Providing Ground Solutions

Mr and Mrs Saleh

17 East Heath Road, London

Basement Impact Assessment – Revision 2

November, 2016

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1. INTRODUCTION

Card Geotechnics Limited (CGL) has been instructed by Mr and Mrs A Saleh to undertake a Basement Impact Assessment (BIA) for the proposed development of 17 East Heath Road, to assess the potential impact on surrounding buildings, infrastructure and hydrological features. The proposed development comprises the lowering of the lower ground floor level by approximately 0.5m, with excavations up to 3.1m in the existing raised garden area for the construction of a gym.

Camden Guidance CPG4[1] requires Basement Impact Assessments to be undertaken for new basements in the borough and sets out five stages:

1. Screening
2. Scoping
3. Site investigation
4. Impact assessment
5. Review and decision making

This report is intended to address the screening, scoping, site investigations and impact assessment processes set out in CPG4 and the Camden geological, hydrogeological, and hydrological study (CGHHS)[2].

[1] Camden Planning Guidance, CPG4, Basements and Lightwells, July 2015.
[2] Ove Arup and Partners Limited (2010). *London Borough of Camden. Camden geological, hydrogeological and hydrological study. Guidance for subterranean development.* Issue 01, November 2010.

2. SITE CONTEXT

2.1 Site location

The site is located at 17 East Heath Road, London NW3 1AL in the London Borough of Camden (LBC). The National Grid Reference for the approximate centre of the site is 526606E, 186229N and a site location plan is presented as Figure 1.

2.2 Site layout

The site is located in the *Hampstead Conservation Area* and is currently occupied by a four storey semi-detached Grade II listed building. The plot of land is approximately 25m in length and 9m wide with the property occupying the majority of the site. The site is bounded to the north by East Heath Road, beyond which is the woodland of *Vale of Health*. The site is bounded to the east by 16 East Heath Road, to the west by Nos. 1 to 4 Squires Mount and to the south by The Cottage, Squires Mount. It is understood that 16 East Heath Road and 3 Squires Mount immediately adjacent to 17 East Heath Road have lower ground floor levels at approximately 117.5m above Ordnance Datum (mOD).

Site level varies between 119.5m OD at the front of the property on the driveway, decreasing to 117.5mOD to the rear of the property, and then increasing again to 120.2mOD in the south of the site on the raised terrace.

London Underground Limited (LUL) Northern Line underground tunnels are located some 300m west of the site and are orientated north-south.

A conceptual site model plan depicting the information above is presented as Figure 2 and a typical section through the existing and proposed lower ground floor is presented as Figure 3a and 3b.

2.3 Proposed development

The proposed development includes the lowering of the existing lower ground floor level by approximately 0.5m and excavations in the rear garden to provide terraced landscaping and a gym. Based on the available drawings, the existing rear garden is currently terraced, with the proposed development including the incorporation of a new hot tub chamber excavation by the rear boundary of the site.

Existing ground floor level and lower ground floor level are approximately 120.2mOD and 117.6mOD respectively. The proposal is to lower the lower ground floor level and reinstate

a slab with a new finish floor formation level FFL at 117.44mOD. The proposed development plans are included in Appendix A.

2.4 Site history

With reference to publicly available historical mapping of the area and a historical assessment of the neighbouring 16 East Heath Road[3], the land around East Heath Road was predominantly open space in the 1800s with various highways. Two semi-detached properties are indicated across the site and neighbouring site of 16 East Heath Road on mapping dated 1893 to 1896[4] and Squire's Mount Cottages are also indicated.

Nos. 16 and 17 East Heath Road were granted Grade II listed status in 1974 due to the buildings' historic association and architectural interest.

2.5 Bomb damage and unexploded ordnance

With reference to available bomb damage records[5],[6], the site experienced no recorded bombing during the Second World War. The closest structures that appear to have experienced bomb damage are approximately 65m east from the site and are recorded as high-explosive bombs. One site was *seriously damaged, doubtful if repairable* and the other was *seriously damaged but repairable at cost*.

2.6 Anticipated ground conditions

2.6.1 Published geology

With reference to the British Geological Survey (BGS) map sheet 256 (North London)[7], the site is directly underlain by the Bagshot Formation, which typically consists of brown to light brown silty sand. The Claygate Member and London Clay Formation underlie the superficial deposits of the Bagshot Formation.

BGS basal contour mapping suggests that the base of the London Clay Formation is present below to the site to an elevation of approximately -10mOD.

2.6.2 Unpublished geology

A number of historical BGS borehole records exist within 100m of the site. Selected records and an indicative location plan are included in Appendix B. A summary of the

[3] Planning application 2011/2365/P. *Historic Garden Assessment of 16 East Heath Road, Hampstead.*
[4] National Library of Scotland (1895) *OS London, Sheet II.89. OS London. 1893 - 1896.*
[5] www.bombsight.org
[6] The London County Council (2015) *The London County Council Bomb Damage Maps 1939-1945.*
[7] British Geological Survey. (1994) North London. Sheet 256. Solid and Drift Geology 1:50,000.

geology encountered in the BGS historical logs is given in Table 1 below and details are included in Appendix B.

The BGS holds records of a number of historical ground investigations within 80m of the site.

Table 1: Summary of BGS historical borehole records

Stratum	Depth to top (mbgl)	Thickness
Loose dark brown gravelly sand and some clay / Tarmac over grey brown clayey sand with gravel. [MADE GROUND]	0.0	0.95 to 4.0
Compacted sandy GRAVEL. Brown poorly sorted sand and some clay / Compact light brown fine silty SAND / Extremely wet and running compact light brown fine silty SAND / Medium dense brown slightly clayey sand with seams of clay / Yellow brown sand. [BAGSHOT FORMATION]	0.95 to 4.0	7.0 to >11.0
Mixture orange grey stiff CLAY and fine sand. [CLAYGATE MEMBER]	8.5	Proven to 15mbgl

The historical BGS borehole records indicate that the geology of the surrounding area consists of a variable thickness of Made Ground over sand deposits of the Bagshot Formation. The thickness of the Bagshot Formation was only proven in historical borehole TQ28NE96, as the base of the stratum was not proven in TQ28NE418 at 15m below ground level (mbgl).

Groundwater was not encountered in historical borehole TQ28NE96; however 'extremely wet and running' sand was recorded between 5.3mbgl and 8.5mbgl. Groundwater seepages and a subsequent strike were recorded in TQ28NE418 at 6.90mbgl and 13.90mbgl, respectively.

2.7 Hydrogeology and hydrology

The Environment Agency[8] has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geology and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

[8] www.environment-agency.gov.uk (September 2014)

The Bagshot Formation underlying the site has been classified as a Secondary A aquifer, which consists of permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. The London Clay Formation has been classified as 'unproductive strata' which consists of low permeability that has negligible significance for water supply or river base flow. The site is not within a Groundwater Source Protection Zone.

The nearest significant surface water features are the *Vale of Health Pond* located some 130m north of the site and *Whitestone Pond* located some 300m west of the site. *Hampstead Ponds* are located between 620m and 720m east to southeast of the site. The site lies 145m south of a tributary of the *River Fleet*, one of London's 'lost' rivers[9], which flowed west to join the main river channel in *Hampstead Heath* before flowing southwards towards *Hampstead Ponds*. The 'lost' *River Westbourne* is located some 300m west of the site, originating at *Whitestone Pond* and flowing towards the southwest.

The Hampstead Health Surface Drainage and Catchment Map (Figure 14) indicates that the site is located adjacent to the southern boundary of the *Hampstead Heath Extension Chain Catchment*. The site is not located adjacent to roads or streets that have been subjected to historical flooding; however Heath Street some 280m to the west of the site was recorded to have flooded in 1975 according to published Camden flooding guidance. The site is not located within an area at risk from surface water flooding or flooding from rivers, seas or reservoirs[10]. A qualitative assessment of the impact of the proposed development on groundwater and surface water flow and flooding will be undertaken as part of this report.

[9] Nicholas Barton, *The Lost Rivers of London*, Historical Publications Ltd; 3rd Revised edition edition (7 Dec. 1992)
[10] Environment Agency maps, [online]: http://www.environment-agency.gov.uk

3. SCREENING (STAGE 1)

3.1 Introduction

A screening assessment has been undertaken in accordance with CPG4, based on the flowcharts presented in that document. Responses to the questions posed by the flowcharts are presented below, and where 'yes' or 'unknown' may be simply answered, with no analysis required, these answers have been provided.

3.2 Subterranean (Groundwater) flow

This section answers questions posed by Figure 1 of CPG4, in Table 2.

Table 2. Responses to Figure 1 of CPG4

Question	Response	Action Required
1a. Is the site located directly above an aquifer?	Yes. The site is located over the Bagshot Formation which is designated a Secondary A aquifer	Investigation and assessment
1b. Will the proposed basement extend beneath the water table surface?	Unknown. Groundwater was recorded between 5.3mbgl and 8.3mbgl in nearby historical BGS boreholes.	Investigation and assessment
2. Is the site within 100m of a watercourse, well, or potential spring line?	No.	None
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No.	None
4. Will the proposed basement development result in a change in the proportion of hard surfacing?	No. The proposed development will not significantly change the proportion of hardstanding on site.	None
5. As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS)?	No. All surface water is likely to be discharged to the sewer network through existing connections.	None
6. Is the lowest point of the proposed excavation close to, or lower than, the mean water level in any local pond or spring lines?	No. There are no evident ponds or spring lines within 100m of the site.	None

In summary, the proposed lower ground floor development, although very shallow, would extend into the Bagshot Formation and therefore has the potential to extend beneath the water table which is anticipated to be present within the stratum. Investigation and impact assessment is required.

The ratio of hardstanding to soft landscaping will remain similar to the existing ratio, and therefore the impermeable surface area of the development will not increase significantly.

3.3 Slope/land stability

This section answers questions posed by Figure 2 of CPG4, in Table 3.

Table 3. Responses to Figure 2 of CPG4

Question	Response	Action required
1. Does the site include slopes, natural or man-made, greater than about 1 in 8?	No.	None
2. Will the proposed re-profiling of the landscaping at site change slopes at the property boundary to greater than about 1 in 8?	No.	None
3. Does the development neighbour land including railway cuttings and the like with a slope greater than about 1 in 8?	No.	None
4. Is the site within a wider hillside setting in which the general slope is greater than about 1 in 8?	No. The topography of the local hillslope setting is less than 1 in 8 although it is noted that the hillslope to the north (*Vale of Health)* is greater than 1 in 8.	None
5. Is the London Clay Formation the shallowest stratum on site?	No. The Bagshot Formation is present above the London Clay.	None
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?	Yes . It is understood that a number of small trees/shrubs will be felled, however underlying soils are non-shrinkable.	None
7. Is there a history of shrink/swell subsidence in the local area and/or evidence of such at the site?	Unknown. Unlikely given the anticipated thickness of non-shrinkable sands beneath the site and the basement is not anticipated to extend into the underlying Claygate or London Clay Formations.	None
8. Is the site within 100m of a watercourse or a potential spring line?	No.	None
9. Is the site within an area of previously worked ground?	Unlikely. The geological map indicates no worked ground. However, there is likely to be limited Made Ground associated with the construction of the current building.	Investigation and assessment
10. Is the site within an aquifer?	Yes The Bagshot Formation is classified as a Secondary A Aquifer.	Investigation and assessment
11. Is the site within 50 m of the Hampstead Heath Ponds?	No.	None

Question	Response	Action required
12. Is the site within 5m of a highway or pedestrian right of way?	Yes. The site is immediately adjacent to East Heath Road to the north. The building itself is further than 5m from the road.	None
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No. The adjacent property (No. 16 East Heath Road) has an existing lower ground floor level); however the properties share a party wall and the effects of ground movements should be investigated.	Impact Assessment
14. Is the site over (or within the exclusion zone of) any tunnels?	No.	None

A review of local topography suggests that local and hillslopes do not exceed a gradient of 1 in 8. It is understood that a number of small trees/shrubs will be felled during the proposed development however the Bagshot Formation beneath the site is non-shrinkable and therefore no impact is anticipated. The lowering of the existing basement will not significantly increase the differential depth of the neighbouring property (16 East Heath Road); however the properties share a party wall and therefore the impacts of ground movements should be investigated.

The proposed basement will be located some 5m from East Heath Road and the ground movements resulting from the excavation are considered to be negligible assuming good workmanship and well-constructed scheme are carried out.

A ground movement assessment is required to investigate the magnitude of ground movements around the basement perimeter and the results should be used to assess the potential impact and damage categories for adjacent structures.

3.4 Surface flow and flooding

This section answers questions posed by Figure 3 of CPG4, in Table 4.

Table 4. Responses to Figure 3 of CPG4

Question	Response	Action required
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No.	None
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.	None
3. Will the proposed development result in a change in the proportion of hard surfaced/paved external areas?	No. The proposed development will not significantly change the proportion of hardstanding on site.	None
4. Will the proposed basement result in a change to the profile of the inflows of surface water being received by adjacent properties or downstream watercourses?	No.	None
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No.	None
6. Is the site in an area known to be at risk from surface flooding or is it at risk from flooding because the proposed basement is below the static water level of a nearby surface water feature?	No. The site is not in a Flood Risk Zone according to Camden Flood Risk Management maps[11].	None

The proposed development will remain a residential property and therefore no significant change of use is anticipated that may increase discharge loads to the existing sewer and drainage systems. The proposed development will not significantly change the proportion of hardstanding on site and is therefore not anticipated to affect run-off/surface attenuation characteristics. The site is not recorded to be within an area at risk from surface water flooding or flooding from rivers, seas or reservoirs.

[11] The Local Borough of Camden flood risk management strategy (2013), Managing flood risk in Camden; *Camden Flood Risk Management Strategy*.

3.5 Conclusion

On the basis of this screening exercise, a Basement Impact Assessment is required for this site which should address the following:

Table 5. Summary of Basement Impact Assessment requirements

Item	Description
1.	*Subterranean (Groundwater) Flow* Investigation and assessment - the basement will extend into the Bagshot Formation and therefore there is the potential for groundwater to be encountered. Investigation should be carried out to assess the ground and groundwater conditions below the site, and the impact of the basement on groundwater flows in and around the proposed structure.
2.	*Slope (land stability)* Investigation and assessment – the limited excavation may cause ground movements, the impacts of which require assessment. The site is not located within an area of worked ground according to the BGS geological map of the area and a review of the site's history; however a limited thickness of Made Ground may be present across the site. The impact of the basement construction on adjacent neighbouring structures requires consideration and an impact assessment is required.
3.	*Surface flow and flooding* None -the proposed development does not include a significant change to the ratio of hardstanding to soft landscaping and is not anticipated to affect run-off/surface attenuation characteristics. The site is not located within an area at risk from surface water flooding or flooding from rivers and seas.
4.	*Cumulative impacts* Negligible - if groundwater is present above basement formation level, groundwater will be diverted around and beneath the proposed basement assuming that it is founded in the granular Bagshot Formation, and groundwater flow would not be significantly inhibited.

4. SCOPING (STAGE 2)

This section of the report provides the scoping process (Stage 2) of CPG4, which is used to identify potential impacts of the new basement as set out in the screening process in Section 3 of this report, and to recommend an appropriate investigation strategy.

On the basis of the screening report, an intrusive investigation is required on site. The intrusive investigation should:

1. Determine the ground conditions on site and their variability;
2. Install groundwater monitoring standpipes to determine groundwater levels;
3. Undertake in-situ testing to assess the strengths of the ground and to support geotechnical assessment; and
4. Obtain soil samples for geotechnical laboratory testing in order to classify the soils on site, to determine where desiccation is present on site, and to support geotechnical design.

A site investigation has been undertaken by CGL and the findings are presented within Section 5.

5. GROUND INVESTIGATION (STAGE 3)

5.1 Current site investigation

An intrusive investigation was undertaken by CGL in August 2016. The investigation comprised a single window sample borehole (WS1) from the front of the house to a depth of 7.45mbgl (i.e. 11.95). The ground investigation was undertaken in accordance with BS 1377:1990[12] and BS 5930:1999[13]. Standard Penetration Tests (SPTs) were undertaken within the borehole and a groundwater monitoring well was installed. It is understood that seven trial pits have been undertaken by others.

The borehole log is included in Appendix C and the exploratory hole location plan is presented in Figure 5.

5.2 Monitoring

Two groundwater monitoring visits were undertaken on 15th and 22nd September 2016 following completion of the site works. The results of the monitoring visits are included in Appendix D.

5.3 Laboratory testing

5.3.1 Geotechnical

Selected soil samples were submitted to an accredited laboratory for geotechnical testing including the following:

- Atterberg Limits tests;
- Particle Size Distribution (PSD) tests;
- Moisture content; and
- BRE analysis in accordance with BRE SD1.

The geotechnical analysis results are included as Appendix E.

[12] British Standards Institution. (1990). *Methods of Test for Soils for Civil Engineering purposes*. BS1377:1990.
[13] British Standards Institution. (2015). *Code of practice for ground investigations*. BS5930:2015

6. STAGE 3 - GROUND AND GROUNDWATER CONDITIONS

6.1 Ground conditions - Summary

The ground conditions encountered during the intrusive investigation broadly corresponded to the published geology and are summarised in Table 6 below.

Table 6. Summary of ground conditions

Stratum	Depth to top of stratum (mOD) [mbgl]	Thickness (m)
CERAMIC TILES and CONCRETE over coarse gravel of concrete, ceramic, brick and flint / grey brown slightly silty gravelly sand / yellow grey fine sand. Sand is fine to medium. Gravel is fine to coarse of flint, brick and concrete. [MADE GROUND]	0.0 [119.4]	0.75
Medium dense yellow grey fine SAND with occasional orange brown bands up to 5mm in thickness / yellow grey slightly clayey fine SAND. [BAGSHOT FORMATION]	0.75 [118.65]	Proven to 7.45mbgl [111.95mOD]

The ground conditions are discussed in the following sections together with the results of the in-situ and laboratory geotechnical tests.

6.2 Made Ground

The Made Ground was found to ceramic tiles and concrete over silty, gravelly sand to a level of 116.41mOD. The gravel comprised brick, flint, concrete and ceramic tile.

6.3 Bagshot Formation

The Bagshot Formation was encountered at beneath the Made Ground at 119.4mOD and comprised medium dense, occasionally slightly clayey, yellow grey fine sand with occasional bands of orange brown sand. The formation extended to the base of the borehole at 111.95mOD.

SPTs undertaken in the stratum recorded 'N' values between N=10 and N=21 corresponding to 'medium dense' deposits. A plot of SPT 'N' values versus level is presented in Figure 6.

Classification testing of the deposits indicates moisture contents between 4.6% and 10.2% and the deposits are classified as non-plastic deposits. Particle Size Distribution testing indicated sand proportions between 78% and 83% and silt/clay proportions between 17% and 22%.

6.4 Groundwater

Whilst a groundwater strike was not recorded during drilling, deposits were recorded as 'wet' from 6.40mbgl (113mOD). During subsequent monitoring groundwater was recorded at 6.58mbgl and 6.60mbgl (112.82mOD and 112.8mOD).

6.5 Sulfate and pH conditions

Three samples of the Bagshot Formation were analysed for pH and sulfate and laboratory results are included in Appendix E. Water soluble sulfate concentrations (2:1 leachate equivalent) range between 0.0056g/l and 0.094g/l and pH values ranged between 8.0 to 10.2.

6.6 Geotechnical design parameters

Geotechnical design parameters are recommended based on the available information from the intrusive investigation and published information. These are summarised in Table 7. The values are unfactored (Serviceability Limit State) parameters and are considered to be characteristic values for the local soils.

Table 7. Geotechnical design parameters

Stratum	Design Level (mOD)	Bulk Unit Weight γ_b (kN/m^3)	Undrained Cohesion c_u (kPa) [c']	Friction Angle ϕ' (°)	Young's Modulus E_u (MPa) [E']
Made Ground (Granular)	119.40	19	n/a	28	[30]
Bagshot Formation	118.65	19	n/a	31	[35]

a. BS 8002:2015 Code of practice for Earth retaining structures, British Standards institution.
b. Burland et. al (Eds) (2001) Building response to tunnelling, CIRIA Special Publication 200, CIRIA
c. z = depth below upper surface of the London Clay
d. Peck, R.B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967.

A design groundwater level of 110.6mOD is recommended based on the groundwater monitoring visits which is some 7m below the proposed basement level.

6.7 Allowable bearing capacity

Based on the structural drawings and ground conditions encountered during site investigation, the underpins will be bearing into the medium dense Bagshot Formation.

The allowable bearing pressure at the underside of the proposed underpinning sections (i.e. 0.5m embedded foundation) has been estimated between 110kPa and 160kPa within the cohesionless Bagshot Formation for the different sections. This estimation allows a factor of safety of 3.

6.8 Buried concrete

The design sulfate (DS) and ACEC classes for the Bagshot Formation based on the results of the geotechnical sulfate and pH testing are DS-1 and AC-1, respectively.

7. IMPACT ASSESSMENT – LAND/SLOPE STABILITY (STAGE 4)

7.1 Introduction

This section provides calculations to determine ground movements that may result from the extension of the lower ground floor and to assess how these may affect adjacent structures. It is understood that an underpinning construction method with reinforced concrete wall will be adopted to form the rear extension of the lower ground floor and also to support the existing foundations beneath the party walls with the neighbouring properties. Possible ground movement mechanisms based on the above assumption are outlined below.

- Elastic movements: The Bagshot Formation at depth is susceptible to short term elastic rebound, which will occur as a result of basement excavation, generating upward ground movements.

- Settlement: Construction of underpins and loading of the foundations can lead to settlement and the amount of settlement depends on the bearing pressure below the underpins (provided in Appendix A) as structural loads are transferred to greater depth; and quality of workmanship in constructing the underpins, in particular in dry-packing between the existing foundation and the new underpins.

- Underpin deflection: Underpins will be acting as stiff concrete retaining walls, which limits the potential for wall deflection. However, deflections that do occur may generate surface settlements that could impact adjacent properties.

- Global stability of the underpins: This relates to an ultimate limit state failure (i.e. sliding/overturning/bearing capacity) of the underpins when they are acting as L-shaped gravity retaining walls. The stability of underpins, therefore, needs to be considered in the design, and they should be propped during construction and over the long term to control lateral displacements and deflections.

- Long term ground movement: The net loading on the formation soils will generate ground movement, which could affect adjacent foundations. The net loading takes into account the existing stress conditions, design loads from new structural slab, the design loads for the superstructure of the lower ground floor and the weight of soil removed. The long term ground movements are associated with the drained heave of the excavated soils.

7.2 Construction sequence

The underpinned basement sections will be constructed in a prescriptive sequence of a minimum 1000m to 1300mm wide bays to distribute the bearing pressure during construction. The proposed lower ground floor construction sequence is set out by FORM Structural Design engineers. Generally, the construction sequence is summarised by the following stages;

1. Demolish existing rear projection roof and non-retaining walls at the existing lower ground floor.

2. Demolish existing lower ground floor slab.

3. Install mass concrete underpins in maximum 1m sections in a hit and miss sequence below party walls with 3 Squires Mount and 16 East Heath Road.

4. Install L-shaped underpins in maximum 1m sections in a hit and miss sequence below party wall with 3 Squires Mount sequentially towards rear of garden. Underpins are proposed to be freestanding.

5. Install L-shaped retaining walls to higher rear garden level in hit and miss fashion.

6. Cast new lower ground floor slab.

7. Install internal and external walls at the lower ground floor.

8. Cast ground floor level terrace slab.

7.3 Ground movements arising from basement excavation

The soils at formation level of the lower ground floor in the garden area will be subject to stress relief during excavation, as an average 2.76m (i.e. 120mOD – 117.24mOD) of overburden is to be removed from the rear ground floor excavation. This is likely to give rise to a degree of elastic rebound over the short term and potential settlement over the longer term as structural loads are reapplied to the proposed structural slab (i.e. internal and external walls, point loads).

A vertical movement assessment has been undertaken using OASYS Limited PDisp (Pressure Induced Displacement) analysis software. PDisp assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (Eu and E') for each stratum input by the user. PDisp

assumes perfectly flexible loaded areas and as such tends to overestimate movements in the centre of loaded areas and underestimate movements around the perimeters. Notwithstanding this, the structure has not been modelled as an evenly loaded flexible raft and loads from the underpins (i.e. bearing pressures) have been accounted for and modelled in the analysis. The calculated movements are, therefore, not considered to be underestimated.

The proposed development gives rise to a net unloading of the underlying sandy strata both during construction and over the long term. The excavation will unload the soils by a maximum of 59kPa allowing for approximately 3.1m of overburden soil removed to form the underside of the reinforced concrete RC retaining wall underpins (i.e. 120.2mOD to 117.1mOD). This gives rise to the elastic rebound (short term) of soils in the region of the new basement level. These values assume a typical bulk unit weight of 19kN/m^3 for the removal of the excavated soils. The combined effects of both the immediate undrained unloading and the long-term load application have been assessed.

Preliminary loads on the top of the underpins have been provided by the structural engineers (loading information has been included in Appendix A) based on the proposed structural specification and underpinning.

Due to the proposed construction scheme, net bearing pressures have been calculated during the excavation and after the reapplication of the structural loading for different sections of the proposed development.

The reinforced concrete L-shaped retaining walls in an underpin fashion have been modelled as rectangular foundations. The underpin walls are taken to be 350mm thick and the footing thickness is assumed 500mm. The self-weight of the underpins has been calculated and an equivalent bearing pressure of the order of 24kPa has been assigned within the model in the short-term.

A mass concrete underpinning section has been modelled at the underside of the perimeter party walls with 3 Squares Mount and 16 East Heath Road. A mass concrete underpinning thickness of 0.5m has been assumed. The installation levels of the underpins have been assigned within the model based on the available information for party and external wall toe levels (Appendix A). An equivalent bearing pressure raking into account the self-weight of the underpins, of the order of 20kPa has been applied in the model in the short-term.

The presence of any vertical supports for the temporary support has been ignored in the analysis. These elements will help to reduce heave movements further, therefore the values predicted in the analysis are likely to be greater than actual movements.

Two displacement lines have been defined for the calculation of ground movement profiles along the adjacent properties. The displacement lines represent the two critical Sections 1-1 and 2-2 as illustrated in Figure 2.

Analytical results from PDisp output can be provided upon request.

7.3.1 Construction loading

A new structural slab is proposed for the lower ground floor with a design load of 12.5kPa. Loading from the internal column, walls and perimeter liner wall is uniformly distributed across the slab element at thicker sections (i.e. 0.45m thickening). Line loading on the top of the underpinning and point loading from the roof slab is provided by the structural engineer (Appendix A).

7.3.2 Short term ground movement during construction

Maximum short term elastic rebound is predicted to be of the order of 2.0mm, occurring at the rear of the lower ground floor excavation where up to 2.76m of overburden will be removed to reach formation level for the proposed lower ground floor. The upward ground movement decreases of the order of 0.5mm around the party and perimeter walls.

A contour plot showing the variation of short term movement across the entire lower ground floor footprint is presented in Figure 6.

7.3.3 Long term ground movement

Maximum long term upward ground movement is predicted to be of the order of 1mm, occurring towards the centre of the rear extension of the lower ground floor. Settlement values are predicted after the application of the column loading, internal and external wall loading with a maximum value of 0.8mm at the rear boundary wall.

A contour plot showing the variation of long term movement across the entire basement footprint is presented in Figure 7.

7.3.4 Settlement due to workmanship

The settlement assessment undertaken within PDisp assumes perfect workmanship in the underpin construction and does not allow for settlement of the dry pack between existing

party wall footings and the new concrete. With good construction practice, these would be expected to be undertaken in a single lift/stage for the underpinning sections below the shared party wall between 3 Squires Mount and 16 East Heath Road. Maximum settlements due to this construction method are not expected to exceed 5mm per underpin lift. This value will be applied to the overall ground movement and corresponding impact assessment to give a worst case damage category for the adjacent party wall properties and external walls.

7.4 L-shaped cast section – Lateral Movements

A reinforced concrete L-shaped wall acting as retaining wall is proposed for the rear boundary of the lower ground floor excavation to support the proposed structural arrangement and retain the earth pressures beneath the wall. Due to relatively high stiffness and relatively shallow depth of the mass concrete section (i.e. 3.1m below the existing surface level at 120.2mOD to the existing rear garden), long term deflection is expected to be negligible (i.e. <2mm). This is based on CGL's involvement in similar basement developments across London and review of monitoring data for similar projects. Damage to the neighbouring structures will be governed by vertical heave and settlement due to bulk excavation and the underpin self- weight.

Ground movement during construction will be dependent on the quality of workmanship adopted. Temporary propping of the top and bottom of each reinforced concrete section during construction will be crucial in controlling horizontal deflection and rotation of the cast wall. The detailing and construction of any reinforcement and connections/curing joints between sections and structural slab will also be critical in controlling deflections.

8. DAMAGE CATEGORY ASSESSMENT (STAGE 4)

The calculated ground movements have been used to assess potential 'damage categories' that may apply to neighbouring properties due to the proposed basement construction. The methodology proposed by Burland and Wroth[14] and later supplemented by the work of Boscardin and Cording[15] has been used, as described in *CIRIA Special Publication 200*[16] and *CIRIA C580*[17].

General damage categories are summarised in Table 8 below.

Table 8. Classification of damage visible to walls (reproduction of Table 2.5, CIRIA C580)

Category	Description
0 (Negligible)	Negligible – hairline cracks
1 (Very slight)	Fine cracks that can easily be treated during normal decoration (crack width <1mm)
2 (Slight)	Cracks easily filled, redecoration probably required. Some repointing may be required externally (crack width <5mm).
3 (Moderate)	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced (crack width 5 to 15mm or a number of cracks > 3mm).
4 (Severe)	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows (crack width 15mm to 25mm but also depends on number of cracks).
5 (Very Severe)	This requires a major repair involving partial or complete re-building (crack width usually >25mm but depends on number of cracks).

For the critical party and boundary wall sections the combined impact of short term heave, settlement due to underpin loading, assumed settlement due to workmanship and corresponding ground movement due to underpin deflection have been combined to

[14] Burland, J.B., and Wroth, C.P. (1974). *Settlement of buildings and associated damage*, State of the art review. Conf on Settlement of Structures, Cambridge, Pentech Press, London, pp611-654

[15] Boscardin, M.D., and Cording, E.G., (1989). *Building response to excavation induced settlement*. J Geotech Eng, ASCE, 115 (1); pp 1-21.

[16] Burland, Standing J.R., and Jardine F.M. (eds) (2001), *Building response to tunnelling, case studies from construction of the Jubilee Line Extension London*, CIRIA Special Publication 200.

[17] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*

determine the overall ground movement of the underpins and adjacent properties due to the reconstruction of the lower ground floor.

8.1 Section 1–1 16 East Heath Road

The maximum impact and ground movement is noted at the party wall between 16 East Heath Road and the rear lower ground floor 17 East Heath Road where a net 5.5mm of settlement is accumulated from the proposed development. Again, very good quality workmanship with a single method is essential in controlling further movement.

Based on the predicted ground movement profile, the differential settlements which are expected to be imposed on the adjacent buildings are of the order of 5mm. Based on available information (Figure 3) the width of the building is 7m, this differential movement corresponds to an angular distortion of 1/1400 which is within published limits for preventing excess cracking and damage to load bearing walls and partitions[18,19]. The maximum deflection caused by the settlements is 2mm, which for a width of 7m corresponds to a deflection ratio of 0.028%.

Taking into account that due to high stiffness and the 'hit and miss' construction method the underpin walls generally induce horizontal ground movements less than 3mm, provided good workmanship is applied, then the effects on the adjacent building are expected to be within Damage Category 1 (very slight).

8.2 Section 2-2 – 3 Squires Mount

It is identified that the maximum impact and ground movement for Section 2-2- is noted at the party wall between 3 Squires Mount and 17 East Heath Road where 5mm of settlement is accumulated mainly from the proposed mass concrete underpin workmanship.

The differential settlements which are expected to be imposed on the adjacent buildings are of the order of 5mm. Based on available information the width of the building is 5m, this differential movement corresponds to an angular distortion of 1/1000 which is within published limits for preventing excess cracking and damage to load bearing walls and

[18] Skempton, A. W. & Mac Donald, D. H. (1956). The Allowable settlement of buildings. Proceedings of the Institution of Civil Engineers, Part 3, No. 5, pp 727-784.
[19] Polshin, D. E. & Tokar, R. A. (1957). Maximum allowable non-uniform settlement of structures. Proc. 4th Int. Conf. SM&FE, Wiesbaden, No. 1, pp. 285.

partitions[20,21]. The maximum deflection caused by the settlements is 1mm, which for a width of 5m corresponds to a deflection ratio of 0.06%.

For the purpose of this assessment, the horizontal strain deflection of the underpins has been limited to a conservative value of 3mm to restrict the damages within the allowable 'Category 1' (very slight damage).

8.3 Summary of Results

Table 9 incorporates superimposed vertical movements derived from both the underpin wall construction (i.e. workmanship), short term heave due to excavation and heave/settlement over the long term due reapplication of structural slab and vertical wall and column loads. The method of deriving these values and establishing an appropriate deflection ratio for the neighbouring structures is illustrated graphically in Figures 8 and 9. The width of the adjacent structures has been assumed from available development plans.

Table 9: Summary of ground movements and corresponding damage category

Boundary-Party Wall Reference	Maximum deflection (mm)	Horizontal Strain ε_h (%)	Deflection ratio Δ/L^b (%)	Damage category
Section 1-1: 16 East Heath Road	2	0.043	0.028	Category 1 – Very slight
Section 2-2: 3 Squires Mount	1	0.06	0.02	Category 1 – Very slight

a. See Figure 2.18 (a) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (L = length of adjacent structure in metres, perpendicular to basement; Δ = relative deflection)

b. See Box 2.5 (v) CIRIA C580 (2003) Embedded retaining walls guidance for economic design.

Based on the above, the maximum damage category imposed on the neighbouring party wall properties due to the proposed development can be controlled to within 'Category 1' corresponding to very slight damage. The building interaction chart for the adjacent party wall structures and neighbouring foundations is presented in Figure 10.

[20] Skempton, A. W. & Mac Donald, D. H. (1956). The Allowable settlement of buildings. Proceedings of the Institution of Civil Engineers, Part 3, No. 5, pp 727-784.

[21] Polshin, D. E. & Tokar, R. A. (1957). Maximum allowable non-uniform settlement of structures. Proc. 4th Int. Conf. SM&FE, Wiesbaden, No. 1, pp. 285.

9. MONITORING STRATEGY

9.1 Party wall structures

The results of the ground movement analysis suggest that with good construction control, damage to adjacent structures generated by the assumed construction methods and sequence are likely to be within Category 1 ('very slight'). To ensure movements do not start to fall outside of those predicted, it is recommended that a formal monitoring strategy is implemented on site in order to observe and control ground movements during construction.

The monitoring system should operate broadly in accordance with the 'Observational Method' as defined in CIRIA Report 185[22]. Monitoring can be undertaken by using positional surveys compared to baseline values established before any excavation work is undertaken onsite. Regular monitoring of these positions will determine if any horizontal translation, tilt or differential settlement of the neighbouring structure is occurring as the construction progresses. Monitoring data should be checked against predefined trigger limits and can also be further analysed to assess and manage the damage category of the adjacent buildings as construction progresses.

The horizontal deflection/translation of the underpins during construction (including any potential horizontal movements caused by the installation of the L-shaped cast section to the south boundary of the site) should be limited to less than 3mm. This limiting horizontal movement of the underpinned sections will control the damage category for the adjacent critical property to within Category 1 'very slight'. These values should form the basis of the 'traffic light' trigger levels established prior to underpinning and piling works commencing onsite. 'Trigger levels' should be discussed and agreed with the party wall surveyor.

[22] Nicholson, D., Tse, Che-Ming., Penny, C. (1999) . *The Observational Method in ground engineering: principles and applications*. CIRIA report R185.

10. CONCLUSIONS

- The proposed development at 17 East Heath Road comprises the refurbishment of a residential building with a lower ground floor level. The excavation is proposed to be enabled with the installation of reinforced concrete and mass concrete underpin walls beneath the boundary and party walls respectively.

- The construction of the lower ground floor will generate ground movements due to a variety of causes including elastic rebound due to ground excavation and vertical ground movements due to underpinning.

- An assessment of the results of the detailed ground movement analysis and displacement profiles indicate that these movements are likely to give rise to a maximum damage level within Category 1 (very slight damage) for the adjacent buildings of 3 Squares Mount and 16 East Heath Road. The rest of the neighbouring structures are expected to be within Category 0 (negligible damage).

- Settlement of the underpin foundations is very much dependent on the strength and stiffness of the soils beneath the foundation. Foundation levels should be inspected to confirm that they are consistent with a 'medium dense' Bagshot formation profile and the applied bearing pressures within the allowable bearing capacity.

- The maximum angular distortion predicted for the neighbouring properties is also within published limits to prevent excess cracking of load bearing structures.

- It is considered that the proposed lower ground floor will not affect groundwater flow as the ground water table has been recorded below the formation level of the underpins.

- The surface water drainage and flow is likely to be impacted as there will a slight change in the relative proportions of hardstanding and soft landscaping.

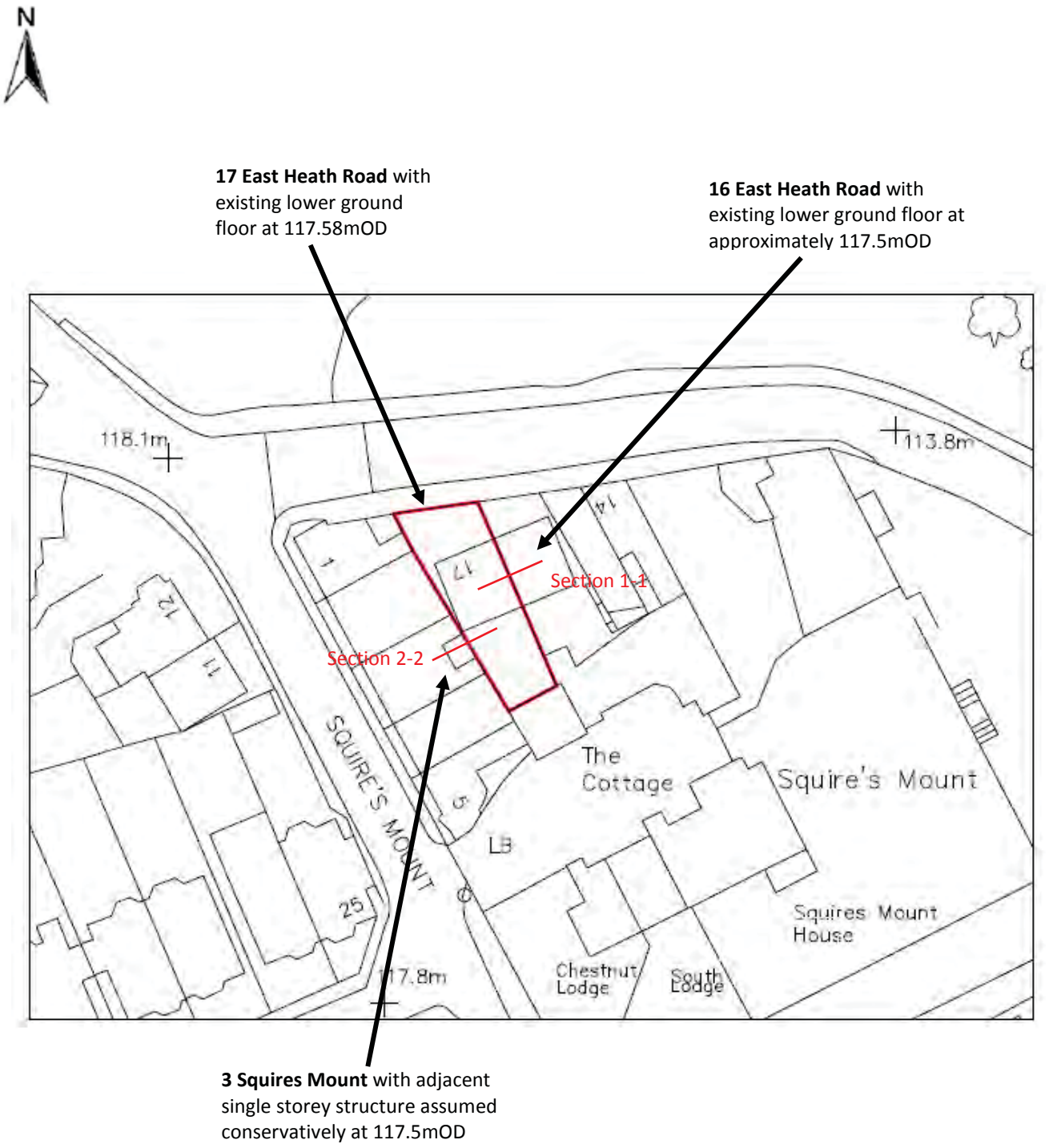
- Flow through permeable strata surrounding the basement is also considered unlikely to be impacted.

- It is recommended that an appropriate monitoring regime is adopted to manage risk and potential damage to the neighbouring properties and any existing buried services.

FIGURES

Site location

Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
CGL	Title: **Site location plan**	**Figure 1**



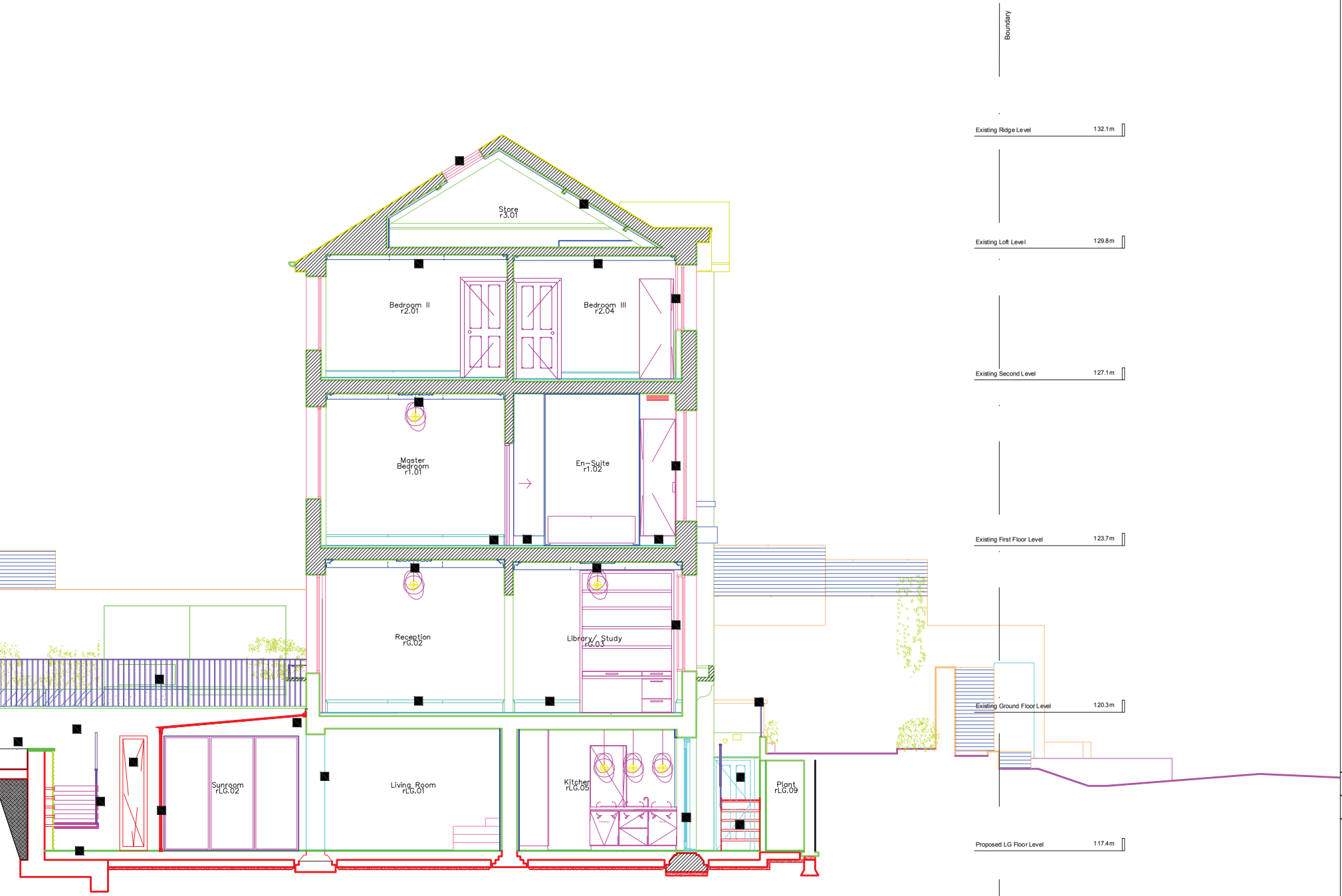
Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
CGL	Title: **Conceptual Site Model**	**Figure 2**

Rev	Date	Comment
2	04/11/16	

Project
17 East Hea

Client
Mr and Mrs

Drawing title
Figure 3a - Ty section (Sout

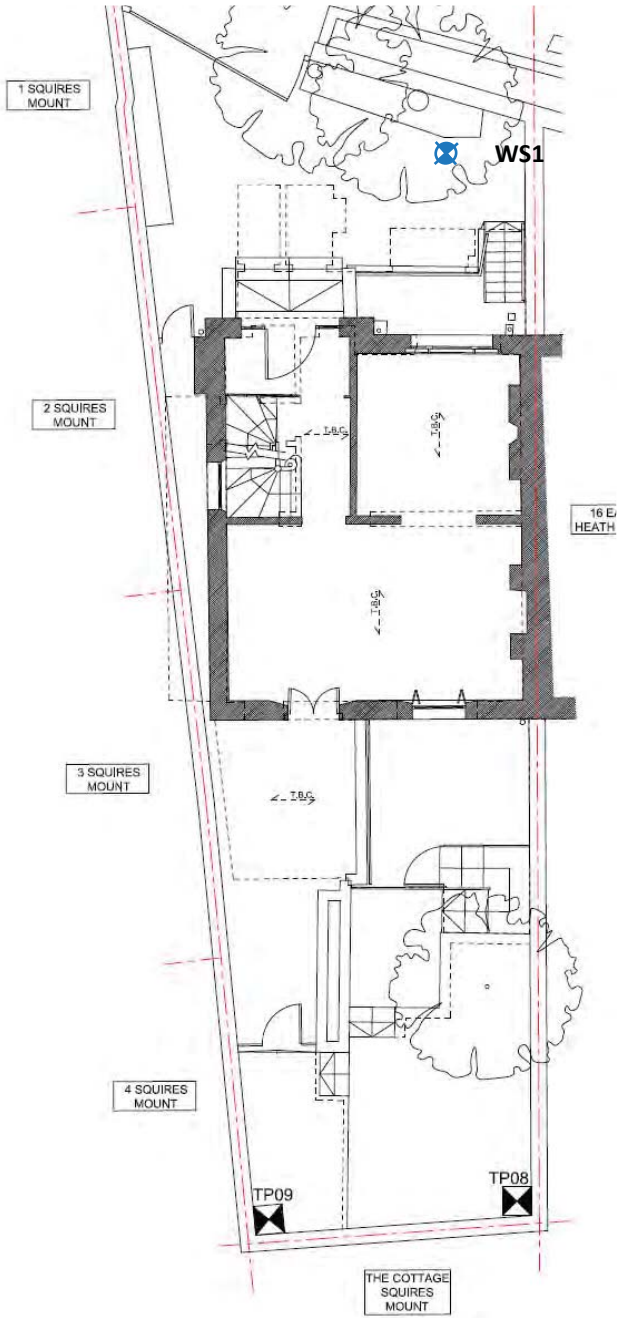


Rev	Date	Comment
2	04/11/16	

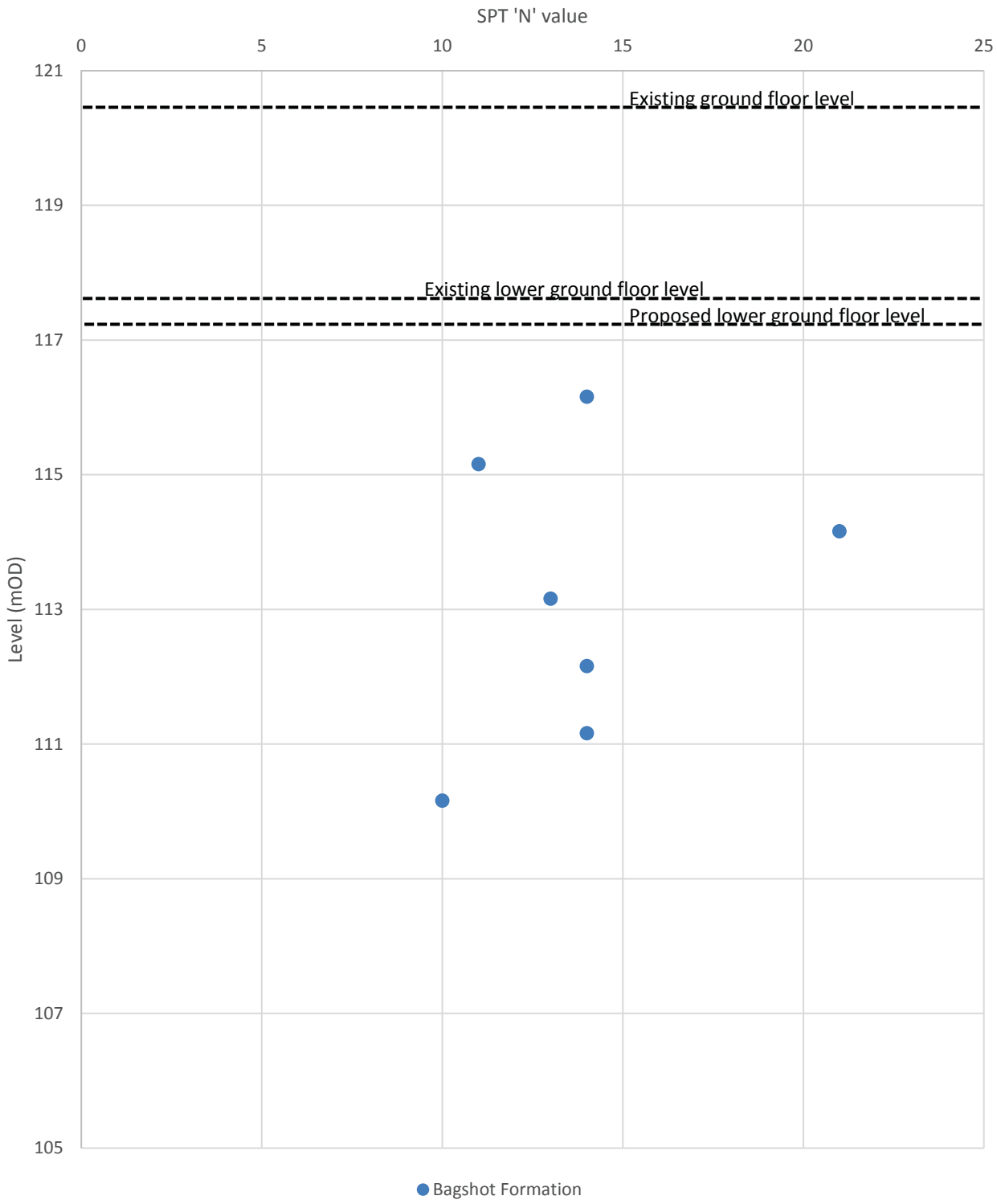
Project **17 East Hea**

Client **Mr and Mrs**

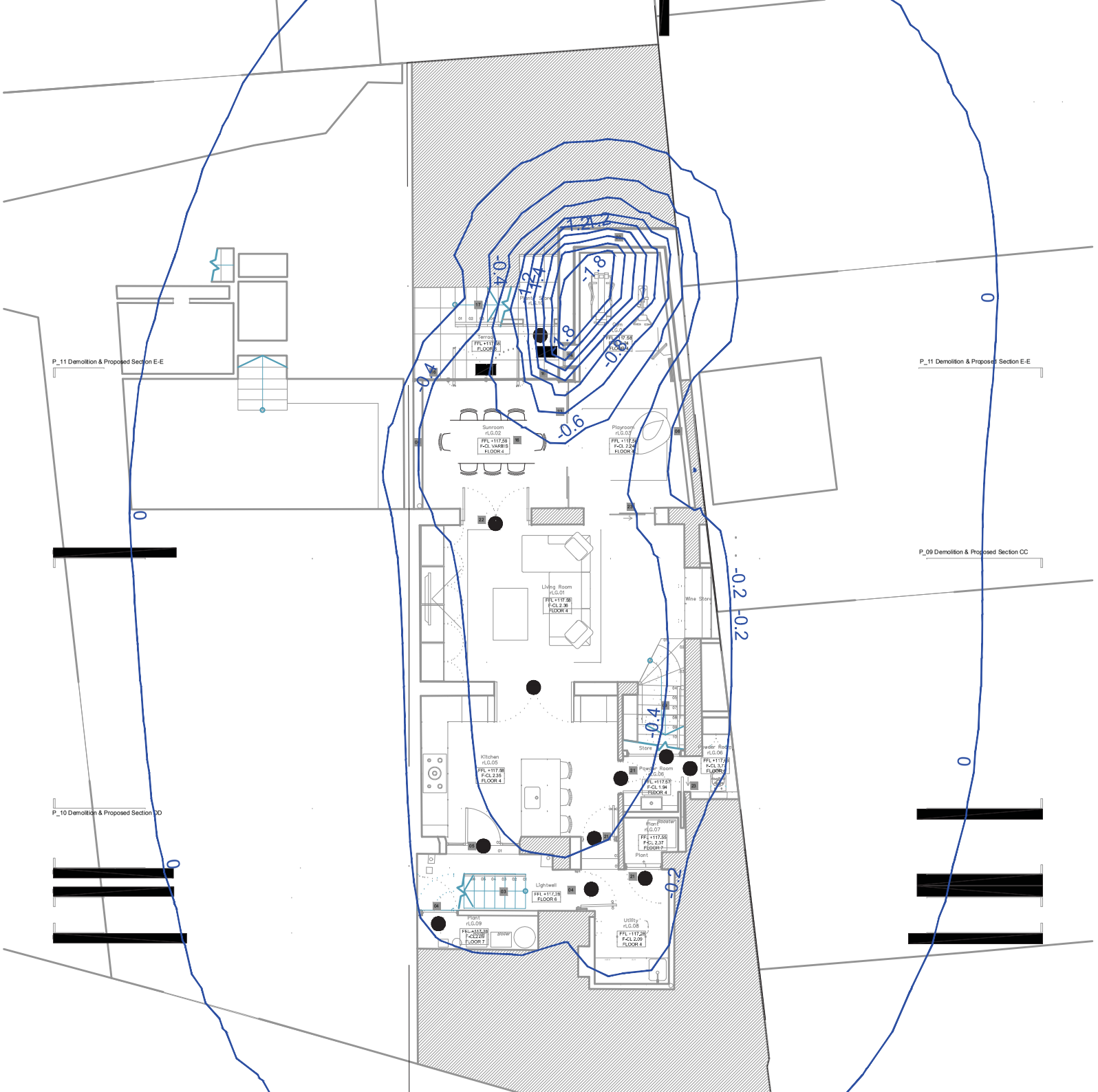
Drawing title **Figure 3b - Ty section (Sout**



Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
CGL	Title **Exploratory hole location plan**	**Figure 4**



Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
CGL	Title **SPT 'N' value versus level**	**Figure 5**



Notes

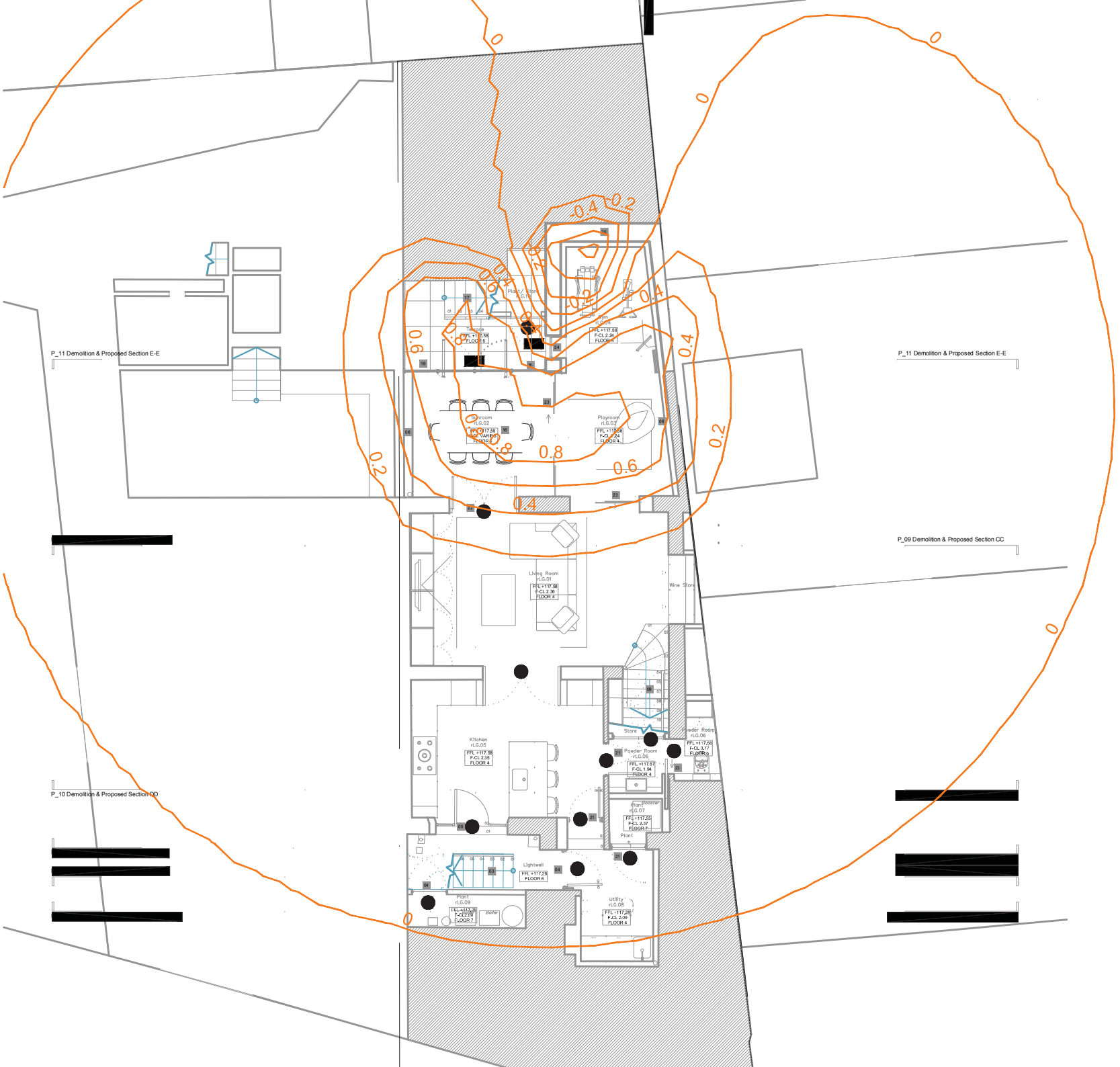
1. Contour values are in
2. Positive values indicat
values indicate heave.
3. Contour intervals are

Rev	Date	Comment
0	30/09/16	

Project **17 East Hea**

Client **Mr and Mrs**

Drawing title **Figure 6 - Sh plots**



Notes

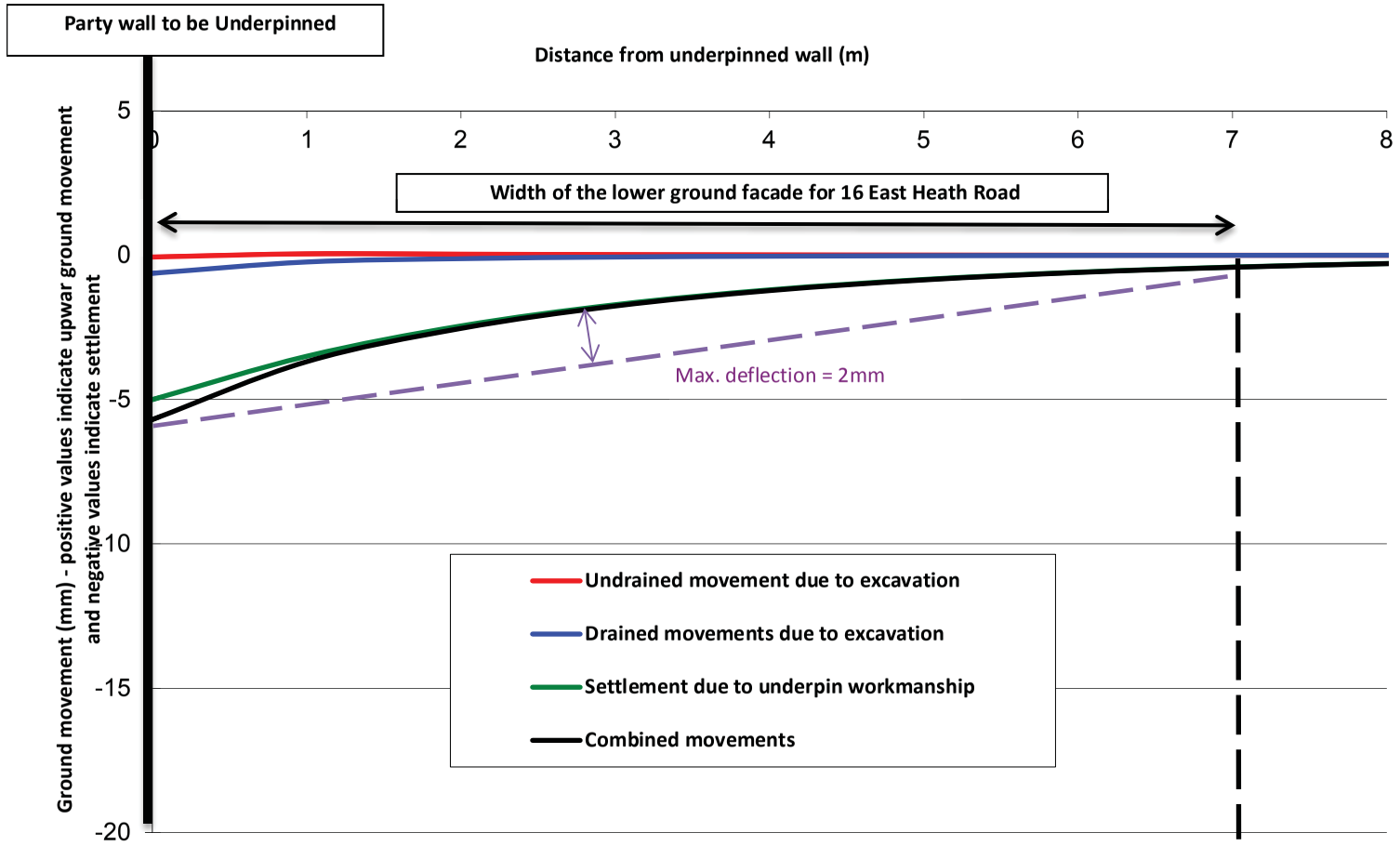
1. Contour values are in
2. Positive values indicat
values indicate heave.
3. Contour intervals are

Rev	Date	Comment
0	30/09/16	

Project **17 East Hea**

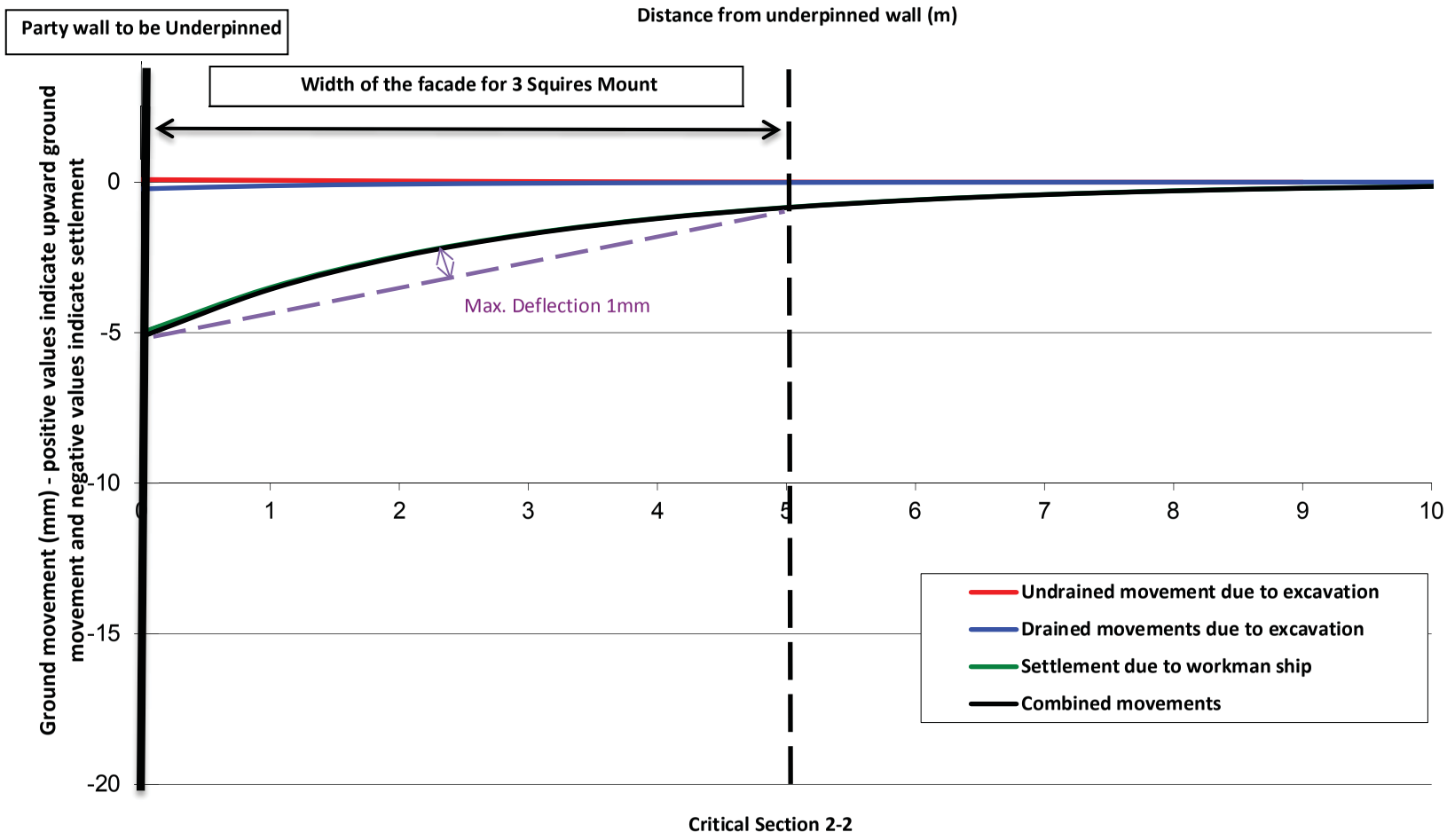
Client **Mr and Mrs**

Drawing title **Figure 7 - Lo plots**

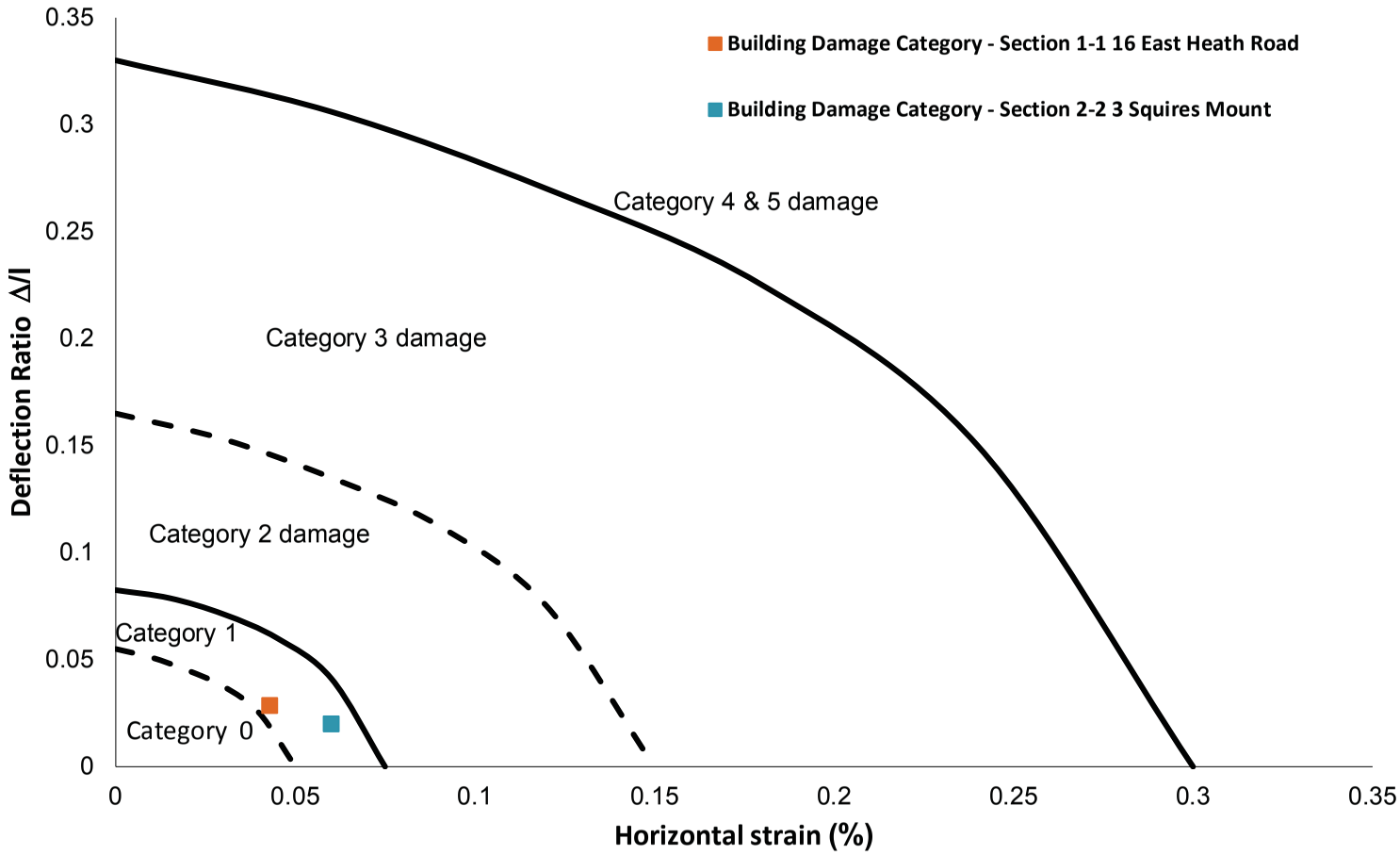


Critical Section 1-1

Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
	Title	
CGL	**Combined vertical movement profile – Section 1-1**	**Figure 8**



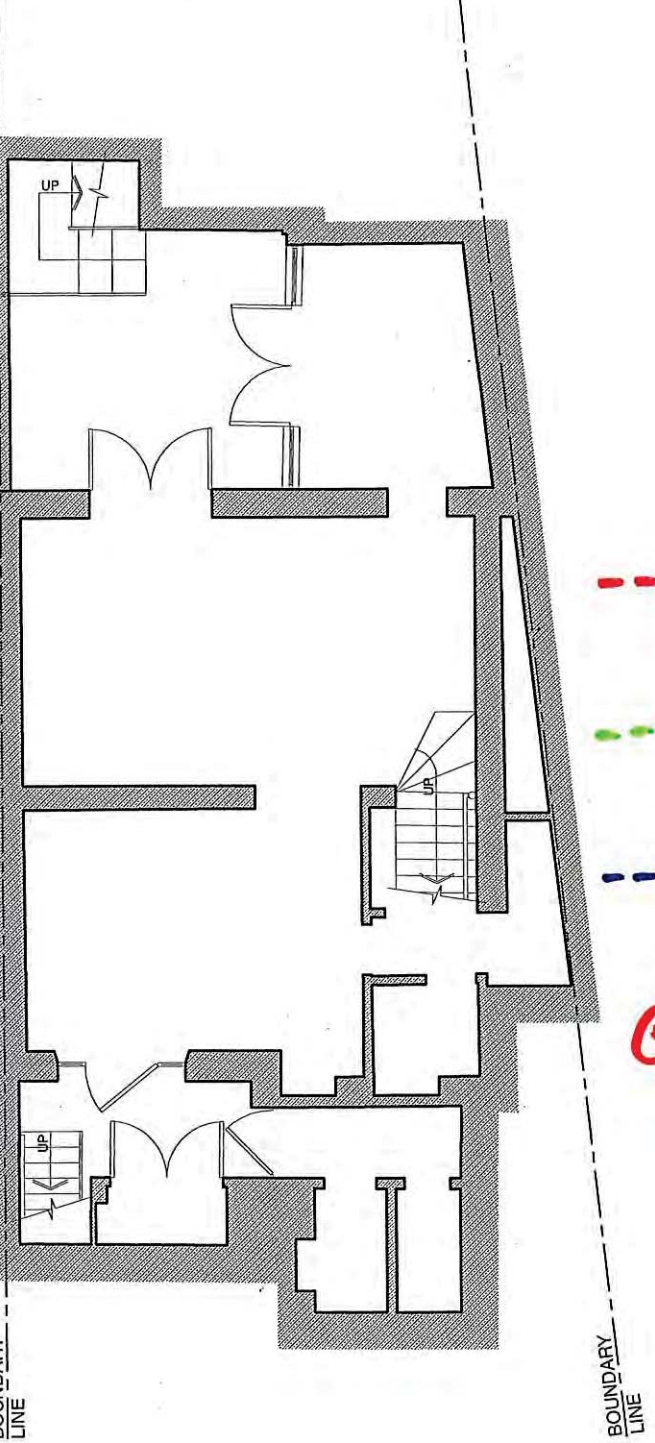
Client	Project	Job No
Mr and Mrs A Saleh	17 East Heath Road, London	CG/18910
CGL	Title: Combined vertical movement profile – Section 2-2	Figure 9



Client	Project	Job No
Mr and Mrs A Saleh	**17 East Heath Road, London**	**CG/18910**
CGL	Title: **Structure interaction chart**	**Figure 10**

APPENDIX A

Development drawings

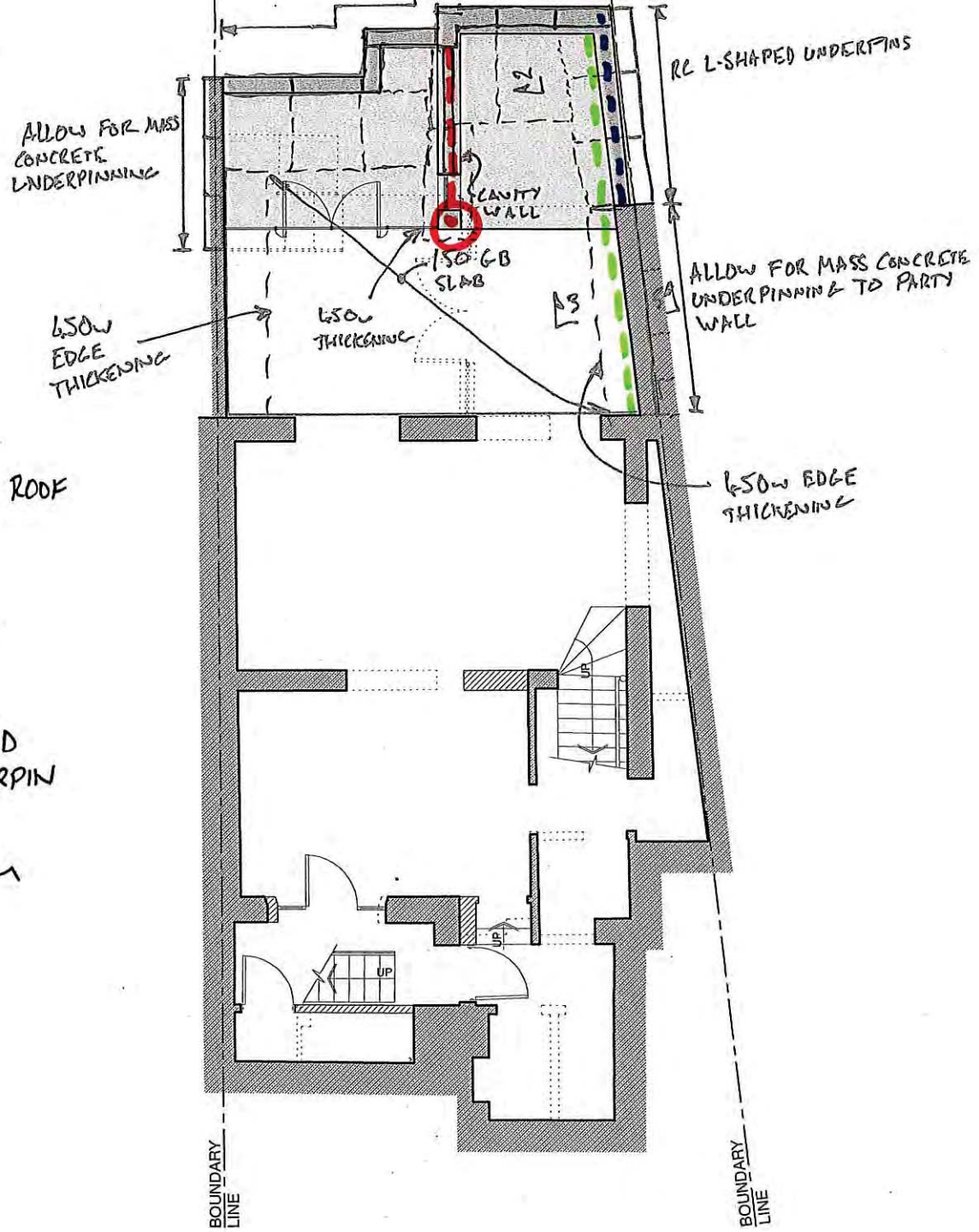


NEW EXT WALL + ROOF SLAB
20kN/m

INTERNAL WALL + ROOF SLAB
15kN/m

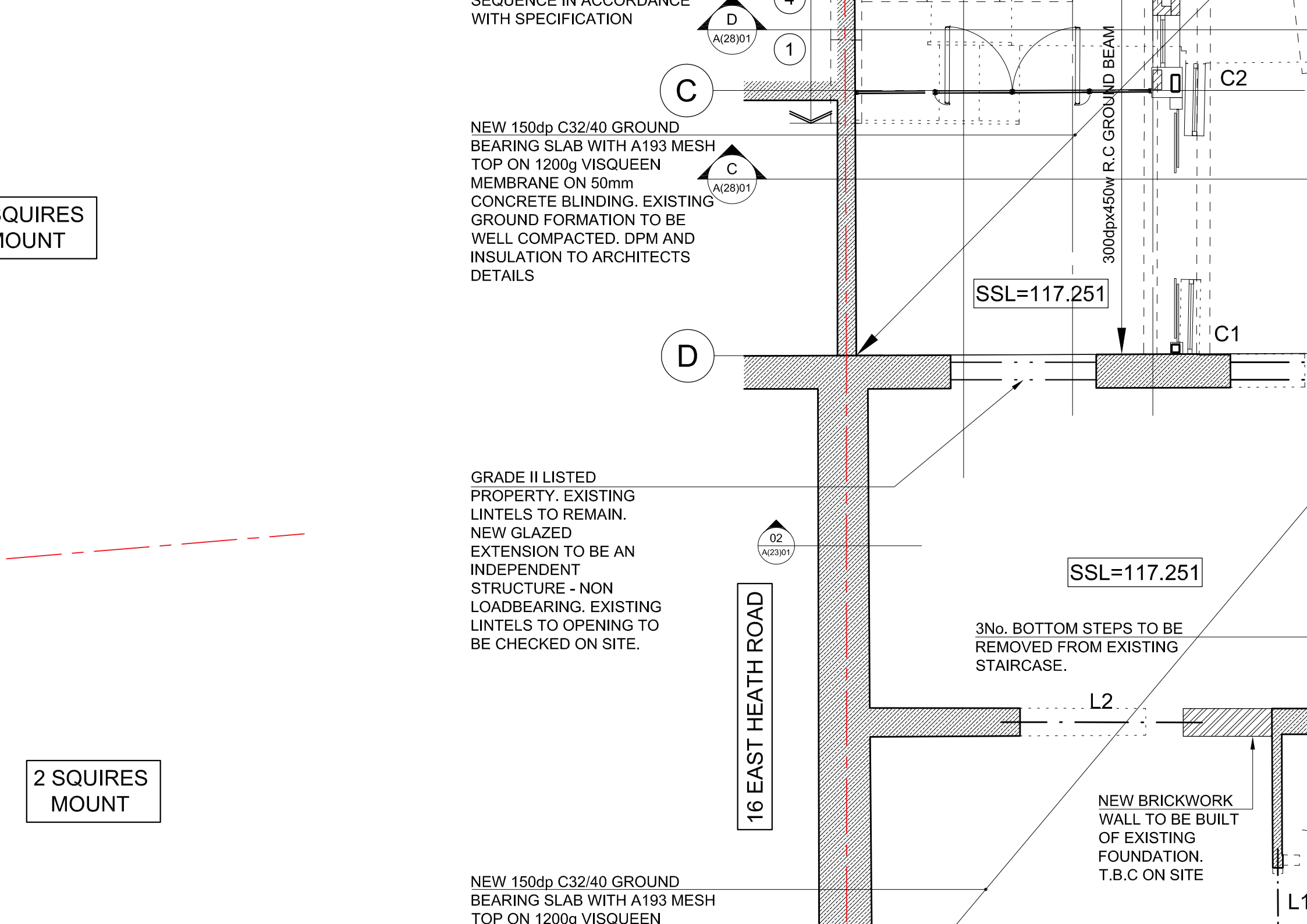
PARTY WALL LOAD TO TOP OF UNDERPIN
16kN/m

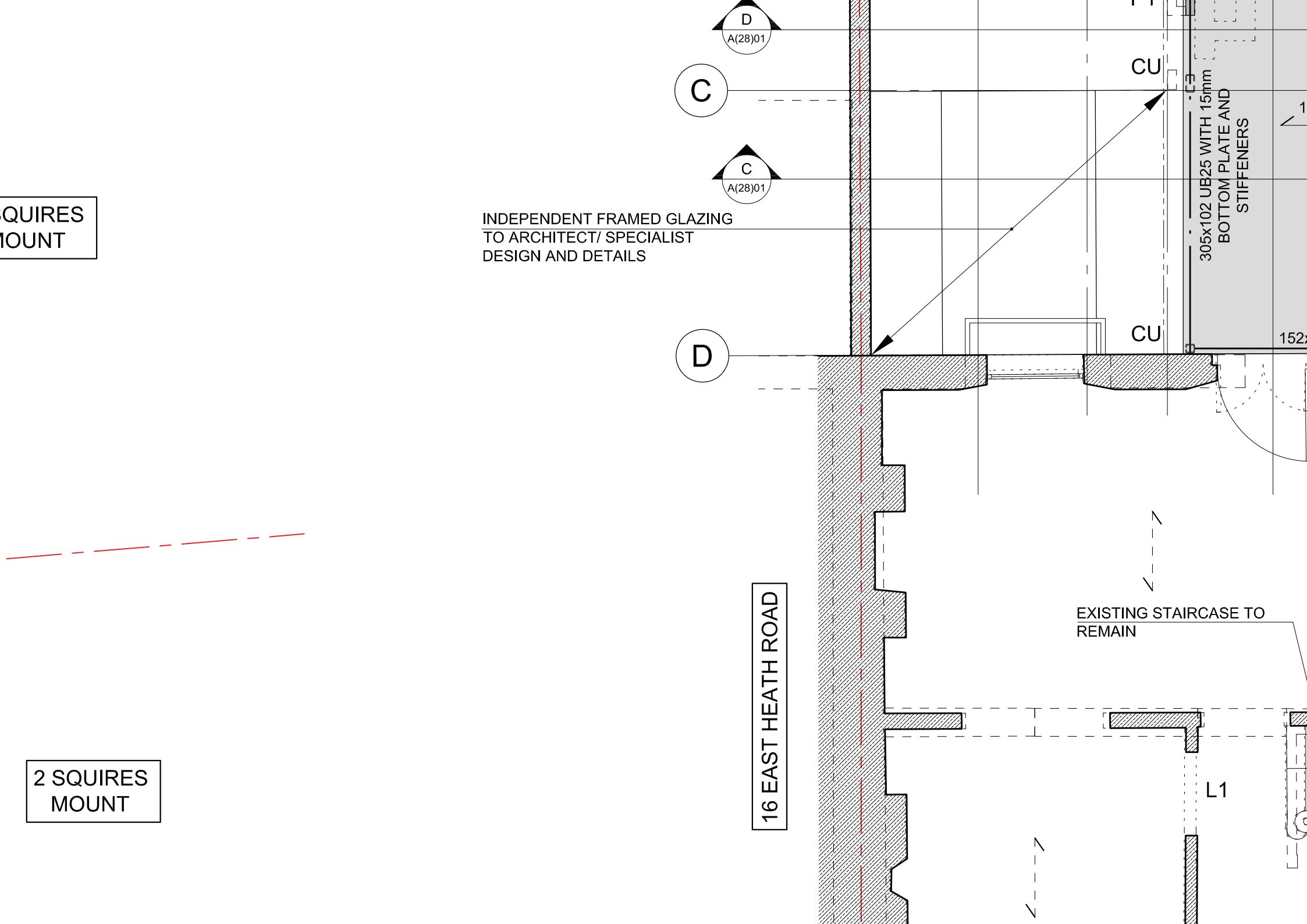
POINT LOAD FROM ROOF SLAB
15kN

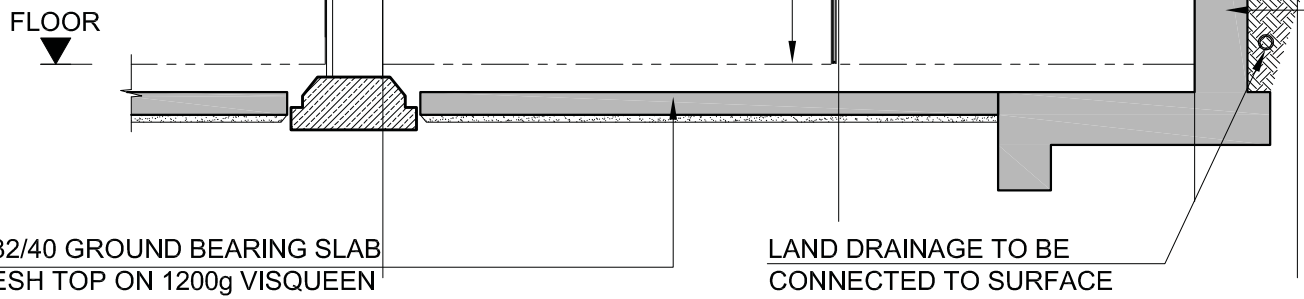


EXISTING LOWER GROUND FLOOR PLAN

PROPOSED LOWER GROUND FLOOR PLAN


SEQUENCE IN ACCORDANCE WITH SPECIFICATION
D
A(28)01
4
1
C
C2
NEW 150dp C32/40 GROUND BEARING SLAB WITH A193 MESH TOP ON 1200g VISQUEEN MEMBRANE ON 50mm CONCRETE BLINDING. EXISTING GROUND FORMATION TO BE WELL COMPACTED. DPM AND INSULATION TO ARCHITECTS DETAILS
C
A(28)01
300dpx450w R.C GROUND BEAM
SSL=117.251
C1
D
GRADE II LISTED PROPERTY. EXISTING LINTELS TO REMAIN. NEW GLAZED EXTENSION TO BE AN INDEPENDENT STRUCTURE - NON LOADBEARING. EXISTING LINTELS TO OPENING TO BE CHECKED ON SITE.
02
A(23)01
SSL=117.251
3No. BOTTOM STEPS TO BE REMOVED FROM EXISTING STAIRCASE.
L2
16 EAST HEATH ROAD
NEW BRICKWORK WALL TO BE BUILT OF EXISTING FOUNDATION. T.B.C ON SITE
NEW 150dp C32/40 GROUND BEARING SLAB WITH A193 MESH TOP ON 1200g VISQUEEN
L1
QUIRES
MOUNT
2 SQUIRES MOUNT


SQUIRES
MOUNT
2 SQUIRES
MOUNT
16 EAST HEATH ROAD
D
A(28)01
C
A(28)01
C
D
INDEPENDENT FRAMED GLAZING
TO ARCHITECT/ SPECIALIST
DESIGN AND DETAILS
CU
CU
305x102 UB25 WITH 15mm
BOTTOM PLATE AND
STIFFENERS
EXISTING STAIRCASE TO
REMAIN
L1

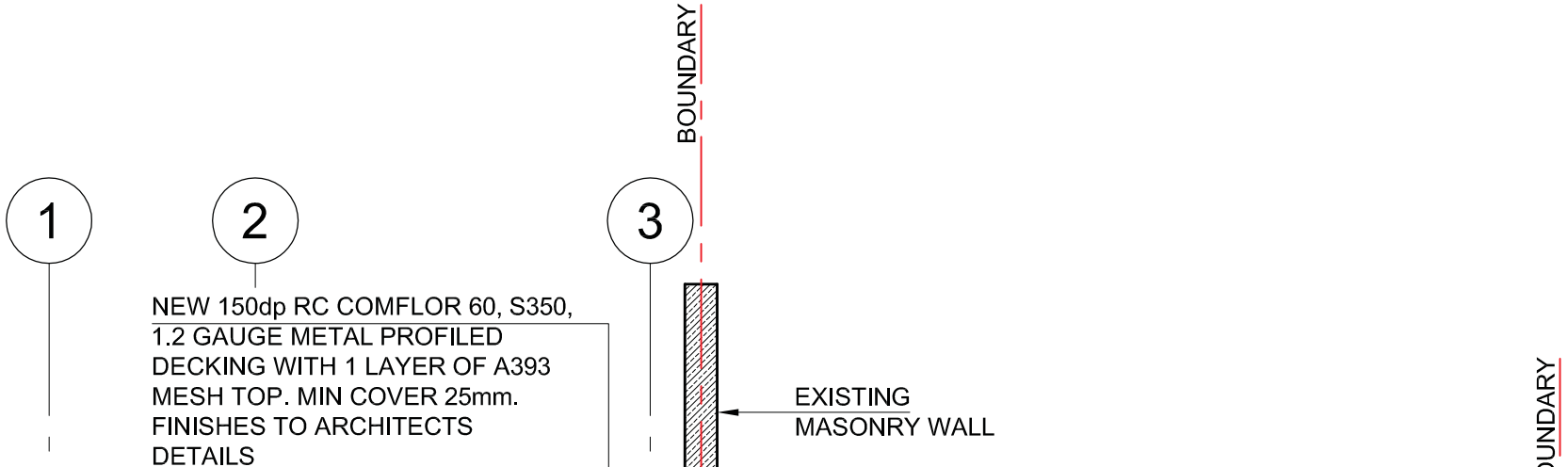


NEW 150dp C32/40 GROUND BEARING SLAB WITH A193 MESH TOP ON 1200g VISQUEEN MEMBRANE ON 50mm CONCRETE BLINDING. EXISTING GROUND FORMATION TO BE WELL COMPACTED. DPM AND INSULATION TO ARCHITECTS DETAILS

LAND DRAINAGE TO BE CONNECTED TO SURFACE WATER SYSTEM

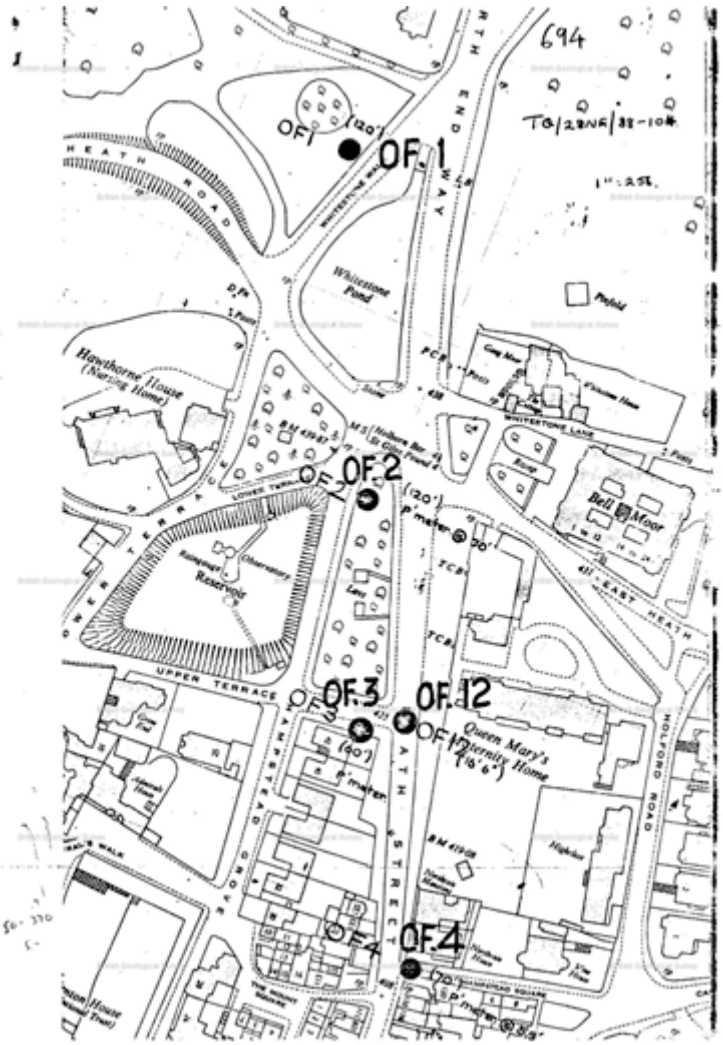
CROSS SECTION B-B

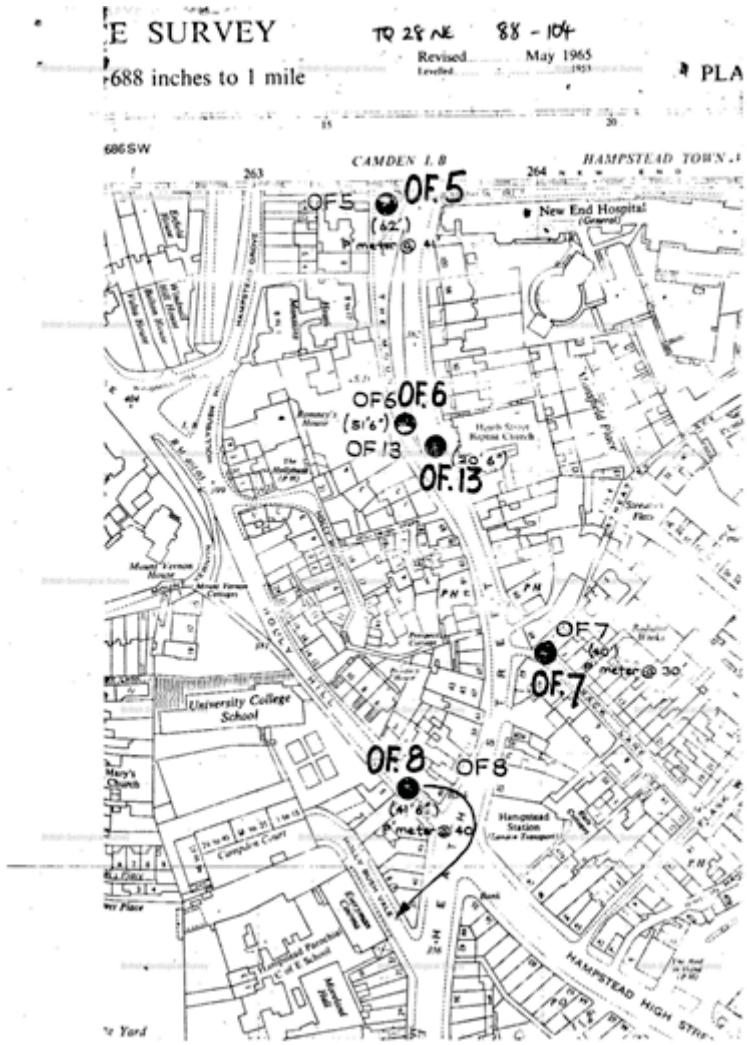
SCALE 1:50 @A1 1:100@A3



APPENDIX B

BGS Borehole logs


694
TQ/28NE/32-104
OF.1
OF.2
OF.3
OF.12
OF.4
Whitestone Pond
Hawthorne House (Nursing Home)
Bell Moor
Queen Mary's Maternity Home
Ramsgate Reservoir
Observatory
HEATH ROAD
UPPER TERRACE
EAST HEATH
HOLFORD ROAD
WHITESTONE LANE
HEATH STREET
HAMPSTEAD


E SURVEY
TQ 28 NE 88 - 104
Revised May 1965
688 inches to 1 mile
PLA
686SW
CAMDEN L.B
HAMPSTEAD TOWN
263
264
OF 5
OF.5
(62')
meter @ 41
New End Hospital
(General)
OF 6
OF.6
(51'6")
OF 13
(20'6")
OF.13
OF 7
(40')
meter @ 30'
OF.7
University College School
OF.8
OF 8
(41'6")
meter @ 40
Hampstead Station
HAMPSTEAD HIGH STRE
Yard

TQ/28NR/96
Q660. 8618 OF9

RECORD OF BOREHOLE No: OE9

SQUIRES MOUNT,
:HAMPSTEAD HEATH
... No. : 481
... : Shell, Auger
... : 21-5-'65

Borehole Dia : 6"
Casing : 6" to 30'0
Ground Level : 385·50'

Water Level	Samples Depth	Type	No.	Strata Legend	Strata Depth	Thickness	Description of Strata
						3'0	MADE GROUND (loose dark brown gravelly sand + some clay)
	2'6	D	1		3'0		
	5'0 (N=31)	D	2			6'0	Compact sandy GRAVEL brown poorly sorted sand (up to 1/8" fragments + some clay.
	7'6	D	3				
					9'0		
	10'0	U	4				
	12'6	D	5			8'6	Compact light brown fine silty SAND
	15'0	U	6				
	17'6	D	7		17'6		
	20'0	D	8				extremely wet and running compact light brown fine silty SAND
	22'6	D	9			10'6	
	25'0 (N=6)	D	10				
	27'6	D	11		28'0		
	30'0	U	12				Mixture orange/grey stiff CLAY and fine sand.
	32'6	D	13				
	35'0	U	14			12'0	
... 40'0 Dry	37'6	D	15				
	40'0	U	16		40'0		

Borehole dry.
U4 Failed at 20'0 (17 blows) very loose wet sand.
Piezometer installed at 23'0

Foundation Engineering Ltd.

ALBURY S.I. LTD
Petworth Road, Witley, Godalming, Surrey GU8 5LH

Borehole No. 1

CONTRACT	East Heath Road, Hampstead	Report No	06/7650/SJC
Client	Asphaltic Freehold Properties Limited	Ground Level	mOD
Site Address	East Heath Road, Hampstead, London, NW3	Boring Commenced Boring Completed	21/03/06 21/03/06

Type and Diameter of Boring: Light cable percussion (shell and auger)

Water Strikes, m		Water Levels Recorded During Boring, m						
1	6.90 (seepage)	Date	21/03	21/03				
2	13.90 (fast)	Hole Depth	13.90	15.00				
3		Casing Depth	10.50	None				
4		Water Level	13.00	10.90				

Remarks

Excavations of starter pit to clear services

Samples of Tests		SPT			
Type	Depth, m	N	Depth	Legend	Strata Description
D	0.30		0.30		Made ground (tarmacadam/gravel)
B	0.50				Made ground (grey/brown sand with gravel)
B	1.00-1.50	5	1.30		Made ground (brown/grey clayey sand with gravel)
D	1.75		1.75		Made ground (grey clayey sand with gravel)
B	2.00-2.50	3			
D	2.75		2.70		Brown/grey sand with gravel (possible fill)
B	3.00-3.50	7			
D	4.00		4.00		Medium dense brown slightly clayey sand
D	4.50-5.00	14			
D	5.50				
D	6.00-6.50	14			
D	7.00		6.90		Medium dense brown clayey sand with seams of clay
D	7.50-8.00	20			
D	8.50				

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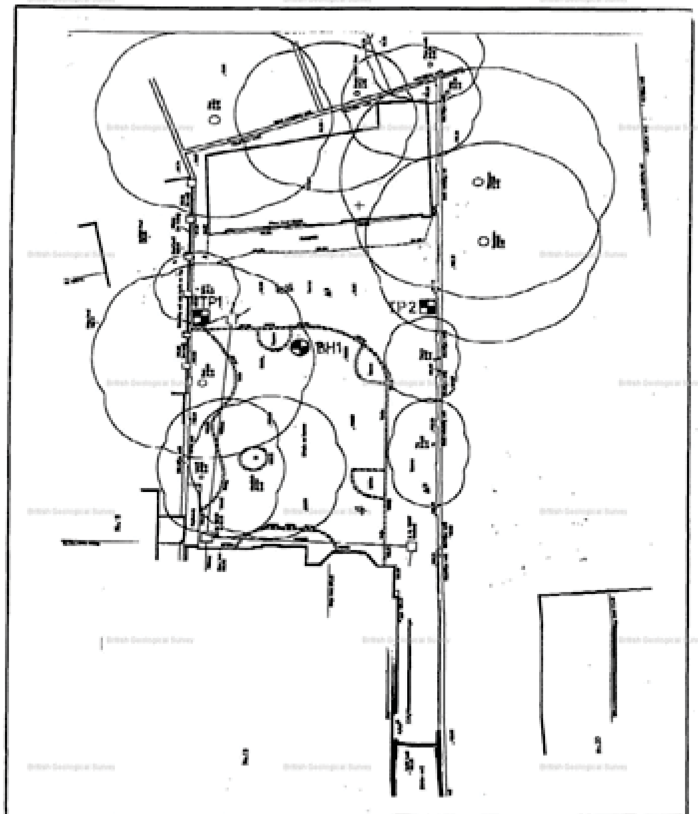
Petworth Road, Witley, Godalming, Surrey GU8 5LH
Continuation Sheet no 1

Borehole No 1

CONTRACT East Heath Road, Hampstead, NW3

REPORT No 06/7650/KJC

Samples or Tests Type	Samples or Tests Depth, m	SPT N	Depth	Legend	Strata Description
U	9.00-9.50		9.00		Stiff brown very sandy clay with seams of sand
D	9.50				
D	10.00		10.00		Medium dense to dense brown clayey sand
D	10.50-11.00	28			
D	11.50				
D	12.00-12.50	27			
D	13.00				
D	13.50-14.00	33			
D	14.25				
D	14.50-15.00	35			
			15.00		



ALBURY S.I. LTD

EAST HEATH DRIVE, HAMPSTEAD	N.T.S.
	06/7650/2

ALBURY S.I. LTD			Trialpit no 2
Contract	East Heath Road, Hampstead		**Report No** 06/7650/KJC
Client	Asphaltic Freehold Properties Limited		**Date** 23.03.06
Site Address	East Heath Road, Hampstead, London, NW3		Ground Level mOD
Type of Excavator	manual	Water level after completion, m	none
Water Strikes, m	Pit Dimensions, m	Ease of Excavation, m	
1 none 2	Length 1.00 Breadth 0.50	Very easy Moderate	Difficult GL – 1.10 Very hard

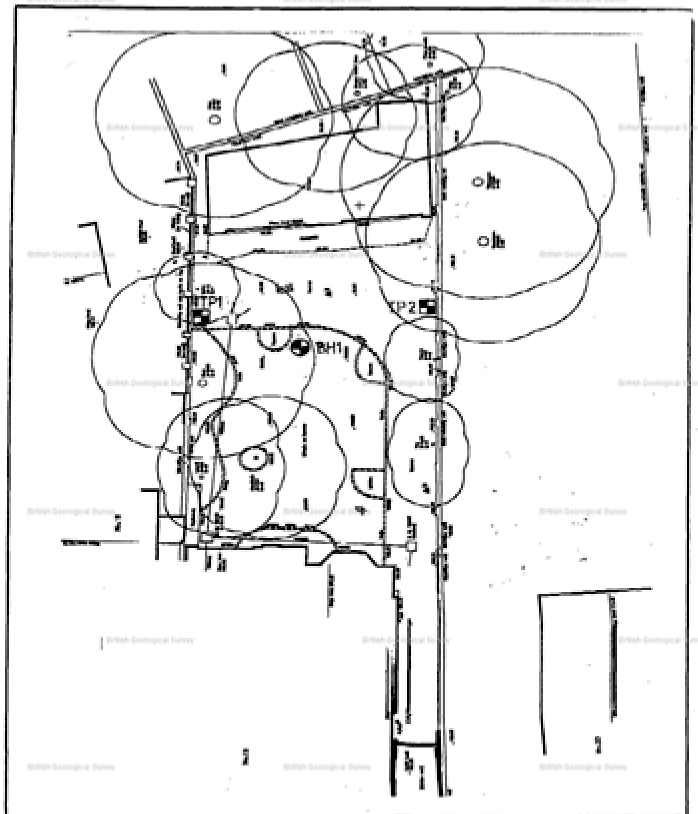
Remarks

Brickwork/concrete obstruction encountered

Sample Type	Depth, m	Cohesion kPa	Scale 40mm: 1m Depth	Legend	Description
D	0.20		0.20		Made ground(tarmacadam/concrete)
D	0.50				Made ground(dark brown sand with gravel, brick and roots)
D	1.00		1.10		

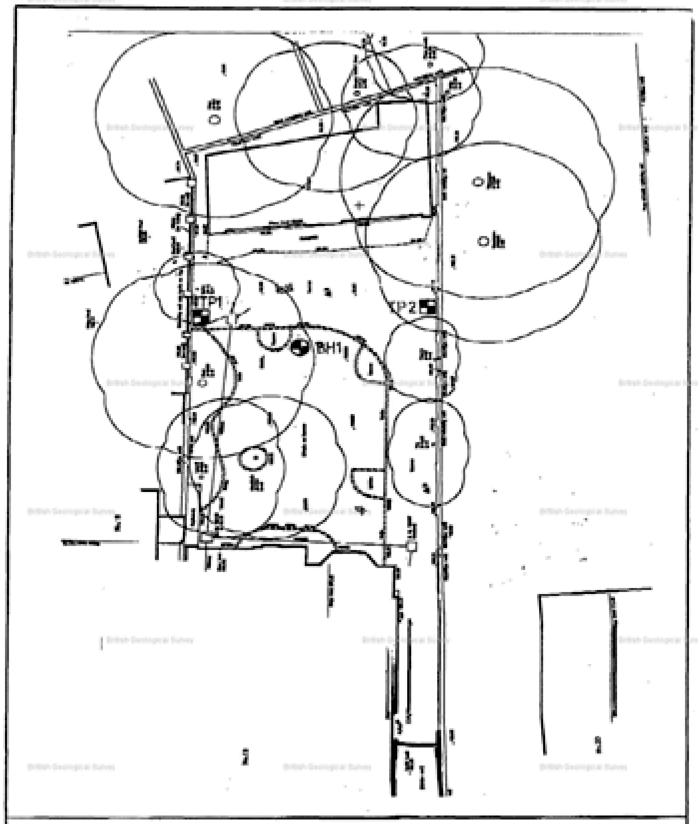
ALBURY S.I. LTD			Trialpit no	1
Contract	East Heath Road, Hampstead		Report No	06/7650/KJC
Client	Asphaltic Frocheld Properties Limited		Date	23.03.06
Site Address	East Heath Road, Hampstead, London, NW3		Ground Level	mOD
Type of Excavator	manual	Water level after completion, m	none	
Water Strikes, m	Pit Dimensions, m	Ease of Excavation, m		
1 none 2	Length 0.60 Breadth 0.50	Very easy Moderate	Difficult Very hard	GL – 1.00
Remarks				

Sample Type	Depth, m	Cohesion kPa	Scale 40mm: 1m Depth	Legend	Description
D	0.20		0.15		Made ground(tarmacadam/concrete)
			0.30		Made ground(dark brown clayey sand)
D	0.50				Made ground(light brown sand with gravel)
D	1.00		0.95		
			1.00		Yellow-brown sand



ALBURY S.I. LTD

EAST HEATH DRIVE, HAMPSTEAD	N.T.S.
	06/7650/2



ALBURY S.I. LTD

EAST HEATH DRIVE, HAMPSTEAD	N.T.S.
	06/7650/2

APPENDIX C

CGL Borehole record

BOREHOLE LOG

Project				BOREHOLE No
18910				WS1
Job No	Date	Ground Level (m)	Co-Ordinates (m)	
CG/18910	19-08-16 19-08-16	119.40	E 526,601.1 N 186,235.5	
Client				Sheet
Mr & Mrs A Saleh				1 of 1

SAMPLES & TESTS			Water	STRATA				Instrument /Backfill
Depth (m)	Type No	Test Result		Reduced Level	Legend	Depth (m) (Thick-ness)	DESCRIPTION	
				119.39		0.01	CERAMIC TILES.	
				119.26		0.14	CONCRETE.	
0.30-0.45	D			119.10		0.30	Coarse gravel of concrete, ceramic, brick and flint [MADE GROUND]	
0.50-0.70	D			118.95		0.45		
				118.65		0.75	Grey brown slightly silty gravelly fine to medium sand. Gravel is fine to coarse of flint brick and concrete. [MADE GROUND]	
1.00		N14					Yellow grey fine sand with occasional fine to medium subangular gravel of crushed red brick. [MADE GROUND]	
1.40-1.60	D						Medium dense yellow grey fine SAND with occasional orange brown bands up to 5mm thick. [BAGSHOT FORMATION]	
2.00		N11						
2.40-2.60	D					(3.70)		
3.00		N21						
3.40-3.60	D							
4.00		N13						
				114.95		4.45		
4.40-4.60	D					(0.45)	Yellow grey slightly clayey fine SAND. [BAGSHOT FORMATION]	
				114.50		4.90		
5.00		N14					Medium dense yellow grey fine SAND with occasional orange brown bands up to 5mm thick. [BAGSHOT FORMATION]	
5.40-5.60	D						4.90 - 5.00 Very dark orange brown bands up to 5mm thick.	
6.00		N14				(2.55)		
6.40-6.60	D						6.40 Becoming wet.	
							6.60 Borehole collapsed at 6.6m following SPT at 7.0m	
7.00		N10						
				111.95		7.45		
							(Borehole terminated at 7.45m)	

Boring Progress and Water Observations

Date	Comment	Strike Depth	Casing Depth	Casing Dia. mm	Standing Depth

General Remarks

1. Borehole terminated at 7.45mbgl.
2. No groundwater strikes recorded.
3. ES = Environmental sample, D = Disturbed sample, B = Bulk sample, U =Undisturbed sample.
4. Cored through surface from 0m to 0.14m.
5. Borehole collapsed at approx. 6.6mbgl following SPT at 7.0m.
6. Install details: 0m - 1m Bentonite, 35mm plain pipe; 1m - 7m gravel, 35mm slotted pipe.
7. Cased to 1mbgl.

Method/ Plant Used	Field Crew	Logged By	Checked By
Tracked window sample rig	RP Drilling	SMS	DRAFT

APPENDIX D

CGL monitoring records

GROUNDWATER MONITORING RECORD SHEET

JOB DETAILS			
Site:	17 East Heath Road	Job No:	CG/18910
Date:	15/09/2016	Engineer:	KJP
Time:	12:00	Client	Mr & Mrs A Saleh
Weather:	Sunny		

MONITORING & SAMPLING DETAILS								
Well / Borehole reference:	WS1							
Monitoring details								
Ground elevation (+mOD)	117.2							
Groundwater depth (mbgl)	6.58							
Groundwater elevation (+mOD)	110.62							
Depth to base of well (mbgl)	6.75							
Diameter of well (m)	0.0035							
Condition of well	GOOD							
Top of response zone (mbgl)	1.00							
Base of response zone (mbgl)	7.00							
Free product thickness (m)	N/A							
Hydrocarbon sheen noted (Y/N)	N/A							
Purging details								
Purge method	N/A							
Purged volume (litres)	N/A							
Recharge (good / poor)	N/A							
Sampling details								
Sampling method	N/A							
Volume of water sample taken (litres)	N/A							
Volume of free product sample taken (litres)	N/A							
Colour / odours noted*	N/A							
In-situ measurements								
pH	N/A							
Temperature (^{o}C)	N/A							
Dissolved oxygen (mg/l)	N/A							
Redox potential (mV)	N/A							
Electrical conductivity (µS/cm)	N/A							
Total dissolved solids (ppt)	N/A							

* Respiratory protective equipment to be worn if odours are noted during initial monitoring & on sites which are potentially contaminated

NOTES

GROUNDWATER MONITORING RECORD SHEET

JOB DETAILS			
Site:	17 East Heath Road	Job No:	CG/18910
Date:	22/09/2016	Engineer:	KJP
Time:	12:00	Client	Mr & Mrs A Saleh
Weather:	Sunny		

MONITORING & SAMPLING DETAILS								
Well / Borehole reference:	WS1							
Monitoring details								
Ground elevation (+mOD)	117.2							
Groundwater depth (mbgl)	6.6							
Groundwater elevation (+mOD)	110.6							
Depth to base of well (mbgl)	6.65							
Diameter of well (m)	0.0035							
Condition of well	GOOD							
Top of response zone (mbgl)	1.00							
Base of response zone (mbgl)	7.00							
Free product thickness (m)	N/A							
Hydrocarbon sheen noted (Y/N)	N/A							
Purging details								
Purge method	N/A							
Purged volume (litres)	N/A							
Recharge (good / poor)	N/A							
Sampling details								
Sampling method	N/A							
Volume of water sample taken (litres)	N/A							
Volume of free product sample taken (litres)	N/A							
Colour / odours noted*	N/A							
In-situ measurements								
pH	N/A							
Temperature (^{o}C)	N/A							
Dissolved oxygen (mg/l)	N/A							
Redox potential (mV)	N/A							
Electrical conductivity (µS/cm)	N/A							
Total dissolved solids (ppt)	N/A							

* Respiratory protective equipment to be worn if odours are noted during initial monitoring & on sites which are potentially contaminated

NOTES

APPENDIX E

Geotechnical laboratory results

4041
Kirsty Poore
Card Geotechnics Ltd
4 Godalming Business Centre
Woolsack Way
Godalming
Surrey
GU7 1XW

t: 01483 310600
f: 01483 527285
e: kirstyP@cgl-uk.com

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 16-26169

Project / Site name:	17 East Heath Road	**Samples received on:**	24/08/2016
Your job number:	CG18910	**Samples instructed on:**	24/08/2016
Your order number:		**Analysis completed by:**	01/09/2016
Report Issue Number:	1	**Report issued on:**	01/09/2016
Samples Analysed:	3 soil samples		

Signed: [redacted]

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

Signed: [redacted]

Emma Winter
Assistant Reporting Manager
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

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

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

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 16-26169

Project / Site name: 17 East Heath Road

Lab Sample Number				620615	620616	620617		
Sample Reference				WS1	WS1	WS1		
Sample Number				1	4	6		
Depth (m)				0.30-0.45	2.40-2.60	4.40-4.60		
Date Sampled				19/08/2016	19/08/2016	19/08/2016		
Time Taken				None Supplied	None Supplied	None Supplied		
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1		
Moisture Content	%	N/A	NONE	12	8.3	9.6		
Total mass of sample received	kg	0.001	NONE	0.64	0.43	0.47		
General Inorganics								
pH - Automated	pH Units	N/A	MCERTS	10.2	8.0	8.6		
Water Soluble Sulphate (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.094	0.0056	0.014		

Analytical Report Number : 16-26169

Project / Site name: 17 East Heath Road

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

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

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
620615	WS1	1	0.30-0.45	Brown clay and sand.
620616	WS1	4	2.40-2.60	Light brown sandy clay.
620617	WS1	6	4.40-4.60	Light brown sandy clay.

Analytical Report Number : 16-26169

Project / Site name: 17 East Heath Road

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

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests, 2:1 water:soil extraction, analysis by ICP-OES.	L038-PL	D	MCERTS

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

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	WC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
WS1		1.40-1.60	D	Brown silty SAND.	4.6		NP		99									Particle Size Distribution
WS1		3.40-3.60	D	Brown silty SAND.	6.9		NP		100									Particle Size Distribution
WS1		5.40-5.60	D	Yellowish brown silty SAND.	10.2		NP		100									Particle Size Distribution

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

NP=Non Plastic

Checked and Approved by

[redacted]

J A Reynolds - Laboratory Manager
09/09/2016

Project Number:

GEO / 24569

Project Name:

17 HEATH ROAD
CG/18910

GEOLABS

BS1377 : Part 2 : Clause 9 : 1990

PARTICLE SIZE DISTRIBUTION

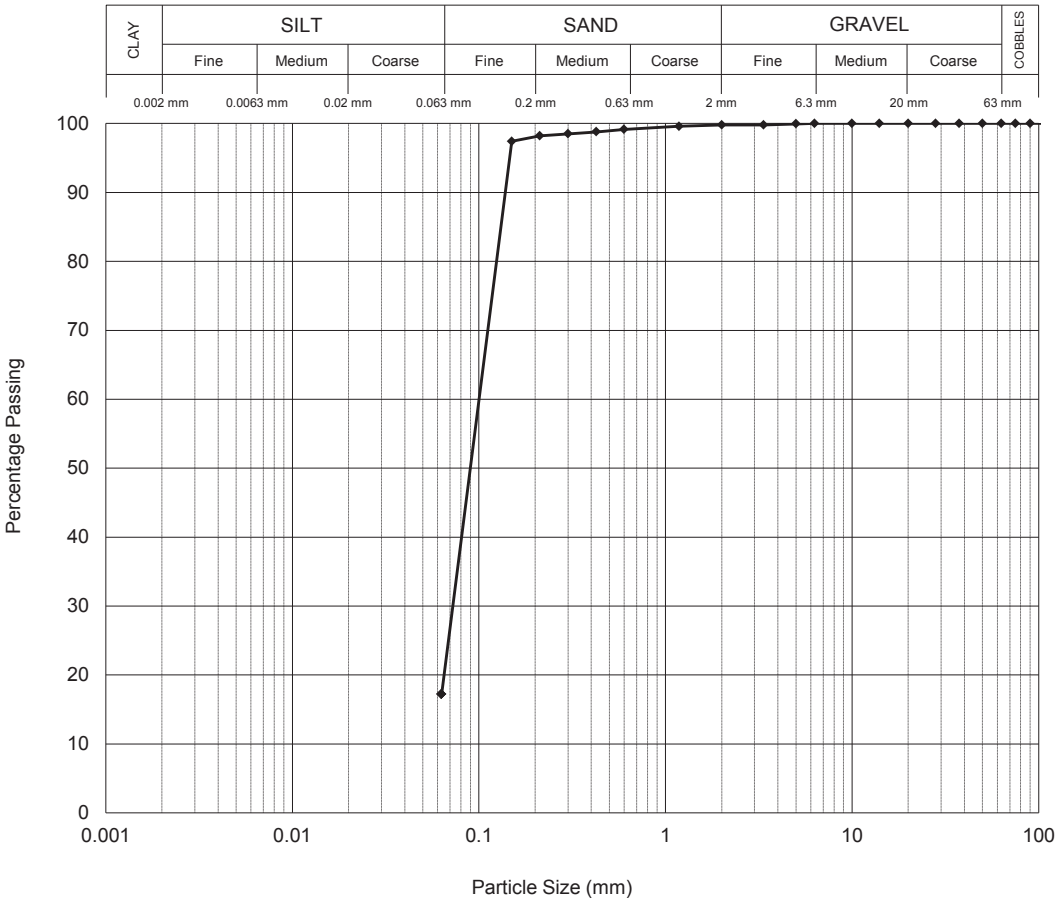
BH / TP No.	WS1
Depth (m)	1.40-1.60
Sample Type	D

Description

Brown silty SAND.

BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Sieve	
Size	% pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
10.0 mm	100
6.30 mm	100
5.00 mm	100
3.35 mm	100
2.00 mm	100
1.18 mm	100
600 µm	99
425 µm	99
300 µm	99
212 µm	98
150 µm	97
63 µm	17



Particle Proportions	
Cobbles	0
Gravel	0
Sand	83
Silt & Clay	17

Checked and Approved by

[redacted]

J A Reynolds - Laboratory Manager
09/09/2016

Project Number:

GEO / 24569

Project Name:

17 HEATH ROAD
CG/18910

GEOLABS

UKAS TESTING

BS1377 : Part 2 : Clause 9 : 1990

PARTICLE SIZE DISTRIBUTION

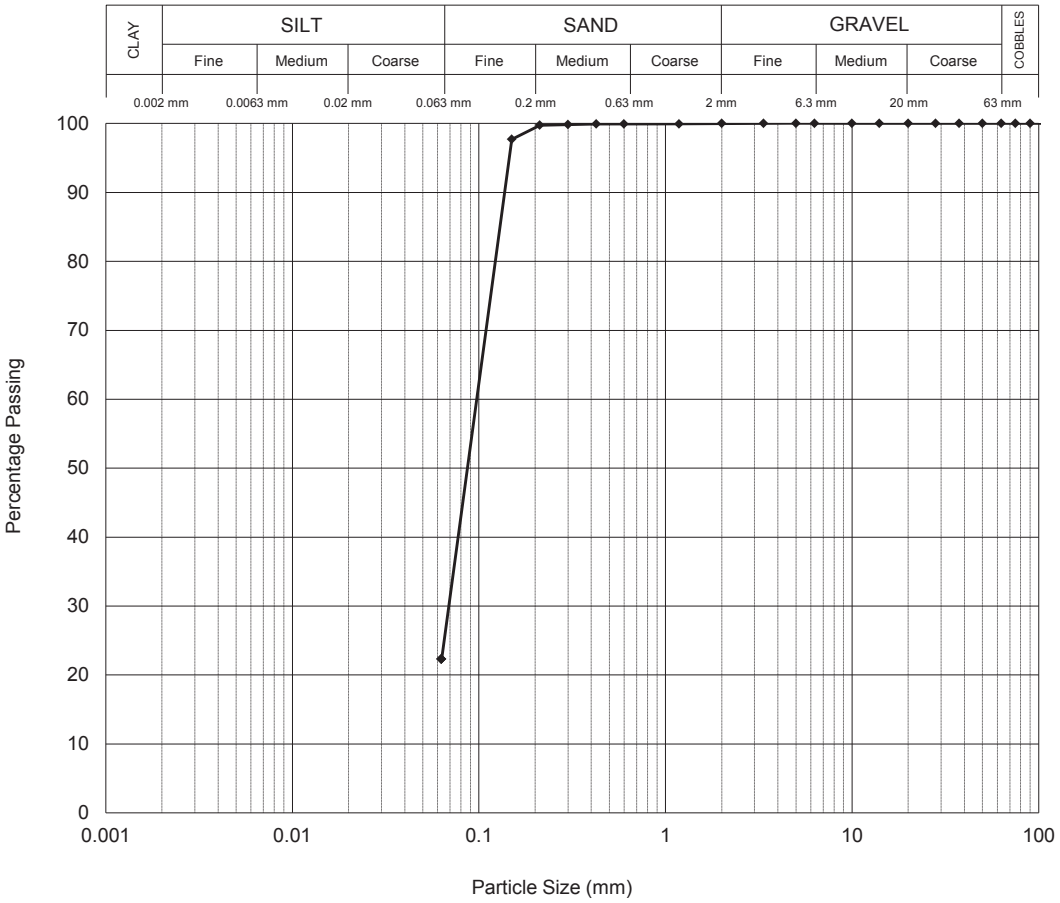
BH / TP No.	WS1
Depth (m)	3.40-3.60
Sample Type	D

Description

Brown silty SAND.

BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Sieve	
Size	% pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
10.0 mm	100
6.30 mm	100
5.00 mm	100
3.35 mm	100
2.00 mm	100
1.18 mm	100
600 µm	100
425 µm	100
300 µm	100
212 µm	100
150 µm	98
63 µm	22



Particle Proportions	
Cobbles	0
Gravel	0
Sand	78
Silt & Clay	22

Checked and Approved by

[redacted]

J A Reynolds - Laboratory Manager
09/09/2016

Project Number:

GEO / 24569

Project Name:

17 HEATH ROAD
CG/18910

GEOLABS

UKAS

BS1377 : Part 2 : Clause 9 : 1990

PARTICLE SIZE DISTRIBUTION

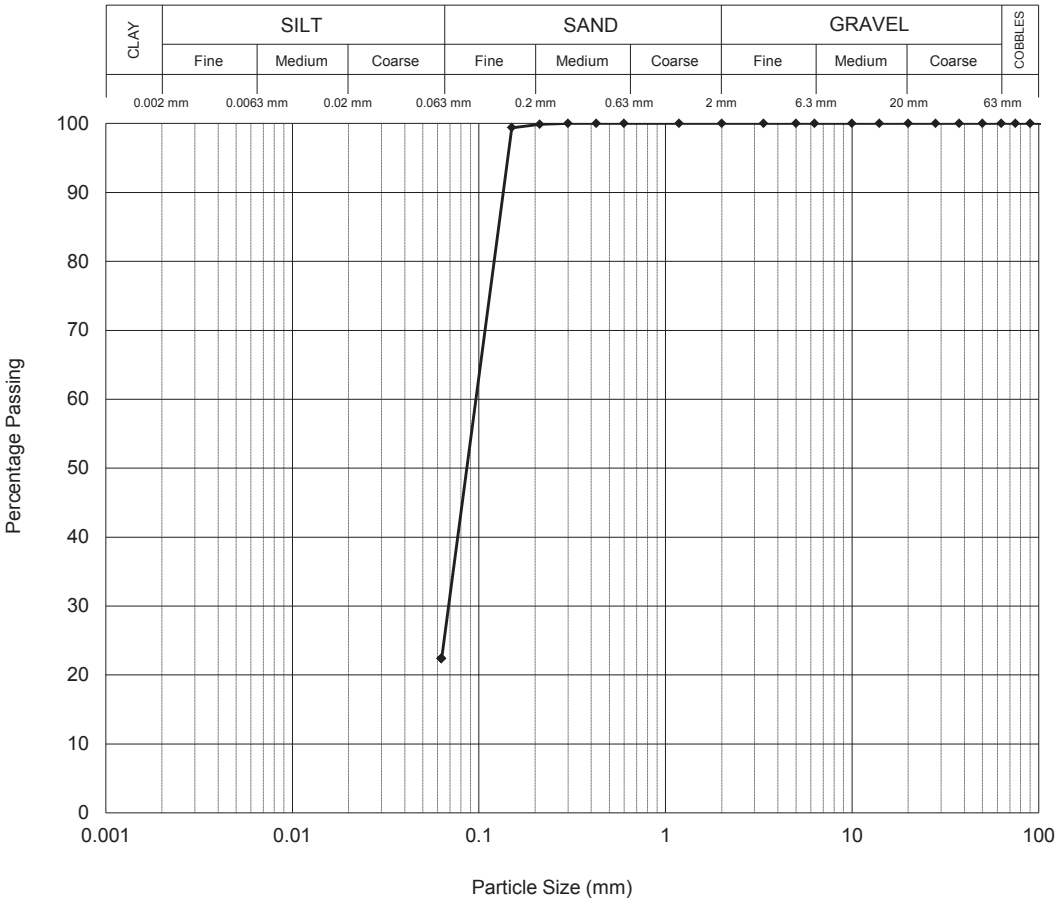
BH / TP No.	WS1
Depth (m)	5.40-5.60
Sample Type	D

Description

Yellowish brown silty SAND.

BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Sieve	
Size	% pass
200.0 mm	100
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
10.0 mm	100
6.30 mm	100
5.00 mm	100
3.35 mm	100
2.00 mm	100
1.18 mm	100
600 µm	100
425 µm	100
300 µm	100
212 µm	100
150 µm	99
63 µm	22



Particle Proportions	
Cobbles	0
Gravel	0
Sand	78
Silt & Clay	22

Checked and Approved by

[redacted]

J A Reynolds - Laboratory Manager
09/09/2016

Project Number:

GEO / 24569

Project Name:

17 HEATH ROAD
CG/18910

GEOLABS

UKAS