Card Geotechnics Limited
Providing Ground Solutions

Mr M Somani and Mrs C Lyndon-Somani

134 ½ Abbey Road, Camden, London

Basement Impact Assessment

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1. INTRODUCTION

Mr M Somani and Mrs C Lyndon-Somani are proposing to redevelop a site at 134 ½ Abbey Road, Camden, London, involving the excavation of a single storey basement. Card Geotechnics Limited (CGL) has been commissioned to provide a Basement Impact Assessment in accordance with guidance developed by Camden Borough Council in their planning document CPG4[1] and with reference to Arup's guidance for subterranean development[2] , comprising:

- Screening assessment – establish potential risks.
- Scoping assessment – clarify potential risks, develop conceptual site model, and determine requirements for ground investigation.
- Investigation – undertake site specific intrusive investigation to allow assessment of issues/risks raised during screening and scoping.
- Basement Impact Assessment – undertake geotechnical analysis to quantify potential risks and provide construction methodology and recommendations to mitigate as appropriate.

This report provides an assessment of geotechnical impacts on adjacent structures and the surrounding area based on available site investigation data for the purposes of a Basement Impact Assessment for planning. It does not obviate the need for further detailed analysis if changes in design loadings and construction methodology occur.

[1] London Borough of Camden. (May 2011). *Camden Planning Guidance: Basements and lightwells*. CPG4.
[2] Arup. (November 2010). London Borough of Camden. *Camden geological, hydrogeological and hydrological study: guidance for subterranean development*. Reference 213923.

2. SITE CONTEXT

2.1 Site location

The site is located at 134 ½ Abbey Road, Camden, London. The National Grid Reference (NGR) for the site is approximately 525611,184048 and the site location is shown in Figure 1.

The site is located on the south western side of Parliament Hill, sloping from to the south-east from a local high of 100mOD at Hampstead Heath, to a level of approximately 70mOD on site. Levels reduce further to some 50mOD at the base of Primrose Hill to the south-east of the site.

2.2 Site description

The north part of the site is currently occupied by a two storey residential building with a small courtyard in the southern area used for parking with a vehicle turntable immediately to the south of the house. A row of semi mature trees is present along the western boundary. Vehicular access is gained via double gates fronting Abbey Road. A single storey studio is present at the southern edge of the courtyard.

The site is bounded to the north by Wavel Mews, the south by Abbey Road, the west by 136 Abbey Road and the east by the rear of 53 Priory Lane. Priory Lane is located approximately 30m to the east of the site.

Plans and elevations showing the existing site layout are presented in Figure 2.

2.3 Proposed development

The proposed development comprises the excavation of a single storey basement under southern half of the existing house, extending into the existing courtyard to form a car lift. The basement will be constructed using a combination of underpinning and piling and will be used as a private workshop for the restoration of classic cars.

The existing 134 ½ Abbey Road is detached and therefore there are no party walls, with the exception of the garden wall on the western site boundary which is shared with 136 Abbey Road. The buildings to the east of the site, fronting Priory Lane, are over 15m from the proposed basement.

Proposed development plans are presented in Appendix A.

2.4 Site history

Godfrey Edition Maps for the Swiss Cottage area, and available Ordnance Survey maps have been reviewed to provide information on the historical development of the site.

The earliest London Town Plan map dated 1850 indicates the site to have been occupied by fields at this time. Abbey Road is noted on the 1871-1872 maps, with the existing terraced houses to the west of the site and a large house fronting Priory Lane, the garden of which is the current site. Wavel Mews is first noted on the 1895 map, to the north of the site. Development in the area between the northern site boundary and Wavel Mews site is first noted on the 1915 map, comprising a collection of rectangular buildings in a similar configuration to those currently fronting Wavel Mews. A row of small rectangular buildings, likely to be garages, is noted on the site on mapping from the 1970s, set back from Abbey Road roughly in-line with the building at 136 Abbey Road.

It is unclear from historical mapping the date that the site was developed to its existing use and layout, although slight changes to the site layout would suggest that this occurred some point between the 1970s/1980s and the 1990s. Satellite imagery indicates that the property was extended in 2008 to include the existing front room.

2.5 Published geology

According to British Geological Map Sheet 256[3] and the North Camden Geological Map (based on BGS 1:10,000 scale mapping) presented in the Arup report[2], the site is underlain by the London Clay Formation. No superficial deposits are noted on the site.

The London Clay Formation is an over-consolidated firm to very stiff, becoming hard with depth, fissured blue to grey silty clay of low to very high plasticity. The upper and lower parts may contain silty or fine grained sand partings, a laminated structured and nodular clay-stones.

2.6 Unpublished geology

The British Geological Survey (BGS) makes available historical boreholes, many with records of groundwater levels and in-situ geotechnical testing. This data has been obtained from the BGS for boreholes local to the site and has been used to supplement intrusive data obtained by CGL.

[3] British Geological Survey. (2006). *North London*. England and Wales Sheet 256. Solid and Drift Geology. 1:50,000.

The ground conditions encountered historically are described Table 1 below and records of nearby BGS boreholes are included in Appendix B.

Table 1. Summary of BGS borehole records.

BH record	Distance (m)	[bearing]	Level (~mOD)	Base of BH (mbgl)	Ground water level (mbgl*)	Stratum (depth encountered in mbgl)		
						MG/TS	Weathered London Clay	London Clay
TQ28SE2062	80	NE	NR	10	NR	GL	1.6	6.5
TQ28SE2063	80	NE	NR	10	NR	GL	1.0	7.7
TQ28SE445	210	SW	40.78	15.25	NR	GL	0.45	8.4
TQ28SE446	150	SW	42.1	7.6	NR	GL	0.3	NR
TQ28SE447	190	SW	40.35	7.6	NR	GL	1.0	NR
TQ28SE448	120	SW	41.46	15.25	NR	GL	0.45	10.2
TQ28SE449	185	SW	38.01	6.1	NR	GL	0.3	NR
TQ28SE450	225	SW	35.81	15.25	NR	GL	0.3	10.05
TQ28SE451	215	SW	35.85	7.6	NR	GL	0.45	NR
TQ28SE377	220	SE	NR	12.2	NR	NR	1.5	3.0
TQ28SE378	190	SE	NR	12.2	NR	NR	1.5	6.0
TQ28SE379	250	SE	NR	14	NR	NR	1.8	9.5
TQ28SE380	245	SE	NR	12.2	NR	NR	2.9	10.9

Notes:
1. NR = Not recorded.
2. GL = ground level

* metres below ground level

The available records indicate a variable thickness of Made Ground over weathered London Clay at between 0.3mbgl and 2.9mbgl and London Clay at between 3.0mbgl and 10.9mbgl.

Weathered London Clay was recorded in BGS records TQ28SE2062 and TQ28SE2063 at depths between 1.0mbgl and 1.6mbgl underlying Made Ground. The soil typically comprised firm, becoming firm to stiff with depth, dark brown, silty clay. In record TQ28SE2063 the weathered London Clay is described as soft, becoming soft to firm, brown, extensively mottled grey, silty clay. Given the relative consistency of the clay, it is possible that the shallow clay in TQ28SE2063 is Head Deposits. From around 3.4mbgl the description of the clay is more characteristic of the weathered London Clay comprising firm to stiff, occasionally fissured, dark brown, mottled grey slightly silty clay with occasional sand partings.

Unweathered London Clay comprising very stiff to hard, fissured, blue grey, slightly silty clay is noted at depths between 6.5mbgl (TQ28SE2063) and 7.8mbgl (TQ28SE2062).

No groundwater was noted on these records.

2.7 Hydrogeology

The Environment Agency[4] 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.

With reference to the Environment Agency website[5] the soils underlying the site are not within a groundwater source protection zone; the closest being an Outer Protection Zone approximately 500m to the south-east of the site. The London Clay underlying the site is classified as a non-aquifer.

2.8 Hydrology

With reference to the *Lost Rivers of London*[6] it is apparent that two tributaries of the River Westbourne were located approximately 300m to the west and east of the site. The river trends in a north-south direction from Hampstead Heath towards the intersection of Kilburn High road and Maida Vale at which point it trends towards the south-west towards Harrow Road before trending in a broadly south-easterly direction towards The Serpentine. It is understood that these water courses are now culverted.

2.9 Flood risk

With reference to the Environment Agency website[5] the site is not within an area considered to be at risk of flooding from rivers, sea or reservoirs. However, Abbey Road and Priory Lane are considered to be at low to medium risk of flooding from surface water.

With reference to the flood map (Figure 15) presented within the Arup report[2], Abbey Road was flooded in 1975, and Priory Lane in 2002.

[4] www.environment-agency.gov.uk (2012)
[5] http://maps.environment-agency.gov.uk/wiyby/
[6] Barton, N. (2009). *The Lost Rivers Of London*. Historical Publications.

2.10 Bomb damage

With reference to the London County Council bomb damage maps[7] of 1939 to 1945, no bomb damage was noted to the site or to the neighbouring properties. Total destruction was noted within the vicinity of the site approximately 150m to the north-west of the site.

[7] London Topographical Society. (2005). *The London County Council Bomb Damage Maps 1939 to 1945*.

3. SCREENING AND SCOPING

3.1 Introduction

A screening process has been adopted based on the approach set out in Camden Borough Council's CPG4[1], based on the flowcharts presented in that document, to identify those geological and hydrogeological issues that need to be targeted for further consideration. The flowcharts consider the potential impact of the basement on groundwater flow, land stability, and surface water flow, with targeted questions to determine what (if any) assessment is required.

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

Table 2: Groundwater flow impacts

Question	Response	Action required
1a. Is the site located directly above an aquifer	No. No superficial deposits are identified beneath the site and the London Clay is a non-productive stratum.	None
1b. Will the proposed basement extend beneath the water table surface.	Unlikely The proposed single storey basement will extend to approximately 3.0m bgl. Although no shallow groundwater is anticipated, perched water may be encountered in the Made Ground (if present).	Confirm by investigation
2. Is the site within 100m of a watercourse, well or potential spring line.	No. Former course of the Westbourne was located approximately 300m to the west of the site, and this is unlikely to influence ground conditions.	None
3. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas.	No. The proposed basement is beneath the existing building and car turning circle.	None

Question	Response	Action required
4. As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS).	No. It is anticipated the existing drainage routes will be maintained.	None
5. 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.	None

In summary, the site is underlain by the London Clay Formation, with no superficial deposits anticipated beneath the site, although Made Ground may be present. Any groundwater present is likely to be between the Made Ground and the London Clay, and is likely to be of limited volume.

Given that the basement box will be within Made Ground and the London Clay, it may encounter limited 'perched' groundwater within the Made Ground. It would not be expected to obstruct general groundwater flow within the relatively impermeable London Clay. A ground investigation should be undertaken to determine ground and groundwater conditions on site and the potential implications for construction.

It is considered that there will be no material change to surface water infiltration or drainage routes. The above items are addressed in later sections of this report.

3.3 Slope/land stability

Table 3: Land stability impacts

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. It is anticipated that no landscaping will change the profile of the ground.	None

Question	Response	Action required
3. Does the development neighbour land including railway cuttings and the like with a slope greater than about 1 in 8?	No. There are no artificial cuttings or embankments in the vicinity.	None
4. Is the site within a wider hillside setting in which the general slope is greater than about 1 in 8?	No. The site is located on the southern slope of Hampstead Heath, with a local slope of approximately 1 in 20, sloping towards the south to south-east.	None
5. Is the London Clay the shallowest stratum on site?	Yes.	Investigation to confirm stratum levels
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 anticipated that the existing semi mature trees in the area of the proposed basement will be felled as part of the proposed redevelopment. It is assumed that the remaining trees, including the mature tree on the southern site boundary, will remain.	None
7. Is there a history of shrink/swell subsidence in the local area and/or evidence of such at the site.	Unknown. No significant evidence of shrink/swell damage to properties was noted during the site walkover. However, the stress relief of the London Clay will result in ground heave, the effects of which will need to be assessed. Trees are present along the site boundary and their effect on shrink/swell should be considered.	Investigation and assessment
8. Is the site within an area of previously worked ground?	No. No known areas of worked ground. Limited Made Ground likely to be encountered on site, most likely associated with previous construction.	None
9. Is the site within an aquifer?	No. The London Clay Formation is classified as a non-productive stratum.	None
10. Is the site within 5m of a highway or pedestrian right of way?	Yes. The site is immediately adjacent to Abbey Road and Wavel Mews.	Impact assessment

Question	Response	Action required
11. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties.	No. The property is detached and 136 Abbey Road has a basement level. The houses fronting Priory Lane to the east of the site are over 15m from the proposed basement.	Investigation and assessment
12. Is the site over (or within the exclusion zone of) any tunnels?	No.	None

In summary, an impact assessment is required to investigate the magnitude of ground movements resulting from the basement excavation and basement box construction. The basement excavation will result in an unloading of the London Clay, resulting in potential heave movements whilst the excavation and construction of the new basement walls may result in lateral ground movements and consequent settlement. These movements will need to be assessed within an Impact Assessment in order to facilitate the preliminary design of control measures.

3.4 Surface flow and flooding

This section covers surface flow and flooding issues as set out in CPG4, however detailed design of the site drainage will be completed by other parties.

Table 4. Surface flow and flooding impacts.

Question	Response	Action required
1. 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. It is understood all surface water will be discharged to the sewer network through existing connections. Drainage strategy to be completed by other parties.	None
2. Will the proposed development result in a change in the proportion of hard surfaced/paved external areas?	No. See Table 2, Question 3.	None
3. Will the proposed basement result in a change to the profile of the inflows of surface water being received by adjacent properties or	No Surface water regime not materially changed from existing condition.	None

Question	Response	Action required
downstream watercourses?		
4. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No Any Made Ground present will be removed as part of the basement construction, removing any potential source of contamination.	None
5. 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?	Yes The site is not in an Environment Agency Flood Risk Zone and it is not below the static water level of nearby water features. Abbey Road is, however, listed as a street flooded in 1975 with reference to the Camden geological, hydrogeological and hydrological study undertaken by Arup.	Flood risk assessment may be required.

The basement construction will not affect surface flows and flooding as there is no material change to the level of impermeable surfacing. It is assumed the existing drainage connections will be maintained, however any drainage strategy will be developed by other parties and does not form part of this assessment.

Given that the site is on a road that flooded in the past, a Flood Risk Assessment is likely to be requested by the London Borough of Camden.

3.5 Summary

On the basis of this screening exercise, the Basement Impact Assessment will be required to address the following (Table 5):

Table 5. Summary of basement impact assessment requirements

Item	Description
1.	*Subterranean (Groundwater flow)* Investigation required to confirm the shallow ground and groundwater conditions. Potential impact on groundwater flow.
2.	*Slope (land stability)* Investigation and assessment required to quantify ground movements associated with underpin settlements, ground heave and ground movements around the basement perimeter.
3.	Impact assessment on adjacent residential properties and infrastructure.
4	*Surface flow and flooding* A Flood Risk Assessment may be required.

The outcomes of the screening assessment are carried forward into the Basement Impact Assessment in the following report sections.

3.6 Scoping

A Conceptual Site Model (CSM) is presented in Figure 3, based on details of the proposed development and the outcomes of the Screening Assessment.

Based on the output of the screening process, the site investigation should comprise the following:

- A borehole to a depth beyond the anticipated basement level to provide details on ground and groundwater conditions (including proving the depth to, and strength of the London Clay).
- In-situ geotechnical testing and laboratory testing to provide adequate information to derive geotechnical design parameters. This will inform the retaining wall and foundation design and should include Standard Penetration Tests (SPTs) and appropriate classification testing (including Atterberg Limits, where cohesive soils impact foundation design, and Particle Size Distribution (PSD) testing where granular soils are encountered).
- Installation of standpipes within the borehole and subsequent groundwater monitoring to determine groundwater levels beneath the site.

- Soil and groundwater observations should be recorded by an appropriately qualified geotechnical engineer.

4. PRESENT GROUND INVESTIGATION

4.1 Fieldworks

An intrusive investigation, comprising six foundation inspection pits and one cable percussion borehole was undertaken on 19th November 2013. The investigation was undertaken generally in accordance with the requirements of current UK guidance including BS5930[8] and BS10175[9].

In order to obtain samples for laboratory testing, and to fully characterise the near surface ground conditions across the site, the trial pit and borehole arisings were recorded, logged and representatively sampled by a suitably qualified engineer from CGL.

Specialist service surveys were undertaken on 19th November 2013 prior to the intrusive investigations and each exploratory hole location was scanned with a Cable Avoidance Tool (CAT), prior to the works commencing.

The cable percussion borehole was positioned in the centre of the existing front drive to confirm the ground conditions, allow in-situ geotechnical testing and facilitate the installation of groundwater and ground gas monitoring wells. Standard Penetration Testing (SPT), using split spoons or cones as appropriate, was undertaken within the cable percussion borehole and a monitoring well was installed.

The foundation inspection pits (FIP) were located around the boundary walls to determine foundation type and depth. The pits were excavated using hand tools. FIP01 was located against the northern side of the existing outbuilding. FIP02 was located in the corner between the party garden wall with 136 Abbey Road (FIP02a) and the front room of 134 ½ Abbey Road (FIP02b).

The exploratory hole locations are presented in Figure 4 and copies of the borehole and foundation inspection pit records are provided in Appendix C and Appendix D, respectively.

4.2 Geotechnical laboratory testing

Representative soil samples were sent to Albury SI and i2 Analytical Limited for geotechnical testing and the results are included in Appendix E. The following soil testing was undertaken.

[8] British Standards Institution. (1999). *Code of practice for site investigations*. BS5930:1999 Inc. Amendment 2.
[9] British Standards Institution. (2011). *Investigation of potentially contaminated sites: Code of practice.* BS10175:2011.

- Atterberg Limits;
- Moisture Content;
- Particle size distribution (PSD);
- Quick undrained triaxial;
- Geotechnical sulfate to BRE SD1; and
- pH.

All of the results have been incorporated in the geotechnical assessment for the site in the following sections.

4.3 Monitoring

Groundwater level and ground gas concentrations were recorded during a single monitoring visit undertaken on 29th November 2013 using the monitoring well installed in BH01.

The monitoring record is presented in Appendix F.

5. GROUND AND GROUNDWATER CONDITIONS

5.1 Summary

The ground conditions encountered during the investigation generally comprised Made Ground over Head Deposits and London Clay. They are summarised in Table 6 below.

Table 6. Summary of ground conditions.

Stratum	Depth to top (mbgl)	Thickness (m)
(MADE GROUND) Comprising medium dense dark brown very gravelly fine to coarse sand. Gravel is fine to coarse subrounded to subangular of flint, brick and occasional ceramic. Occasional rootlets noted.	0.0	0.5
Firm medium strength friable dark orange brown mottled grey sandy CLAY. Sand is fine to coarse. Occasional fine to medium subrounded to subangular flint gravel noted. [HEAD DEPOSITS]	0.5	2.0
Firm becoming stiff medium to high strength dark grey brown mottled grey CLAY. [LONDON CLAY FORMATION]	2.5	Proven to 10mbgl

Further details of the ground conditions encountered are presented in the following report sections. Plots of SPT 'N' and undrained shear strength (c_u) are presented in Figure 5 and Figure 6, respectively.

5.2 Made Ground

Made Ground was encountered each exploratory hole location and typically comprised a loose to medium dense, dark brown, very gravelly, fine to coarse sand between 0.25m and 0.5m thick.

5.3 Head Deposits

Material consistent with description of Head Deposits was encountered in borehole BH01 at 0.5mbgl and was 2.0m thick. This material comprised a firm, medium strength, friable, dark orange brown, mottled grey, sandy clay with occasional gravel. The sand was fine to coarse and the gravel was fine to medium, subrounded to subangular, of flint.

A single SPT 'N' value of 12 was recorded, corresponding to an shear strength value (c_u) of approximately 54kPa based on standard correlations and using an f_1 value of 4.5[10].

Classification parameters were recorded in the following ranges:

- Moisture content: 24.4% to 32.7%;
- Plastic Limit: 25%;
- Liquid Limit: 71%; and
- Plasticity Index: 46%.

These results correspond to a clay of 'very high' plasticity[8] with a high volume change potential[11] using a modified plasticity index. Moisture contents are less than 40% of the Liquid Limit in the samples analysed from 1.0mbgl, suggesting the material may be desiccated[12].

5.4 London Clay Formation

The London Clay Formation was encountered in borehole BH01 at 2.5mbgl and comprised firm, medium strength, becoming stiff and high strength with depth, dark grey brown mottled grey, clay. Occasional sand partings and fine gravel sized selenite crystals were noted from 3.0mbgl.

SPT 'N' values were recorded in the range of 15 to 25, corresponding to c_u values in the order of 68kPa to 113kPa, or a relative consistency of 'firm' becoming 'stiff', based on established correlations (where f_1 = 4.5[10]).

Undrained shear strength values as determined by quick undrained triaxial tests (QUU) of 50kPa to 135kPa were recorded between 2.5mbgl and 8.5mbgl. The c_u values from 2.5mbgl and 4.5mbgl are in general agreement with the 'N' value derived c_u values. However, the values obtained from samples at 6.5mbgl and 8.5mbgl are somewhat higher than those derived from SPT 'N' values.

Geotechnical laboratory testing indicated the following classification parameters in the weathered and un-weathered London Clay:

[10] Stroud, M.A. (1975). *The standard penetration test in insensitive clays and soft rocks*. Proceedings of Symposium on Penetration Testing, 2, 367-375.
[11] NHBC. (2013). *NHBC Standards: Chapter 4.2 Building near trees*.
[12] Crilly, M. (1996). *Desiccation in clay soils*. BRE Digest 412

- Moisture content: 27.1% to 33.5%;
- Plastic Limit: 27% to 29%;
- Liquid Limit: 75% to 78%; and
- Plasticity Indices: 46% to 50%.

These results correspond to a clay of 'very high' plasticity[8] with a high volume change potential[11]. Moisture contents are greater than 40% of the Liquid Limit in the two shallow samples from 3.0mbgl and 5.0mbgl, indicating this soil is not significantly desiccated. Although the moisture content recorded in the sample from 6.5mbgl is less than 40% of the Liquid Limit, the Liquidity Index for this sample is greater than 0, and on this basis the reduced moisture content is unlikely to be desiccation-induced.

5.5 Groundwater

No groundwater strikes were recorded during the intrusive works.

Subsequent groundwater monitoring was undertaken on the 29th November 2013 using the monitoring well installed in the Head Deposits and London Clay in borehole BH01. A standing water level of 1.23mbgl (~18.57mOD) was recorded. This water level corresponds to the level of a band of sandy clay within the Head Deposits which contained occasional fine to medium flint gravel.

5.5.1 Rising head permeability test

A rising head permeability test was undertaken on 29th November 2013. The head of water within borehole BH01 was purged to 3.98mbgl (base of well is 4.05mbgl) and the water level was monitored to observe its recovery over a period of two hours.

The final water level was recorded at 3.65mbgl, indicating a recharge of a 33cm head of water during the test period. An infiltration rate of 2.6×10^{-7} m/s has been calculated corresponding to very low permeability[13]. This is in the range expected for the Head Deposits.

[13] Preen et al. (2000). *Groundwater control – design and practice*. CIRIA C515.

5.6 Geotechnical sulfates and pH

Selected soil samples from the each stratum were analysed for sulfate concentrations and pH in general accordance with BRE guidance[14]. The results are summarised in Table 7 with details presented in Appendix E.

Table 7. Summary of sulfate testing.

Stratum	No. of samples	pH	Water Soluble Sulfate as SO_4 (2:1) (mg/l)	Total Sulfur (% S)	Oxidisable sulfides (OS % SO_4)	Total potential sulfate (TPS % SO_4)
Head	2	7.1 to 7.2	250 to 740	350 to 490	0.007 to 0.022	0.105 to 0.147
London Clay	1	7.1	5100	28000	2.4	8.4

The London Clay is potentially a pyritic soil and consideration has therefore been given to the content of oxidisable sulfides (OS % SO_4). It is noted that an oxidisable sulfide concentration greater than 0.3% was recorded in the sample of the London Clay, and Design Sulfate Classes should be adjusted accordingly.

The implications of these results on the construction of the proposed development are discussed further in Section 6.4 of this report.

[14] Building Research Establishment. (2005). *Concrete in aggressive ground*. Special Digest 1, 3rd Ed.

6. GEOTECHNICAL RECOMMENDATIONS

6.1 Geotechnical design parameters

Geotechnical design parameters for the proposed development are summarised in Table 8 below. They are based on the borehole records and the results of laboratory and in-situ testing obtained from the current site investigation and nearby relevant investigations. Reference has been made to published data for the well-studied London geology.

Table 8. 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	19.8	18	-	28[a]	[25]
Head Deposits	19.3	19	60	24[b]	36 [27]
London Clay Formation	17.3	20	60 + 7.5z[c] [5]	24 [b]	36 + 4.5z[d] [27 + 3.38z][e]

a. BS 8002:1994 Code of practice for Earth retaining structures, British Standards institution.
b. Peck, R.B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967, p.310.
c. z = depth below 6.0mOD
d. Based on 600 Cu - 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.
e. Based on 0.75Eu - 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.

The parameters in Table 12 are unfactored (Serviceability Limit State) and considered to be 'moderately conservative' design values.

6.2 Excavations

Based on the proposed construction methodology, some of the excavations in the Made Ground are likely to be supported with piles. Where this is not the case (i.e. where underpins are proposed), excavations in the Made Ground may require battering back to a safe angle at the front of the underpin and temporary support behind the underpin to prevent ground loss during construction.

Excavations in the Head Deposits and London Clay are likely to remain stable over the short term, although they will be susceptible to deterioration during inclement weather.

Perched water seepages may be encountered, although ingress rates are likely to be low and such seepages should be easily controlled by sump pumping or similar during construction.

6.3 Allowable bearing pressure

Conventional spread foundations or underpins formed in the Head Deposits/London Clay should be designed for an allowable bearing pressure of 120kPa.

6.4 Concrete design

The design sulfate (DS) and ACEC classes for each stratum are presented below in Table 9 based on the results of the geotechnical sulfate and pH testing, including DS and ACEC classes based on water soluble sulphate (WSS) and total potential sulfate (TPS).

Table 9. Summary DS and ACEC classes.

Stratum	Water Soluble Sulphate (2:1 Leachate Equivalent)		Total potential sulfate	
	DS class	ACEC Class	DS class	ACEC Class
Head Deposits	DS-2	[AC-1s]	n/a	
London Clay	DS-4	[AC-3s]	DS-5	AC-4s

The availability of total potential sulphate (TPS) in pyritic soils (London) is dependent on the extent to which the soils are disturbed, and the level to which the soils may oxidise, resulting in sulfate ions that may reach the concrete. In this regard, BRE SD1 guidance[14] states the that *"Concrete in pyritic ground which is initially low in soluble sulfate does not have to be designed to withstand a high potential sulfate class unless it is exposed to ground which has been disturbed to the extent that contained pyrite might oxidise and the resultant sulfate ions reach the concrete. This may prompt redesign of the structure or change to the construction process to avoid ground disturbance; for example, by using precast or cast-in-situ piles instead of constructing a spread footing within an excavation"*.

It is anticipated that the piled basement wall will be toed into the London Clay. On this basis, it is considered appropriate to use the DS and ACEC class based on Water Soluble Sulfate for the London Clay Formation (e.g. DS-4, AC-3s).

7. GROUND MOVEMENT ASSESSMENT

7.1 Introduction

This section provides calculations to assess ground movements that could result from the construction of the single basement level and how these may affect the adjacent structures. It is understood that reinforced concrete underpinning will be constructed to form the new basement wall beneath the existing walls on the western and eastern side of the basement, with piled walls around the remainder of the basement perimeter.

The basement beneath the existing building will ultimately be propped at the top with the ground floor slab. The piled wall around the proposed car lift pit will not be propped at ground floor level, with the wall cantilevered in the long-term condition.

The existing property forming 134 ½ Abbey Road is detached and therefore there are no party walls, with the exception of the garden wall on the western site boundary which is shared with 136 Abbey Road.

Ground movements are derived from:

- Pile wall installation: Lateral ground and vertical movement occurs due to the installation of the piles to form the retaining wall.
- Heave movements: The Head Deposits and London Clay are susceptible to short term heave and time dependant swelling on unloading, which occurs as a result of basement excavation, generating upward ground movements.
- Underpin deflection: Underpins act as stiff concrete retaining walls, which limits the potential for wall deflection. Appropriate temporary works are critical in controlling such deflections.
- Retaining wall deflections: Lateral and vertical ground movement occurs due to deflections as soils are excavated from in front of the retaining wall.
- Settlement: construction of underpins beneath existing foundations can lead to settlement and the amount of settlement depends on the quality of workmanship in constructing the underpins, in particular in dry-packing between the existing foundation and the new underpins. In addition, there may be settlement as

structural loads are transferred to greater depth, on to soils that have not previously been loaded.

- Long term ground movement: The net loading on formation soils will generate ground movement, which could affect adjacent foundations. This takes into account existing stress conditions, additional loads from the basement structure and the weight of soil removed.

7.2 Conceptual site model and critical sections

A conceptual site model (CSM) has been developed based on the available data and is presented in Figure 3. The CSM comprises a section indicating the proposed basement, variation in excavation depth across the site to reach formation level and the location of neighbouring properties in relation to the proposed development.

Three critical sections for analysis have been identified for consideration, corresponding to the piled wall supported the car lift pit excavation adjacent to 136 Abbey Road (Section A-A'), the underpinned garden wall shared with 136 Abbey Road (Section B-B'), where the car lift pit is slightly deeper than the remaining basement level, and the underpinned 'existing' flank wall of 134 ½ Abbey Road (Section C-C'), where the basement is shallowest.

These sections have been analysed to assess the potential for ground movements due to the construction of the basement to cause damage to the neighbouring property. The properties at the corner of Prior Road and Abbey Road are located over 15m to the east of the proposed basement and at this distance the proposed basement will have a negligible effect on the structural integrity of these structures.

7.3 Assumed construction methodology

7.3.1 Underpins

The basement wall below the existing western and part of the eastern flank walls of 134 ½ Abbey Road will be constructed using traditional underpinning techniques with pins excavated in sequence in typically 1.2m wide bays. It is assumed, based on the existing structural drawings and depth of the basement, that the underpins will be constructed in a single lift. Based on the anticipated line loads provided by Form SD and included in Appendix G and an allowable bearing capacity of 120kPa in the Head Deposits/London Clay, the underpins should be constructed on concrete bases measuring a minimum of 0.85m wide.

The underpins will be constructed in supported trenches with a central soil mass retained to provide support for temporary props and formwork. It is recommended that temporary propping be installed at the top, middle and bottom of the excavation to resist sliding and rotation of the wall prior to casting the lower and upper basement concrete floor slabs. Temporary propping should remain in place until the lower and upper basement floor slabs develop sufficient strength to sustain soil loads.

The underpins will be generally supported in the permanent condition by the ground floor and basement slab, which should be cast before removing the temporary propping.

7.3.2 Piled wall

The piled basement walls will be formed with 350mm contiguous piles at 500mm spacing.

In the basement area beneath the existing building, temporary propping will be installed as excavation commences in order to control deflections during construction. Over the long term the basement walls will be propped by permanent lower ground and basement floor slabs.

The piled wall around the perimeter of the car lift pit will be propped only at basement floor slab level as there will be no ground floor level.

Given the ground conditions encountered to date and in order to limit disturbance to neighbours, Continuous Flight Auger (CFA) or bored piled methods are recommended.

7.4 Assumed loading

Details of loading assumptions used in the heave/settlement analysis are summarised in the following sections. Loading information provided by the client can be found in Appendix G.

7.4.1 Underpin loading

The net loading at formation level below the underpins includes stress relief due to the removal of overburden during excavation and the transfer of building loads to the new formation level via the underpins. It has been assumed from development plans that the existing loads will be spread evenly below a 0.85m wide underpin base. The underpins beneath the existing garden wall will be 0.5m wide.

The proposed development gives rise to a net loading beneath the western and eastern flank walls (P1 and P3) and net unloading of the underlying strata beneath the existing garden wall (P2) both during construction and over the long term.

The excavation will unload the soils at the underpin formation level by between 34kPa (P1 and P3) and 44kPa (P2). These values assume a typical bulk unit weight of 20kN/m^3 for the excavated soils.

Table 10. Stress conditions beneath underpins.

Underpin wall reference	Stress relief from overburden (kPa)	Bearing pressure below underpin (kPa)[a]	Net load (kPa)
P1 & P3 (0.85m wide)	-34	118	84
P2 (0.5m wide)	-44	30	-14

7.4.2 Raft Loading

It has been assumed for the analysis that the load from internal walls and any column point loads will be evenly distributed across the raft slab, giving an estimated raft load of some 20kPa (i.e. 12kPa for raft slab and 8kPa additional load) once construction is complete. Raft loading is summarised in Table 11 below.

Table 11. Stress conditions at internal raft formation level.

Raft reference	Stress relief from overburden (kPa)	Average bearing pressure below slab (kPa)	Net load (kPa)
approx. 1.7m dig	-74	20	-54
approx. 2.2m dig	-62	20	-42

7.4.3 Piled wall loading

It is understood that the majority of the proposed piled basement walls will not be significantly load bearing, with line loads of around 10kN/m anticipated.

7.4.4 Surcharges

The foundations of No. 136 Abbey Road, adjacent to the western site boundary, will apply a surcharge of the order of 156kPa (assuming 125kN/m line load on a 0.8m wide spread foundation) at a distances of 2.8m (Section A-A), 0.8m (Section B-B) and 0.9m (Section C-C) from the excavation.

It is assumed that the base of the foundation is at approximately 18.2mOD, i.e. 0.7m below the internal basement floor level of 136 Abbey Road).

A highly conservative live load of 10kPa has been assumed over the basement floor slab, extending some 7m away from the external wall.

7.5 Ground movements due to pile wall installation

With reference to CIRIA C580[15], vertical and horizontal surface movements due to installation of a contiguous piled wall are generally in the region of 0.04% of the wall depth.

On this basis, and assuming the piles are toed into the London Clay at a level of 13.7mOD, or 6.1mbgl, the lateral movement at the top of the wall has been calculated at 2.4mm, translating to 0.6mm of settlement at the nearest building foundation of 136 Abbey Road (approximately 3m from the piled wall) and 1mm of settlement beneath the garden wall (approximately 1.5m from the piled wall) forming the boundary with 136 Abbey Road.

7.6 Ground movement due to piled wall deflections

Ground movements due to wall deflections have been calculated using GeoSolve WALLAP retaining wall analysis software. One critical section has been identified and analysed for Serviceability Limit State (SLS) in accordance with *BS 8002:1994 Code of practice for Earth retaining Structures*. Preliminary indicative construction details and methodology have been assumed based on the information supplied by the structural engineer.

7.6.1 WALLAP model assumptions

The WALLAP analysis includes the following assumptions:

1. A contiguous piled wall of 350mm diameter piles at 500mm centres will be installed to retain the soil during excavation;

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

2. A 0.4m deep capping beam will be constructed at the top of the piled wall;

3. Perched water was encountered at 1.2mbgl (18.6mOD), within the Head Deposits, during groundwater monitoring. Groundwater has been assumed to act at this level on the active side, and has been reduced to below the basement and piled wall level on the passive side assuming adequate groundwater/perched water control.

4. Adjacent property foundations surcharge loads of 125kN/m have been assumed, applying a bearing pressure of 156kPa assuming a 0.8m wide foundation at a distance of 2.8m from the wall;

5. A garden wall surcharge of 15kN/m has been assumed, applying a bearing pressure of 50kPa assuming a 0.3m wide foundation at a distance of 1.5m from the wall at an elevation of 19.4mOD;

6. A concrete lining wall is to be installed in front of the piled wall.

In addition to the 136 Abbey Road building foundation surcharge, a highly conservative statutory surcharge of 10kPa has been applied behind the 136 Abbey Road building foundation. The surcharges provided are summarised in Section 7.4.4.

7.6.2 WALLAP construction sequence

The following construction sequence was been assumed for the development:

- Install 350mm diameter contiguous piles around perimeter of the basement at a spacing of 500mm;
- Break down piles and install 0.4m deep capping beam;
- Excavate to formation level (approx. 16.7mOD) and cast basement floor slab and internal concrete walls.

The piled wall will be cantilevered in the short and long term and on this basis, no temporary propping has been allowed in the analysis. The piled wall toe level of 13.7mOD has been chosen to control deflections at the top of the wall and ensure a minimum Factor of Safety (FoS) of 1.2 is achieved.

7.6.3 WALLAP results

The WALLAP results for piled wall deflections are summarised in Table 12 below.

Table 12. Summary of piled wall lateral movements.

Section	Deflection at ground level mm	Maximum deflection (mm)	Level (max. deflection) (mOD)
Section A-A'	8.0	8.0	19.8

These lateral movements have been added to the calculated piled wall installation deflections to provide total lateral movement and are summarised in Table 13.

Table 13. Summary of total piled wall lateral movements.

Section	Lateral movements due to installation of piles at top of pile (mm)	Maximum total lateral movements (mm)	Level of maximum lateral movements mOD
Section A-A'	2.4	10.4	19.8

The lateral movements are summarised in Table 12 and Table 13 and full WALLAP output provided in Appendix H, and should be reviewed once the loading, construction sequence and methodology have been finalised.

7.7 Ground movements arising from basement excavation

A heave analysis has been undertaken using OASYS Limited *VDISP* (***V****ertical* ***DISP****lacement*) analysis software. *VDISP* assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E') for each stratum input by the user. VDISP assumes perfectly flexible loaded areas and as such tends to overestimate movements in the centre of loaded areas and underestimate movements around the perimeters.

7.7.1 Assessment of short term ground movement

Maximum short term heave is predicted to be approximately 5mm to 6mm, occurring in the centre of the proposed basement excavation beneath the existing building, where unloading is greater due to the higher elevation of the existing floor levels (21mOD) compared to external ground level (19.8mOD). Approximately 1mm of heave occurs below the underpins supporting the existing western flank wall, and approximately 1mm to 2mm beneath the underpin on the eastern side of the basement. Approximately 2mm to 3mm of heave occurs below the garden wall (shared with 136 Abbey Road), and around the piled wall perimeter.

With the skin friction of the contiguous piled wall providing resistance, it is anticipated that heave values around these areas of the basement perimeter will be considerably lower than calculated.

A contour plot showing the variation of heave over the short term across the basement excavation and likely impact on the adjoining property is presented within Figure 7.

Full VDISP output can be provided upon request.

7.7.2 Assessment of long term ground movement

Long term heave movements may occur as pore pressures recover within the London Clay at depth. Maximum long term heave is predicted to be approximately 5.0mm to 6.0mm occurring in the centre of the proposed basement excavation beneath the existing building, reducing to approximately 2.0mm to 4.0mm at the edges of the excavation.

As with the movements predicted for the undrained condition, it is anticipated that heave values around areas of the basement perimeter with the piled wall will be considerably lower than calculated due to the effect of skin friction resisting heave movements.

A contour plot showing the variation of heave over the long term across the basement excavation and likely impact on the adjoining property is presented within Figure 8.

Full VDISP output for both the short and long term ground movement assessments can be provided upon request.

7.7.3 Underpin settlement due to workmanship

The heave/settlement assessment undertaken within VDISP assumes perfect workmanship in the underpin construction and does not allow for settlement of the dry pack between existing footings and the new concrete. With good construction practice, actual settlements would be expected to not exceed 5mm. This value will be applied to the overall ground movement and corresponding impact assessment to calculate a predicted damage category for the adjacent properties.

7.8 Ground movement due to underpin wall deflection

Due to relatively shallow basement depth (single storey) and high stiffness of the reinforced concrete underpins, long term lateral deflection is considered to be negligible (i.e. <2mm). This is based on CGL's experience with similar underpinned basement developments in the area.

Ground movement during construction will be dependent on the quality of workmanship of the contractor, particularly in the provision of dry-packing and timely and accurate installation of temporary propping during construction. Temporary propping of the top, middle and bottom of each underpin section during construction will be crucial in controlling horizontal deflection and rotation of the underpins. The detailing and construction of any reinforcement and connections/curing joints between underpin sections and basement slab will also be critical in controlling deflections.

7.9 Damage Category assessment

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[16] and later supplemented by the work of Boscardin and Cording[17] has been used, as described in *CIRIA Special Publication 200*[18] and *CIRIA C580*[19].

General damage categories are summarised in Table 14 below:

Table 14. 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).

[16] 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
[17] Boscardin, M.D., and Cording, E.G., (1989). *Building response to excavation induced settlement*. J Geotech Eng, ASCE, 115 (1); pp 1-21.
[18] 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.
[19] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*

Category	Description
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 piled wall section (Section A-A') the combined impact of short term heave, long term movements following application of structural loads on the basement raft, assumed settlement due to pile installation and corresponding ground movement due to piled wall deflection have been combined to determine the deflection ratio for the adjacent property. It is anticipated that skin friction from the contiguous piled wall will significantly reduce the potential heave values around the basement perimeter, reducing the effect on the adjacent structures.

For the critical underpin wall section (Section B-B' and Section C-C') the combined impact of short term heave, settlement due to wall loading and assumed settlement due to workmanship have been combined to determine the deflection ratio for the adjacent property. This value has then been used to establish a limiting horizontal displacement of 5mm to ensure that the predicted damage category does not exceed Category 1 'very slight' damage.

The results are summarised in Table 15.

Table 15. Summary of ground movements and corresponding damage category

Party Wall Reference	Horizontal movements[c] (mm)	Maximum deflection (mm)	Horizontal Strain Δ/L^b (%)	Deflection ratio δ_h/L^a (%)	Damage category
Section A-A'	0.4	1.0[d]	0.015	0.015	0 - Negligible
Section B-B'	Limiting 5.0mm	0.9	n/a	0.011	1 – very slight (worst case[e])
Section C-C'	Limiting 5.0mm	2.2	n/a	0.024	1 – very slight (worst case[e])

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. (δh = horizontal movement in metres*
c. *The movement corresponding to the level of the party wall foundations.*
d. *Actual movement negligible.*
e. *Worst case damage category assuming max 5.0mm maximum horizontal movements.*

The predicted damage category imposed on the neighbouring properties due to the proposed basement development and assuming a good standard of workmanship will be 'Category 0' to 'Category 1' corresponding to negligible to very slight damage respectively at the boundary with 136 Abbey Road. The 'Category 1' damage category is based on limiting horizontal displacement of underpins to not exceed 5mm by adopting suitable construction sequence and good workmanship. The building interaction chart is presented in Figure 12.

It is noted that the proposed basement does not extend beneath the full footprint of the existing structure of 134 ½ Abbey Road. Only the southern end of western flank and part of the internal wall on the eastern side of the basement will be underpinned. There is therefore potential for differential movement within the structure itself and this should be accounted for in the structural design.

7.10 Monitoring strategy

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 0) 'negligible'. To ensure movement do not start to fall outside of that predicted, it is recommended that a formal monitoring strategy should be 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[20]. 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.

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

As discussed previously, the horizontal deflection/translation of the underpins during construction should be limited to less than 5mm to restrict the damage category for the adjacent critical properties to not exceed Category 1 ‘very slight damage’ comprising fine cracks which are typically less than 1mm and can be early repaired. This value should form the basis of the ‘traffic light’ trigger levels established prior to underpinning works commencing onsite.

8. CONCLUSIONS

The findings of this report summarised below:

- It is proposed to excavate a new single storey basement beneath 134 ½ Abbey Road. The site does not share party walls with the neighbouring properties, other than a garden wall shared with 136 Abbey Road.

- A desk study has been undertaken and indicates the site to have been residential in use. No significant contamination is anticipated on site based on its historical usage.

- Given that the site is on road that flooded in the past, a Flood Risk Assessment is likely to be requested by the London Borough of Camden.

- An intrusive investigation was undertaken on site, comprising one cable percussion borehole and two foundation inspection pits. A groundwater monitoring standpipe was installed within the borehole.

- The ground conditions on site were found to comprise Made Ground, overlying Head Deposits and London Clay. Groundwater was encountered as perched within the Head Deposits.

- The construction of the basement will generate ground movements due to a variety of causes including; heave, settlement, underpin construction and piled wall deflection during and after excavation. Preliminary calculations indicate that these will give rise to a maximum damage category within 'Category 1' (very slight damage) for the adjacent 136 Abbey Road. This assumes a good standard of workmanship and limiting horizontal deflection of the underpins during construction to less than 5mm.

- It is noted that the proposed basement does not extend beneath the full footprint of the existing structure of 134 ½ Abbey Road. There is therefore potential for differential movement within the structure itself and this should be accounted for in the structural design.

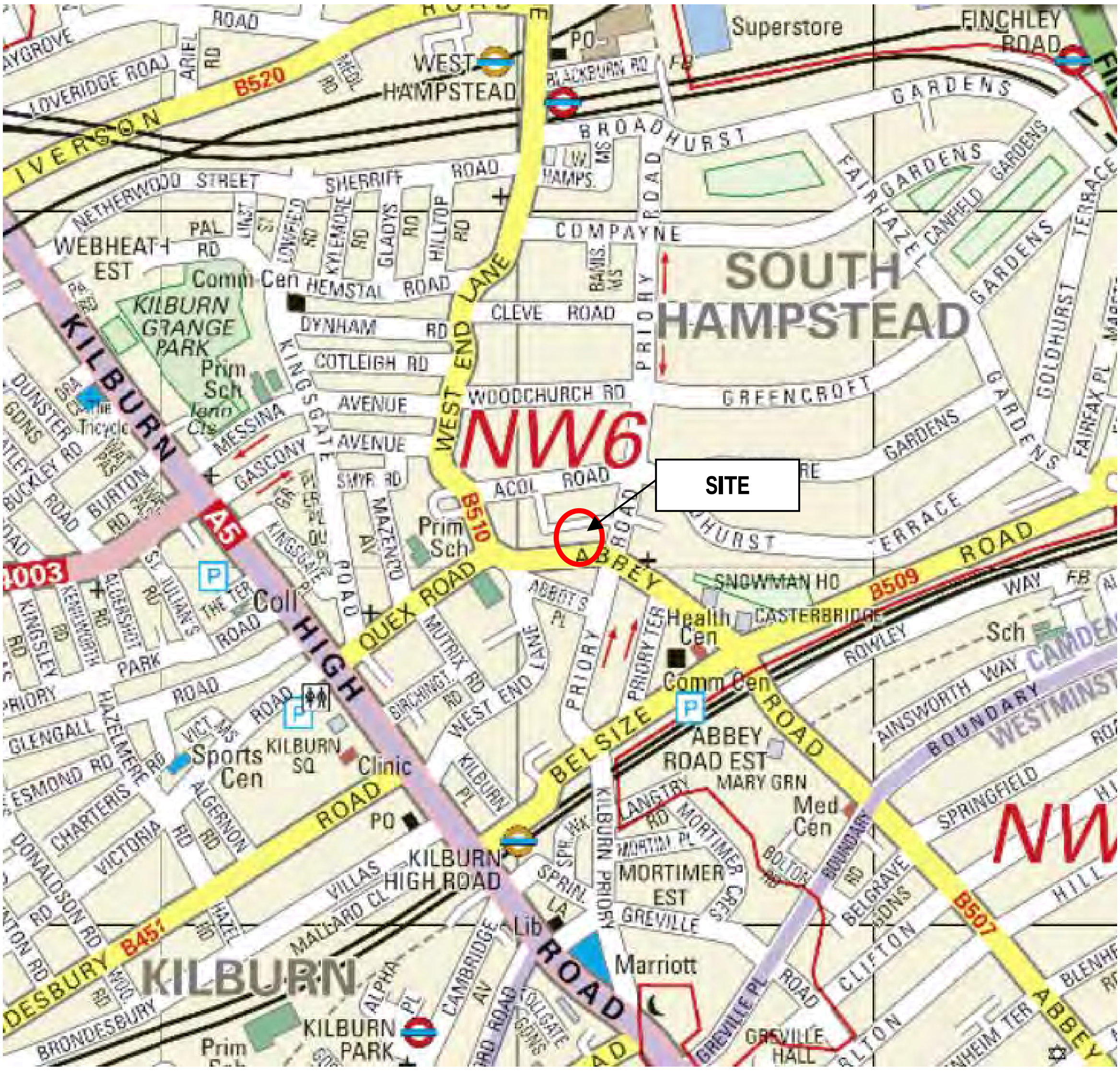
- It is recommended that all perimeter foundations are propped prior to any excavation commencing below them. The underpins should also be propped at regular intervals as construction progresses. This is required to control horizontal deflection and prevent rotation and sliding of the underpins prior to the basement and ground floor slab being cast.

- It is proposed that due to the close proximity of neighbouring property to the proposed basement foundation works, an appropriate monitoring regime be adopted to manage risk and potential damage to the neighbouring structures as construction progresses onsite.

- Where perched groundwater is encountered measures should be put in place by the contractor to control ingress. This can be achieved by adopting isolated sump pumping. Additionally, where perched groundwater is encountered the sides of the excavation may become unstable. Sacrificial trench sheeting should be used to support such excavations. This will be critical to controlling settlement due to loss of ground below neighbouring foundations.

- As the neighbouring property foundations will surcharge the proposed basement retaining walls, ensuring excavation stability, reducing ground loss and adopting a robust propping and monitoring strategy during construction will be critical to controlling ground movements and corresponding damage to the neighbouring properties. Overall, quality of workmanship will be the critical factor to prevent excessive ground movement.

FIGURES



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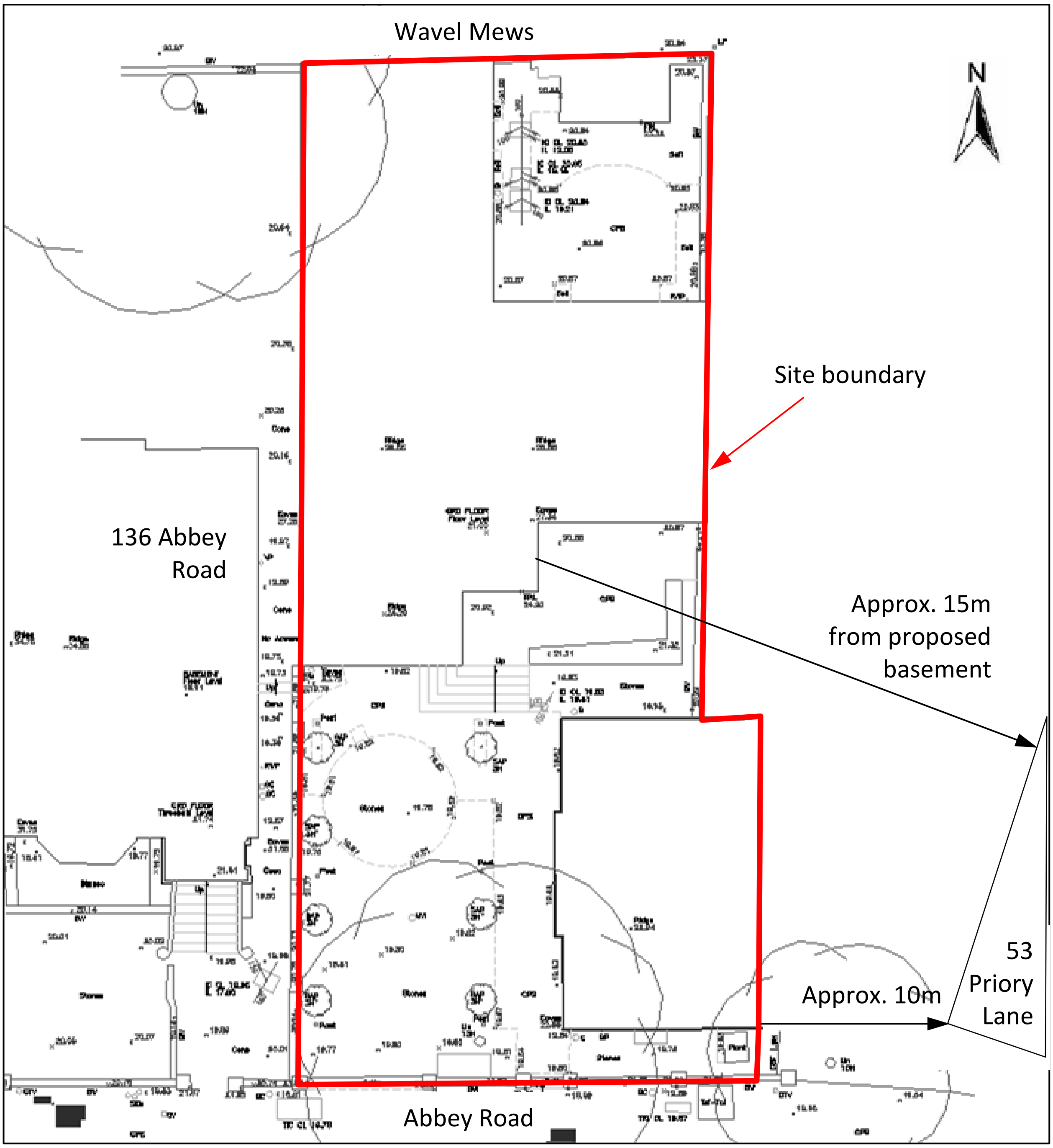
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title: **Site location plan**	**Figure 1**



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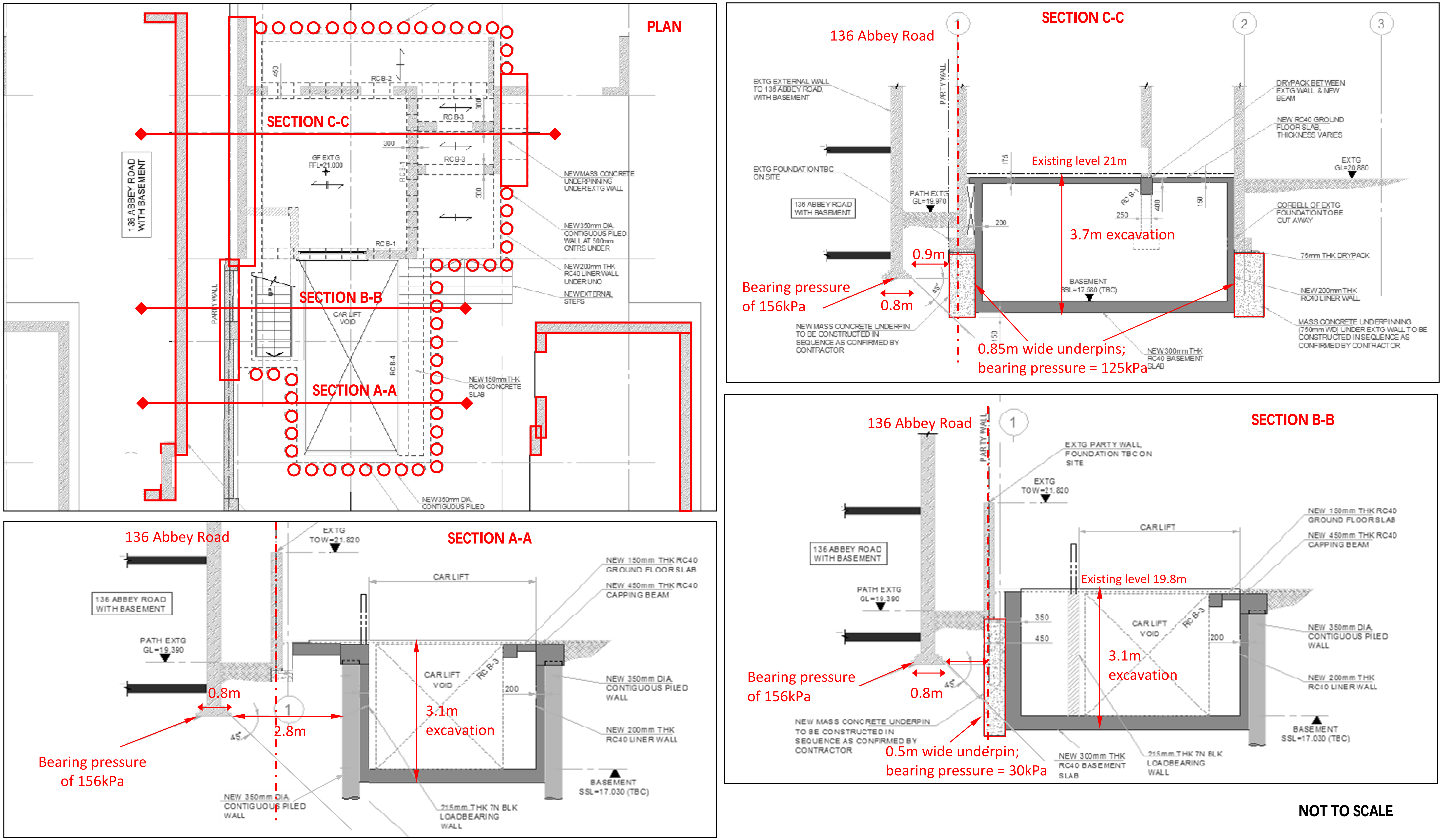
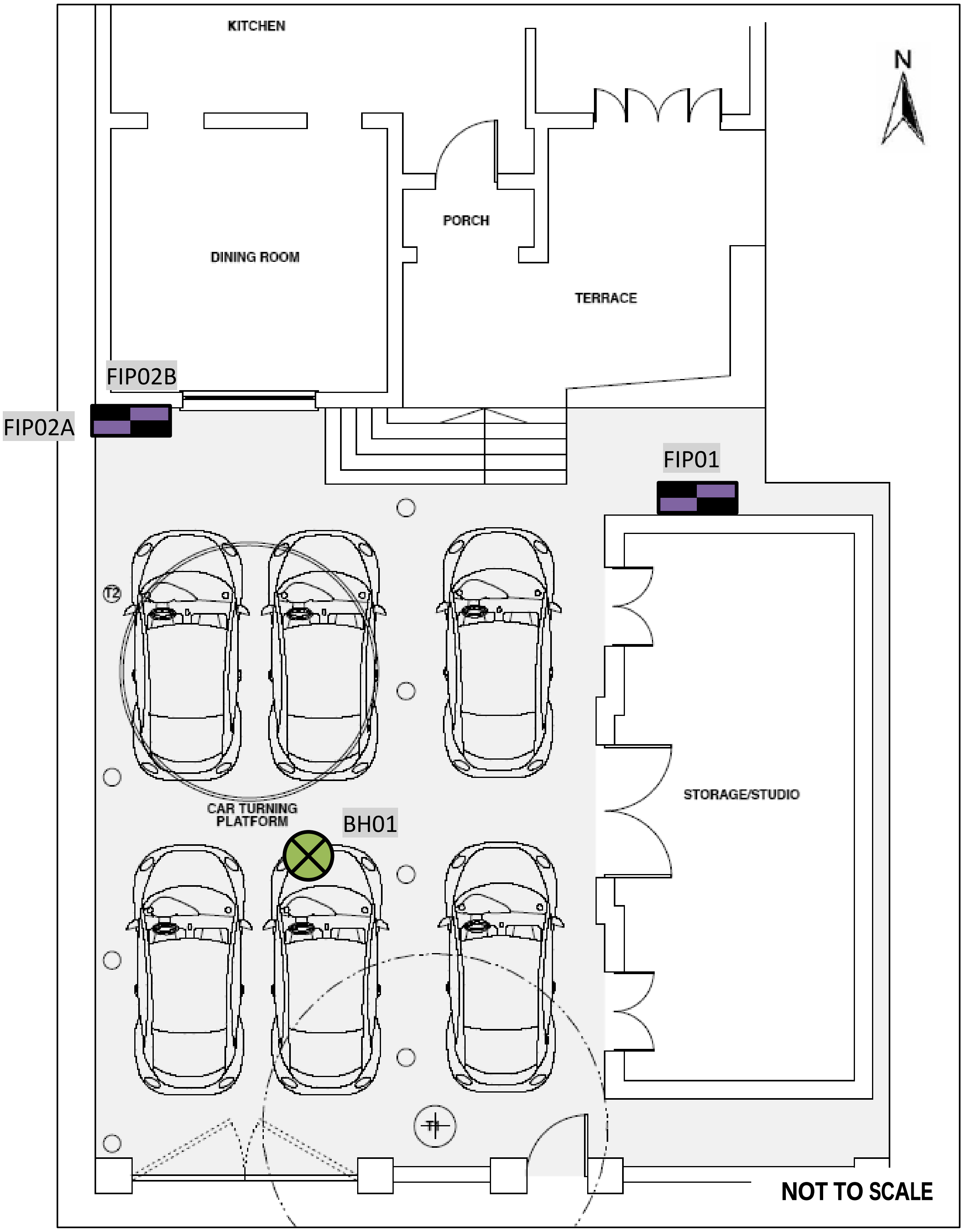
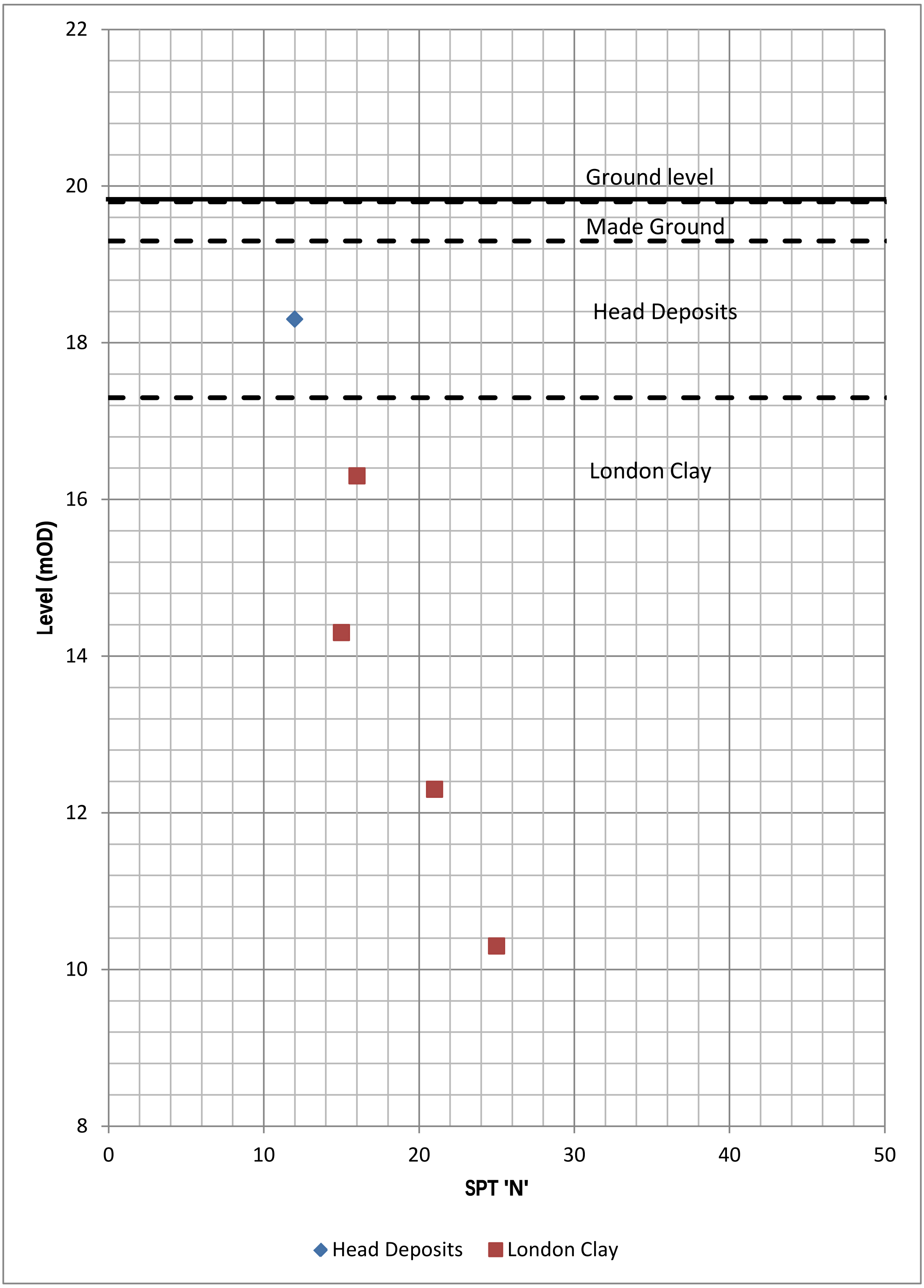
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Site layout plan**	**Figure 2**



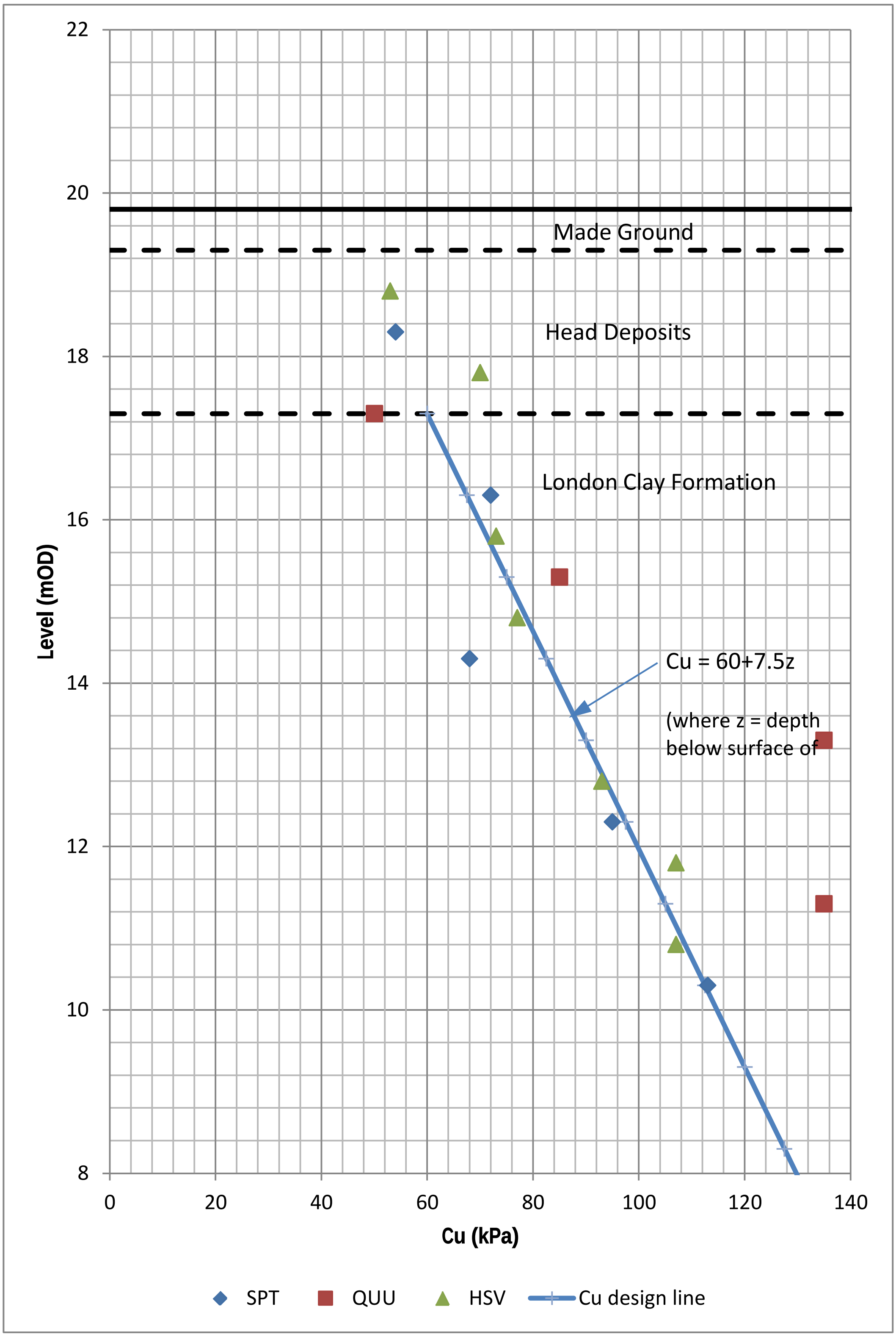
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	134 ½ Abbey Road, Camden, London	CG/08624
CGL	Title: Conceptual site model	Figure 3



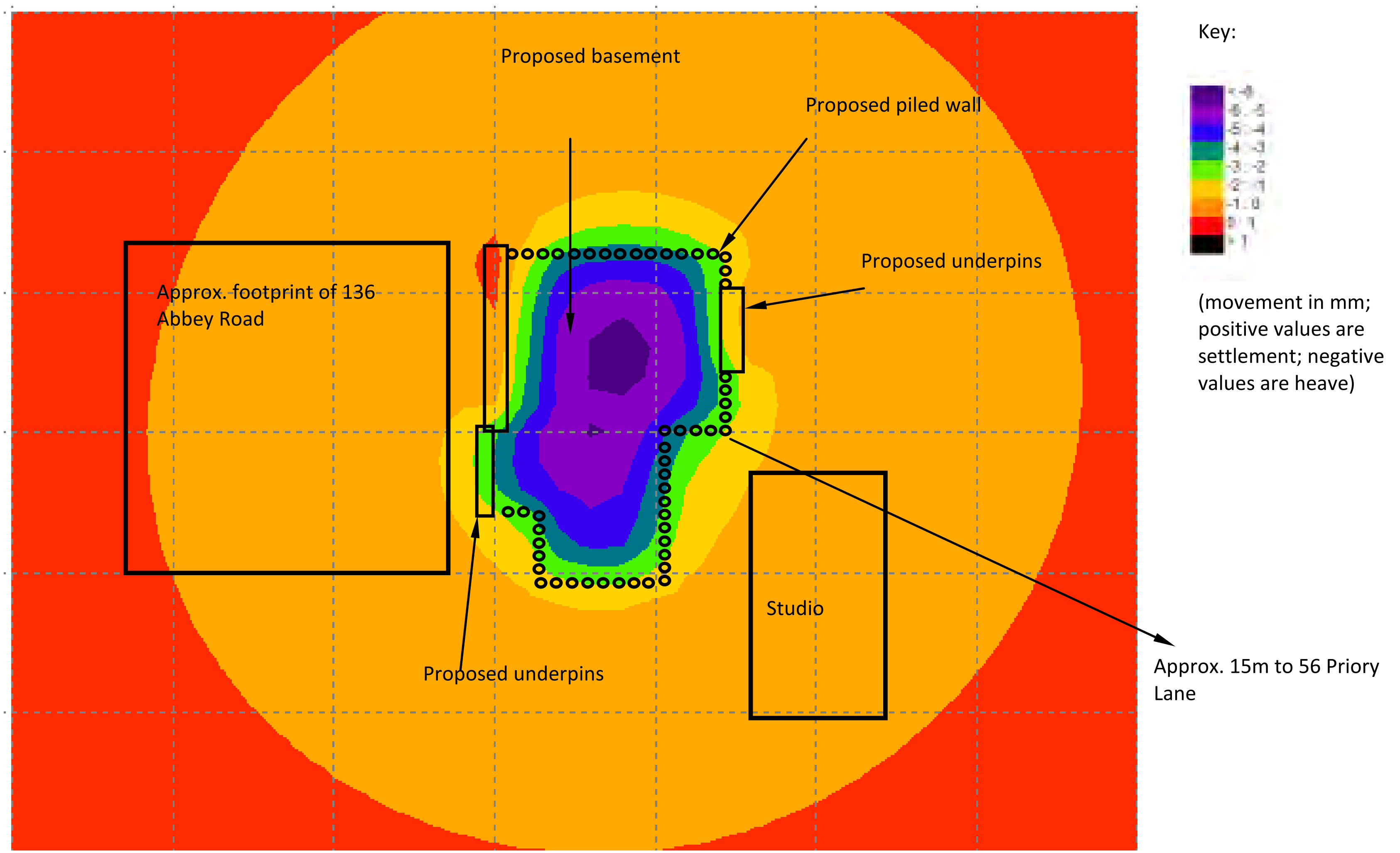
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Exploratory hole location plan**	**Figure 4**



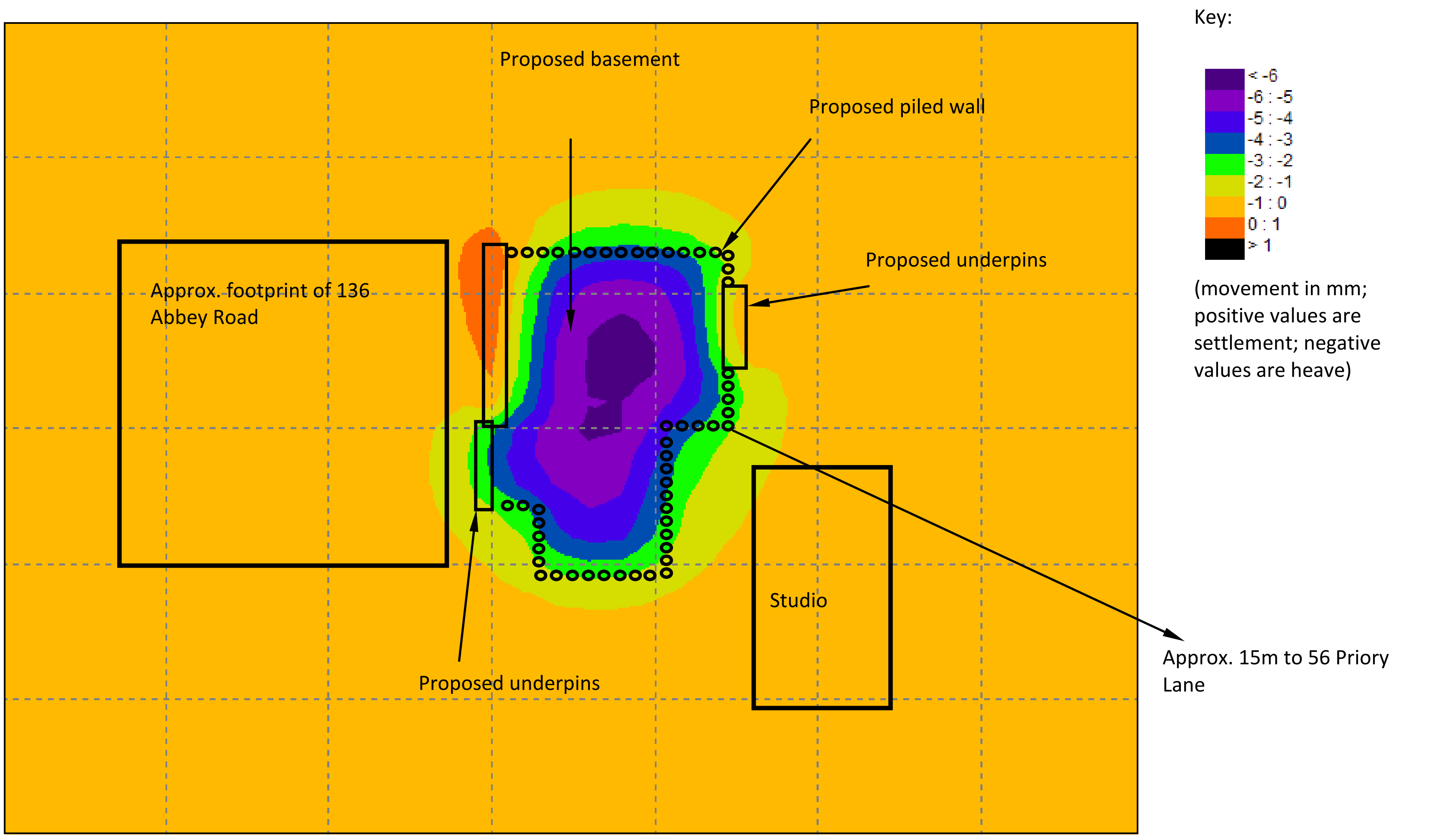
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **SPT 'N' versus level**	**Figure 5**



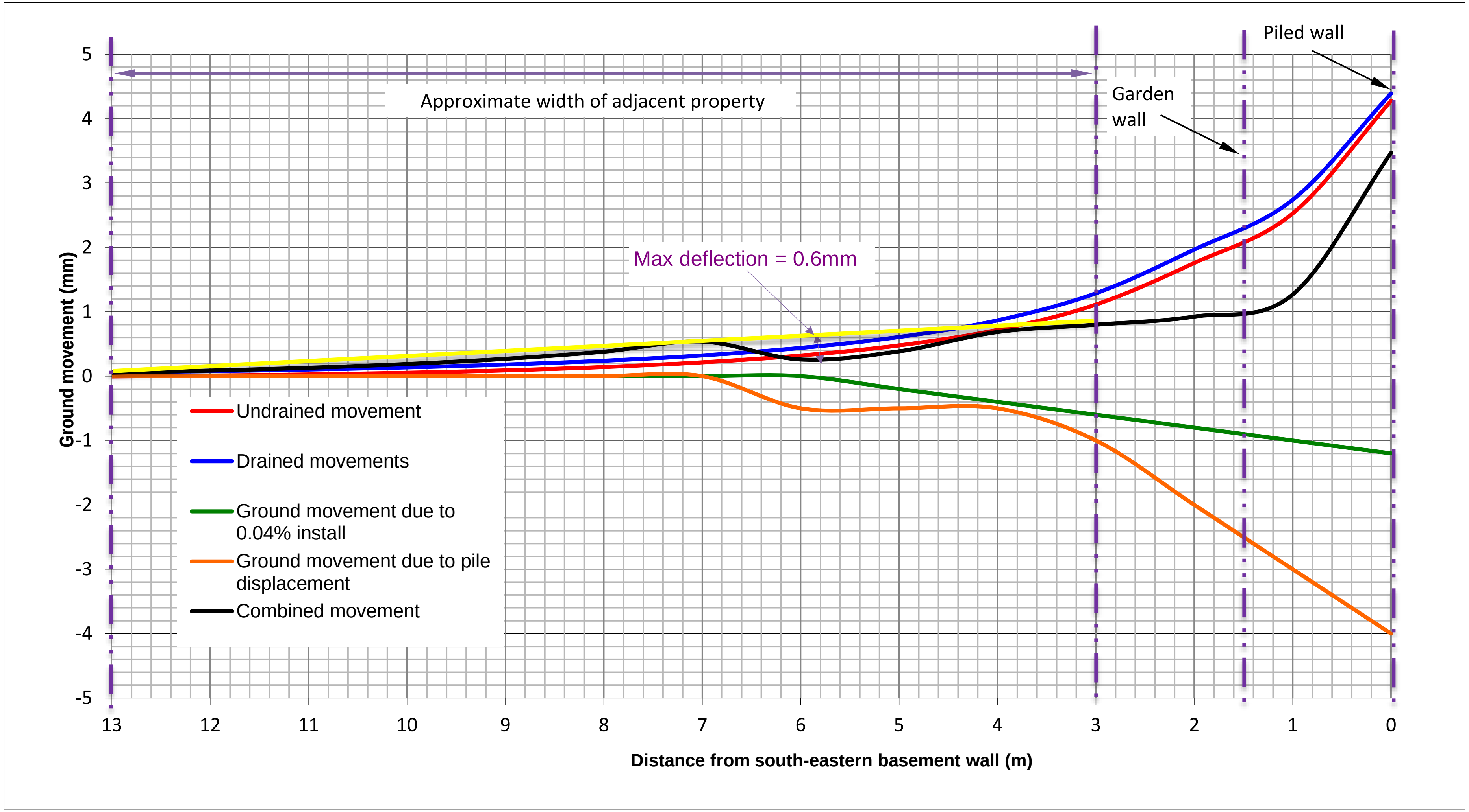
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **c_u versus level**	**Figure 6**



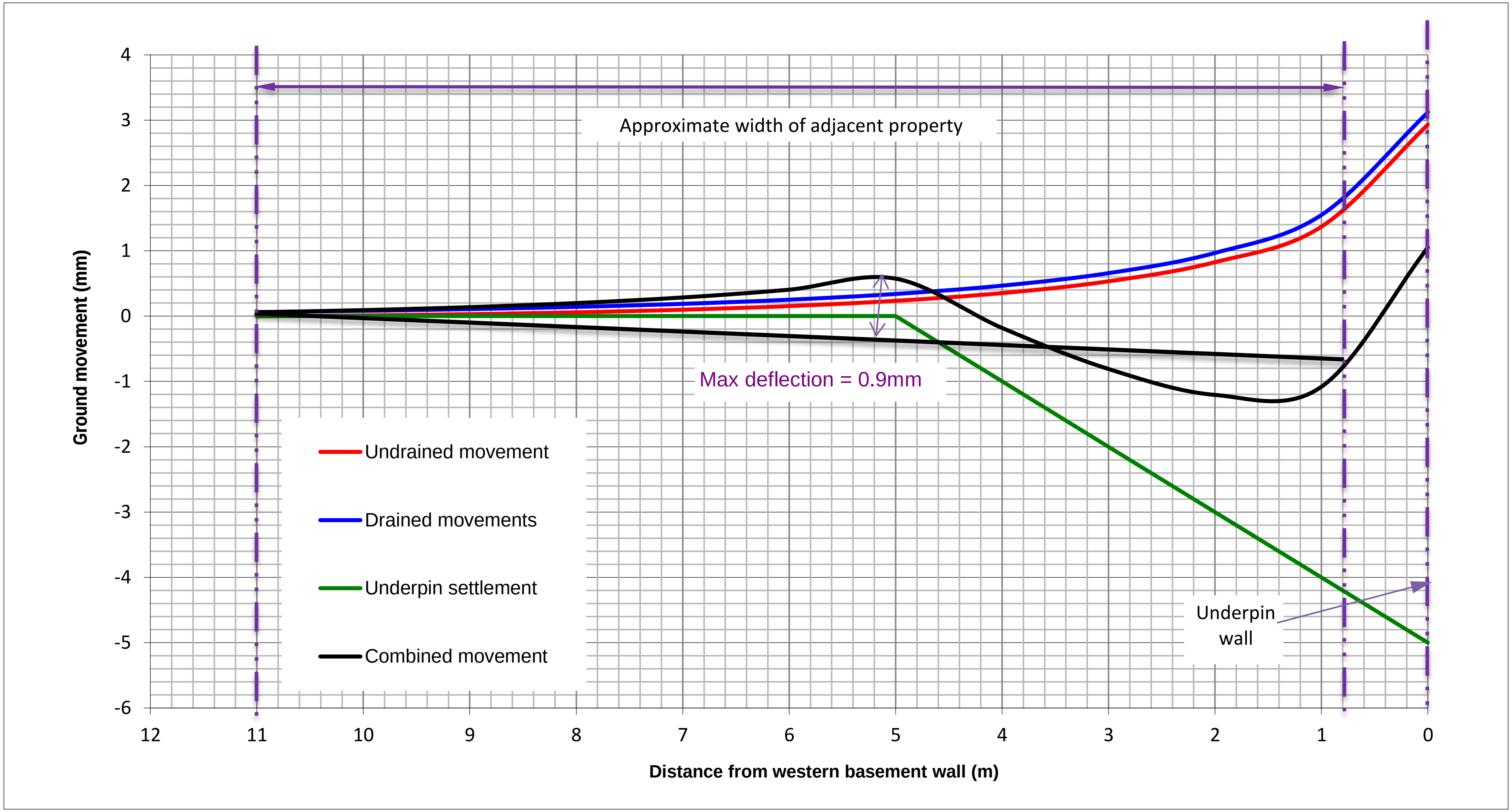
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Short term ground movement**	**Figure 7**



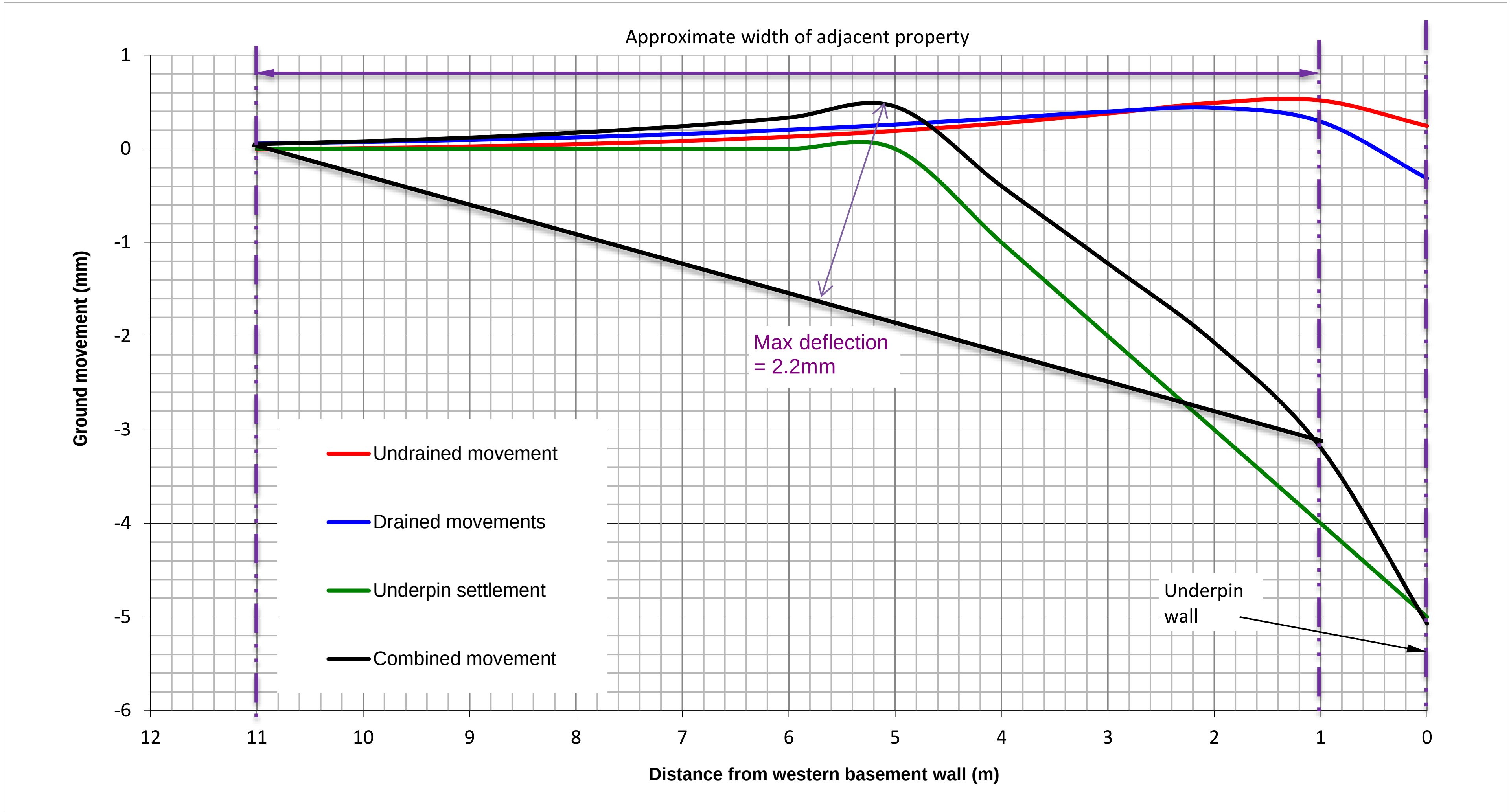
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Long term ground movement**	**Figure 8**



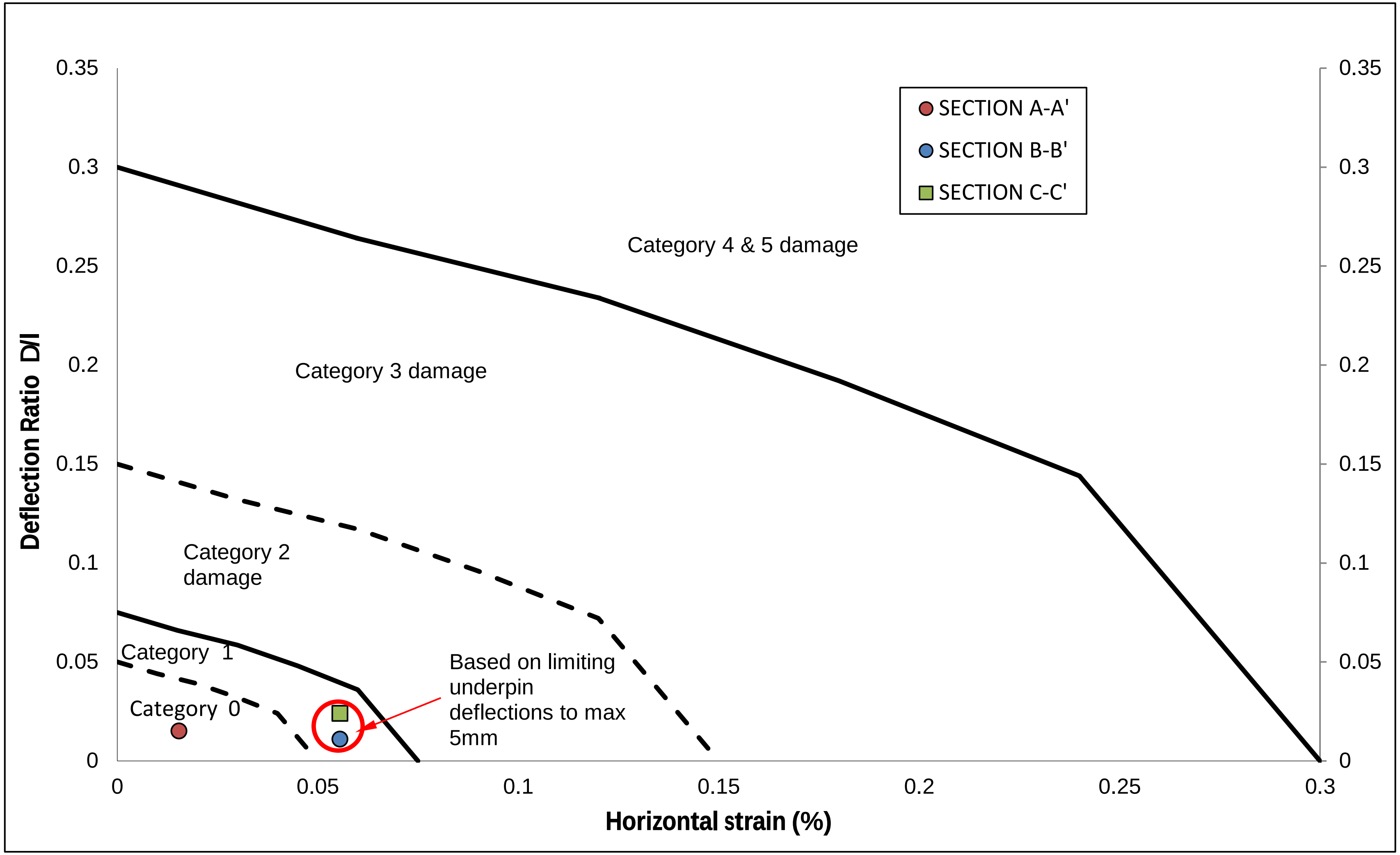
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Combined vertical movements Section A-A**	**Figure 9**



Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Combined vertical movements Section B-B**	**Figure 10**



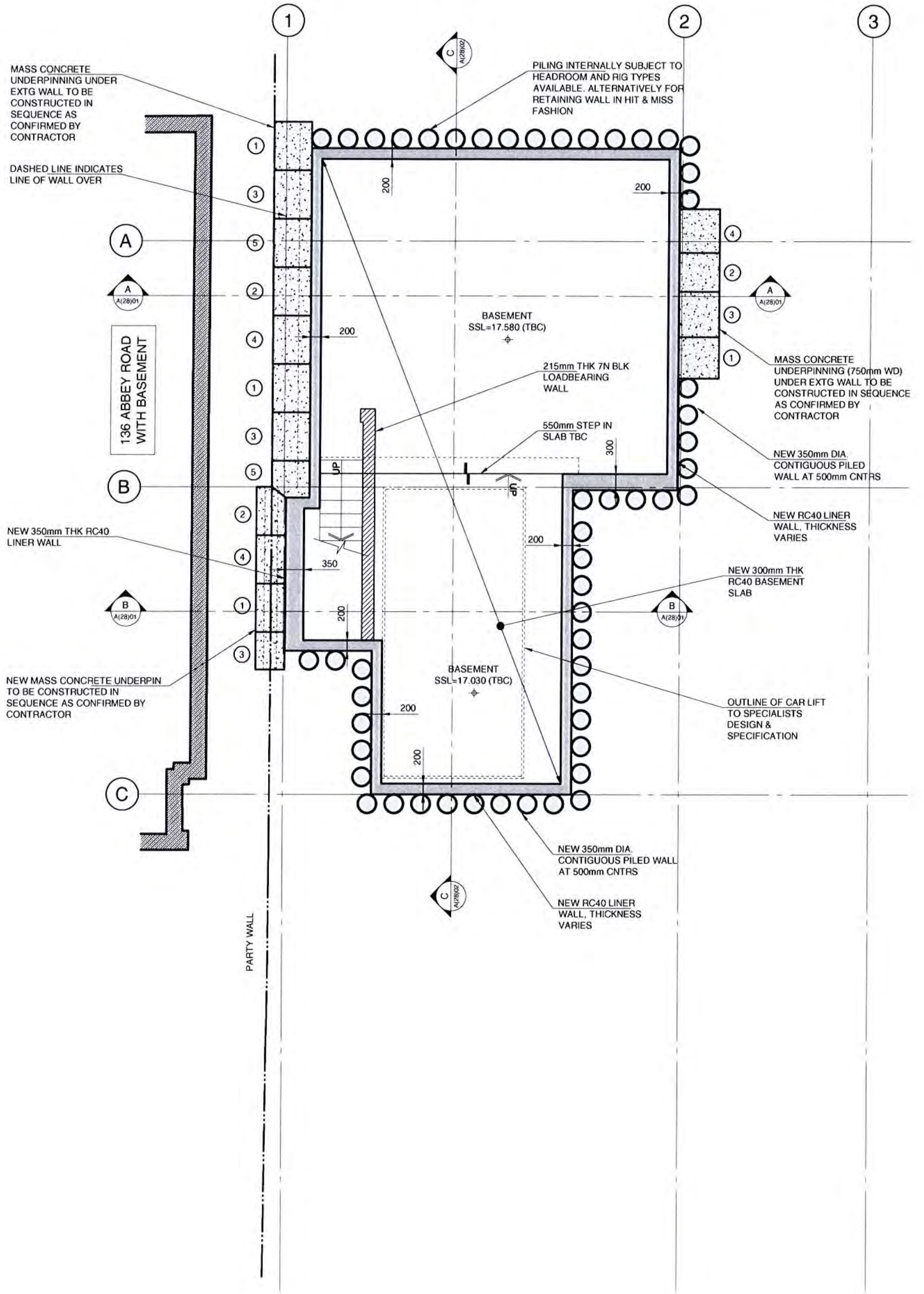
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Combined vertical movements Section C-C**	**Figure 11**



Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road, Camden, London**	**CG/08624**
CGL	Title **Building Interaction Chart**	**Figure 12**

APPENDIX A

Proposed development plan



PROPOSED BASEMENT LEVEL PLAN

1:50 @ A1

0m 1.0m 2.0m 3.0m 4.0m 5.0m

Notes

THIS DRAWING IS COPYRIGHT OF FORM.

DO NOT SCALE FROM THIS DRAWING WORK ONLY TO FIGURED DIMENSIONS.

THE CONTRACTOR IS TO VERIFY ALL DIMENSIONS ON SITE BEFORE COMMENCING WORK. ALL ERRORS AND OMISSIONS ARE TO BE REPORTED TO THE ENGINEER.

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS, SERVICES ENGINEERS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.

KEY

WALL TYPES

EXISTING WALL.

EXISTING WALL TO BE REMOVED.

NEW 7N/mm² MEDIUM DENSE BLOCKWORK IN DESIGNATION (iii) MORTAR.

NEW NON LOAD BEARING PARTITION.

LOAD BEARING WALL UNDER.

NEW BRICKWORK TO BE FULLY TOOTHED IN AND PACKED UP TO EXISTING BRICKWORK.

W STAINLESS STEEL WALL EXTENSION PROFILES.

ALL MASONRY BELOW DPC LEVEL TO BE FROST RESISTANT AND IN DESIGNATION (i) MORTAR.

LEGEND

DENOTES SPAN OF NEW 150mm THK RC40 CONCRETE SLAB

DENOTES SPAN OF NEW 175mm THK RC40 CONCRETE SLAB

NOT FOR CONSTRUCTION

Rev	Date	Amendment	Drawn	Chkd
P1	18.03.14	PRELIMINARY ISSUE	CC	RJM

Drawing Status: PRELIMINARY

Form

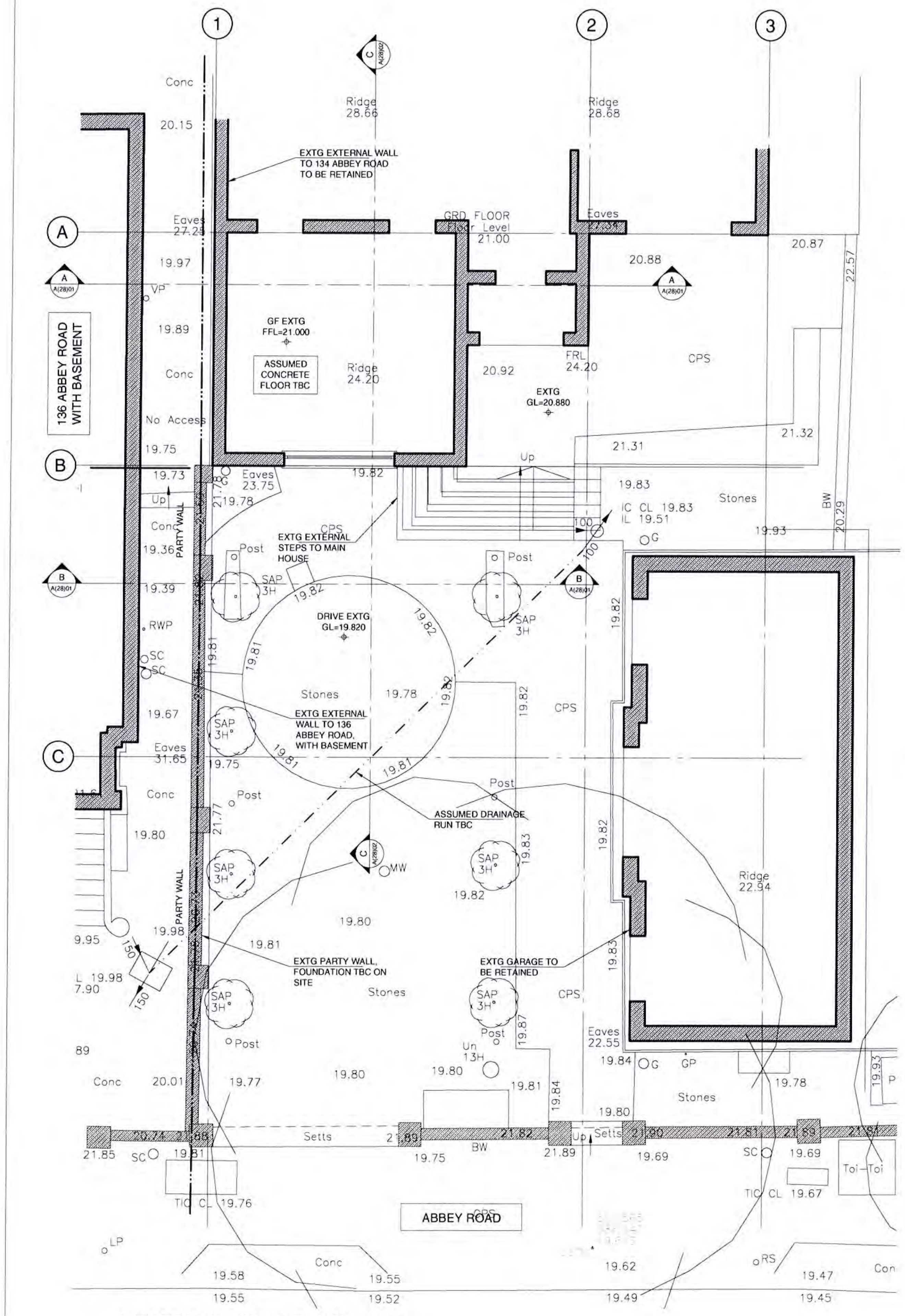
Job Title
134 1/2 ABBEY ROAD,
LONDON,
NW6

Drawing Title
PROPOSED BASEMENT PLAN

Form Structural Design Ltd 77 St John Street London EC1M 4NN
T 020 7253 2893 E studio@form-sd.com W www.form-sd.com

Date	Scale	Drawn	Checked
FEB 14	1:50 (A1)	CC	RJM

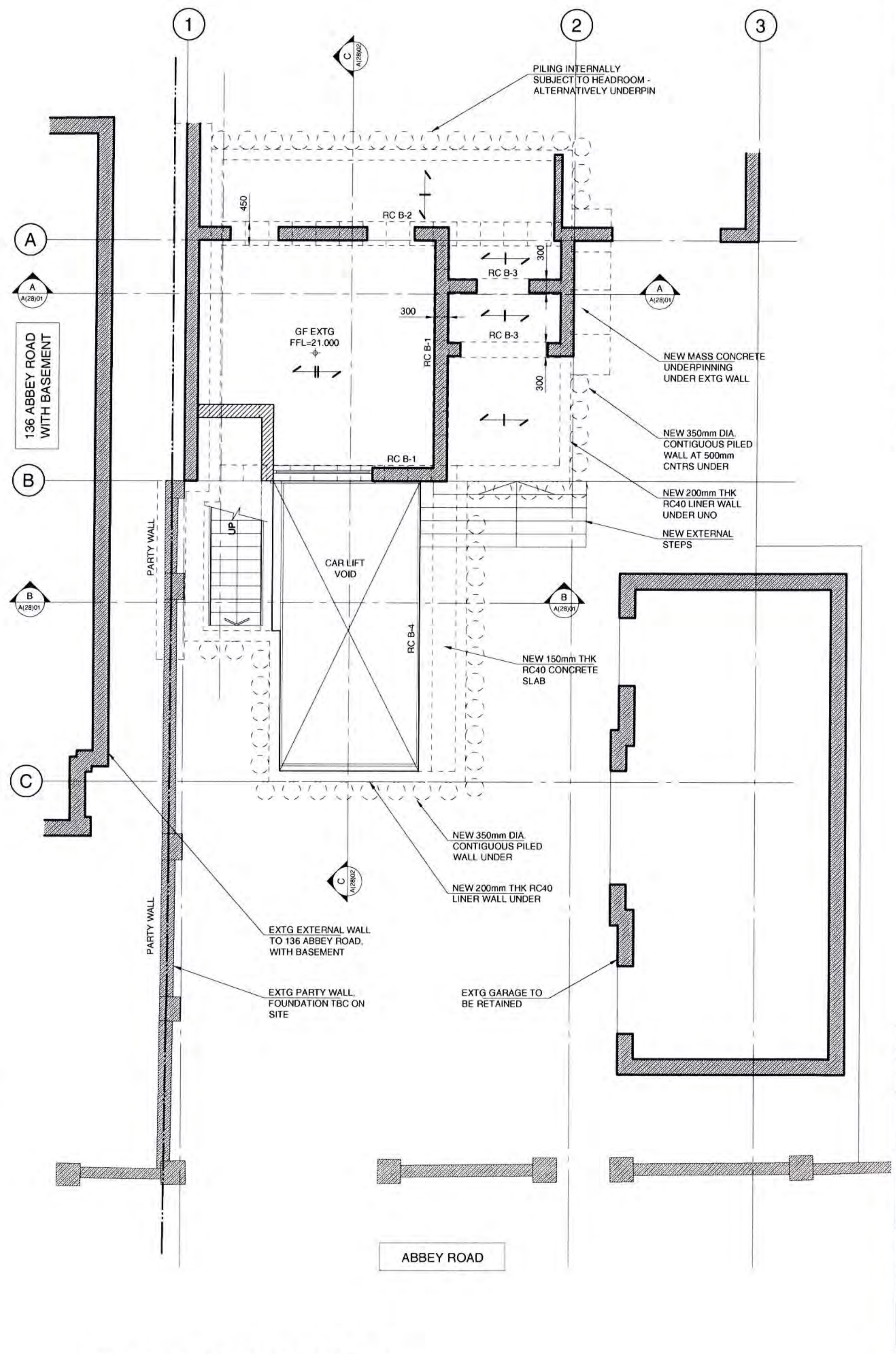
Job No	Drawing No	Revision
132085	L(23)01	P1



EXISTING GROUND FLOOR PLAN

1:50 @ A1

0m 1.0m 2.0m 3.0m 4.0m 5.0m



PROPOSED GROUND FLOOR PLAN

1:50 @ A1

Notes

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THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS, SERVICES ENGINEERS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.

KEY

WALL TYPES

- EXISTING WALL.
- EXISTING WALL TO BE REMOVED.
- NEW 7N/mm² MEDIUM DENSE BLOCKWORK IN DESIGNATION (iii) MORTAR.
- NEW NON LOAD BEARING PARTITION.
- LOAD BEARING WALL UNDER.
- NEW BRICKWORK TO BE FULLY TOOTHED IN AND PACKED UP TO EXISTING BRICKWORK.
- W — STAINLESS STEEL WALL EXTENSION PROFILES.

ALL MASONRY BELOW DPC LEVEL TO BE FROST RESISTANT AND IN DESIGNATION (i) MORTAR.

LEGEND

- DENOTES SPAN OF NEW 150mm THK RC40 CONCRETE SLAB
- DENOTES SPAN OF NEW 175mm THK RC40 CONCRETE SLAB

BEAM SCHEDULE

MARK	DESCRIPTION
RC B-1	PYNFORD TYPE STOOL ARRANGEMENT BEAM 300mm WD x 450mm DP
RC B-2	PYNFORD TYPE STOOL ARRANGEMENT BEAM 450mm WD x 500mm DP
RC B-3	300mm WD x 300mm DP BEAM
RC B-4	UPSTAND RC40 EDGE BEAM 250mm WD x 600mm DP

NOT FOR CONSTRUCTION

Rev	Date	Amendment	Drawn	Chkd
P1	18.03.14	PRELIMINARY ISSUE	CC	RJM

Drawing Status: PRELIMINARY

Form

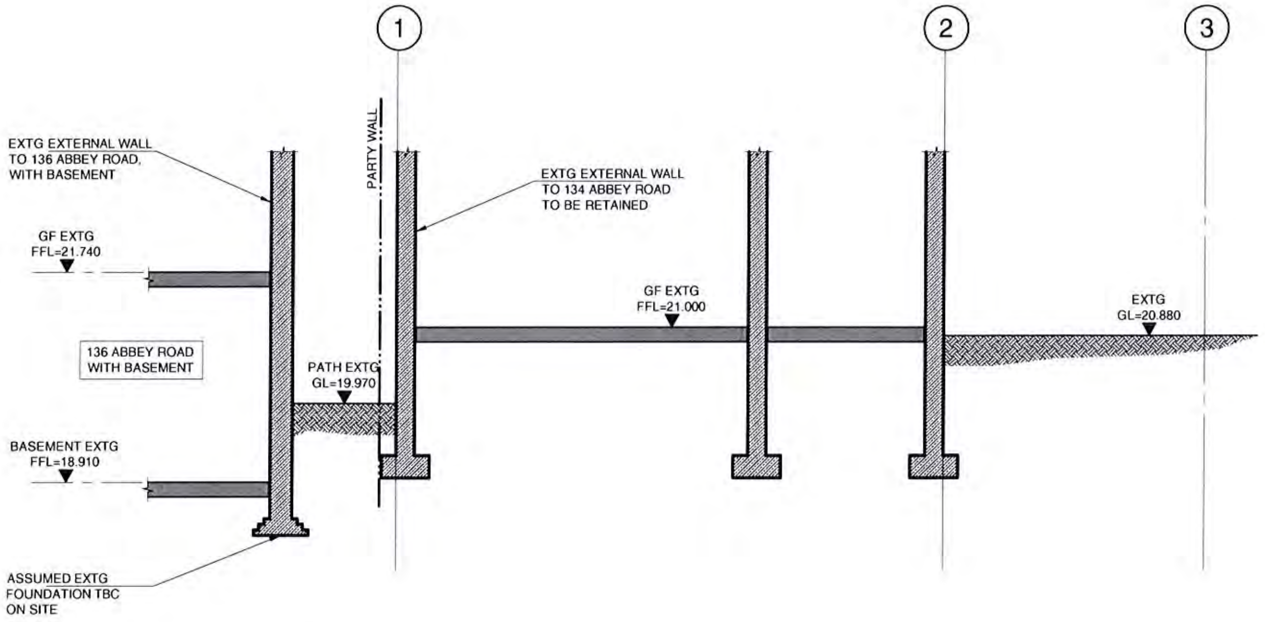
Job Title: 134 1/2 ABBEY ROAD, LONDON, NW6

Drawing Title: EXISTING & PROPOSED GROUND FLOOR PLAN

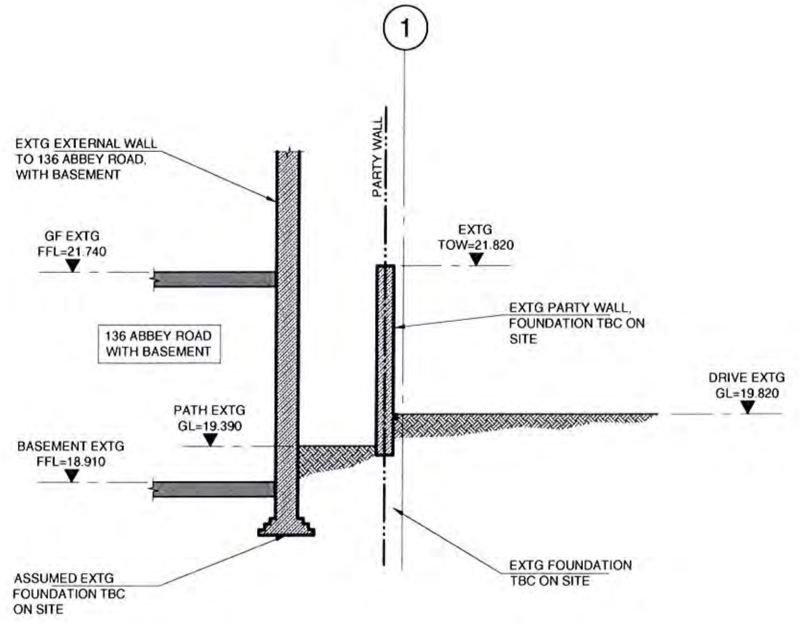
Form Structural Design Ltd 77 St John Street London EC1M 4NN T 020 7253 2893 E studio@form-sd.com W www.form-sd.com

Date	Scale	Drawn	Checked
FEB 14	1:50 (A1)	CC	RJM

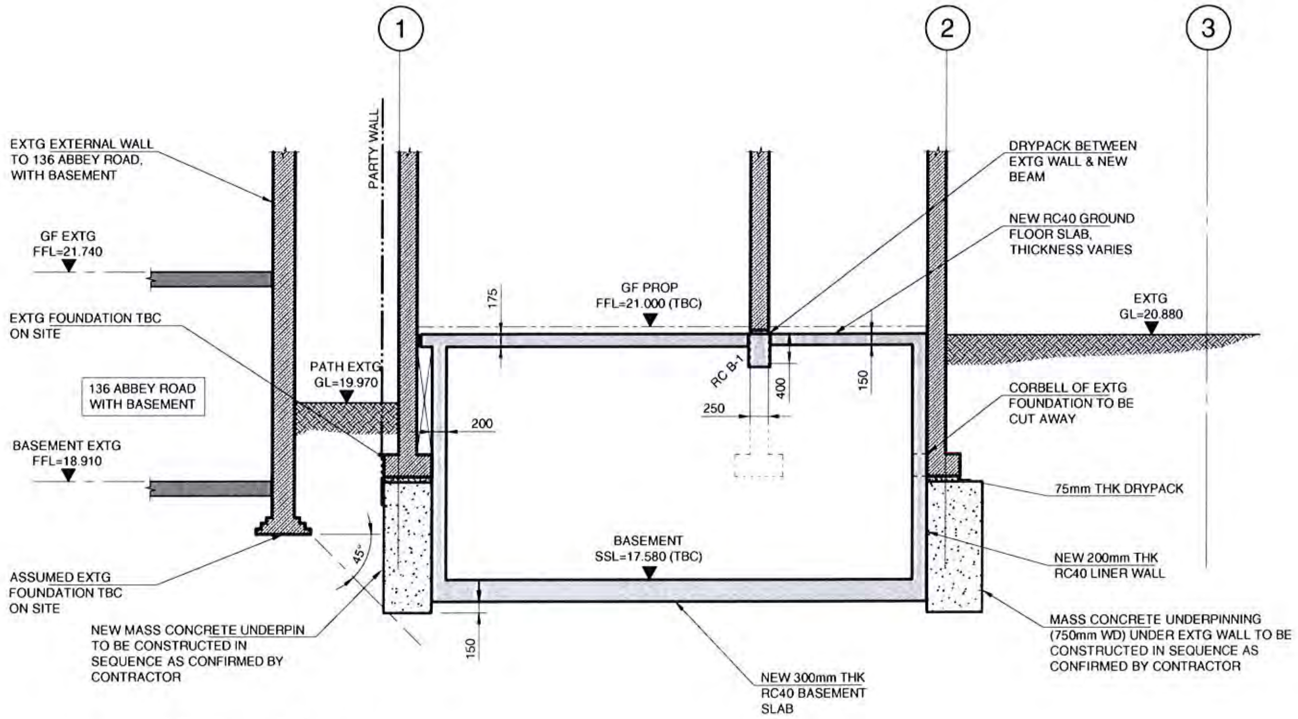
Job No	Drawing No	Revision
132085	L(23)02	P1



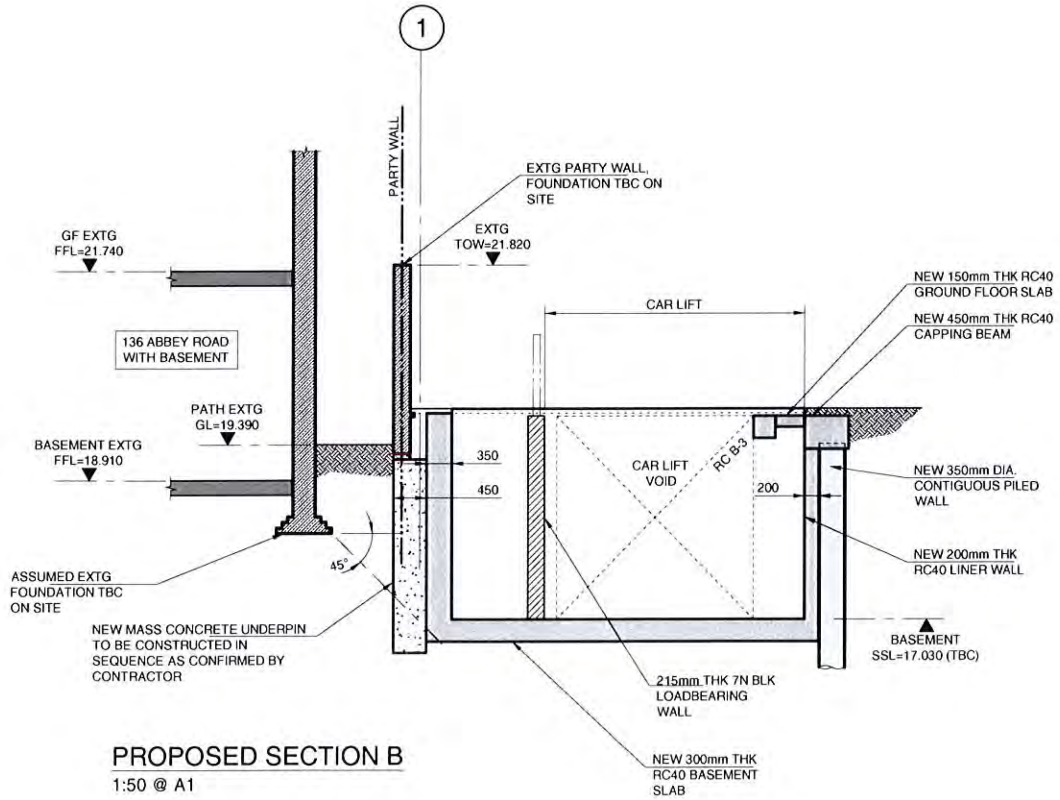
EXISTING SECTION A
1:50 @ A1



EXISTING SECTION B
1:50 @ A1



PROPOSED SECTION A
1:50 @ A1



PROPOSED SECTION B
1:50 @ A1

0m 1.0m 2.0m 3.0m 4.0m 5.0m

Notes

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BEAM SCHEDULE

MARK	DESCRIPTION
RC B-1	PYNFORD TYPE STOOL ARRANGEMENT BEAM 300mm WD x 450mm DP
RC B-2	PYNFORD TYPE STOOL ARRANGEMENT BEAM 450mm WD x 500mm DP
RC B-3	300mm WD x 300mm DP BEAM
RC B-4	UPSTAND RC40 EDGE BEAM 250mm WD x 600mm DP

NOT FOR CONSTRUCTION

Rev	Date	Amendment	Drawn	Chkd
P1	18.03.14	PRELIMINARY ISSUE	CC	RJM

Drawing Status: PRELIMINARY

Form

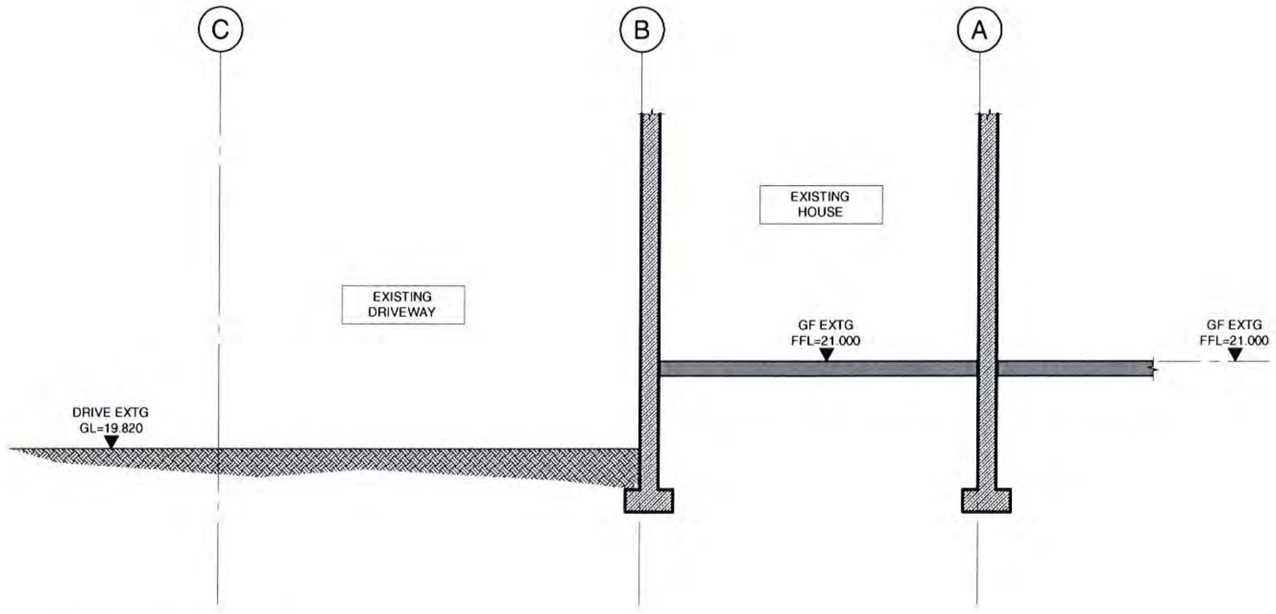
Job Title: 134 1/2 ABBEY ROAD, LONDON, NW6

Drawing Title: EXISTING & PROPOSED SECTIONS A & B

Form Structural Design Ltd 77 St John Street London EC1M 4NN
T 020 7253 2893 E studio@form-sd.com W www.form-sd.com

Date	Scale	Drawn	Checked
FEB 14	1:50 (A1)	CC	RJM

Job No	Drawing No	Revision
132085	A(28)01	P1



EXISTING SECTION C

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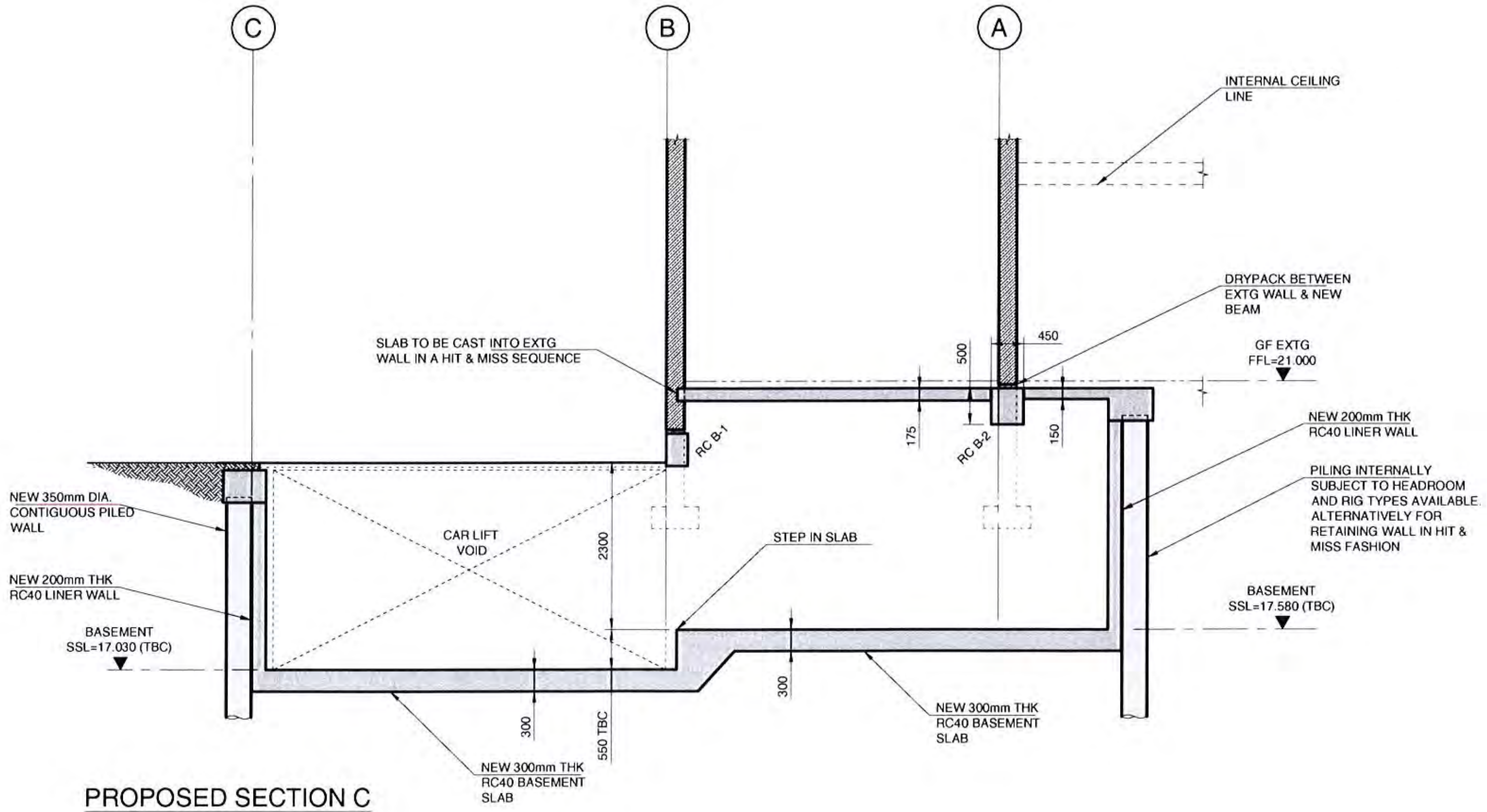
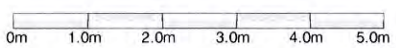


PROPOSED SECTION C

1:50 @ A1



Notes

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MARK	DESCRIPTION
RC B-1	PYNFORD TYPE STOOL ARRANGEMENT BEAM 300mm WD x 450mm DP
RC B-2	PYNFORD TYPE STOOL ARRANGEMENT BEAM 450mm WD x 500mm DP
RC B-3	300mm WD x 300mm DP BEAM
RC B-4	UPSTAND RC40 EDGE BEAM 250mm WD x 600mm DP

NOT FOR CONSTRUCTION

Rev	Date	Amendment	Drawn	Chkd
P1	18.03.14	PRELIMINARY ISSUE	CC	RJM

Drawing Status PRELIMINARY

Job Title

134 1/2 ABBEY ROAD,
LONDON,
NW6

Drawing Title

EXISTING & PROPOSED
SECTION C

Form Structural Design Ltd 77 St John Street London EC1M 4NN
T:020 7253 2893 E:studio@form-sd.com W:www.form-sd.com

Date	Scale	Drawn	Checked
FEB 14	1:50 (A1)	CC	RJM

Job No	Drawing No	Revision
132085	A(28)02	P1

APPENDIX B

BGS borehole records

BOREHOLE ONE

65 Priory Road, Hampstead

Date of boring *6-7 January, 1983*

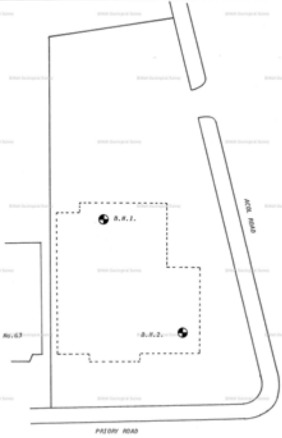
Diameter of boring : *200*mm

Lining tubes : *200* mm to *1.5* m.

Ground Level *-*

Description of Strata	Change of Strata: Legend	Change of Strata: Depth (m)	Change of Strata: Reduced Level (m)	S.P.T. C.P.T. N-value	Samples: Depth (m)	Samples: Type	Water Level (m)	Depth of Casing (m)
MADE GROUND Soft to firm brown clay with many broken bricks and de-composed mortar		1.00						
LONDON CLAY Firm slightly silty brown mottled grey CLAY with extensive close fissuring. Occassional clay stones.				SPT 5	1.50	J		1.50
		2.00						
					2.50 – 2.95	U100		
Becoming firm to stiff		3.00						
Very stiff slightly silty dark brown slightly mottled grey CLAY with some fissures and thin partings of grey fine silt					3.50 – 3.95	U100		
		4.00						
					4.50 – 4.95	U100		
Gypsum crystals from 5.00m		5.00						
		6.00		SPT27	6.00	J		
		7.00						
				SPT33	7.50	J		
		8.00						
Very stiff to hard slightly silty blue-grey CLAY with many large fissures. Some silty and sandy partings					8.75	J		
		9.00						
					9.50 – 9.95	U100	B.H. Dry	
Becoming hard		10.00						

APPENDIX A



65 PRIORY ROAD - BOREHOLE LOCATIONS

APPENDIX B.

Report No. 5.590

January 1983

BOREHOLE TWO

65 Priory Road, Hampstead

Date of boring 7th January, 1983

Diameter of boring = 200 mm

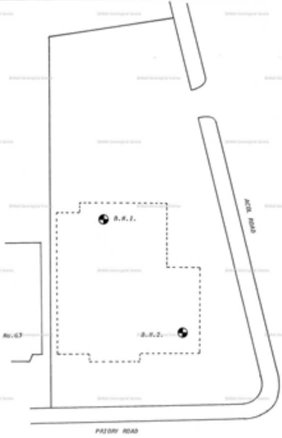
Lining tubes = 200 mm to 1.5 m.

Ground Level -

Description of Strata	Change of Strata: Legend	Change of Strata: Depth	Change of Strata: Reduced Level	S.P.T. C.P.T. N-value	Samples: Depth	Samples: Type	Water Level	Depth of Casing
		m	m		m		m	m
MADE GROUND Soft to firm brown clay with broken bricks and de-composed mortar (very wet)		1.00						
LONDON CLAY Soft silty brown CLAY with extensive grey mottling. Very weathered		2.00			1.50-1.95	U100		1.50
Becoming soft-firm					2.50-2.95	U100		
Becoming firm with many partings of sand and occasional fine roots.		3.00						
Firm to stiff dark brown slightly silty mottled grey CLAY with some fissuring and sandy partings		4.00			3.50-3.95	U100		
Becoming stiff at 4.00m Very stiff to hard					4.50-4.95	U100		
Gypsum crystals from 5.00m		5.00						
		6.00		SPT28	6.00	J		
		7.00						
Very stiff to hard slightly silty blue-grey CLAY with many large fissures. Some silty and sandy partings.		8.00			7.50-7.95	U100		
				SPT39	8.50	J		
		9.00						
					9.50-9.95	U100	B.H. Dry	
Becoming very hard		10.00						

APPENDIX A

Report No. [illegible] | BOREHOLE LOG | [illegible]



65 PRIORY ROAD - BOREHOLE LOCATIONS

APPENDIX B.

Report No. 5.590

January 1983

GEOLOGICAL SURVEY OF GREAT BRITAIN

RECORD OF SHAFT OR BORE FOR MINERALS

(For Survey use only)

6-inch Map Registered No. TQ28SE/377

Name of Shaft or Bore given by Geological Survey:

Name and Number given by owner: Abbey estate no 15.

Nat. Grid Reference 2572 8384

For whom made

Town or Village Hampstead County London

Exact site see plan { Attach a tracing from a map, or a sketch-map, if possible.

Purpose for which made Trial

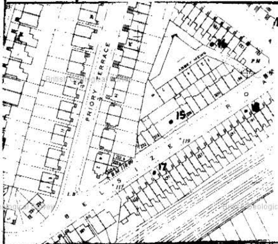
1" N.S.Map No.	1" O.S.Map No.	Confidential or not
256		

Ground Level at shaft/bore relative to O.D. If not ground level give O.D. of beginning of shaft/bore

Made by Date of sinking

Information from Date received

Examined by



…BERS AND ADDITIONAL NOTES

(For Survey use only) GEOLOGICAL CLASSIFICATION	DESCRIPTION OF STRATA	THICKNESS FT.	THICKNESS IN.	DEPTH FT.	DEPTH IN.
3'6"-5'0"	Brown fissured clay, blue in fissures with selenite crystals				
8'6"-10'0"	Brown fissured clay with selenite crystals				
13'6"-15'0"	Brown fissued clay with selenite crystals				
18'6"-20'0"	Brown fissured clay with selenite crystals				
23'6"-25'0"	Blue fissured clay				
28'6"-30'0"	Blue fissured clay				
33'6"-35'0"	Blue fissured clay				
38'6"-40'0"	Blue fissured clay				

(5412) Wt.32837/PS.154 2m 10/64

GEOLOGICAL SURVEY OF GREAT BRITAIN

RECORD OF SHAFT OR BORE FOR MINERALS

(For Survey use only)

6-inch Map Registered No. TQ28SE/378

Name of Shaft or Bore given by Geological Survey:

Name and Number given by owner: Abbey estate no. 16.

For whom made L.C.C.

Town or Village Hampstead County London

Exact site see plan filed under TQ28SE/377 (Attach a tracing from a map, or a sketch-map, if possible.)

Purpose for which made Trial

Nat. Grid Reference 25758390

1" N.S.Map No.	1" O.S.Map No.	Confidential or not
256		

Ground Level at shaft/bore relative to O.D. .... If not ground level give O.D. of beginning of shaft/bore ....

Made by .... Date of sinking ....

Information from .... Date received ....

Examined by ....

SPECIMEN NUMBERS AND ADDITIONAL NOTES

(For Survey use only) Geological Classification	Description of Strata	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
3'6"- 5'0"	Brown fissured clay with fine roots				
8'6"-10'0"	Brown fissured clay, blue in fissures with selenite crystals				
13'6"-15'0"	Brown fissured clay, blue in fissures with selenite crystals				
18'6"-20'0"	Brown fissured clay with selenite crystals				
23'6"-25'0"	Brown fissured clay with selenite crystals				
28'6"-30'0"	Blue fissured clay				
33'6"-35'0"	Blue fissured clay				
38'6"-40'0"	Blue fissured clay				

(5412) Wt.32837/PS.154 2m 10/64 G.W.B.Ltd. Gp.863

GEOLOGICAL SURVEY OF GREAT BRITAIN

RECORD OF SHAFT OR BORE FOR MINERALS

(For Survey use only)

6-inch Map Registered No. TQ28SE/379

Name of Shaft or Bore given by Geological Survey:

Name and Number given by owner: Abbey estate no 17

For whom made: LCC

Town or Village: Hampstead   County: London

Exact site: See plan with TQ28SE/377   Attach a tracing from a map, or a sketch-map, if possible.

Purpose for which made: Trial

Nat. Grid Reference: 2571.8380

1" N.S.Map No.	1" O.S.Map No.	Confidential or not
256		

Ground Level at shaft/bore relative to O.D. .... If not ground level give O.D. of beginning of shaft/bore ....

Made by .... Date of sinking ....

Information from .... Date received ....

Examined by ....

SPECIMEN NUMBERS AND ADDITIONAL NOTES

(For Survey use only) Geological Classification	Description of Strata	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
4'6"-6'0"	Brown fissured clay with fine roots				
9'6"-11'0"	Brown fissured clay, blue in fissures with selenite crystals				
14'6"-16'0"	Brown fissured clay, blue in fissures with selenite crystals				
19'6"-21'0"	Brown fissured clay with selenite crystals				
24'6"-26'0"	Brown fissured clay with selenite crystals				
29'6"-31'0"	Brown fissured clay with selenite crystals				
34'6"-36'0"	Blue fissured clay				
39'6"-41'0"	Blue fissured clay				
44'6"-46'0"	Blue fissured clay				

(5412) Wt.32837/PS.154 2m 10/64 G.W.B.Ltd. Gp.863

(For Survey use only)

6-inch Map Registered No. TQ285E/380

GEOLOGICAL SURVEY OF GREAT BRITAIN

RECORD OF SHAFT OR BORE FOR MINERALS

Name of Shaft or Bore given by Geological Survey:

Name and Number given by owner: Abbey estate no. 18

For whom made: L.C.C.

Town or Village: Hampstead County: London

Exact site: See plan with TQ285E/377 (Attach a tracing from a map, or a sketch-map, if possible.)

Purpose for which made: Trial

Nat. Grid Reference: 2575.8383

1" N.S.Map No.	1" O.S.Map No.	Confidential or not
256		

Ground Level at shaft/bore relative to O.D. If not ground level give O.D. of beginning of shaft/bore

Made by Date of sinking

Information from Date received

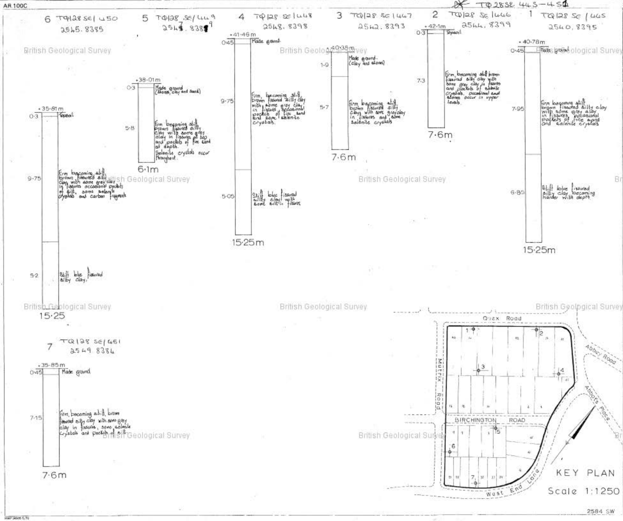
Examined by

SPECIMEN NUMBERS AND ADDITIONAL NOTES

(For Survey use only) Geological Classification	Description of Strata	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
9'6"-11'0"	Brown fissured clay, blue in fissures with selenite crystals and fine roots				
14'6"-16'0"	Brown fissured clay, blue in fissures with selenite crystals				
19'6"-21'0"	Brown fissured clay, blue in fissures with selenite crystals				
24'6"-26'0"	Brown fissured clay with selenite crystals				
29'6"-31'0"	Brown fissured clay with selenite crystals				
24'6"-36'0"	Blue fissured clay				
38'6"-40'0"	Blue fissured clay				

(5412) Wt.32837/PS.154 2m 10/64 G.W.B.Ltd. Gp.863

AR 100C



Size A2 16½" x 23⅜" — 420mm x 594mm

div	job no.	drg. no.	rev.
HO	746	01	

JOB
KILBURN VALE EST
BIRCHINGTON ROAD
CAMDEN

TITLE
TRIAL BORINGS 1–7
KEY PLAN & SECTIONS

scale VERTICAL 1 : 100

date	drawn	checked
18 · 8 · 1971	Ab.	H.C.T.

GLC ILEA
Dept of Architecture and Civic Design

Architect Roger Walters

01-633 5000 Ext. 8381

NOTES

1 Newlyn Datum Levels
2 –o– Denotes Trial Boring
3 Water was not encountered at the time of boring in March April 1971

REVISIONS

no.	date

COPY

reference

div.	job no.	drg. no.	rev.
HO	746	01	

Size A2 16½" x 23⅜" — 420mm x 594mm

APPENDIX C

Exploratory hole records

BOREHOLE LOG

CGL Card Geotechnics Limited

Project				BOREHOLE No
134.5 Abbey Road				**BH1**
Job No CG/08624	Date 19-11-13	Ground Level (m) 39.90	Co-Ordinates (m)	
Client Mr Mahmood Somani				Sheet 1 of 2

SAMPLES & TESTS			Water	STRATA				Instrument /Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	
0.10	B1					(0.50)	Medium dense dark brown very gravelly sand. Sand is fine to coarse. Gravel is fine to coarse subrounded to subangular of flint, brick and occasional ceramic. Occasional rootlets noted. [MADE GROUND]	
0.30	ES1							
0.30	B2			39.40		0.50		
0.50	B3						Firm medium strength friable dark orange brown mottled grey sandy CLAY. Sand is fine to coarse. [HEAD DEPOSITS] 0.60 - 1.20 Occasional gravel noted. Gravel is fine to medium subrounded to subangular of flint.	
0.60	ES2							
1.00	BC1							
1.00	HSV	50,50,60						
1.10	ES3							
1.50	D4					(2.00)		
1.50		N12						
2.00	BC2							
2.00	HSV	70,70,70						
2.25	B5							
				37.40		2.50		
2.50	U100	15 blows					Firm becoming stiff medium to high strength dark grey brown mottled grey CLAY. [LONDON CLAY FORMATION]	
3.00	B7						3.00 Occasional coarse sand sized selenite crystals noted. Occasional partings of fine to coarse orange sand.	
3.00	BC3							
3.25	B8							
3.50	D9							
3.50		N16						
4.00	BC4						4.00 Becoming stiff and high strength.	
4.00	HSV	80,80,60						
4.25	B10							
4.50	U100	20 blows						
5.00	BC5							

Boring Progress and Water Observations

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

General Remarks

1. Groundwater was encountered at 2.1mbgl.

2. ES = environmental sample, B = bulk sample, BC = Cling-filmed bulk sample, D = disturbed sample, HSV = hand shear vane, N = SPT 'N' value.

3. Installation details; 0.0 to 1.0mbgl: plain pipe with bentonite backfill, 1.0 to 4.0mbgl: slotted pipe with gravel backfill, 4.0 to 5.0mbgl: bentonite backfill, 5.0 to 10.0mbgl: arisings backfill.

4. Level estimated from topographical survey.

Method/ Plant Used	Field Crew	Logged By	Checked By
Pilcon 1 Ton	GWD	JJM	RJB

BOREHOLE LOG

Card Geotechnics Limited

Project				BOREHOLE No
134.5 Abbey Road				**BH1**
Job No: CG/08624	Date: 19-11-13	Ground Level (m): 39.90	Co-Ordinates (m):	
Client: Mr Mahmood Somani				Sheet: 2 of 2

SAMPLES & TESTS / STRATA

Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument /Backfill
5.00	HSV	70,80,80					Firm becoming stiff medium to high strength dark grey brown mottled grey CLAY. [LONDON CLAY FORMATION] *(continued)*	
5.25	B12							
5.50	D13							
5.50		N15						
6.00	BC6							
6.25	B14					(7.50)		
6.50	U100	24 blows						
7.00	B16							
7.00	BC7							
7.00	HSV	100,90,90						
7.25	B17							
7.50	D18							
7.50		N21						
8.00	BC8							
8.00	HSV	100,110,110						
8.25	B19							
8.50	U100	31 blows						
9.00	B21							
9.00	BC9							
9.00	HSV	110,90,120						
9.25	B22							
9.50	D23							
9.50		N25						
				29.90		10.00		
10.00	B24						*(Borehole terminated at 10m)*	
10.00	BC10							

Boring Progress and Water Observations

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

General Remarks

1. Groundwater was encountered at 2.1mbgl.

2. ES = environmental sample, B = bulk sample, BC = Cling-filmed bulk sample, D = disturbed sample, HSV = hand shear vane, N = SPT 'N' value.

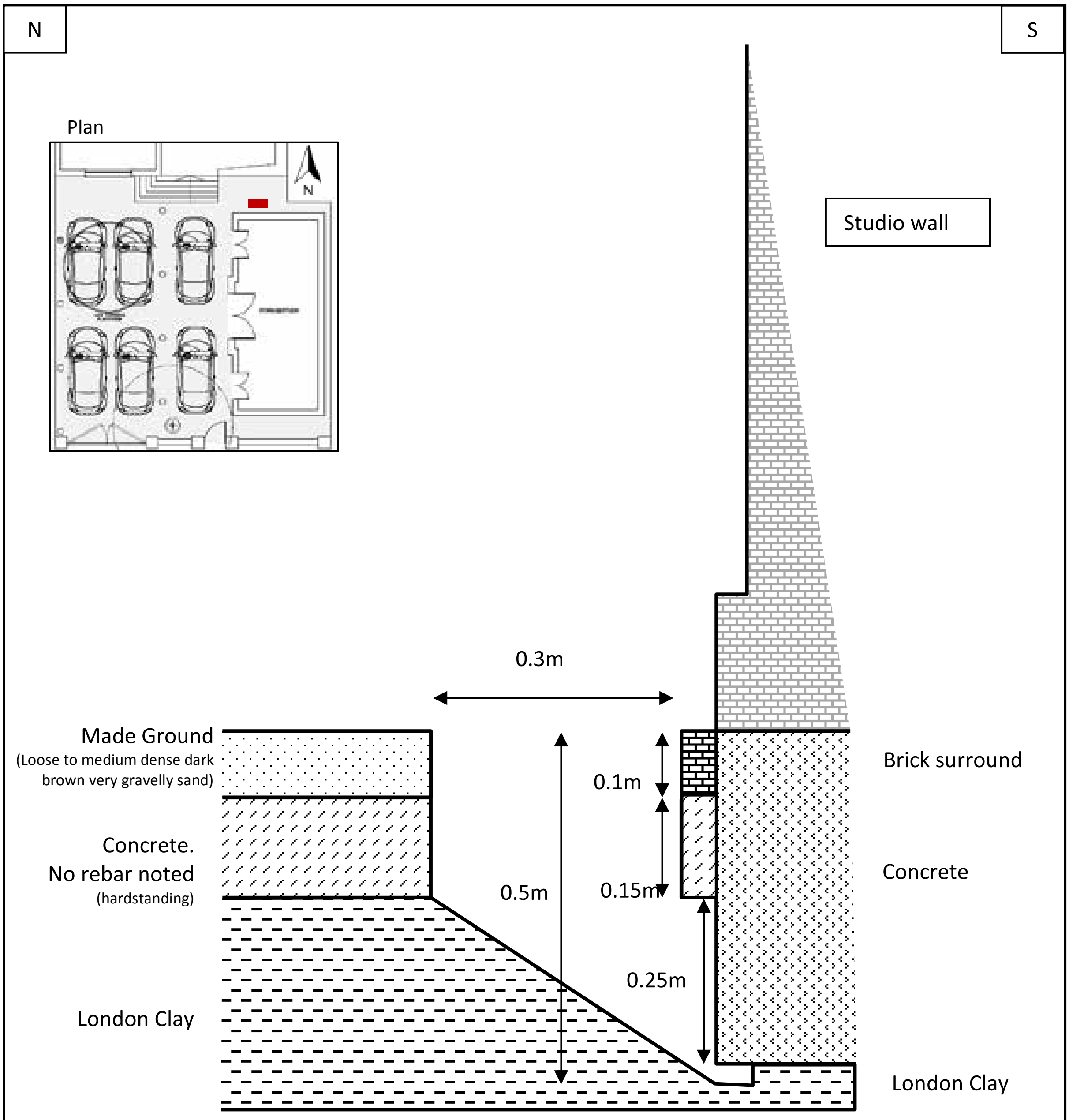
3. Installation details; 0.0 to 1.0mbgl: plain pipe with bentonite backfill, 1.0 to 4.0mbgl: slotted pipe with gravel backfill, 4.0 to 5.0mbgl: bentonite backfill, 5.0 to 10.0mbgl: arisings backfill.

4. Level estimated from topographical survey.

Method/Plant Used	Field Crew	Logged By	Checked By
Pilcon 1 Ton	GWD	JJM	RJB

APPENDIX D

Foundation inspection pit records



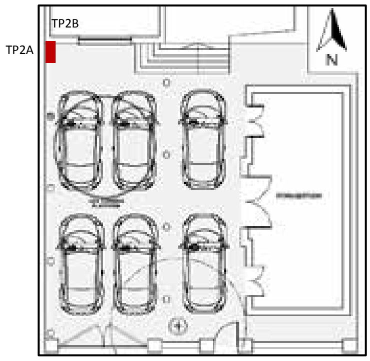
Not to scale

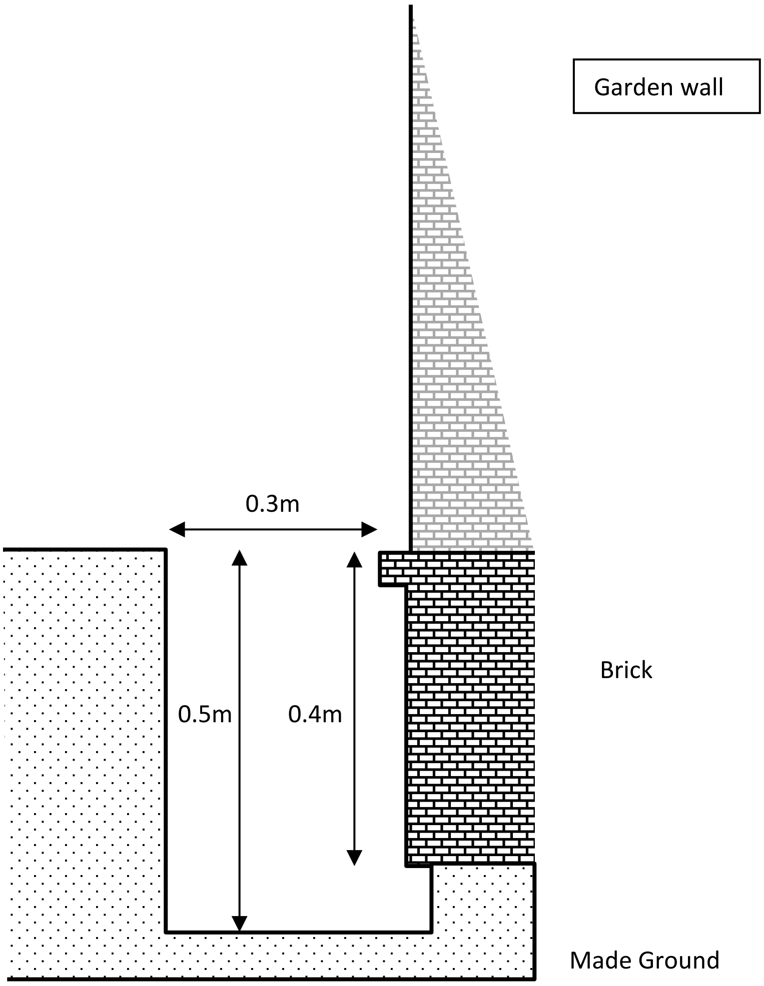
Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road**	**CG/08624**
CGL	Title **Foundation inspection pit sketch**	**TP1**

E

W

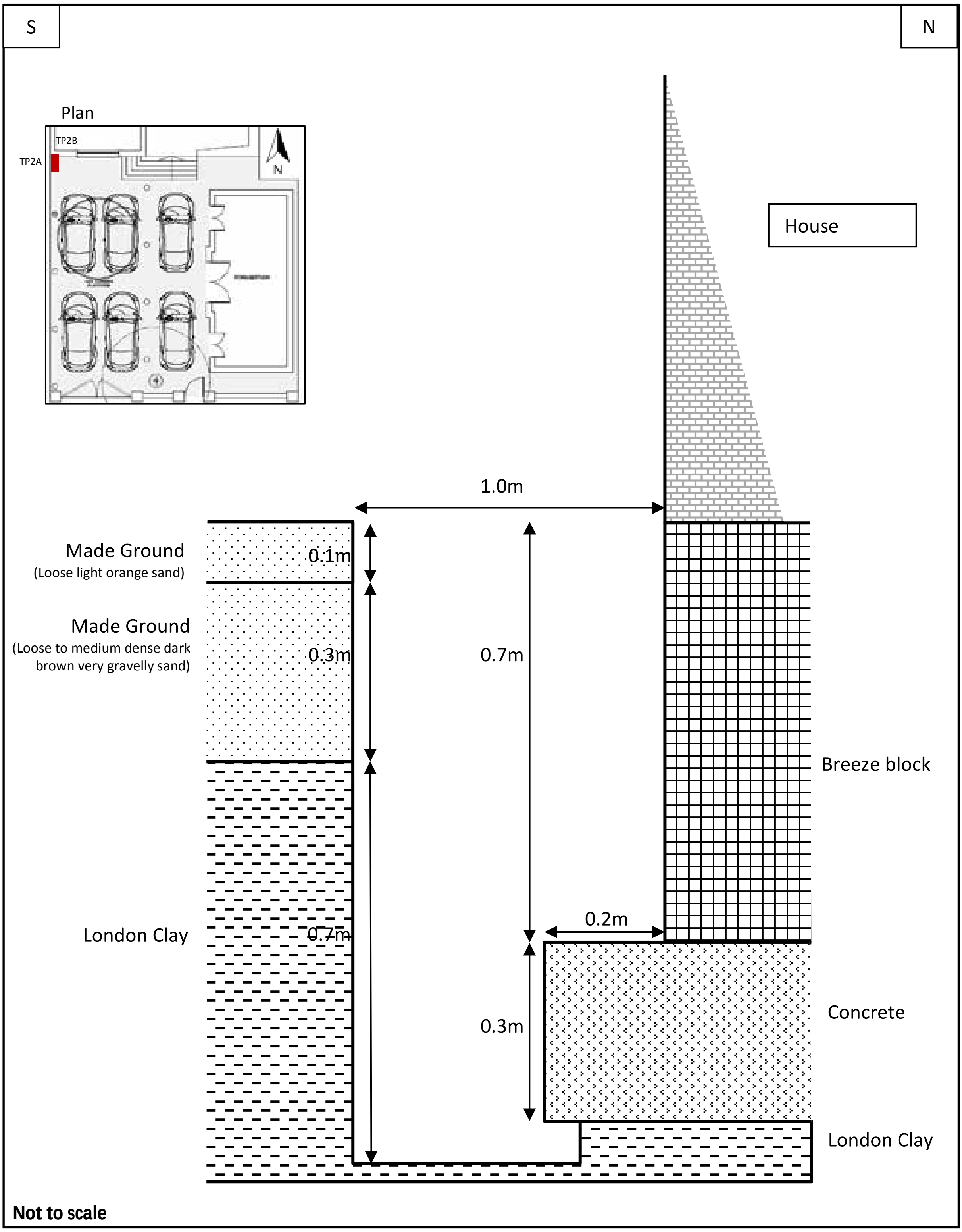
Plan





Not to scale

Client	Project	Job No
Mr M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road**	**CG/08624**
CGL	Title **Foundation inspection pit sketch**	**TP2A**



Client	Project	Job No
M Somani and Mrs C Lyndon-Somani	**134 ½ Abbey Road**	**CG/08624**
	Title **Foundation inspection pit sketch**	**TP2B**

APPENDIX E

Geotechnical laboratory analysis

RESULTS OF TRIAXIAL COMPRESSION TESTS

Contract: 134 ½ Abbey Road
Report no: T13/1239

BH No	Depth of Sample m	Description of Sample	INDEX PROPERTIES				TRIAXIAL COMPRESSION						
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Soil Classification	Code	Lateral Pressure kPa	Compression Strength kPa	Cohesion kPa	Angle of Friction (degrees)	Bulk Density kg/m^3	Water Content (% dry wt)
1	1.00	Brown clay with occasional gravel.	71	25	46	CV							24.4
	1.50	Brown clay, with occasional grey veining and occasional seams of selenite crystals.											32.7
	2.00	Brown clay with occasional grey veining and very occasional selenite crystals.											31.0
	2.50-2.95	Brown clay, with occasional grey veining and selenite crystals.					100U	50	100	50	0	2040	33.5
	3.00	Brown clay with occasional grey partings and occasional selenite crystals.	75	29	46	CV							32.2
	3.50	Dark brown clay with occasional selenite crystals.											31.7
	4.00	Dark brown clay with occasional selenite crystals.											32.4

TRIAXIAL COMPRESSION TEST CODE: 38-38mm dia specimen 100-100mm dia specimen
U-Undrained CD-Consolidated Drained CU-Consolidated Undrained P-Pore water pressure measurement M-Multistage F-Functional R-Remoulded LV-Laboratory Vane Test

BH No	Depth of Sample m	Description of Sample	INDEX PROPERTIES				TRIAXIAL COMPRESSION						
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Soil Classification	Code	Lateral Pressure kPa	Compression Strength kPa	Cohesion kPa	Angle of Friction (degrees)	Bulk Density kg/m^3	Water Content (% dry wt)
1	4.50-4.95	Brown clay, with occasional pockets of red-brown silt and selenite crystals.					100U	90	170	85	0	2055	32.0
	5.00	Brown clay with occasional selenite crystals.	78	29	49	CV							32.3
	6.50-6.95	Dark brown clay.	77	27	50	CV	100U	130	270	135	0	2090	29.4
	8.50-8.95	Dark grey-brown clay.					100U	170	270	135	0	2150	27.1

TRIAXIAL COMPRESSION TEST CODE: 38-38mm dia specimen 100-100mm dia specimen **REMARKS**

U-Undrained CD-Consolidated Drained CU-Consolidated Undrained P-Pore water pressure measurement

M-Multistage F-Functional R-Remoulded LV-Laboratory Vane Test

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Card Geotechnics Ltd
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GU7 1XW

t: 01483 310600
f: 01483 527285
e: adamc@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 : 13-48400

Project / Site name:	134 1/2 Abeby Road	**Samples received on:**	21/11/2013
Your job number:	CG-08624	**Samples instructed on:**	21/11/2013
Your order number:	CG/08624/ADC002	**Analysis completed by:**	02/12/2013
Report Issue Number:	1	**Report issued on:**	02/12/2013
Samples Analysed:	3 soil samples		

Signed:

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

Signed:

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

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

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

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

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

Analytical Report Number: 13-48400

Project / Site name: 134 1/2 Abeby Road
Your Order No: CG/08624/ADC002

Lab Sample Number				299536	299537	299538		
Sample Reference				BH1	BH1	BH1		
Sample Number				BC1	BC2	BC4		
Depth (m)				1.00	2.00	4.00		
Date Sampled				19/11/2013	19/11/2013	19/11/2013		
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	16	22	22		
Total mass of sample received	kg	0.001	NONE	0.39	0.70	0.61		
General Inorganics								
pH	pH Units	N/A	MCERTS	7.1	7.2	7.1		
Total Sulphate as SO_4	mg/kg	100	ISO 17025	830	1400	60000		
Water Soluble Sulphate (Soil Equivalent)	g/l	0.0025	MCERTS	0.49	1.5	10		
Water Soluble Sulphate as SO_4 (2:1)	mg/kg	2.5	MCERTS	490	1500	10000		
Water Soluble Sulphate (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.25	0.74	5.1		
Total Sulphur	mg/kg	100	NONE	350	490	28000		

Analytical Report Number : 13-48400

Project / Site name: 134 1/2 Abeby 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 topsoil/loam soil types. Data for unaccredited types of solid should be interpreted with care.
Stone content of a sample is calculated as the % weight of the stones not passing a 2 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
299536	BH1	BC1	1.00	Light brown clay.
299537	BH1	BC2	2.00	Light brown clay.
299538	BH1	BC4	4.00	Light brown clay.

Analytical Report Number : 13-48400

Project / Site name: 134 1/2 Abeby 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	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight. Sample	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 extraction with water followed by ICP-OES. Results reported corrected for extraction ratio (soil equivalent) as g/l and mg/kg; and upon the 2:1	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L038-PL	D	MCERTS
Total sulphate (as SO4 in soil)	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L038-PL	D	ISO 17025
Total Sulphur in soil	Determination of total sulphur in soil by extraction with aqua-regia, potassium bromide/bromate followed by ICP-OES.	In-house method based on BS1377 Part 3, 1990, and MEWAM 2006 Methods for the Determination of Metals in Soil	L038-PL	D	NONE

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.

APPENDIX F

Monitoring record

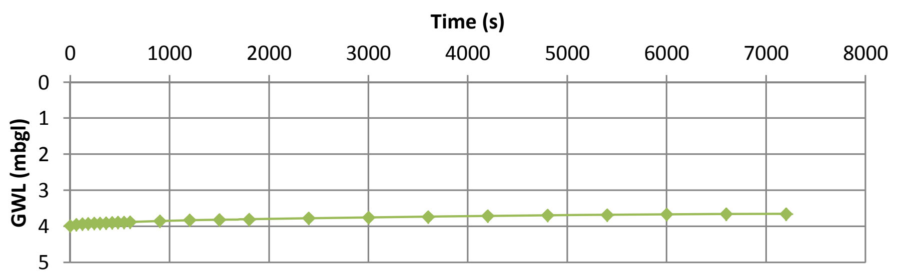
Rising Head Test - BH01

134 1/2 Abbey Road

CG/08624

29-Nov-13

Time (mins)	Time(s)	Depth (m)	H (m)	H/Ho
0	0	3.98	2.75	1
1	60	3.95	2.72	0.9890909
2	120	3.93	2.7	0.9818182
3	180	3.92	2.69	0.9781818
4	240	3.91	2.68	0.9745455
5	300	3.91	2.68	0.9745455
6	360	3.9	2.67	0.9709091
7	420	3.89	2.66	0.9672727
8	480	3.885	2.655	0.9654545
9	540	3.88	2.65	0.9636364
10	600	3.875	2.645	0.9618182
15	900	3.85	2.62	0.9527273
20	1200	3.825	2.595	0.9436364
25	1500	3.815	2.585	0.94
30	1800	3.8	2.57	0.9345455
40	2400	3.77	2.54	0.9236364
50	3000	3.75	2.52	0.9163636
60	3600	3.73	2.5	0.9090909
70	4200	3.705	2.475	0.9
80	4800	3.69	2.46	0.8945455
90	5400	3.68	2.45	0.8909091
100	6000	3.665	2.435	0.8854545
110	6600	3.65	2.42	0.88
120	7200	3.65	2.42	0.88



General Approach (After Horvslev 1951)

Initial GW depth	1.23	mbgl
Well depth	4.05	mbgl
Well pipe diameter	52	mm
F	0.143	intake Factor - Fig 6 BS5930
D	0.052	m - Diameter of standpipe
H1	2.75	m
H2	2.42	m
t1	0	s
t2	7200	s
A	0.002123717	m2

$$k = \frac{A}{F(t_2 - t_1)} \ln \frac{H_1}{H_2}$$

***k* = <u>2.63677E-07</u> m/s**

APPENDIX G

Structural loadings

Selina Adams

From: Rob Markovits <RobM@form-sd.com>
Sent: 17 March 2014 16:57
To: Andy O'Dea
Cc: Hazel Gillett; Adam Cadman; Charlotte Cattell
Subject: RE: 134 1/5 Abbey Road NW6 -draft scheme

HI Andy

Following our conversation I can advise that we shall be issuing our drawings in draft format tomorrow by Charlotte, the Architect is applying pressure to issue our report for planning along with your BIA report as soon as possible.

If you can aim to have your report to us next week and as early as possible that will help to keep things ticking over with the Architect.

For the time being allow for 125kN/m in the flank wall to 136 Abbey Road and to 134 ½ Abbey Road flank wall allow for 100kN/m.

The boundary party wall along gridline 1, allow for 15kN/m run.

Let me know if you need anything else.

thanks

Rob Markovits CEng MIStructE | Associate Director
DD: 020 7553 9358 | M: 07969 110 458 | E: robm@form-sd.com

FORM Structural Design | 77 St John Street | London | EC1M 4NN

T: 020 7253 2893 | F: 020 7608 0151 | E: studio@form-sd.com | W: www.form-sd.com

---

From: Andy O'Dea [mailto:AndyO@cgl-uk.com]
Sent: 28 February 2014 16:16
To: Rob Markovits
Cc: Hazel Gillett; Adam Cadman
Subject: RE: 134 1/5 Abbey Road NW6 -draft scheme

Rob

Please find attached DRAFT logs for 134 ½ Abbey Road.

Regards
Andy

APPENDIX H

WALLAP output - contiguous piled wall deflections

```
CARD GEOTECHNICS LIMITED                                        | Sheet No.
Program: WALLAP  Version 6.05  Revision A41.B56.R46             | Job No. CG/8624
                              Licensed from GEOSOLVE            | Made by :   ADC
Data filename/Run ID: Contig pile wall_Section BB_SLS           |
134 1/2 Abbey Road                                              | Date:27-03-2014
Section B-B' contig piled wall analysis                         | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
```

INPUT DATA

SOIL PROFILE

```
Stratum   Elevation of    ------------------ Soil types -------------------
  no.    top of stratum   Active side              Passive side
   1          19.80       1  MG                    1  MG
   2          19.30       2  Head                  2  Head
   3          17.30       4  LC                    4  LC
```

SOIL PROPERTIES

```
                      Bulk    Young's   At rest  Consol  Active  Passive
-- Soil type --     density  Modulus    coeff.  state.  limit    limit   Cohesion
No. Description      kN/m3   Eh,kN/m2     Ko    NC/OC    Ka       Kp      kN/m2
  (Datum elev.)             (dEh/dy ) (dKo/dy) (  Nu ) ( Kac ) (  Kpc ) ( dc/dy )
 1  MG               18.00          0   0.530     NC    0.318    3.868
                            (  880.0)         (0.200) (0.000) ( 0.000)
 2  Head             19.00      36000   0.609     NC    1.000    1.000     60.00u
                                              (0.490) (2.389) ( 2.390)
 3  Head -           19.00      27000   0.609     NC    0.392    2.914        0.0d
    drain                                     (0.200) (1.432) ( 4.509)
 4  LC               20.00      36000   0.642     OC    1.000    1.000     60.00u
    (   17.30 )             (   4500)         (0.490) (2.389) ( 2.390) (  7.500)
 5  LC - drai..      20.00      27000   0.642     OC    0.376    3.077     5.000d
    (   17.30 )             (   3375)         (0.200) (1.401) ( 4.665)
```

Additional soil parameters associated with Ka and Kp

```
                          --- parameters for Ka ---  --- parameters for Kp ---
                            Soil     Wall    Back-    Soil      Wall    Back-
------- Soil type ------- friction adhesion  fill   friction adhesion  fill
No. Description             angle    coeff.  angle    angle    coeff.  angle
 1  MG                      28.00    0.500   0.00     28.00    0.500   0.00
 2  Head                     0.00    0.500   0.00      0.00    0.500   0.00
 3  Head - drain            23.00    0.500   0.00     23.00    0.500   0.00
 4  LC                       0.00    0.500   0.00      0.00    0.500   0.00
 5  LC - drained            24.00    0.500   0.00     24.00    0.500   0.00
```

GROUND WATER CONDITIONS

```
 Density of water = 10.00 kN/m3
                                  Active side    Passive side
 Initial water table elevation       18.60           18.60

 Automatic water pressure balancing at toe of wall :  No

 Water            Active side                      Passive side
 press. ------------------------------  ------------------------------
profile Point   Elev.     Piezo   Water   Point   Elev.     Piezo   Water
  no.    no.              elev.   press.   no.              elev.   press.
                  m         m     kN/m2               m         m     kN/m2
   1      1     18.60     18.60     0.0     1     15.70     15.70     0.0 MC+WC
```

WALL PROPERTIES

```
                         Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = 13.70
             Maximum finite element length =  0.30 m
                  Youngs modulus of wall E = 3.0000E+07 kN/m2
               Moment of inertia of wall I = 1.4700E-03 m4/m run
                                       E.I = 44100 kN.m2/m run
                      Yield Moment of wall = Not defined
```

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	16.85	1.00	0.250000	3.000E+07	2.50	0.00	0	Yes
2	19.50	1.00	0.062500	2.000E+08	3.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	18.20	2.80(A)	3.00	0.80	156.00	=	N/A	1.00 -
2	18.60	3.60(A)	3.00	7.00	10.00	=	N/A	1.00 -
3	19.40	1.50(A)	3.00	0.30	50.00	=	N/A	1.00 -

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.3 at elevation 19.40
2	Apply surcharge no.1 at elevation 18.20
3	Apply surcharge no.2 at elevation 18.60
4	Change EI of wall to 44100 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
5	Apply water pressure profile no.1 (Mod. Conserv.)
6	Excavate to elevation 16.70 on PASSIVE side
7	Install strut or anchor no.1 at elevation 16.85
8	Change properties of soil type 2 to soil type 3 Ko pressures will be reset
9	Change properties of soil type 4 to soil type 5 Ko pressures will be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.20

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 5.000 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 5.00 m

Width of excavation on active side of wall = 4.00 m
Width of excavation on passive side of wall = 7.00 m

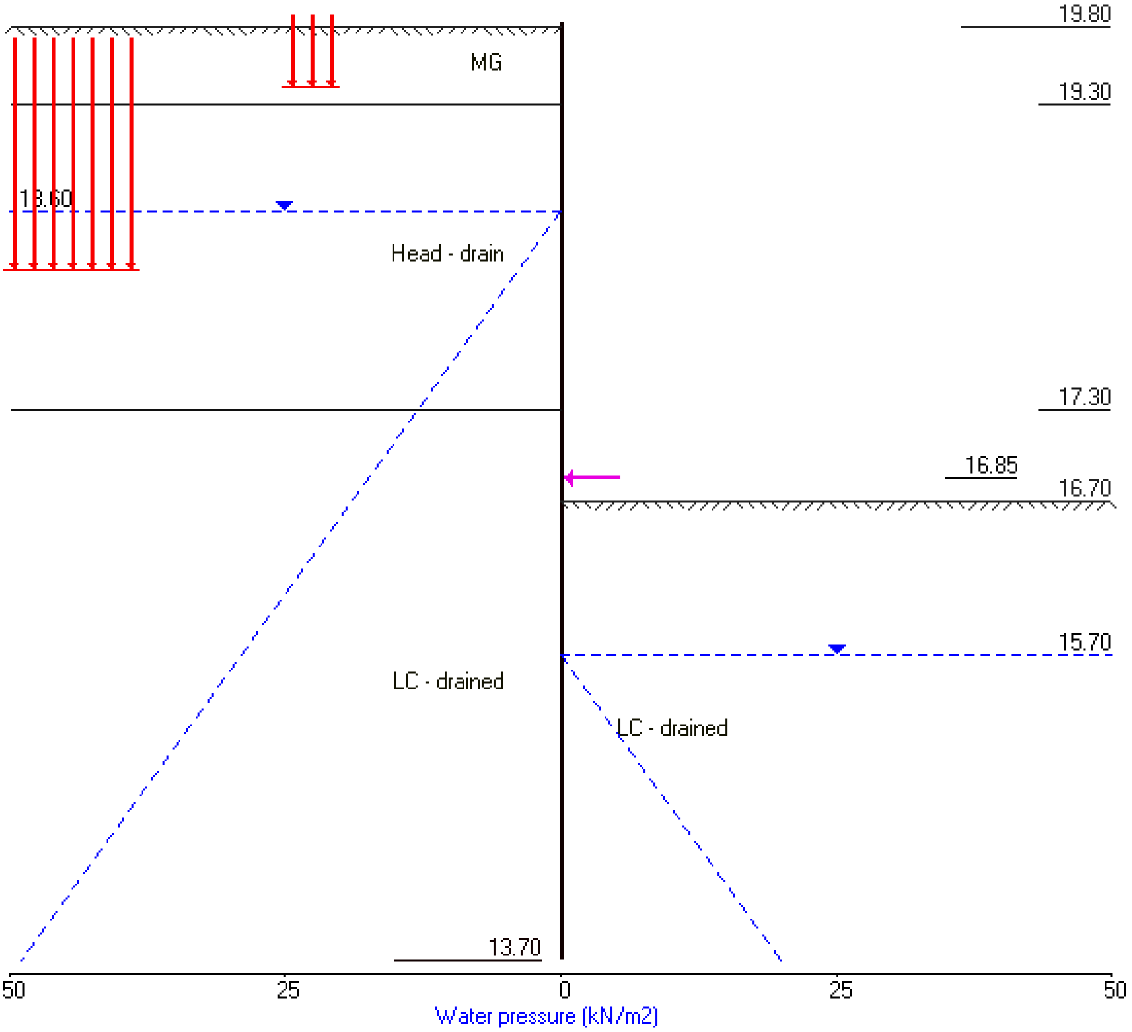
Distance to rigid boundary on active side = 30.00 m
Distance to rigid boundary on passive side = 7.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.3 at elev. 19.40	No	No	No
2	Apply surcharge no.1 at elev. 18.20	No	No	No
3	Apply surcharge no.2 at elev. 18.60	No	No	No
4	Change EI of wall to 44100kN.m2/m run	No	No	No
5	Apply water pressure profile no.1	No	No	No
6	Excav. to elev. 16.70 on PASSIVE side	Yes	Yes	Yes
7	Install strut no.1 at elev. 16.85	No	No	No
8	Change soil type 2 to soil type 3	No	No	No
9	Change soil type 4 to soil type 5	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

```
CARD GEOTECHNICS LIMITED                                       | Sheet No.
Program: WALLAP  Version 6.05  Revision A41.B56.R46            | Job No. CG/8624
                         Licensed from GEOSOLVE                | Made by :   ADC
Data filename/Run ID: Contig pile wall_Section BB_SLS          |
134 1/2 Abbey Road                                             | Date:27-03-2014
Section B-B' contig piled wall analysis                        | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
```

Stage No.9   Change soil type 4 to soil type 5



Units: kN,m

Stage No. 9 Change properties of soil type 4 to soil type 5
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 13.70: Factor of Safety	FoS for toe elev. = 13.70: Moment equilib. at elev.	Toe elev. for FoS = 1.200: Toe elev.	Toe elev. for FoS = 1.200: Wall Penetr -ation
9	19.80	16.70	16.85	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 5.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 30.00 from wall
Passive side 7.00 from wall

*** Wall displacements reset to zero at stage 4

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	19.80	0.00	0.008	2.11E-03	0.0	-0.0	
2	19.60	1.22	0.008	2.11E-03	0.1	0.0	
3	19.40	2.51	0.007	2.11E-03	0.5	0.1	
4	19.30	3.19	0.007	2.11E-03	0.8	0.1	
		8.02	0.007	2.11E-03	0.8	0.1	
5	19.10	9.30	0.006	2.11E-03	2.5	0.5	
6	18.90	10.62	0.006	2.11E-03	4.5	1.2	
7	18.60	12.68	0.005	2.09E-03	8.0	3.0	
8	18.40	15.29	0.005	2.07E-03	10.8	4.9	
9	18.20	17.86	0.005	2.05E-03	14.1	7.4	
10	17.95	21.01	0.004	1.99E-03	19.0	11.5	
11	17.70	26.22	0.004	1.91E-03	24.9	17.1	
12	17.50	30.39	0.003	1.82E-03	30.5	22.6	
13	17.30	34.43	0.003	1.70E-03	37.0	29.3	
		38.03	0.003	1.70E-03	37.0	29.3	
14	17.08	41.35	0.002	1.53E-03	45.9	38.6	
15	16.85	44.52	0.002	1.30E-03	55.6	50.1	90.2
		44.52	0.002	1.30E-03	-34.6	50.1	
16	16.70	46.55	0.002	1.14E-03	-27.7	45.4	
		23.22	0.002	1.14E-03	-27.7	45.4	
17	16.45	11.08	0.002	8.99E-04	-23.5	38.9	
18	16.20	-1.15	0.002	6.92E-04	-22.2	33.2	
19	15.95	1.10	0.001	5.15E-04	-22.2	28.0	
20	15.70	5.71	0.001	3.69E-04	-21.4	22.4	
21	15.50	8.32	0.001	2.74E-04	-20.0	18.2	
22	15.30	10.16	0.001	1.98E-04	-18.1	14.4	
23	15.00	11.71	0.001	1.14E-04	-14.8	9.4	
24	14.70	12.17	0.001	6.15E-05	-11.3	5.4	
25	14.40	11.90	0.001	3.26E-05	-7.7	2.6	
26	14.10	11.23	0.001	2.02E-05	-4.2	0.8	

(continued)

Stage No.9 Change properties of soil type 4 to soil type 5
Ko pressures will be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
27	13.90	10.67	0.001	1.78E-05	-2.0	0.2	
28	13.70	9.24	0.001	1.73E-05	0.0	0.0	

Strut force at elev. 16.85 = 90.18 kN/m run = 90.18 kN/strut

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	19.80	0.00	0.00	0.00	0.00	0.00	0.00	15.2
2	19.60	0.00	3.60	1.15	13.93	1.22	1.22	91.5
3	19.40	0.00	7.20	2.29	27.85	2.51	2.51	183
4	19.30	0.00	9.00	2.87	34.82	3.19	3.19	229
		0.00	9.00	3.53	26.23	8.02	8.02	14032
5	19.10	0.00	12.86	5.04	37.46	9.30	9.30	14032
6	18.90	0.00	16.83	6.60	49.05	10.62	10.62	14032
7	18.60	0.00	23.03	9.03	67.09	12.68	12.68	14032
8	18.40	2.00	25.23	9.89	73.51	13.29	15.29	14032
9	18.20	4.00	27.42	10.75	79.88	13.86	17.86	14032
10	17.95	6.50	30.08	11.80	87.66	14.51	21.01	14032
11	17.70	9.00	32.72	12.83	95.33	17.22	26.22	14032
12	17.50	11.00	34.84	13.67	101.52	19.39	30.39	14032
13	17.30	13.00	37.01	14.52	107.85	21.43	34.43	14032
		13.00	37.01	6.93	137.22	25.03	38.03	14032
14	17.08	15.25	39.75	7.95	145.64	26.10	41.35	14426
15	16.85	17.50	42.55	9.01	154.26	27.02	44.52	13899
16	16.70	19.00	44.44	9.72	160.08	27.55	46.55	14146
17	16.45	21.50	47.61	10.91	169.83	28.29	49.79	14557
18	16.20	24.00	50.77	12.10	179.53	28.97	52.97	14969
19	15.95	26.50	53.86	13.27	189.06	29.65	56.15	15380
20	15.70	29.00	56.88	14.40	198.34	30.38	59.38	15791
21	15.50	31.00	59.22	15.28	205.54	31.01	62.01	16120
22	15.30	33.00	61.49	16.14	212.55	31.67	64.67	16449
23	15.00	36.00	64.79	17.38	222.69	32.72	68.72	16942
24	14.70	39.00	67.96	18.57	232.43	33.83	72.83	17436
25	14.40	42.00	71.01	19.72	241.82	34.95	76.95	17929
26	14.10	45.00	73.97	20.83	250.93	36.06	81.06	18423
27	13.90	47.00	75.90	21.56	256.88	36.78	83.78	18752
28	13.70	49.00	77.81	22.28	262.75	37.47	86.47	19081

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	19.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	19.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	19.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	19.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	18.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	18.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	17.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0

(continued)

Stage No.9 Change properties of soil type 4 to soil type 5
Ko pressures will be reset

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
11	17.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	17.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	17.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	16.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	16.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	23.33	23.33	23.33p	14744
17	16.45	0.00	5.00	0.00	38.71	38.71	38.71p	15173
18	16.20	0.00	10.01	0.00	54.12	54.12	54.12p	15601
19	15.95	0.00	15.03	0.00	69.58	55.05	55.05	16030
20	15.70	0.00	20.07	0.55	85.09	53.67	53.67	16459
21	15.50	2.00	22.12	1.32	91.40	51.68	53.68	16801
22	15.30	4.00	24.19	2.10	97.76	50.51	54.51	17144
23	15.00	7.00	27.33	3.28	107.44	50.02	57.02	17659
24	14.70	10.00	30.53	4.49	117.27	50.66	60.66	18173
25	14.40	13.00	33.79	5.71	127.28	52.05	65.05	18687
26	14.10	16.00	37.10	6.96	137.48	53.83	69.83	19202
27	13.90	18.00	39.34	7.80	144.38	55.11	73.11	19545
28	13.70	20.00	41.61	8.65	151.36	57.23	77.23	19887

Note: 12.34a Soil pressure at active limit
54.12p Soil pressure at passive limit

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CARD GEOTECHNICS LIMITED                                      | Sheet No.
Program: WALLAP  Version 6.05  Revision A41.B56.R46           | Job No. CG/8624
                             Licensed from GEOSOLVE           | Made by :   ADC
Data filename/Run ID: Contig pile wall_Section BB_SLS         |
134 1/2 Abbey Road                                            | Date:27-03-2014
Section B-B' contig piled wall analysis                       | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
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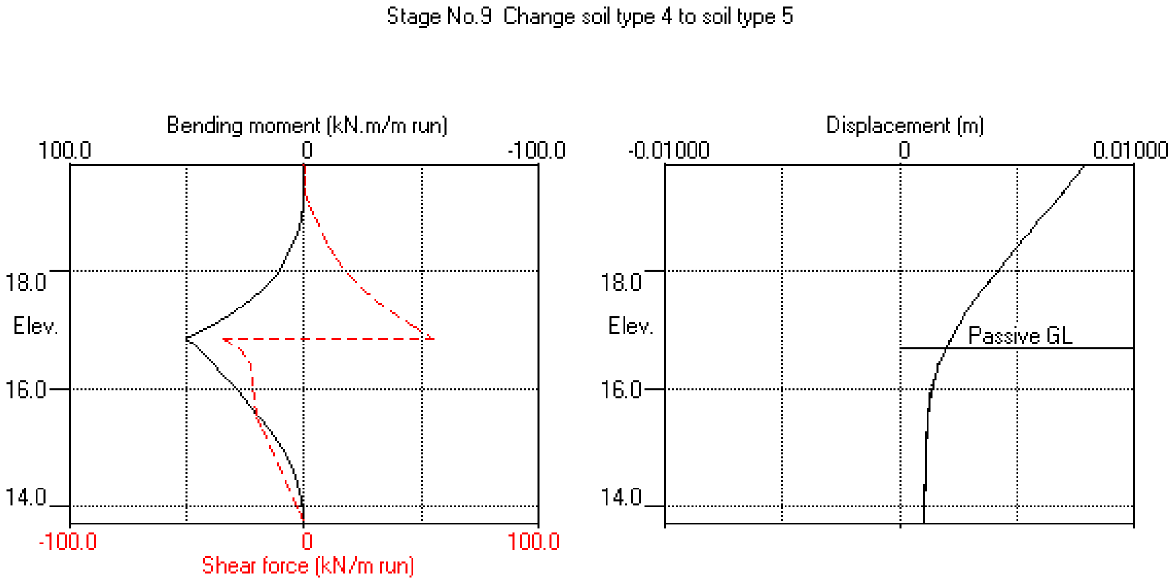

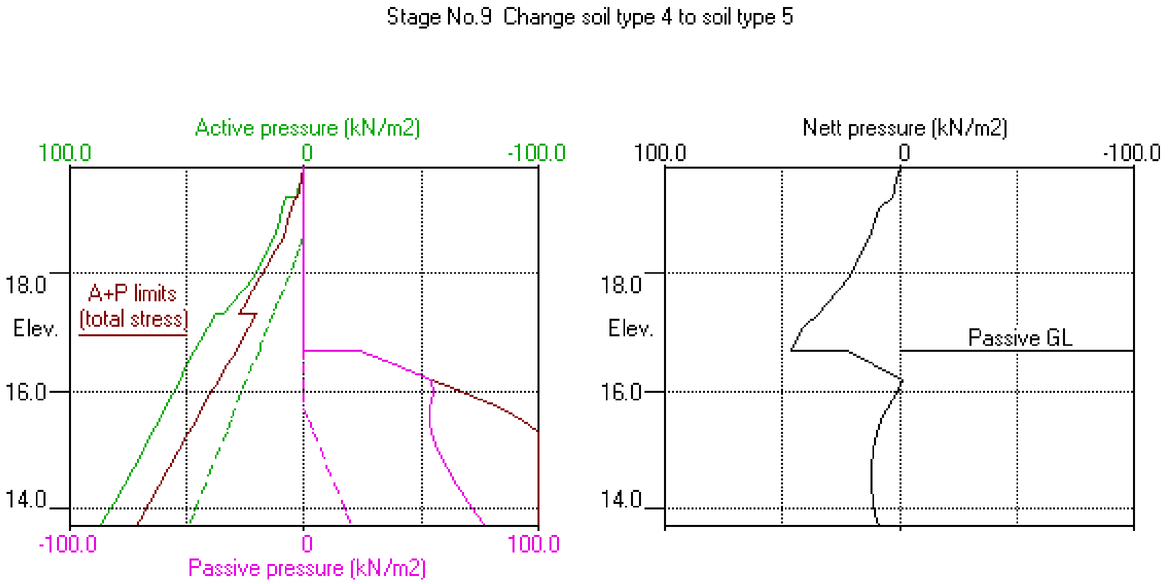

Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				FoS for toe elev. = 13.70		Toe elev. for FoS = 1.200	
Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation
1	19.80	19.80	Cant.	Conditions not suitable for FoS calc.			
2	19.80	19.80	Cant.	Conditions not suitable for FoS calc.			
3	19.80	19.80	Cant.	Conditions not suitable for FoS calc.			
4	19.80	19.80		No analysis at this stage			
5	19.80	19.80	Cant.	Conditions not suitable for FoS calc.			
6	19.80	16.70	Cant.	3.654	14.05	15.46	1.24
7	19.80	16.70		No analysis at this stage			
8	19.80	16.70	16.85	Conditions not suitable for FoS calc.			
9	19.80	16.70	16.85	Conditions not suitable for FoS calc.			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 5.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 30.00 from wall
Passive side 7.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	19.80	0.008	-0.000	0.0	-0.0	0.0	0.0
2	19.60	0.008	-0.000	0.0	-0.0	0.1	-0.0
3	19.40	0.007	-0.000	0.1	-0.0	0.5	-0.0
4	19.30	0.007	-0.000	0.1	-0.0	0.8	-0.0
5	19.10	0.007	-0.000	0.5	-0.0	2.5	-0.1
6	18.90	0.006	-0.000	1.2	-0.0	4.5	-0.3
7	18.60	0.006	0.000	3.0	-0.1	8.0	-0.4
8	18.40	0.005	0.000	4.9	-0.2	10.8	-0.5
9	18.20	0.005	0.000	7.4	-0.3	14.1	-0.4
10	17.95	0.004	0.000	11.5	-0.4	19.0	-0.4
11	17.70	0.004	0.000	17.1	-0.5	24.9	-0.3
12	17.50	0.003	0.000	22.6	-0.5	30.5	-0.4
13	17.30	0.003	0.000	29.3	-0.6	37.0	-0.5
14	17.08	0.003	0.000	38.6	-0.5	45.9	-0.5
15	16.85	0.002	0.000	50.1	-0.5	55.6	-34.6
16	16.70	0.002	0.000	45.4	-0.5	24.2	-27.7
17	16.45	0.002	0.000	40.3	-0.6	10.0	-23.5
18	16.20	0.002	0.000	38.7	-0.7	0.3	-22.2
19	15.95	0.001	0.000	35.3	-0.7	0.3	-22.2
20	15.70	0.001	0.000	30.2	-0.7	0.3	-21.6
21	15.50	0.001	0.000	25.7	-0.7	0.2	-22.7
22	15.30	0.001	0.000	21.1	-0.7	0.3	-22.5
23	15.00	0.001	0.000	14.6	-0.5	0.4	-20.4
24	14.70	0.001	0.000	8.9	-0.4	0.5	-16.9
25	14.40	0.001	0.000	4.4	-0.2	0.5	-12.4
26	14.10	0.001	0.000	1.5	-0.1	0.4	-7.3
27	13.90	0.001	0.000	0.4	-0.0	0.2	-3.8
28	13.70	0.001	0.000	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	elev.	Bending moment minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	Shear force minimum kN/m	elev.
1	0.0	14.10	-0.6	17.30	0.3	16.20	-0.5	18.40
2	0.0	18.60	-0.6	15.70	0.4	14.70	-0.3	16.85
3	0.0	18.60	-0.6	15.70	0.4	14.40	-0.3	16.85
4	No calculation at this stage							
5	0.1	18.60	-0.7	15.70	0.5	14.70	-0.5	17.08
6	30.5	16.20	-0.0	19.80	24.2	16.70	-18.2	15.30
7	No calculation at this stage							
8	40.3	16.45	-0.0	19.80	36.9	16.85	-22.7	15.50
9	50.1	16.85	-0.0	19.80	55.6	16.85	-34.6	16.85

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	16.85	0.000	19.80	Apply surcharge no.3 at elev. 19.40
2	0.000	13.70	-0.000	19.80	Apply surcharge no.1 at elev. 18.20
3	0.000	13.70	-0.000	19.80	Apply surcharge no.2 at elev. 18.60
4	Wall displacements reset to zero				Change EI of wall to 44100kN.m2/m run
5	0.000	13.70	-0.000	19.80	Apply water pressure profile no.1
6	0.007	19.80	0.000	19.80	Excav. to elev. 16.70 on PASSIVE side
7	No calculation at this stage				Install strut no.1 at elev. 16.85
8	0.008	19.80	0.000	19.80	Change soil type 2 to soil type 3
9	0.008	19.80	0.000	19.80	Change soil type 4 to soil type 5

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 16.85 kN/m run	kN/strut
8	25.97	25.97
9	90.18	90.18

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CARD GEOTECHNICS LIMITED                                    | Sheet No.
Program: WALLAP  Version 6.05  Revision A41.B56.R46         | Job No. CG/8624
                              Licensed from GEOSOLVE        | Made by :   ADC
Data filename/Run ID: Contig pile wall_Section BB_SLS       |
134 1/2 Abbey Road                                          | Date:27-03-2014
Section B-B' contig piled wall analysis                     | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
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