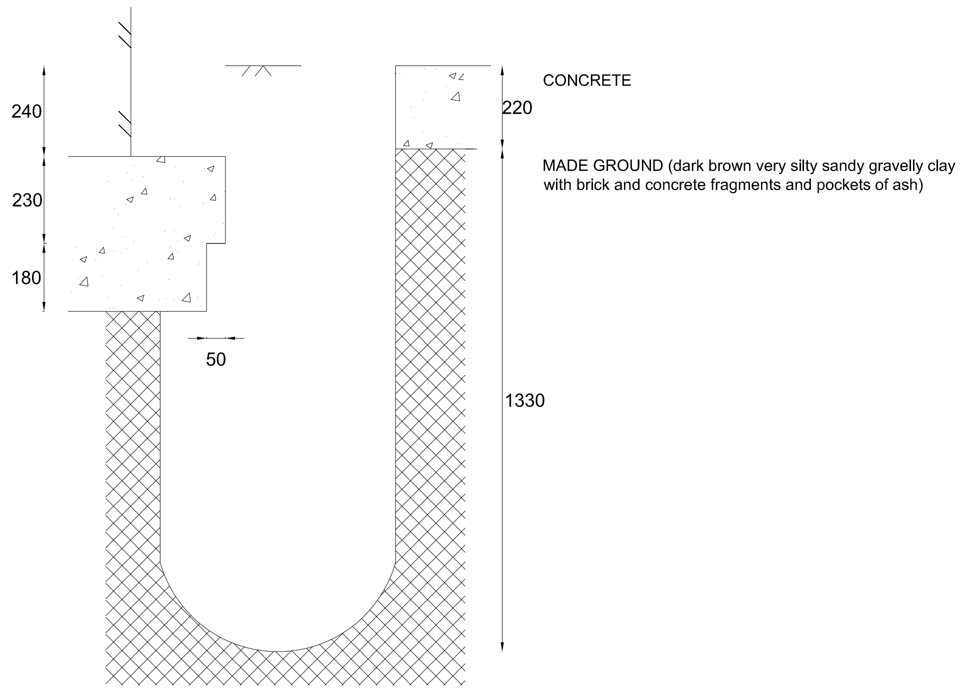

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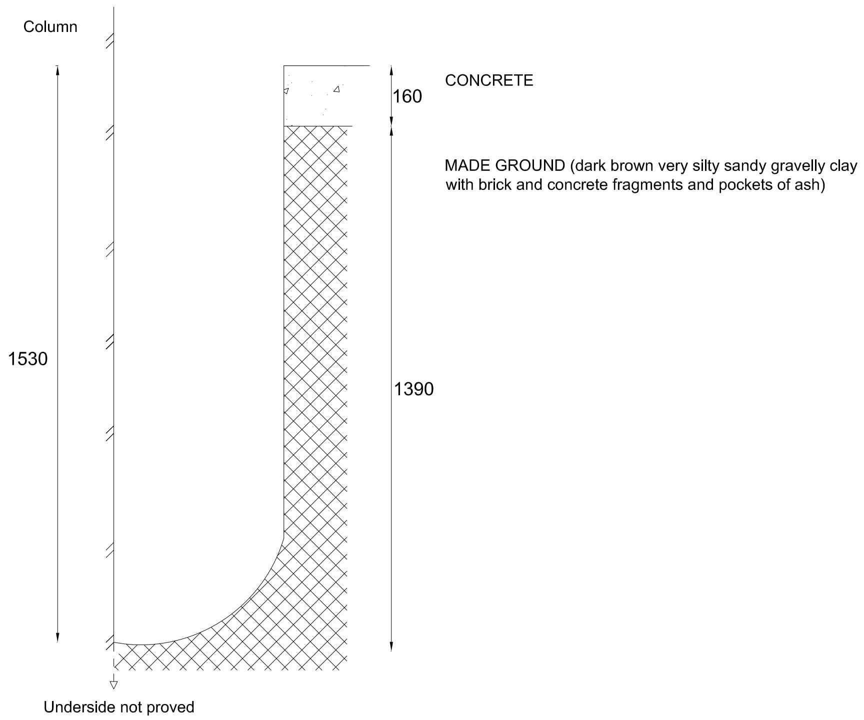


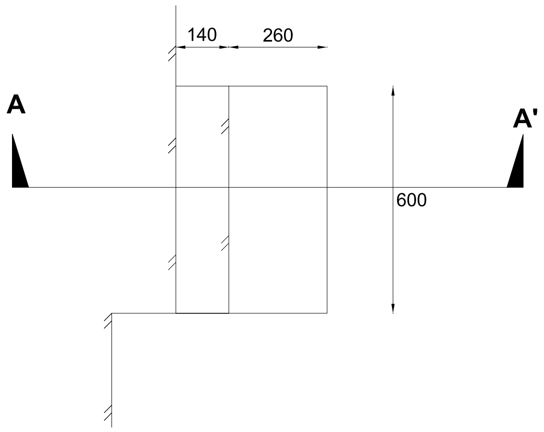
Notes:
Groundwater not encountered

Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates	Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE	Site 159-163 Kings Cross Road, London WC1X 9BN			Trial Pit Number
Excavation Method Manual	**Dimensions** 400 x 600 x 1950 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180	**TP2A**
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1	

Plan



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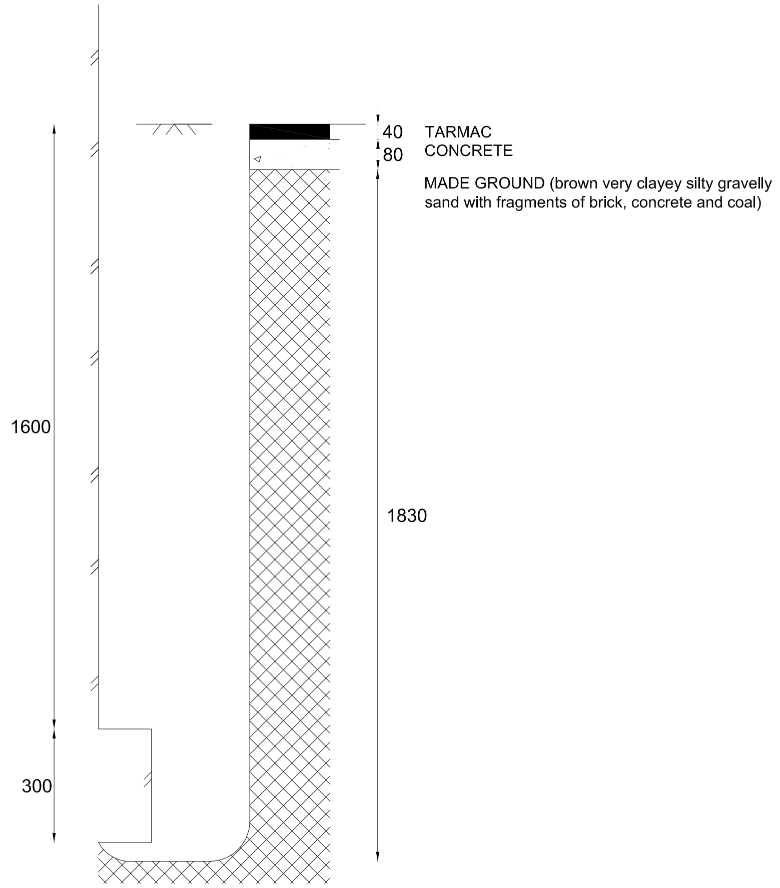
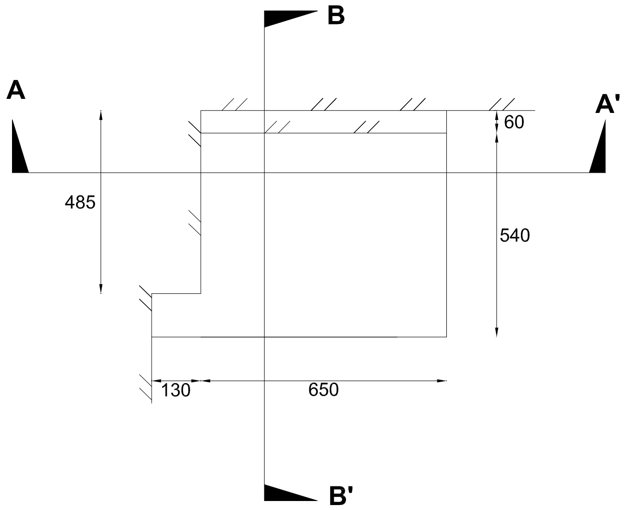


Notes:
Groundwater not encountered

Scale	1 : 20
Logged By	CA

Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE	Site: 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method: Manual	**Dimensions**: 780 x 600 x 1020 mm	**Ground Level (m OD)**:	**TP3**
Client: Balcap RE	**Job Number**: J16180		
Location:	**Date**: 31/08/16 to 01/09/16	**Engineer**: Parmarbrook	**Sheet Number**: 1 of 1

Plan



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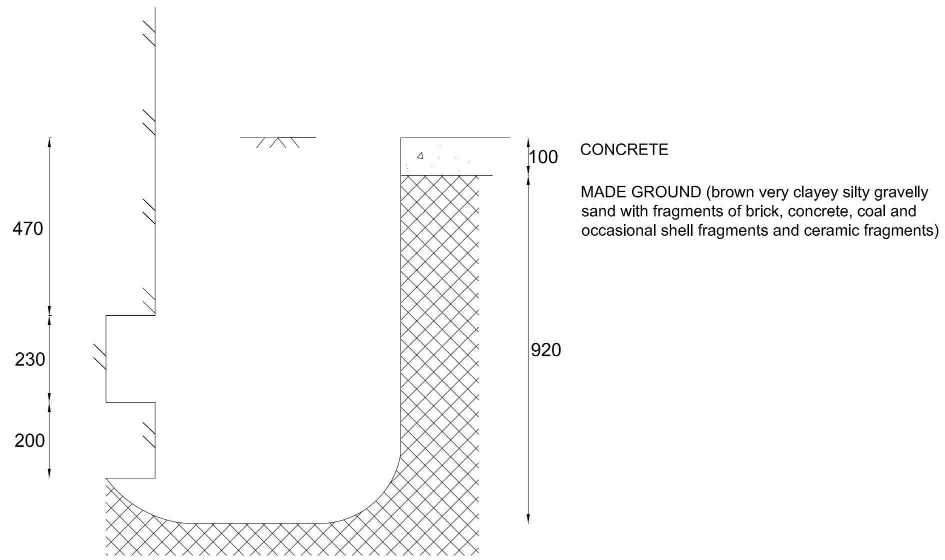

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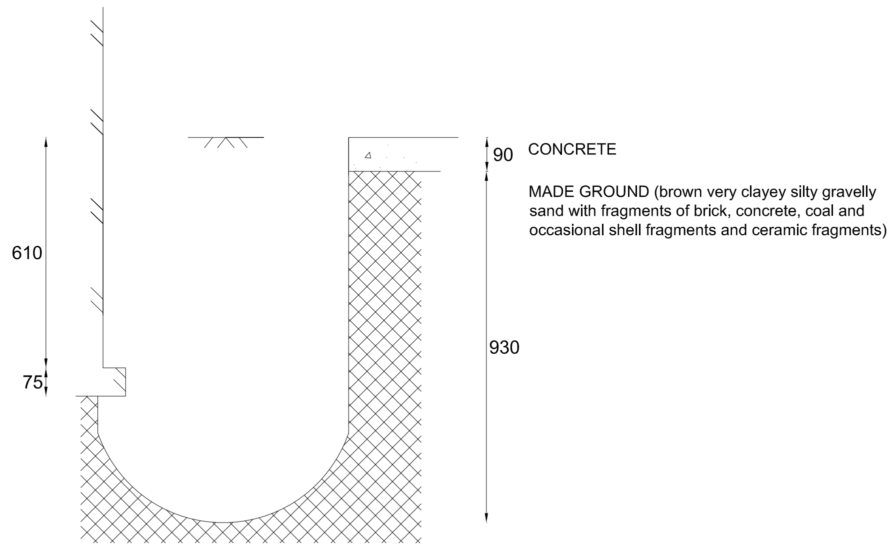


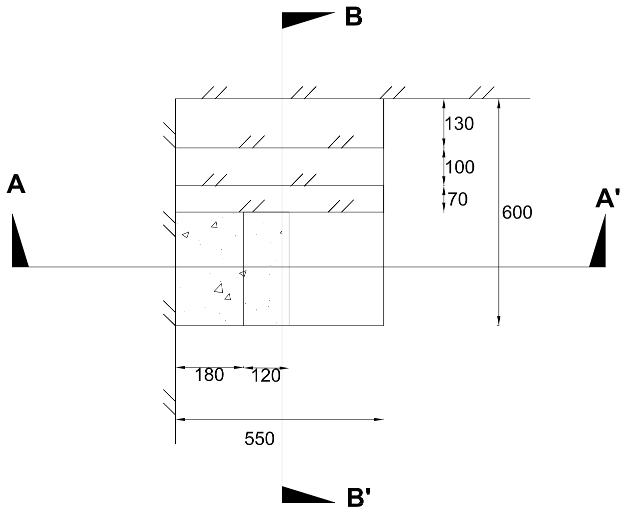
Notes:
Groundwater not encountered

Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 550 x 600 x 1460 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180	**TP4**
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1	

Plan



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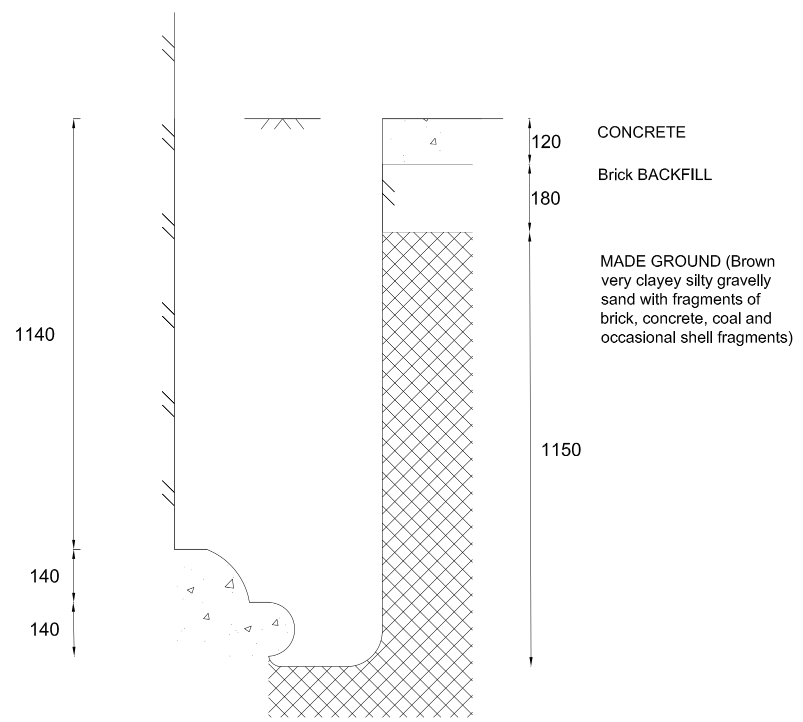

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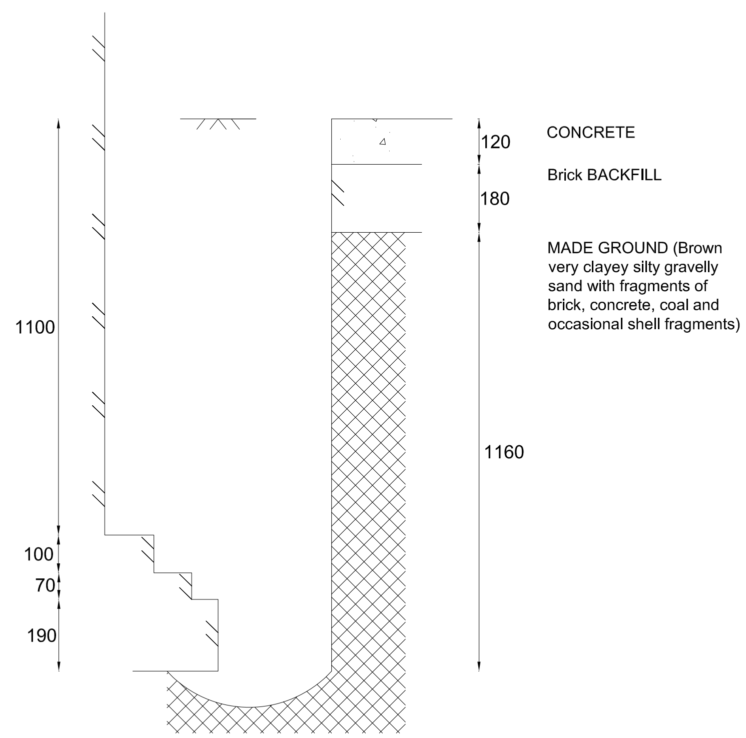


Notes:
Groundwater not encountered

Scale 1 : 20

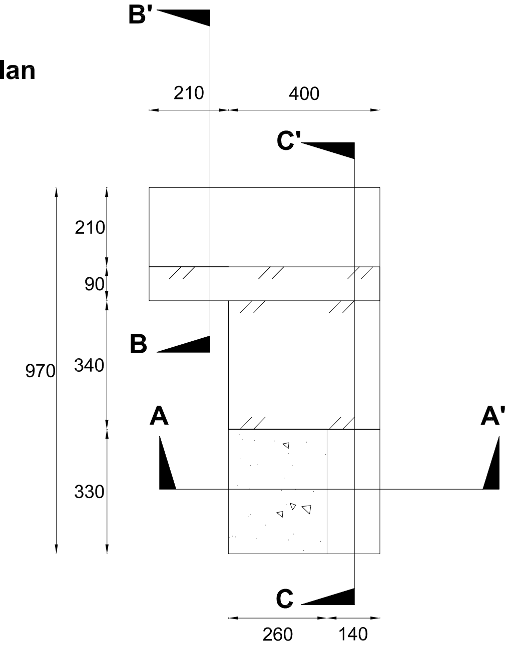
Logged By CA

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Site 159-163 Kings Cross Road, London WC1X 9BN

Excavation Method	Dimensions	Ground Level (m OD)	Client	Job Number	Trial Pit Number
Manual	610 x 970 x 1430 mm		Balcap RE	J16180	TP5
	Location	**Date**	**Engineer**	**Sheet Number**	
		31/08/16 to 01/09/16	Parmarbrook	1 of 1	

Plan



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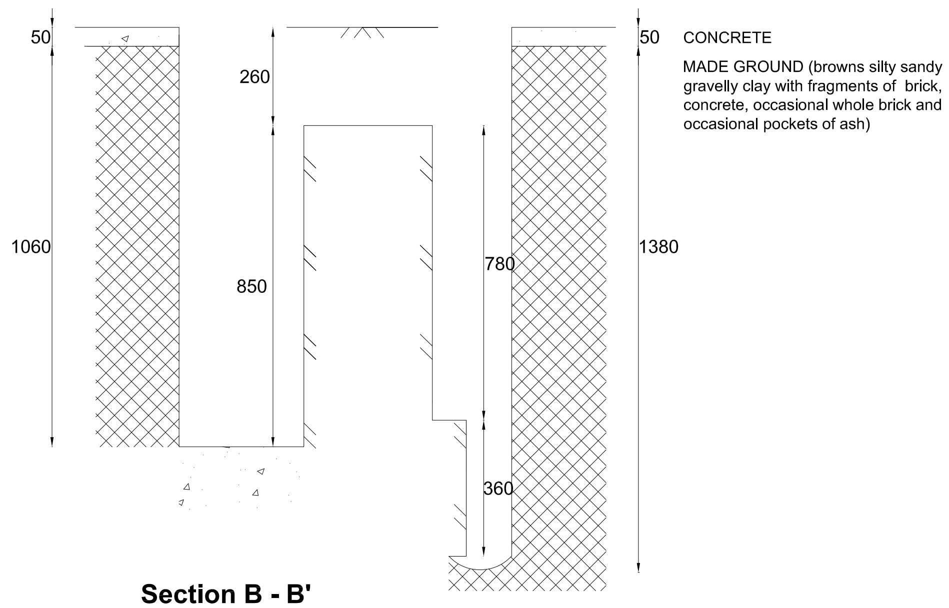

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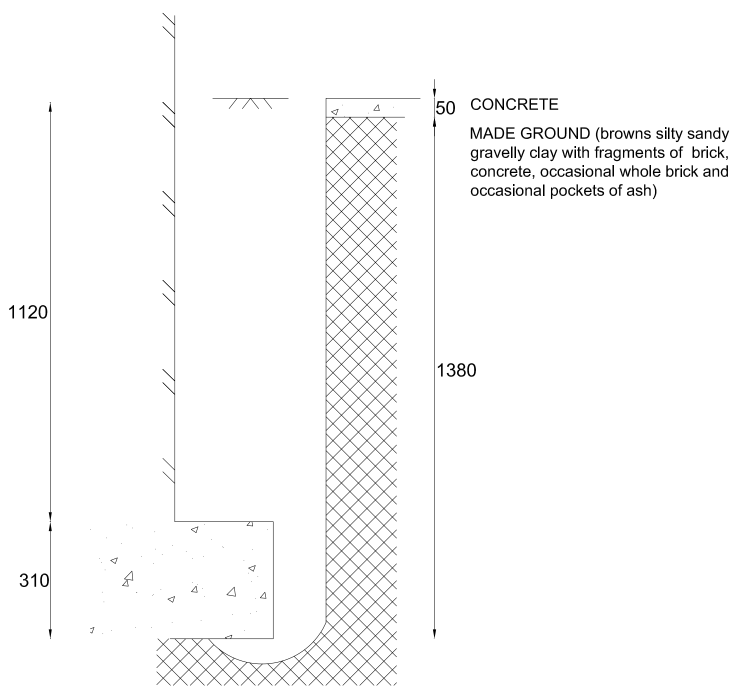

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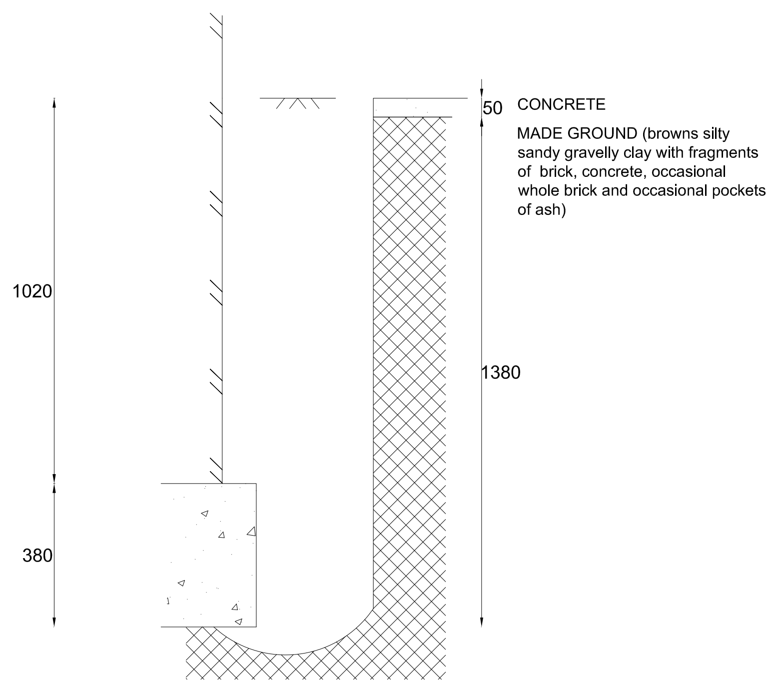


Notes:
Groundwater not encountered

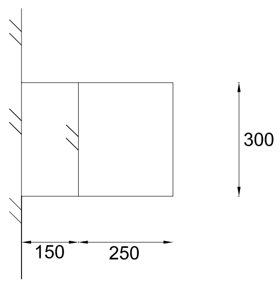
Scale 1 : 20

Logged By CA

Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 400 x 300 x 1300 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

TP6

Plan



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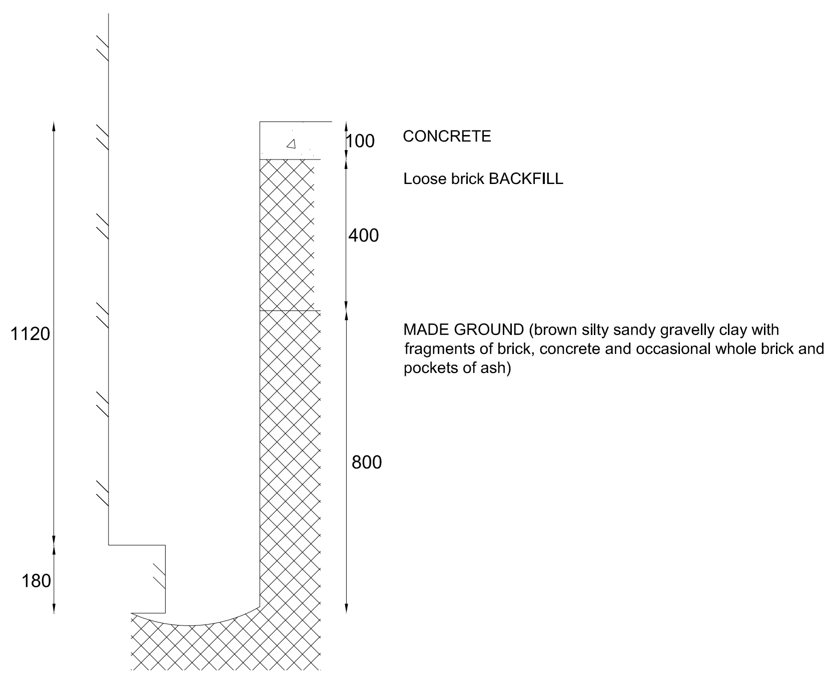
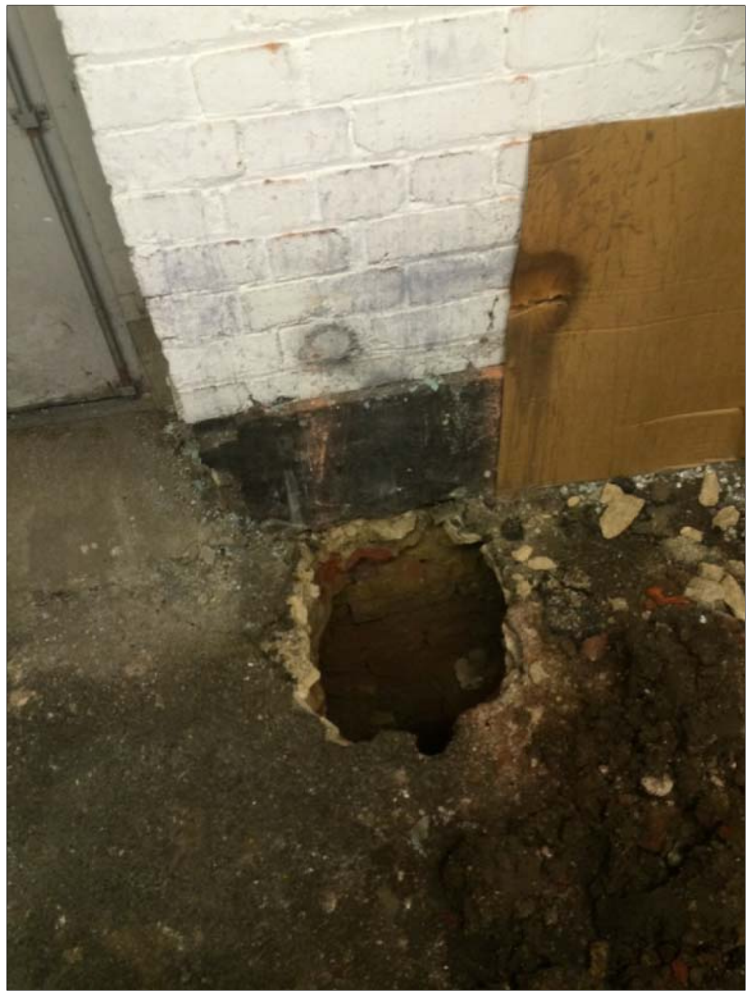




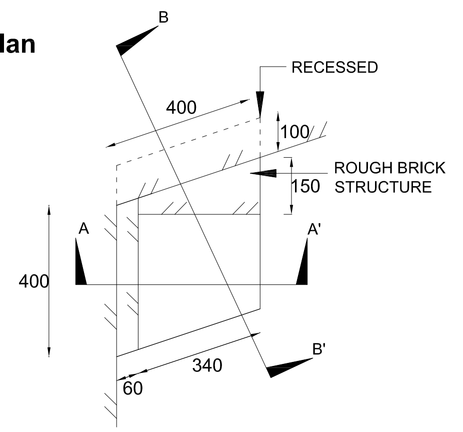
Notes:
Groundwater not encountered

Scale
1 : 20

Logged By
CA

GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 400 x 400 x 1500 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 27/09/2016	**Engineer** Parmarbrook	**Sheet Number** 1 of 1
				TP7

Plan



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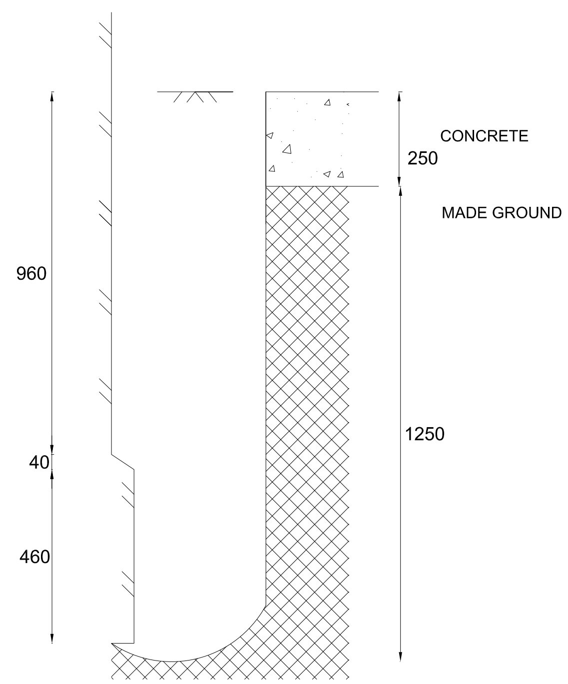

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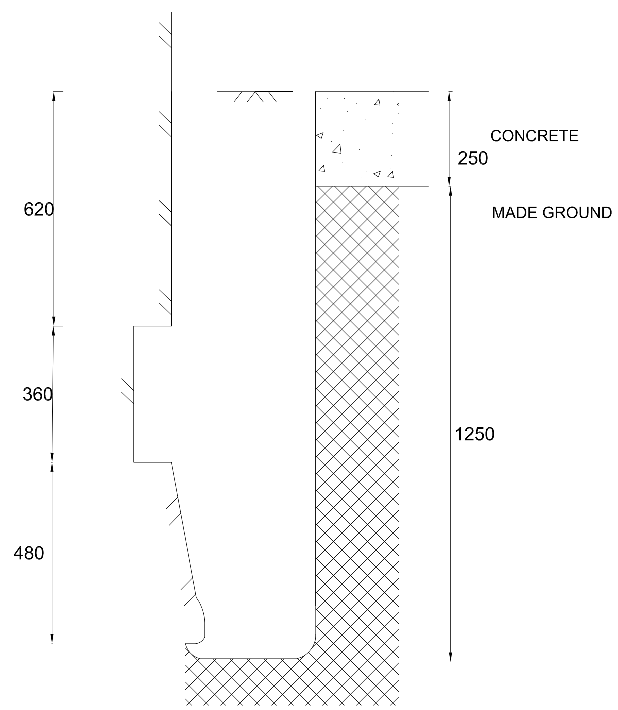


Notes:
Groundwater not encountered

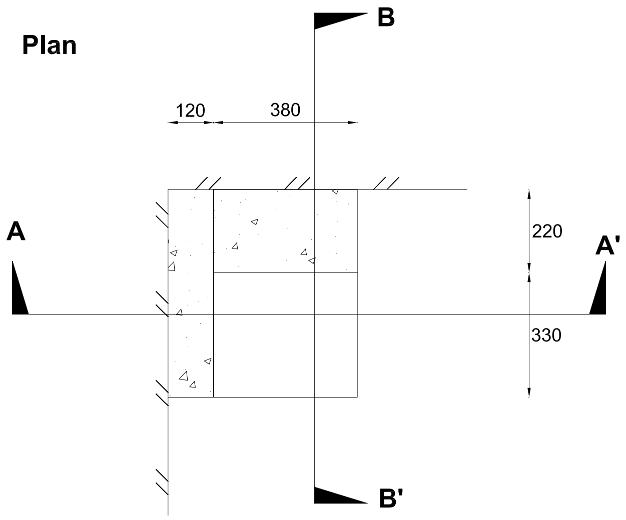
Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site: 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 650 x 300 x 1300 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

Trial Pit Number: TP8

Plan



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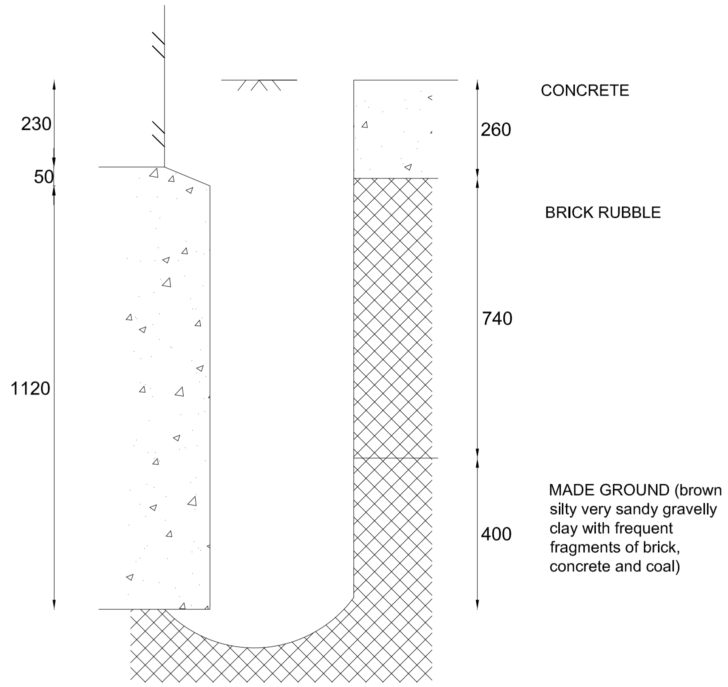

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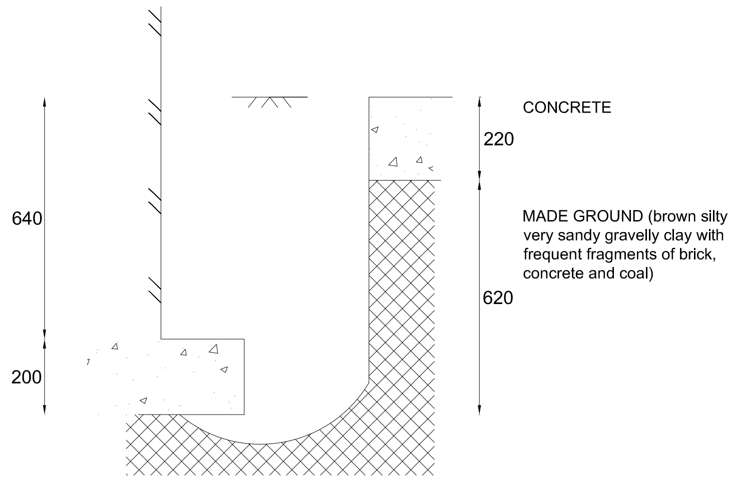


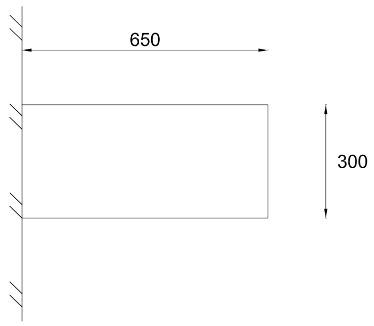
Notes:
Groundwater not encountered

Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number **TP9**
Excavation Method Manual	**Dimensions** 650 x 300 x 1300 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

Plan



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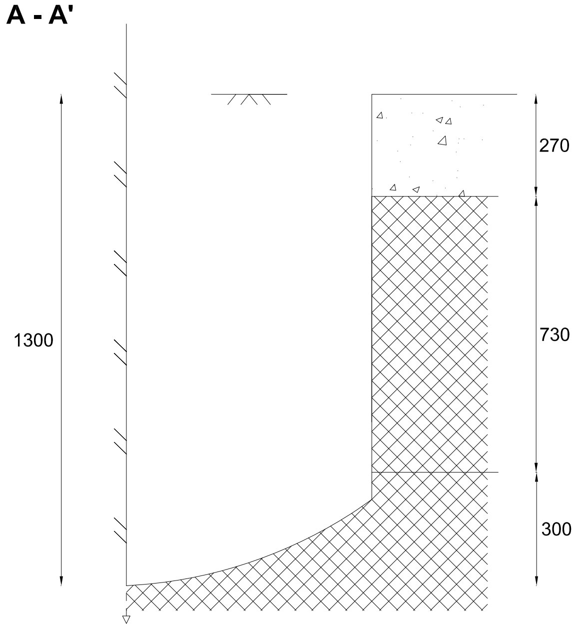


Notes:
Groundwater not encountered

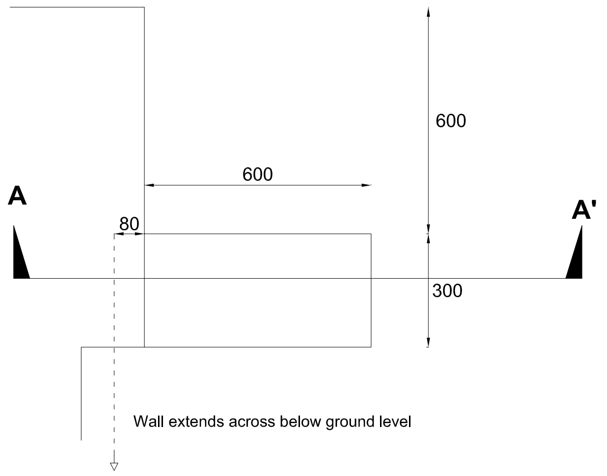
Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates, Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 600 x 300 x 1300 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 27/09/2016	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

TP9A

Plan



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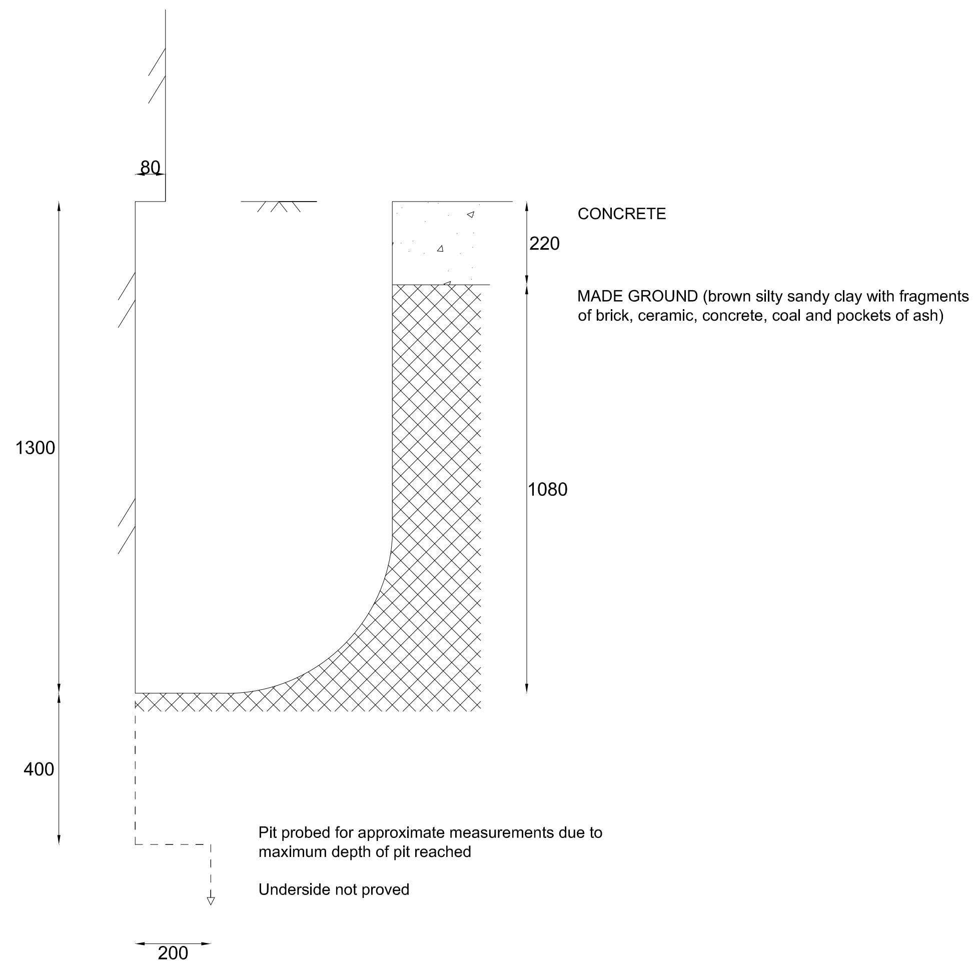
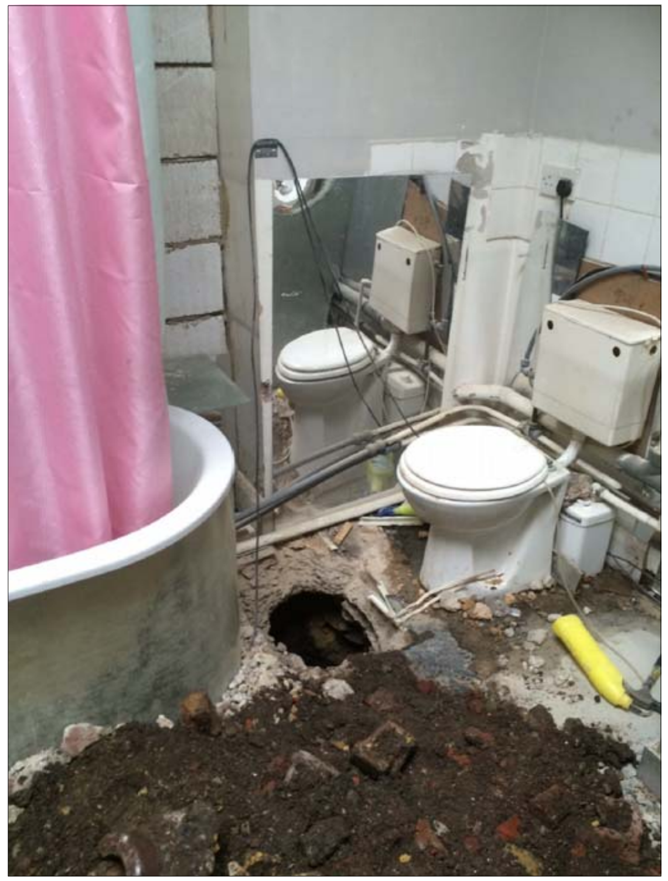




Notes:
Groundwater not encountered

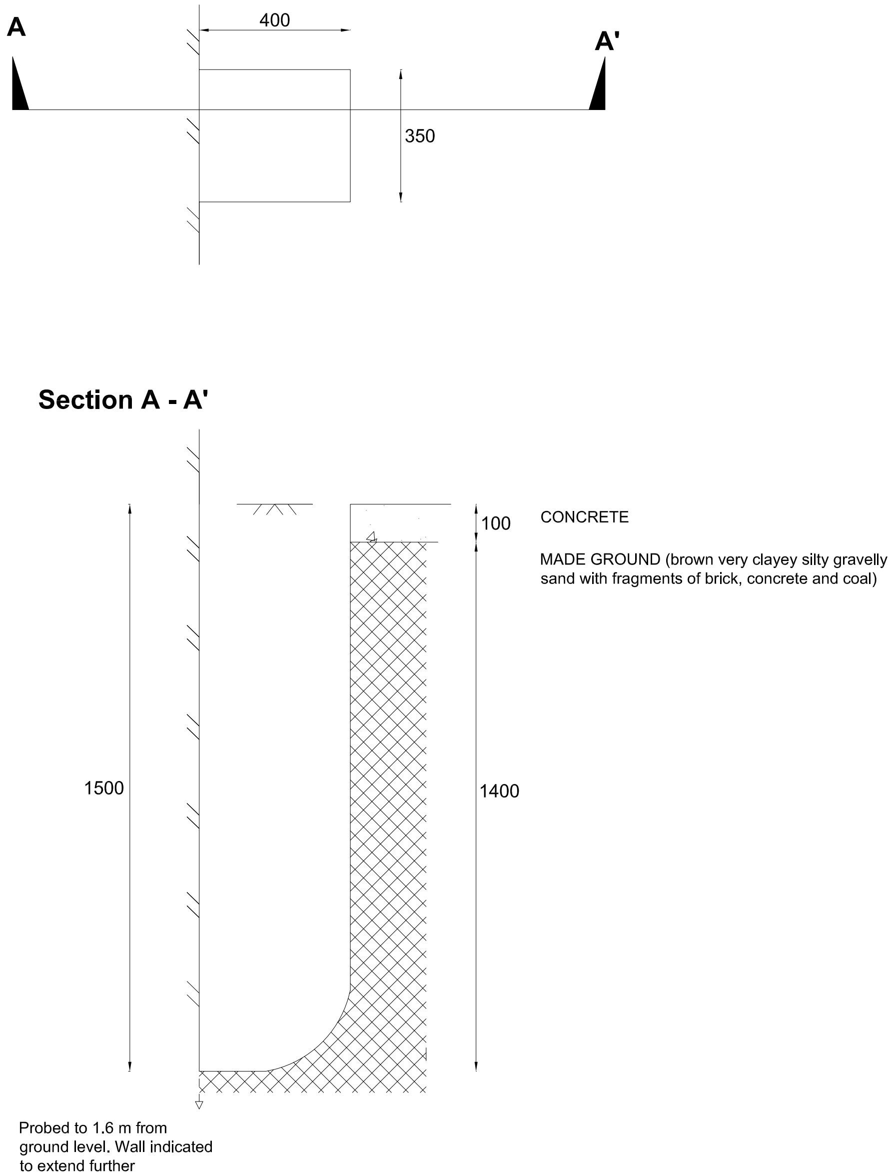
Scale 1 : 20

Logged By CA

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 159-163 Kings Cross Road, London WC1X 9BN			**Trial Pit Number** TP10
Excavation Method Manual	**Dimensions** 400 x 350 x 1500 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180	
	Location	**Date** 31/08/16 to 01/09/16	**Engineer** Parmarbrook	**Sheet Number** 1 of 1	

Plan

Section A - A'



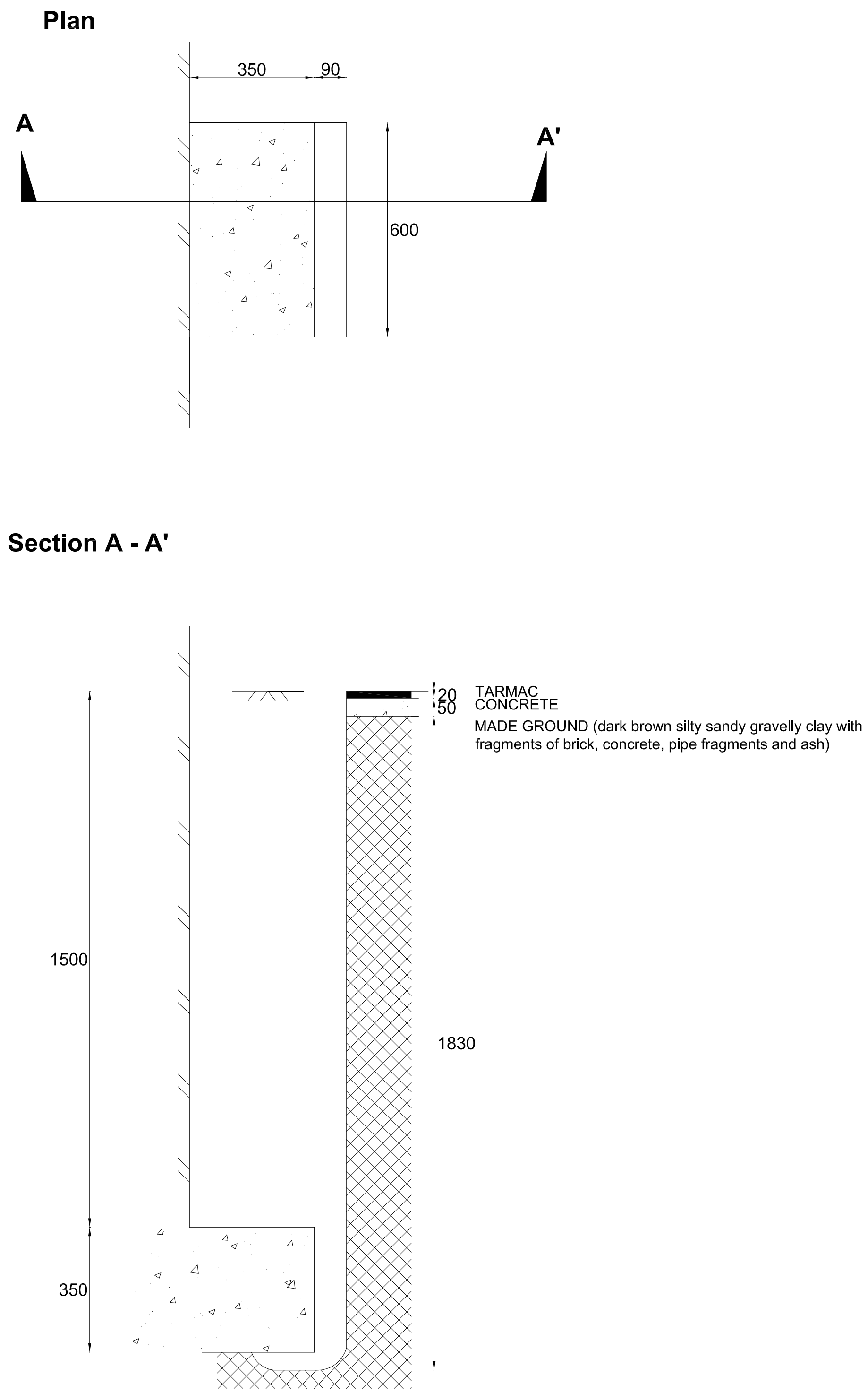
Notes:
Groundwater not encountered

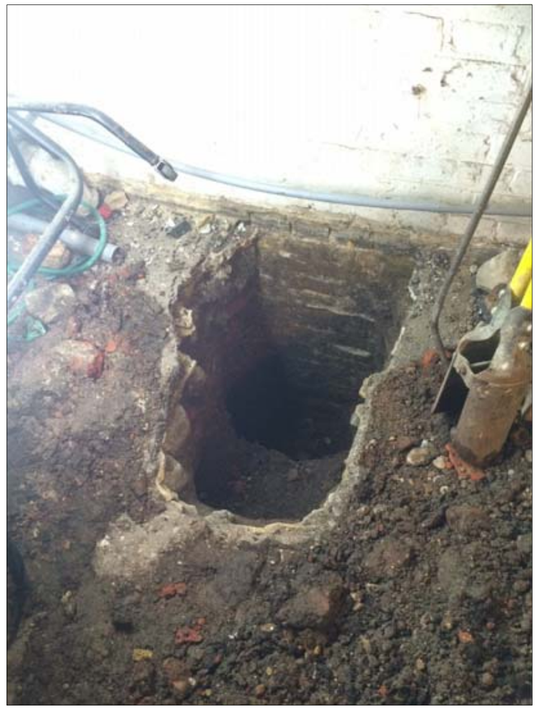
Scale 1 : 20

Logged By CA

Geotechnical & Environmental Associates, Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site 159-163 Kings Cross Road, London WC1X 9BN		Trial Pit Number
Excavation Method Manual	**Dimensions** 440 x 600 x 1850 mm	**Ground Level (m OD)**	**Client** Balcap RE	**Job Number** J16180
	Location	**Date** 27/09/2016	**Engineer** Parmarbrook	**Sheet Number** 1 of 1

Trial Pit Number: TP10A





Notes:
Groundwater not encountered

Scale 1 : 20

Logged By CA

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware,Herts
SG12 7QE

Standard Penetration Test Results

Site : 159-163 Kings Cross Road, London WC1X 9BN

Client : Balcap RE

Engineer : Parmarbrook

Job Number J16180

Sheet 1 / 1

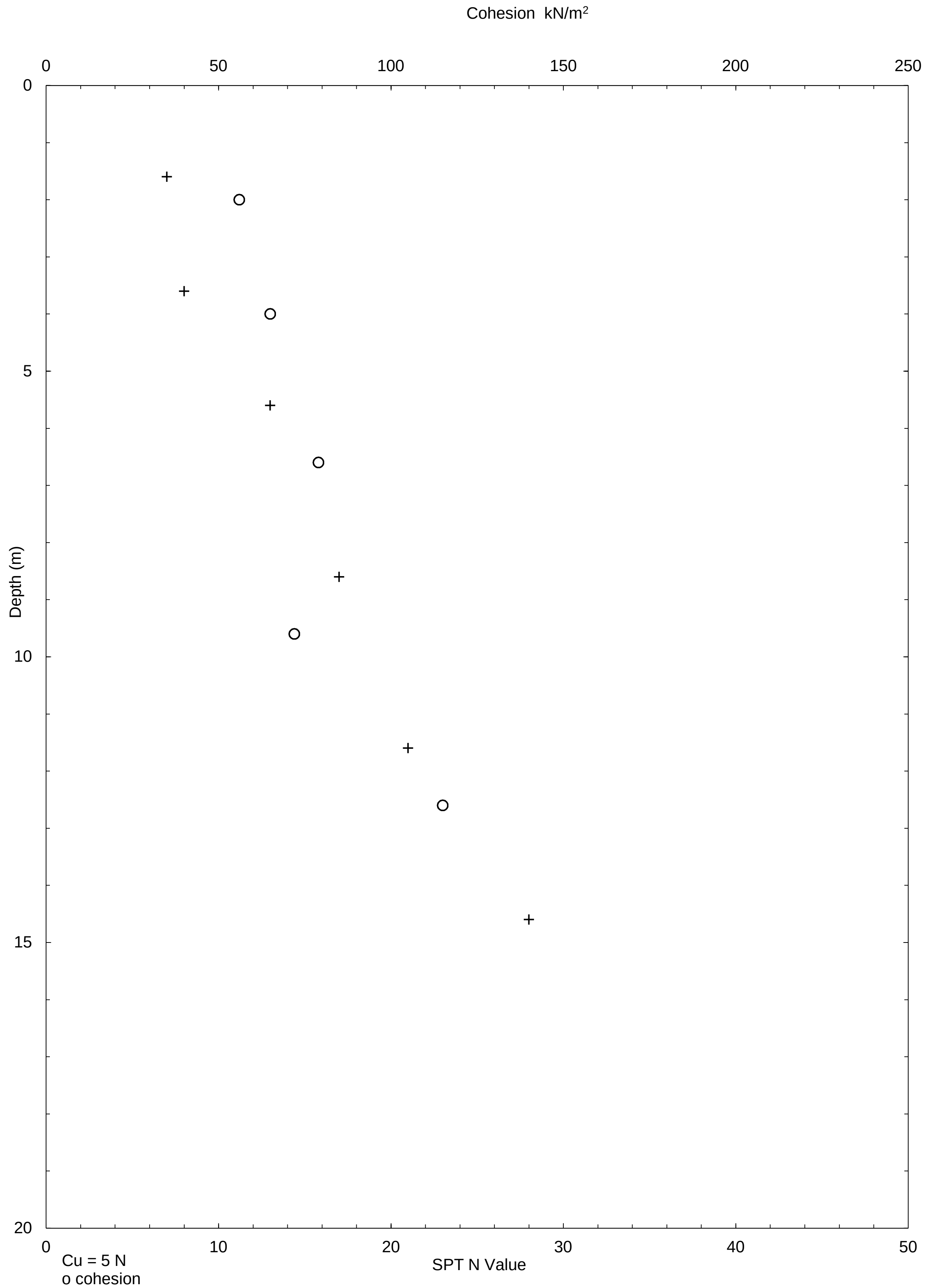
Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
BH1	1.00	1.15	1.45	CPT	1	1	1	1	2	2	N60=7	
BH1	3.00	3.15	3.45	SPT	1	1	1	2	2	2	N60=8	
BH1	5.00	5.15	5.45	SPT	1	2	2	3	3	3	N60=13	
BH1	8.00	8.15	8.45	SPT	2	2	3	3	4	4	N60=17	
BH1	11.00	11.15	11.45	SPT	2	2	3	4	5	6	N60=21	
BH1	14.00	14.15	14.45	SPT	2	3	4	5	7	8	N60=28	
BH2	1.00	1.15	1.45	SPT	0	0	1	1	0	1	N=3	
BH2	2.00	2.15	2.45	SPT	0	0	0	0	0	1	N=1	
BH2	3.00	3.15	3.45	SPT	0	0	1	0	1	1	N=3	
BH2	4.00	4.15	4.45	SPT	9	4	3	1	0	1	N=5	
BH2	5.00	5.15	5.45	SPT	0	0	0	1	0	1	N=2	
BH2	6.00	6.15	6.45	SPT	3	2	2	3	4	3	N=12	

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

SPT & Cohesion / Depth Graph

Site	Rear of 159-163 King's Cross Road, London WC1X 9BN	**Job Number** J16180
Client	Balcap RE	**Sheet** 1 / 1
Engineer	Parmarbrook	



Cu = 5 N
o cohesion
+ SPT N Value