P&T Architects and Engineers

9A The Grove, London

Ground Movement Assessment

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1. INTRODUCTION

It is proposed to construct a single level basement beneath the existing property at 9A The Grove in the London Borough of Camden. The basement will cover the existing building footprint, extend below the rear garden and form a lightwell in the front garden. The basement will be formed by underpinning the perimeter whilst a contiguous pile wall will be installed at the front garden for the construction of the lightwell. The structure will be used as habitable space.

The London Borough (LB) of Camden's Planning Guidance[1] was published in September 2013 and outlines requirements relating to basements within the borough. The assessment included in this report has full regard to the requirements of Camden's Planning Policy Framework, including Policy CS14 of the Core Strategy and Policy DP27 of the Development Policies Plan Document (DPD), as well as CPG4.

A Basement Impact Assessment (BIA) has already been undertaken for the property[2]by Geotechnical & Environmental Associates (GEA). The aforementioned assessment includes a desk study and a screening process addressing hydrological, hydrogeological and geotechnical issues specific to the property, following the methodology set out in CPG4.

The scope of this report is to provide an impact assessment in relation to land stability, and includes the prediction of ground movements due to the excavation and construction of the proposed basement. This has been completed in order to assess the potential damage that might be inflicted to the neighbouring properties, namely No.8 and No.9 The Grove, and any other structures that might be in the influence zone of the proposed development.

[1] *The London Borough of Camden Planning Guidance: Basements and Lightwells* (CPG4), September 2013
[2] *Geotechnical & Environmental Associates (GEA), Rep. No. J15047, April 2015*

2. SITE CONTEXT

2.1 Site location

The site is located in The Grove in the London Borough of Camden, N6 6JU. The Ordnance Survey Grid Reference for the approximate centre of the site is 528177E, 187307N. A site location plan is shown in Figure 1.

2.2 Site description

The site is broadly rectangular in plan with dimensions some 50m in length and some 15m in width (at the widest section). The dimensions of the proposed excavation are approximately 20m in length and some 10m in width, with the length orientated in an east-west direction perpendicular to The Grove. The existing building comprises a three level residential property (ground floor, first floor and second floor).

With reference to information provided by the GEA BIA, the typical elevation at the site is approximately 128m above Ordnance Datum (AOD) and the ground slopes gently towards the south and south-west. A survey plan showing the existing structure is included in Appendix A.

The existing house shares party walls with No. 9 to the north and No. 8 to the south. The property at No. 9 has an existing lower ground floor and has recently had a basement extension to the rear of the property (Camden planning ref. 2011/1047/P). A boundary wall to the east of the site separates the property from The Grove. To the west, the rear garden of the property is adjacent to boundaries of other properties along Highfields Grove.

No underground structures, including London Underground Limited assets, or buried services that could affect the works or be affected by them have been identified in the proximity of the property.

A site plan depicting the information above is presented as Figure 2 (from available survey drawings provided by the engineers HRW).

2.3 Proposed development

The proposed development comprises the construction of a basement level which will cover the existing house footprint and extend into the rear garden. A lightwell will be formed in the front garden.

The proposed basement will be constructed within an underpinned wall along the western and southern boundary with No.8. The party wall with No.9, which already has a lower ground floor, will not be underpinned. A 300mm diameter contiguous pile wall will be installed for the excavation and construction of the lightwell. The proposed basement formation level is at 125m AOD (which corresponds approximately to 3m below existing ground level). The foundation for the basement has been designed as a ground bearing raft with loads from party walls and internal walls transferred uniformly across the raft footprint.

Proposed development plans are included in Appendix B. A typical section through the proposed basement is presented as Figure 3 (from available drawing No. 1290SE010 T1, dated March 2015).

2.4 Anticipated geology

2.4.1 Published geology

The available online BGS Maps[3] and the BGS Geological Map Extract of the area (Sheet No. 256) indicate that the bedrock geology at the site comprises the Bagshot Formation underlain by the Claygate Member of the London Clay Formation.

The Bagshot Formation comprises beds of fine sand with occasional seams of clay and silt and local beds of flint gravel. Its thickness in the area can reach up to 18m.

The Claygate Member constitutes the upper units of the London Clay Formation and comprises alternate units of clayey silt, sandy silt and silty sand with sandier units typically being predominant towards the top of the member becoming more clay dominant towards the base. The thickness of the Claygate Member is approximately 15m in the local area.

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. The stratum may also contain laminated, structured, nodular claystone and rare sand partings.

[3] BGS Website www.bgs.ac.uk (Accessed 02/08/2015)

3. GROUND INVESTIGATION

An intrusive site investigation was undertaken in February 2015 by Geotechnical & Environmental Associates (GEA)[4] at the instruction of the engineer (engineersHRW).

The investigation comprised a single cable percussive borehole (BH1) drilled to a depth of 15m below ground level (bgl), two window sampler boreholes (BH2 and BH3) to a depth of 6m bgl each and a total of ten trial pits (TP1 to TP10, inclusive) to a maximum depth of 1.6m bgl. The exploratory holes were undertaken at selected positions to characterise the existing ground conditions, retrieve soil samples and investigate the extent and nature of the existing foundations. Borehole BH1 was drilled in the front garden whilst boreholes BH2 and BH3 were drilled in the rear garden. The trial pits were excavated at various locations within the footprint of the house and in the gardens.

In-situ testing comprised Standard Penetration Tests (SPT) between 1.2m and 13.5m bgl in borehole BH1. Bulk, disturbed and undisturbed samples were retrieved from the window sampler boreholes and the cable percussive boreholes. Standpipes were installed in the three boreholes to 6m depth.

Relevant factual data from the ground investigation report referenced above has been included within Appendix C, including the borehole logs and laboratory test results.

Laboratory tests on selected soil samples were completed by Geolabs Limited, a UKAS accredited geotechnical laboratory. The tests included the following:

- Unconsolidated undrained triaxial compression;
- Atterberg Limits;
- Moisture content;
- Particle Size Distribution;
- Bulk and Dry Density; and
- Chemical Tests.

Geotechnical test results are included in Appendix C.

[4] *Geotechnical & Environmental Associates (GEA), Rep. No. J15047, April 2015*

4. GROUND AND GROUNDWATER CONDITIONS

4.1 Summary

The ground conditions encountered during the intrusive investigations are generally consistent with those expected from the desk study information reviewed in Section 2.5 of this report. The ground conditions on site derived from the GEA investigation are summarised in Table 1 below.

Table 1. Summary of ground conditions

Strata	Depth to top m bgl[a] [m AOD]	Thickness (m)
Brown clayey SAND/Brown sandy CLAY with gravel and brick fragments. [MADE GROUND]	0 [127.5 – 127.8]	1.80 – 3.40
Soft becoming stiff brown mottled sandy CLAY with occasional pockets of fine to medium sand. [BAGSHOT FORMATION]	1.80 – 3.40 [124.3 – 125.9]	0.90 – 3.85
Medium dense orange-brown slightly clayey fine to medium SAND. [BAGSHOT FORMATION]	4.10 – 7.25 [120.63 – 123.41]	7.65
Stiff grey silty CLAY. [CLAYGATE MEMBER]	14.90 [112.98]	Base not proven

a) mbgl = metres below existing ground level; mAOD = metres above Ordnance Datum

Each stratum is discussed in the following sections together with the results of the geotechnical tests. Plots of SPT 'N' values and undrained shear strength, c_u (kPa) versus level (m bgl) are presented in Figure 4 and Figure 5 respectively.

4.2 Made Ground

The Made Ground encountered was described by GEA as predominantly sandy clay with layers of clayey sand in the front garden. The thickness of Made Ground varies between 1.8m and 3.4m, but typically in excess of 3m in proximity to the basement perimeter (BH1 and BH3). The Made Ground will be removed as part of the basement excavation.

4.3 Bagshot Formation

The Bagshot Formation was encountered directly below the Made Ground and is described as soft becoming stiff clay, underlain by medium dense slightly clayey fine to medium sand. The thickness of the clayey layer varies from 0.9m to 3.85m with the sandy units extending down to 14.9m bgl in borehole BH1.

A single SPT test in the clayey layer of Bagshot Formation recorded an 'N' value of 15, indicating firm to stiff clay. Measurements in the sand units at depth varied between 19 and 33 indicating generally medium dense to dense granular soils.

Particle size distribution tests indicate that the sandy units are generally uniformly graded with clay/silt fractions varying between 30.6% and 62%.

Two undrained triaxial tests were undertaken on samples at 4m and 6m bgl in borehole BH1, recording results of 70kPa and 22kPa, respectively. These results, and particularly the lower value, should be treated with caution given the high sand/silt content as they do not reflect the soil descriptions in the logs. The cohesive soils are generally of low to intermediate plasticity.

4.4 Claygate Member

The Claygate Member was identified in borehole BH1 at 14.9m bgl (113mAOD) towards the base of the borehole, described as a stiff silty clay. No further in-situ or laboratory testing was undertaken to further classify this material, although it is likely to be beyond the depth of influence of the proposed basement. The London Clay at depth was not encountered.

4.5 Groundwater

Groundwater was encountered during the ground investigation as a seepage in borehole BH1 at a depth of 10.2m within the Bagshot Sand. A second slow inflow was recorded at 12.7m bgl and rose to 12.3m after 20 minutes. Monitoring standpipes were installed in all boreholes to 6m bgl during the site investigation. Two subsequent monitoring visits were undertaken and in both cases the standpipes were recorded as dry.

4.6 Geotechnical design parameters

Geotechnical design parameters for the proposed development are summarised in Table 2 below. These are based on the results of laboratory and in-situ testing. It should be noted that the parameters below are for heave/settlement calculations only.

Table 2. Geotechnical design parameters

Stratum	Design Level (Depth to top) (m bgl)* [m AOD]*	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 (CLAY)	0 [127.7]	17[a]	30[b] [0]	27[c]	15[d] [11.25][d]
Made Ground (SAND)	0 [128.0]	17[a]	-	28[c]	[2.5z][d]
Bagshot Formation (CLAY)	3.2 [124.5]	19[a]	50[b] [0]	23[c]	30 [22.5][d]
Bagshot Formation (SAND)	6.2 [121.5]	19[a]	-	31[c]	[46][d]

*m bgl: metres below ground level

m AOD: metres above Ordnance Datum

Notes:

- The clayey Made Ground is considered to be representative for the calculation of heave, whereas the granular Made Ground is appropriate for the retaining wall analysis. This is because granular Made Ground was encountered in the front garden where the retaining wall is proposed to be installed.
- Young's Modulus values for the clays in this table have been adopted for heave analysis. Different values are appropriate for retaining wall analysis (see reference [d] below).
- Drained parameters have only been used in retaining wall analysis.

a. BS8002, assuming medium dense sand and firm clay for Bagshot Formation; loose sand and soft clay for Made Ground.

b. Based on log description of soft clay for Made Ground; for Bagshot Formation based on Cu=4.5N for N = 11

c. Sands (Made Ground and Bagshot Sand): Derived from SPT values for granular soil (CIRIA R143 for loose and medium dense sand respectively). Bagshot 'clay': Derived from PI based on BS8002 for PI=25. Made Ground (clay): Assumed.

d. Stiffness for granular Made Ground selected conservatively as E=1.5N for N=5 at 3m bgl, increasing linearly from ground surface. E=1.5N has been adopted from interpretation of CIRIA R143 (Table 11, page 84). Stiffness for Bagshot Sand based on E'=2N (CIRIA R143, pg84, from interpretation of Table 11). Stiffness for Bagshot 'clay' based on Eu = 600Cu (kPa) and for clayey Made Ground on Eu=500Cu (Lower bound). E' for clays derived as $E'=Eu(1+v')/(1+v_u)$ based on page 87 of CIRIA R143, assuming v'=0.2. Eu for the retaining wall analysis was derived as Eu=1000Cu (kPa).

5. BASEMENT IMPACT ASSESSMENT – LAND STABILITY

5.1 Introduction

As noted in Section 2.3 of this report, the majority of the basement perimeter will be constructed by reinforced concrete underpinning methods which do not cause significant lateral ground movements due to their high stiffness. The underpins will be supported by temporary props during construction and by the floor slab in the permanent condition. Therefore the neighbouring buildings are expected to be affected only by ground heave and settlement due to workmanship (noting that No.9 will not be underpinned and therefore unaffected by the latter). Groundwater is not expected to affect the development. However, should inflows be recorded during the excavation appropriate contingency measures should be put in place.

The contiguous pile wall which is proposed to be installed at the front garden will be parallel to the façades of the adjacent buildings and therefore its effects on the properties are not expected to be significant. Nevertheless, a retaining wall analysis has been undertaken to assess the magnitude of ground movements that could affect the highway.

This section provides calculations to determine ground movements that will result from stress release due to excavations and settlements that will be induced by the reapplication of structural loadings. The predicted ground movements will be used for a damage assessment on the buildings adjacent to No. 9A.

The following construction process and effects are likely to give rise to ground movement that may impact upon adjacent structures:

1. Heave. Excavation of the basement gives rise to undrained elastic heave, resulting in upwards movement of the foundation soils. It has been noted that the thickness of the clayey materials which are subject to heave on unloading vary across the site. For this analysis it has been assumed conservatively that the basement is underlain by cohesive units of the Bagshot Formation. The amount of long-term heave/settlement depends on final construction loads and basement floor slab detailing. Heave movements are not anticipated to be significant within the granular layers of the Bagshot Formation and therefore they have been ignored.

2. Underpinning. Underpinning for the support of the walls of the existing basement is not expected to generate significant ground movements as the process involves

construction at intervals of relatively small width (~1m). The use of reinforced concrete limits the potential for lateral deflection and horizontal strain within the retained soils. The long term net bearing pressures beneath the underpins have been considered in the assessment, as well estimated party wall settlement due to workmanship.

3. Retaining wall installation and deflection. Both processes have the potential to generate vertical and lateral ground movements within the soils on the retained side of the wall, principally between the wall and The Grove highway. It is therefore considered that the installation of the wall and the subsequent excavation will not affect the adjacent properties to the north and south.

5.2 Critical sections for analysis

The critical constraints that will be considered for assessment are:

- No. 8 The Grove
- No. 9 The Grove
- The Grove highway

The plan locations of the critical sections are presented on Figure 2.

5.3 Ground movements arising from basement excavation

The clayey soils below basement formation level will be subject to stress relief during basement excavation. This is likely to give rise to a degree of elastic heave over the short term and potential heave or settlement over the long term as pore pressures recover in the clays and structural loads are reapplied. It is understood that a raft will form the permanent foundation system. The analysis assumes that the raft foundation will be formed directly on the firm clays of the Bagshot Formation (i.e. with Made Ground and softer zones removed).

The magnitude of ground movements has been calculated using OASYS Limited PDisp analysis software. PDisp assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E’) input for each stratum.

5.3.1 Short term ground movements

For the short term analysis, the net stress change at proposed basement formation level due to various construction activities has been calculated and considers the following:

1. Stress decrease during excavation;
2. Application of stresses induced by the basement raft and the walls around the basement.

The load values used for each stage of construction and corresponding cumulative values applied in the PDisp analysis at proposed basement formation level (124.7m AOD) are summarised in Table 3.

The bulk unit weight of 19kN/m^3 for the excavated soils (Made Ground and Bagshot Formation) has been adopted in Table 3, whilst a depth of 3m bgl has been adopted for the calculation of overburden relief. The gross raft load will be applied after the construction works and is estimated to be 26.8kPa. This has been modelled as a uniformly distributed load (UDL) across the basement footprint. This is based on distribution of the loads provided by HRW (Appendix D) and includes the self-weight of the slab. Modelling the load as a UDL is conservative as it is anticipated the structural loading will be concentrated locally beneath the underpin bases and reducing towards the centre of the raft. This would serve to reduce the heave around the basement perimeter and in proximity to the party walls. In addition, there is a load of 65kPa imposed by a steel frame along a 5.7X1.5 strip as shown on the available drawing 1290-GA001-P3 which has also been taken into account for the long term ground movement analysis.

Table 3. Net load calculations for PDISP analysis

Stage 1 [a]	**Stage 2** [a]	**Stage 2** [a]	**Stage 2** [a]
Total basement excavation from ground level (kN/m^2) [b]	**Loads applied by basement raft (kN/m^2)** [c]	**Loads applied by perimeter walls and live loads on the raft (kN/m^2)** [d]	**Load applied by steel frame on a 5.7mX1.5m area (kN/m^2)**
-57	+6.25 [d]	+20.5	+65

a. Positive values (+) indicate stress increase and negative (-) values indicate stress reduction.
b. Assumes 3m basement excavation depth.
c. Assumes average slab thickness of 0.25m with unit weight of 25kN/m^3.
d. Based on average wall load, distributed uniformly over the slab combined with the load over the slab as provided by the structural engineer.

At the centre of the excavation the maximum short term heave after the excavation is predicted to be 18mm which will be removed during the excavation process itself. The maximum net long term heave is expected to be in the order of 13mm. These values reduce at the locations of the party walls to 13mm and 9mm respectively, as shown in the following sections.

The amount of undrained unloading (short term) has been estimated and the effects on the structures are presented as displacement contour plots within Figure 6. Displacement lines have been added to the PDISP models to illustrate the ground movement profiles at the locations of the adjacent structures and to undertake an impact/damage assessment for each of the affected structures.

5.3.2 *Long term ground movements*

Imposed loads and drained conditions have also been considered in a similar manner for the estimation of ground movements after the construction. The results are presented in Figure 7 which shows the predicted settlements at the level of the existing buildings foundations as well as the level of the excavation.

5.3.3 *Total movements due to basement excavation*

The total movements are expected to reach a maximum of 31mm of net heave, again for the centre of the excavation. The stiffness of the slab will further reduce these effects.

The vertical heave movements for the adjacent structures will be reduced due to their distance from the centre of the excavation. The total net maximum heave for Nos. 8 and 9 is predicted to be 22.5mm (occurring at the points closest to the excavation).

The results of the vertical ground movement analysis are summarised in Table 4 below for both short and long term. The PDISP output can be provided separately upon request.

Table 4. Summary of maximum heave movements within excavation and at constraint locations

Stage	Centre of excavation (mm)[a,b]	No. 8 (mm)[a,b]	No. 9 (mm)[a,b]
Short term movement	-17.6	-13.0	-13.0
Long term movement [b]	-12.7	-9.5	-9.5

a. Based on results of displacement line at level and plan location of constraint
b. Positive values (+) indicate settlement and negative (-) values indicate heave.

The results of the above assessment and corresponding ground movement profiles have been brought forward into Section 6 where the cumulative impact due to demolition, excavation, pile wall installation and deflection on neighbouring properties has been assessed.

5.4 Underpin settlement due to workmanship

The heave/settlement assessment undertaken within PDisp assumes perfect workmanship in the underpin construction and does not allow for settlement of the dry pack between the party wall with No. 8 and the new RC underpins. With good construction practice, actual settlements would be expected to not exceed 5mm for a single lift underpinning operation. This value will be applied to the overall ground movement and corresponding impact assessment to calculate a predicted damage category for No. 8 The Grove.

5.5 Ground movement due to retaining wall deflection

As mentioned above the proposed retaining wall is not expected to have an impact on the adjacent buildings. However an analysis has been undertaken in order to assess the potential ground movements on the highway to the east of the basement. This section summarises the results of the analysis to illustrate the potential ground movements behind the wall and at a distance of 3.5m where the road is located based on the available drawings. The proposed construction methodology and sequence which was adopted is summarised below:

1. Install contiguous piled wall (ground level at 128m AOD).
2. Excavate to 125.0m AOD (wall assume to act as cantilever).
3. Install permanent 'strut' at 125.0m AOD (the basement slab).

Output from the analysis using WALLAP retaining wall analysis software, is provided in Appendix E.

The total predicted horizontal deflections at the back of the wall are calculated as the sum of the movements induced by the excavation and the movements induced by the installation of the piles (taken as 0.08% of the pile length as a conservative assessment for a clayey sand, based on empirical correlations outlined in CIRIA C580, Table 2.2 page 50). The results have been summarised within Table 5. The corresponding ground settlements at the critical constraints are also provided.

To estimate the horizontal ground movements at a distance of 3.5m behind the wall it has been assumed that the distance to negligible horizontal movements behind the wall is twice the excavation depth (6m). Linear interpolation was then undertaken to determine the displacements at the road level.

Vertical ground movement immediately behind the wall, induced by excavation, has been calculated by taking 0.25% of the excavation depth as suggested by CIRIA C580 for excavations in sand. The reduction of the settlements with distance behind the wall is based on the factors provided within the relevant figures in CIRIA C580.

Vertical ground movement induced by pile installation has been taken as 0.05% of the pile length, based on interpretation of Table 2.2 of CIRIA C580 as for the horizontal movements on the previous page.

Table 5: Results of retaining wall analysis

Section	Maximum wall deflection (mm)[a]	Total Horizontal deflection at location/level of constraint (mm)[a]	Vertical settlement below location of constraints (mm)[b]
The Grove	14.0	8.0	4.7

a. Positive values indicate lateral wall deflection towards the basement excavation. Values derived from adding movements both from installation and excavation (from WALLAP analysis)
b. Positive values (+) indicate settlement and negative (-) values indicate heave behind the piled wall. Values derived from adding settlements both from installation and excavation (from CIRIA C580 correlations)

The vertical ground movements predicted by the above calculations are approximately of the same magnitude as the predicted heave at the same distance, therefore the net vertical ground movement will be negligible. A horizontal ground movement of 8mm is not expected to cause damage to the road.

In addition it should be noted that WALLAP uses a Winkler spring analysis to determine the wall displacements. In a Winkler medium, springs are used to represent a continuum and there is no transfer of shear stresses between the springs. In general, the application of this concept can lead to an overestimation of structural deformations; hence the resulting wall displacements and corresponding impact on the nearby structures and infrastructure may be over-predicted by the WALLAP program. However, the analysis is considered suitability conservative for the purposes of this assessment.

6. BUILDING DAMAGE ASSESSMENT

The calculated ground movements have been used to assess potential 'damage categories' that may apply to neighbouring structures due to the proposed basement construction method and assumed construction sequence. The methodology proposed by Burland and Wroth[5] and later supplemented by the work of Boscardin and Cording[6] has been used, as described in *CIRIA Special Publication 200*[7] and *CIRIA C580*.

General damage categories are summarised in Table 6 below:

Table 6. Classification of damage visible to walls (reproduction of Table 2.5, CIRIA C580)

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

The above assessment criteria are primarily relevant for assessing masonry structures founded on strip footings. Therefore, this methodology will be adopted within the damage assessment for the affected structures in The Grove.

[5] 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

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

[7] 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.

6.1 Impact Assessment – No.8 & No.9 The Grove

The results of the predicted ground movement below No. 9A The Grove due to the proposed basement development have been compiled to determine the overall lateral and vertical deflection of the two adjacent structures (Nos. 8 & 9).

6.1.1 No. 9 The Grove

Figure 8 shows the combined vertical ground movement due to the basement construction. The maximum total vertical ground movement at the location of the party walls is predicted in Section 5.3 to be 22.5mm of heave . As mentioned previously, the calculations conservatively assume application of a UDL across the raft footprint.

The maximum differential movement along the building is 18mm, resulting in a distortion of 1/830 (i.e. 18mm/15,000mm) which is within published limits[8, 9] for preventing excess cracking and damage to load bearing walls and partitions. The corresponding maximum relative deflection is 6.5mm corresponding to a deflection ratio of 0.043%, calculated over a length of 15m (i.e. the width of the neighbouring property).

6.1.2 No. 8 The Grove

Settlements due to underpin workmanship for No.8 will serve to counteract the heave movement and slightly reduce the associated deflection ratio which has been estimated to 0.04% for a deflection of 6mm.

As noted in Section 5.1 the horizontal movements due to underpin deflection are not expected to be significant and therefore no specific calculations have been undertaken. However, based on the calculated maximum deflection ratio of 0.04%, the limiting horizontal strain for the buildings to exceed the limits of Damage 0 Category is 0.017%. For a building length of 15m this corresponds to a horizontal movement of 2.5mm. The limiting strain for the building to exceed Category 1 is 0.053%, corresponding to horizontal movement of 8mm at the party wall location. It is therefore considered that No 8 The Grove should not exceed Category 1 (very slight damage) with good quality workmanship and lateral support to the underpinning during the temporary works.

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

This assessment is not applicable to No. 9 as no underpinning will be undertaken beneath this house. Therefore, No. 9 is considered to be affected only by heave and minor deflection with negligible impact on the structure.

Table 7 incorporates a summary of the maximum vertical deflection (mm) and limiting horizontal movement (mm) and strain for No. 8 The Grove.

Table 7. Summary of ground movements and corresponding damage category

Constraint	Limiting Net Horizontal movements (to exceed Category 0) (mm)[a]	Maximum deflection (mm)	Limiting Horizontal Strain (to exceed Category 0) ε_h[b] (%)	Deflection ratio Δ/L[c] (%)	Damage category corresponding to the limiting values
Nos. 8	2.5	6	0.017	0.04	1 – Very Slight

a. *Net horizontal movement along neighbouring structure.*
b. *See Box 2.5 (v) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (δ_h = horizontal movement in metres).*
c. *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).*

Damage 'Category 1' corresponds to 'very slight' damage, or fine cracks of up to 1mm in width. The damage assessment plot is presented in Figure 9.

7. CONSTRUCTION MONITORING

The results of the ground movement analysis suggest that with good construction control, damage to the structures surrounding the basement, generated by the assumed construction methods and sequence should not exceed Category 1 (very slight damage). The locations of buried services are not known, however based on the predicted ground movements, strain levels on such services are expected to be sustainable.

The monitoring system should operate broadly in accordance with the 'Observational Method' as defined in CIRIA Report 185[10]. Monitoring can be undertaken by using positional surveys compared to baseline values established before any excavation work is undertaken onsite. Regular monitoring of these positions will determine if any horizontal translation, tilt or differential settlement of the neighbouring structure is occurring as the construction progresses. Monitoring data should be checked against predefined trigger limits and can also be further analysed to assess and manage the damage category of the adjacent buildings as construction progresses.

The horizontal deflection/translation of the secant pile wall during construction should be limited to restrict the damage category for the adjacent critical properties to within Category 1 'very slight'. This value should form the basis of the 'traffic light' trigger levels established prior to excavation commencing onsite. 'Trigger levels' should be discussed and agreed with the party wall surveyor.

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

8. CONCLUSIONS

- The scope of this report was to provide a summary of the ground conditions on site and an assessment of the potential ground movements due to the proposed development. An assessment of hydrological and hydrogeological issues has already been undertaken by others (*Geotechnical & Environmental Associates, Rep. No. J15047, April 2015).*

- The proposed development at 9A The Grove comprises the construction of a single basement beneath the house footprint and partly beneath the rear garden. The basement is proposed to be constructed by underpinning techniques, although the existing basement walls with No.9 will not be underpinned as part of the construction. The site is underlain by the Bagshot Formation and it has been assumed the raft will be formed directly onto the natural firm cohesive soils of this stratum. The underpin and raft formation levels should be inspected by a competent geotechnical engineer before casting.

- The construction of the basement will generate ground movements predominantly due to excavation induced heave. Assessment of induced settlement due to underpin construction and contiguous wall construction has also been considered.

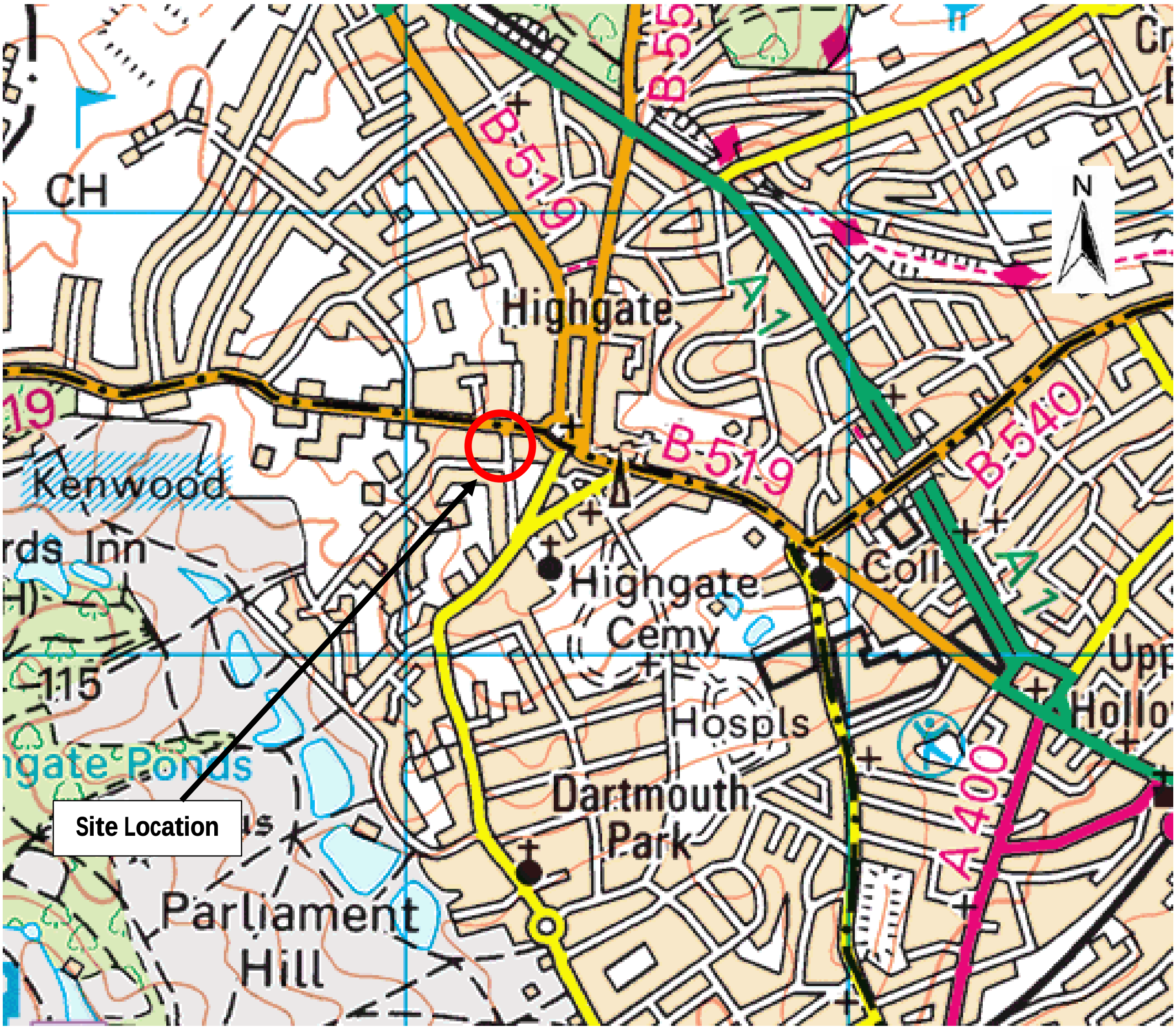
- A conservative assessment indicates that the calculated ground movement would limit building damage categories to no worse than 'Category 1' (very slight). Damage Category 1 is within allowable limits as specified by London Borough of Camden's *Camden Planning Guidance: Basements and Lightwells,* September 2013.

- It should be noted that good workmanship will be critical in controlling ground movements during construction. Reference should be made to the Association of Specialist Underpinning Contractors guidance[11] in this respect.

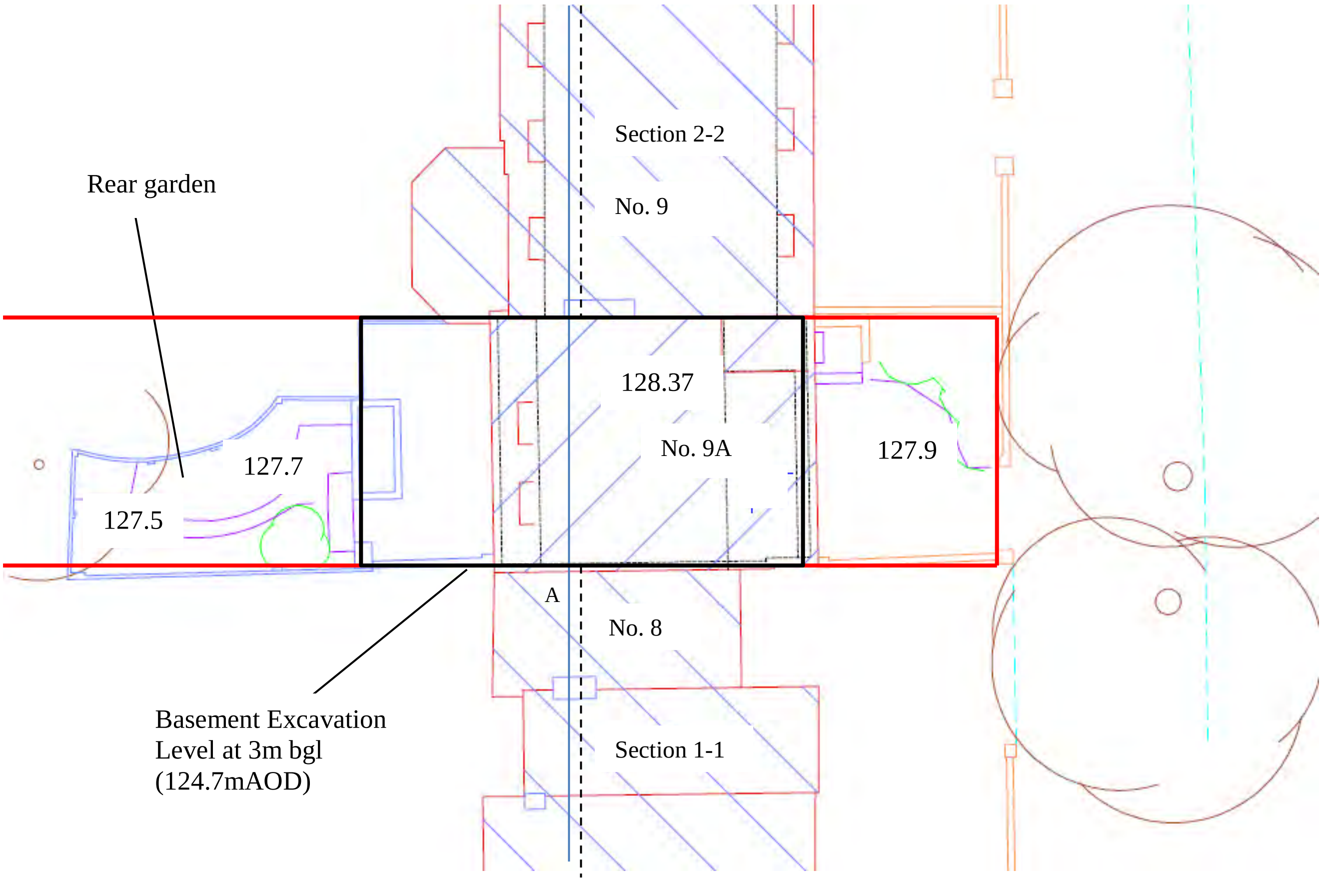
- It is proposed that an appropriate monitoring regime is in place before construction commences, in order to manage risk and potential damage to the adjacent properties and any existing buried services.

[11] ASUC (October 2013) *Guidelines on safe and efficient basement construction directly below or near to existing structures.*

FIGURES



Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
	Title	
	Site Location Plan	**Figure 1**



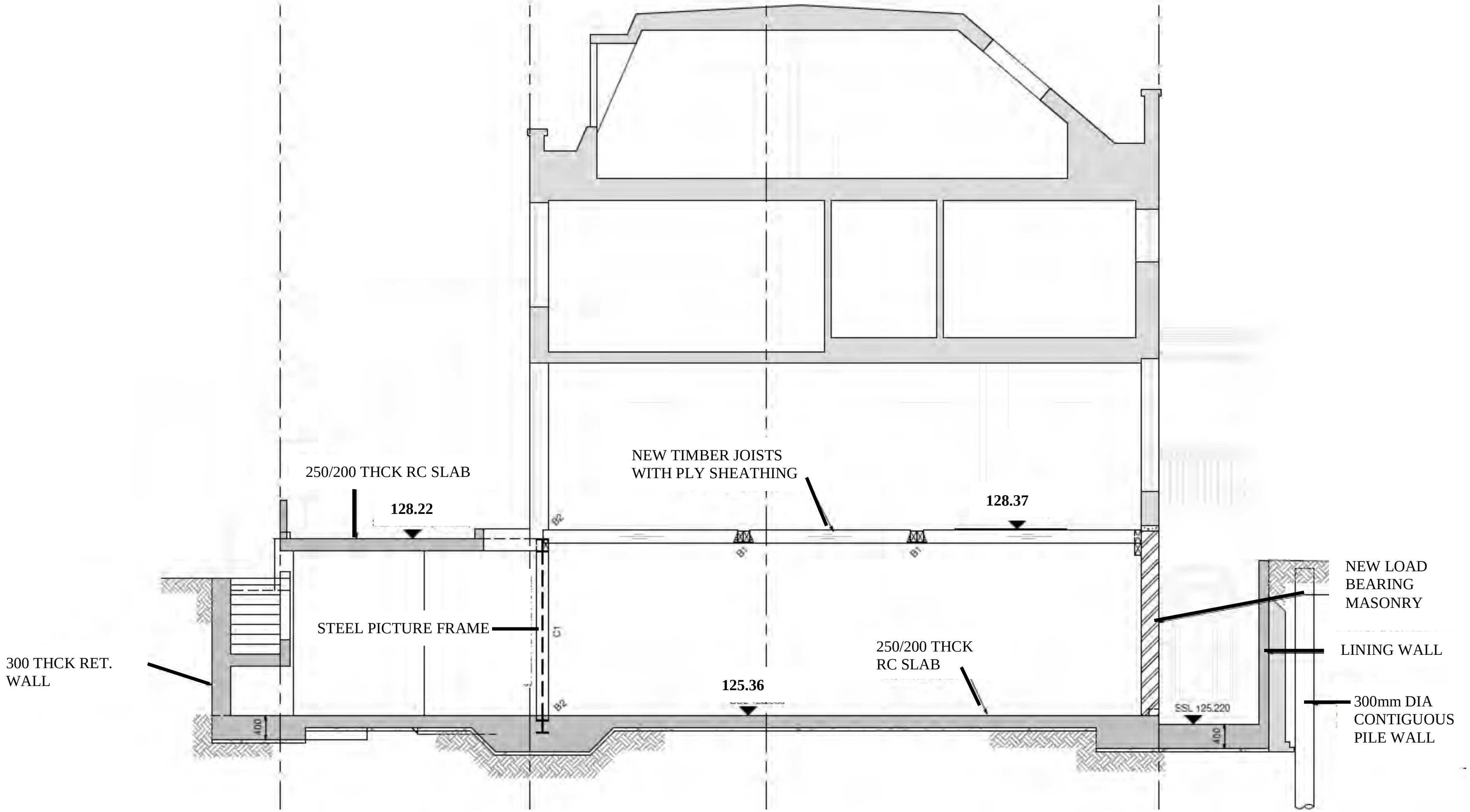
Property Boundary

Proposed Basement Boundary

Displacement Line

Elevations are in m above Ordnance Level (mAOD). Taken from available exploratory hole logs and drawings.

Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
CGL	Title **Site Layout**	**Figure 2**



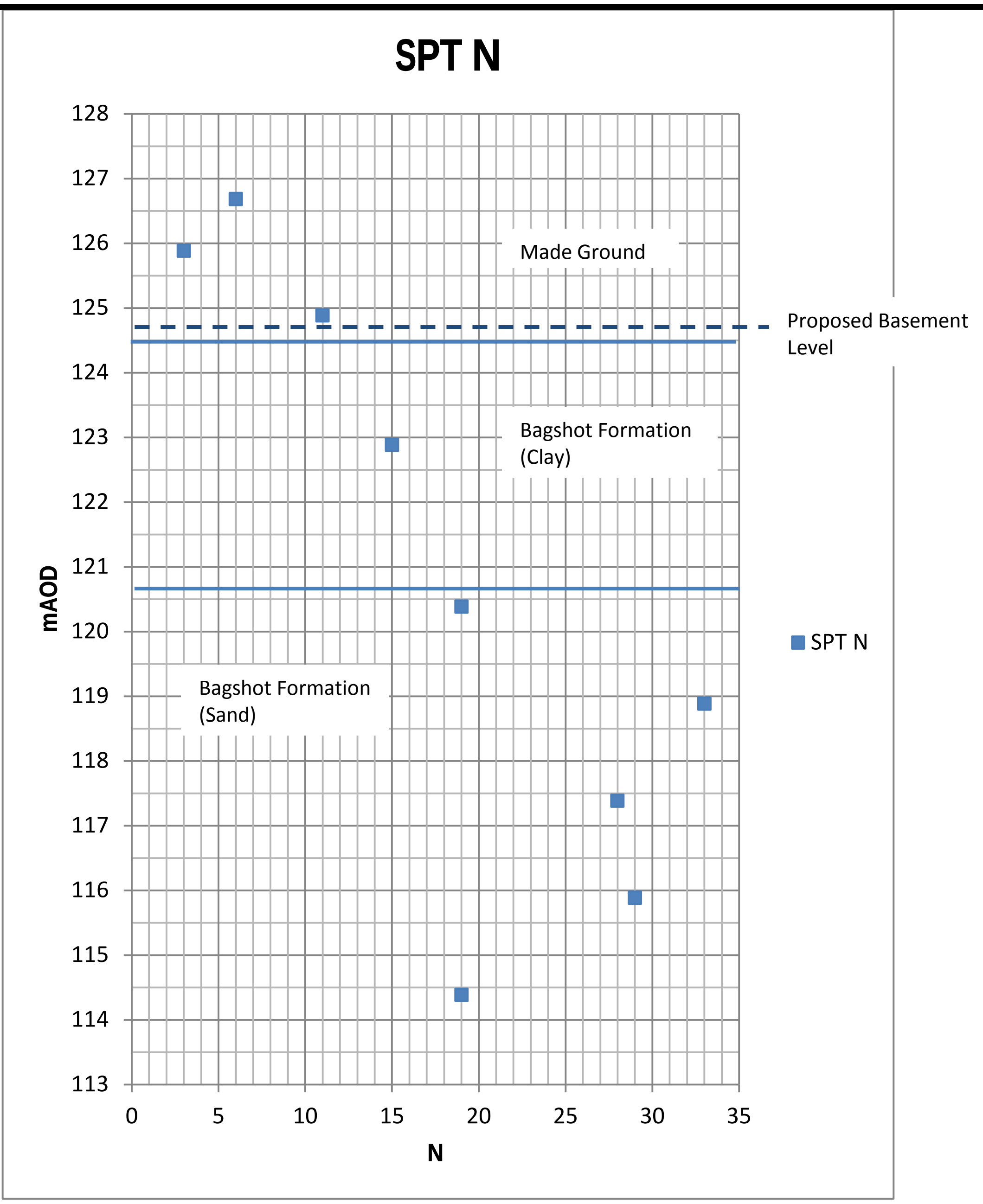
Client
P&T Architects and Engineers

Project
9A The Grove, London

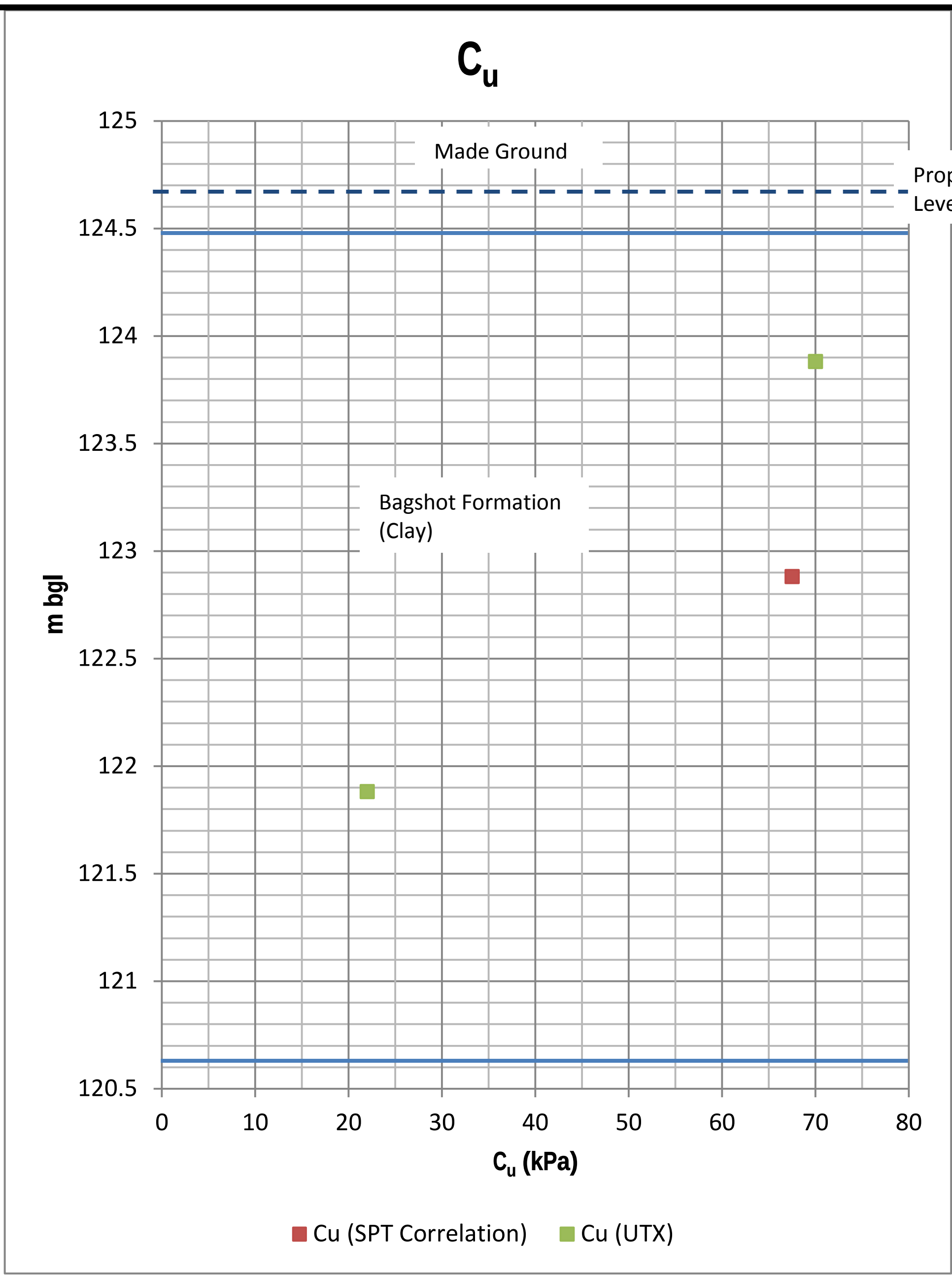
Job No
CG/18545

Title
Typical Section through Basement

Figure 3

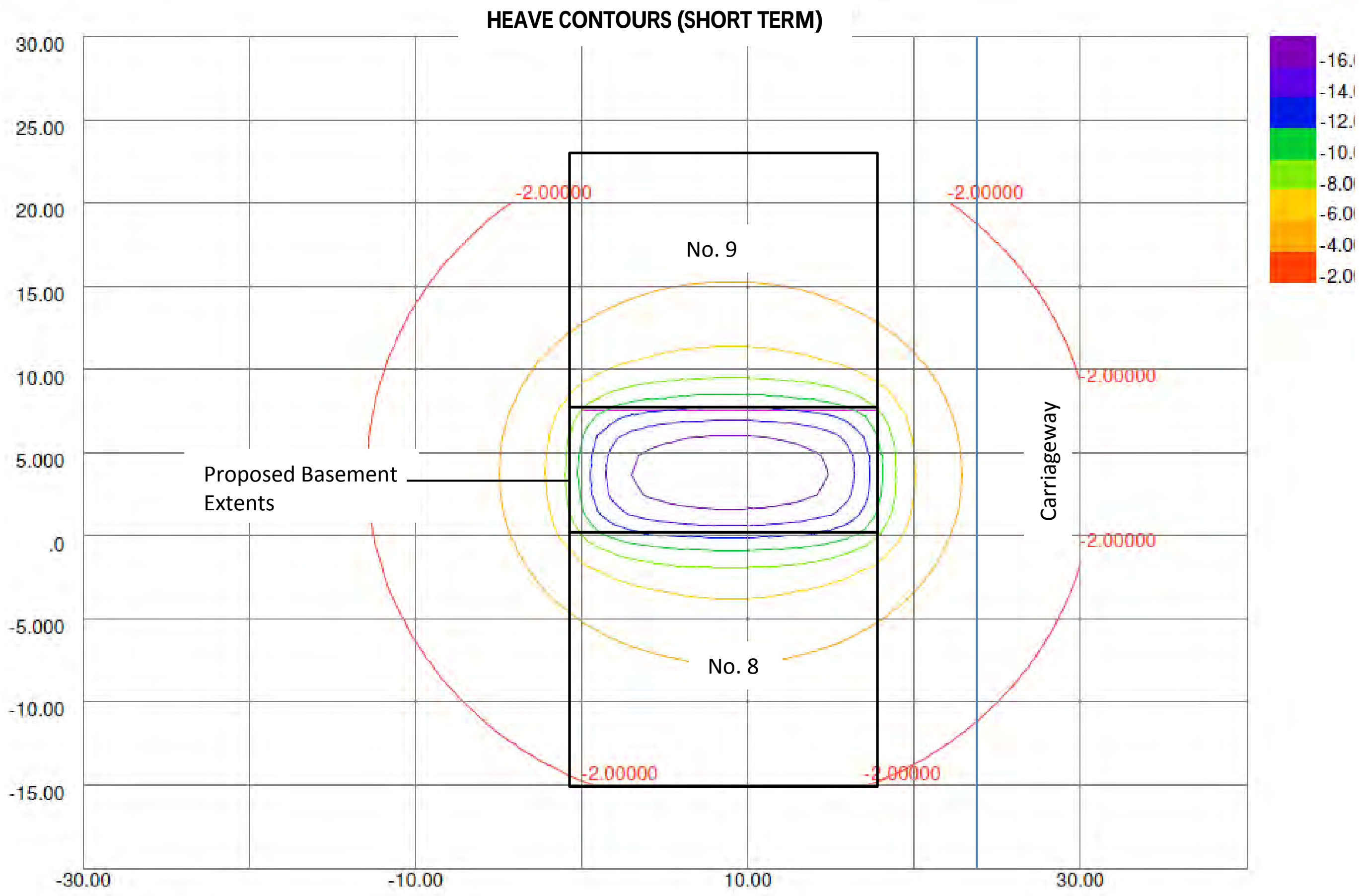


Client	Project	Job No
P&T Architects and Engineers	9A The Grove, London	CG/18545
CGL	Title: SPT ‘N’ Values vs Level	Figure 4

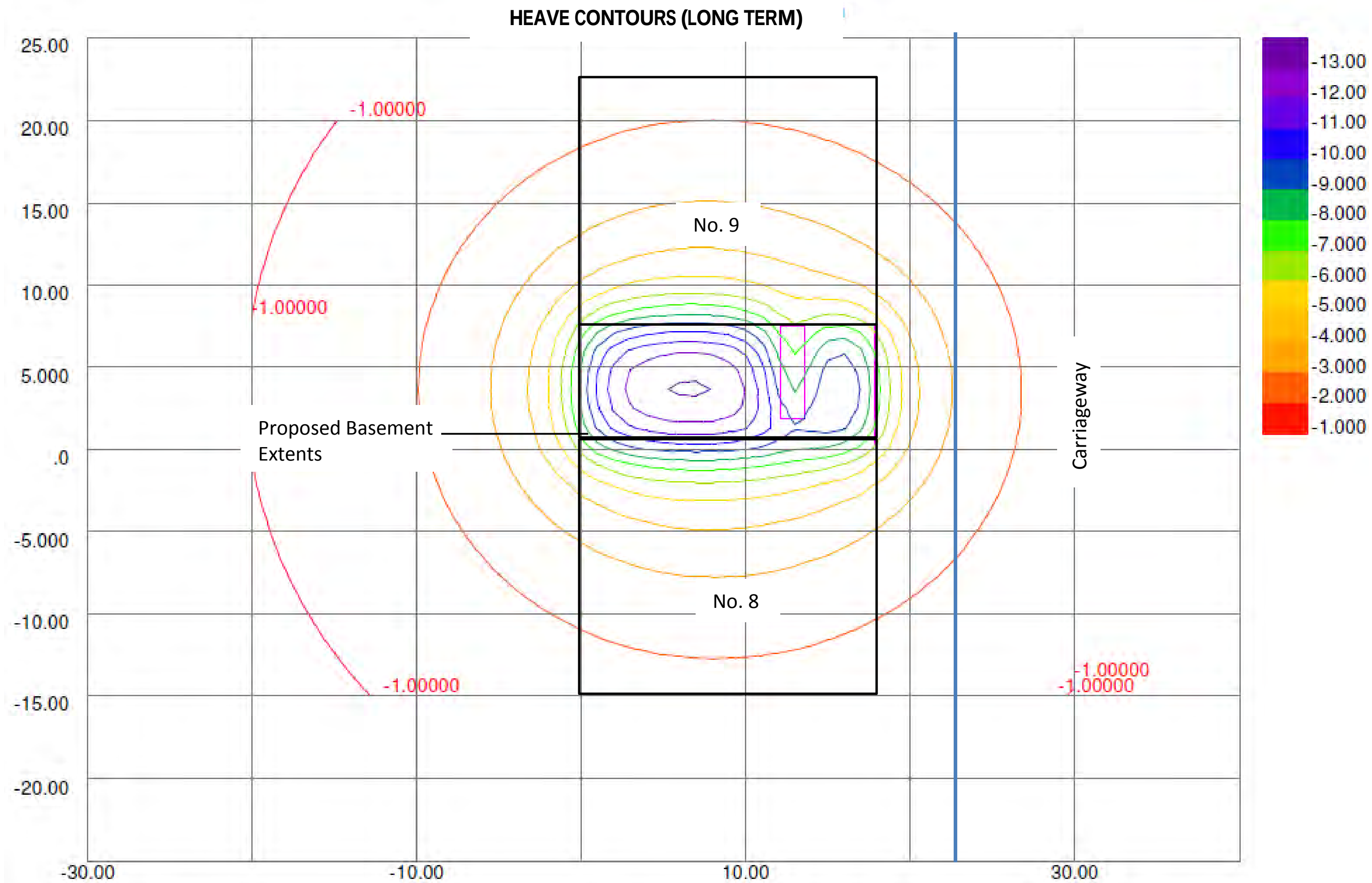


UTX: Undrained Triaxial Test

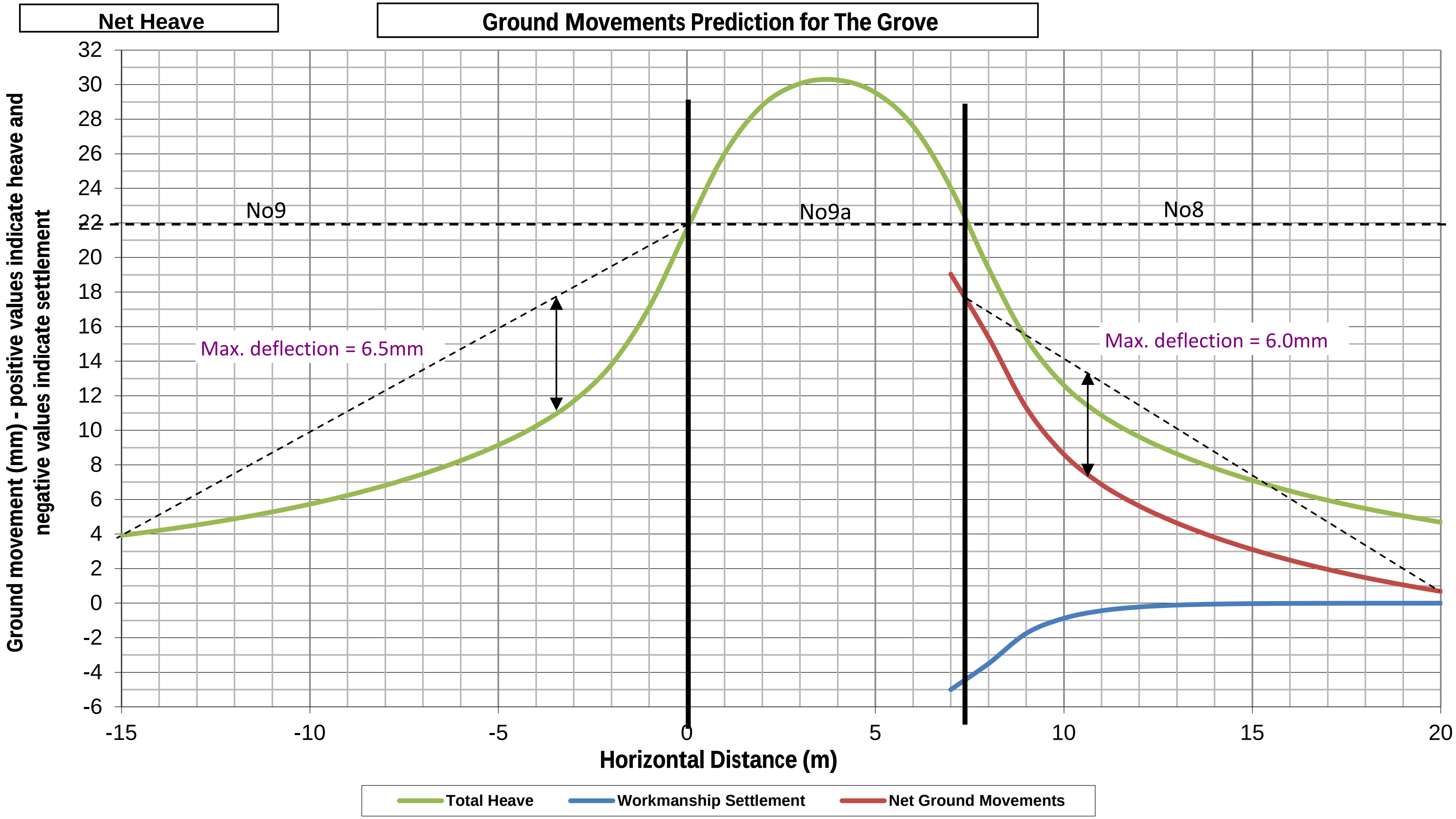
Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
CGL	Title **Undrained Shear Strength vs Level**	**Figure 5**



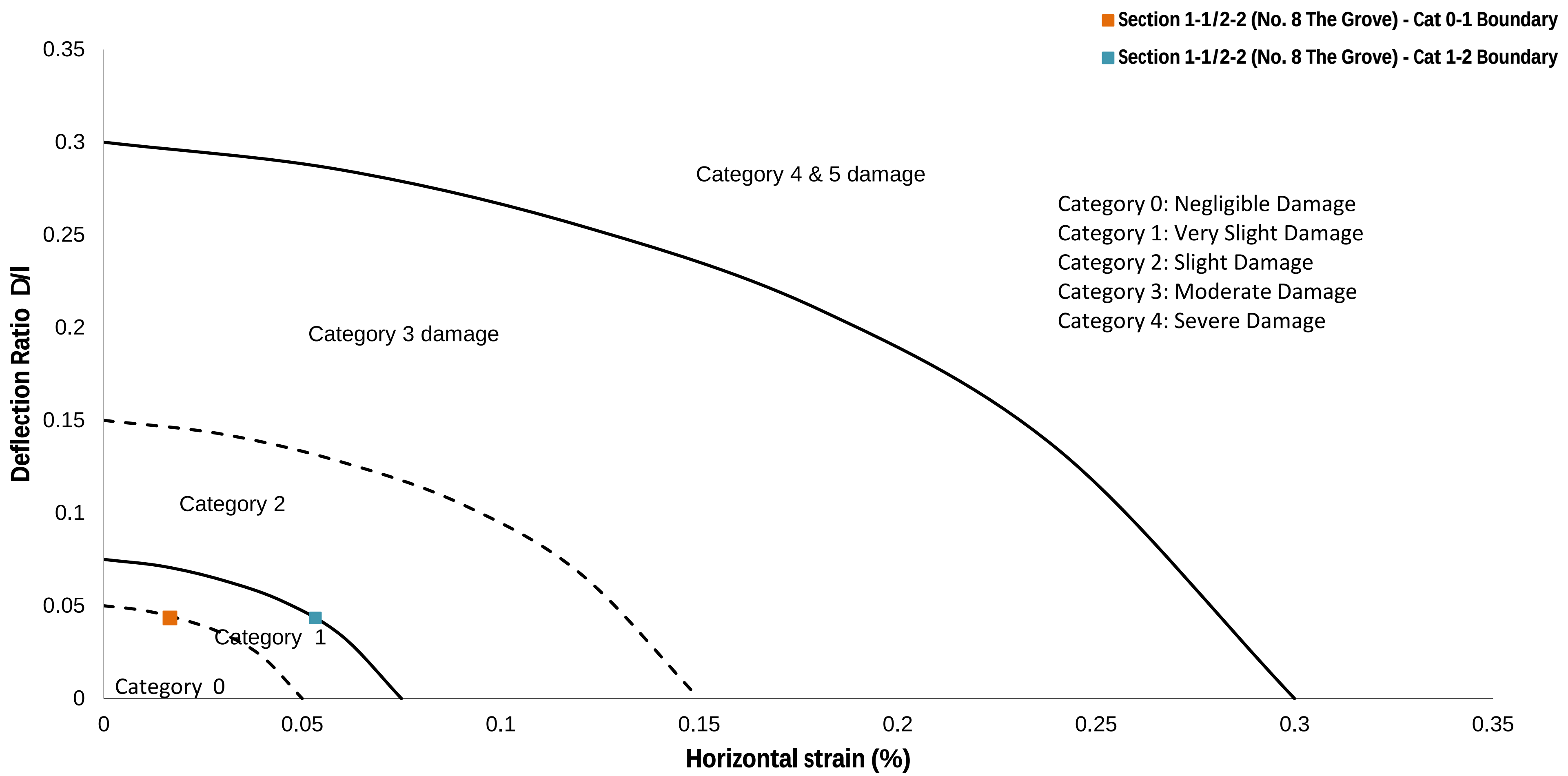
Client **P&T Architects and Engineers**	Project **9A The Grove, London**	Job No **CG/18545**
CGL	Title **Undrained (Short Term) Ground Movements**	**Figure 6**



Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
CGL	Title: **Long Term Ground Movements**	**Figure 7**



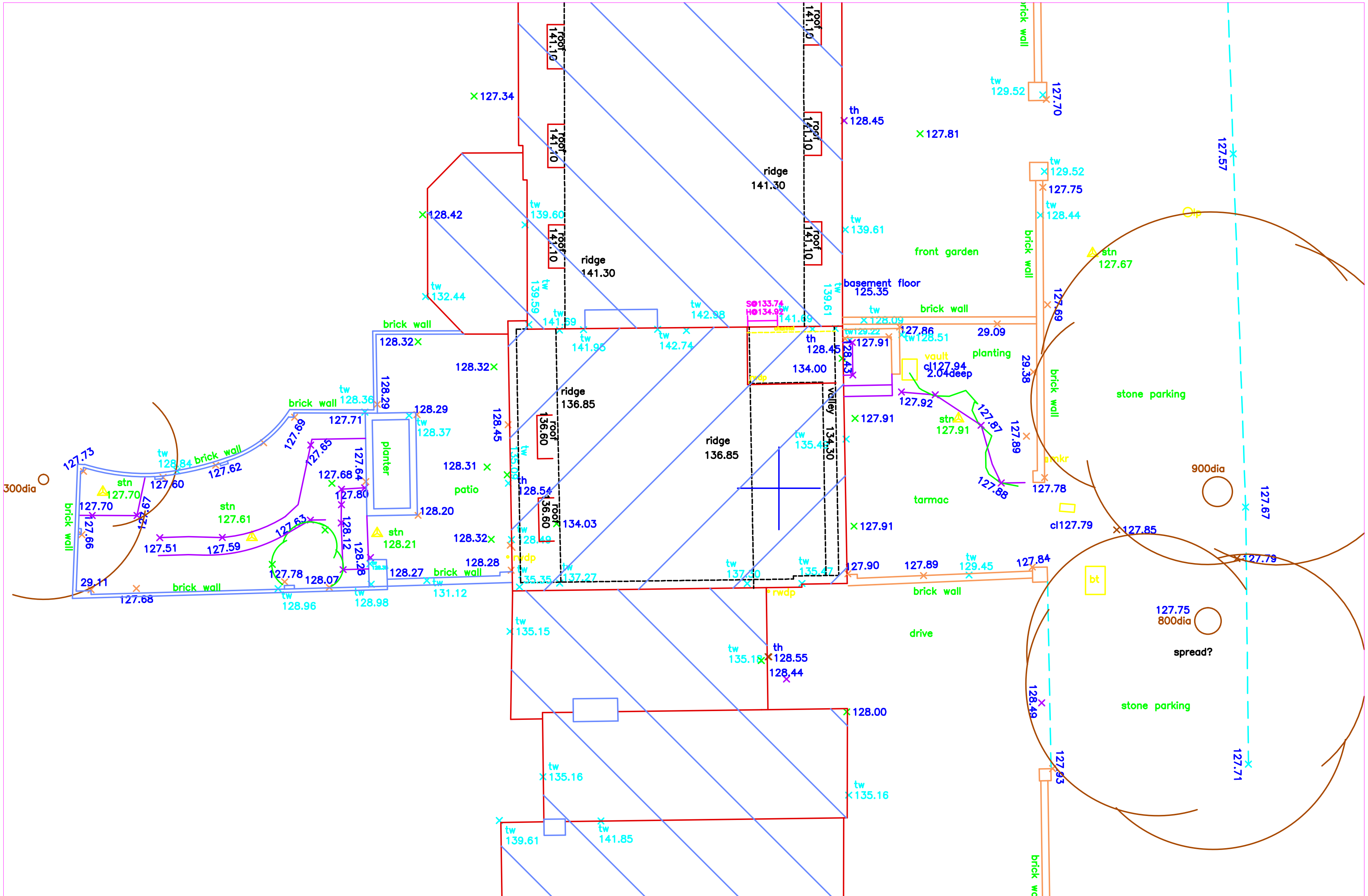
Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
CGL	Title **Net Vertical Ground Movements (Nos. 8 & 9)**	**Figure 8**



Client	Project	Job No
P&T Architects and Engineers	**9A The Grove, London**	**CG/18545**
CGL	Title **Building Damage Category Assessment Plot**	**Figure 9**

APPENDIX A

Existing Development Survey Plan



JOB	9A THE GROVE, HIGHGATE N6 FOR N. BURNS	TITLE	PROPOSED DRAWINGS SITE PLAN

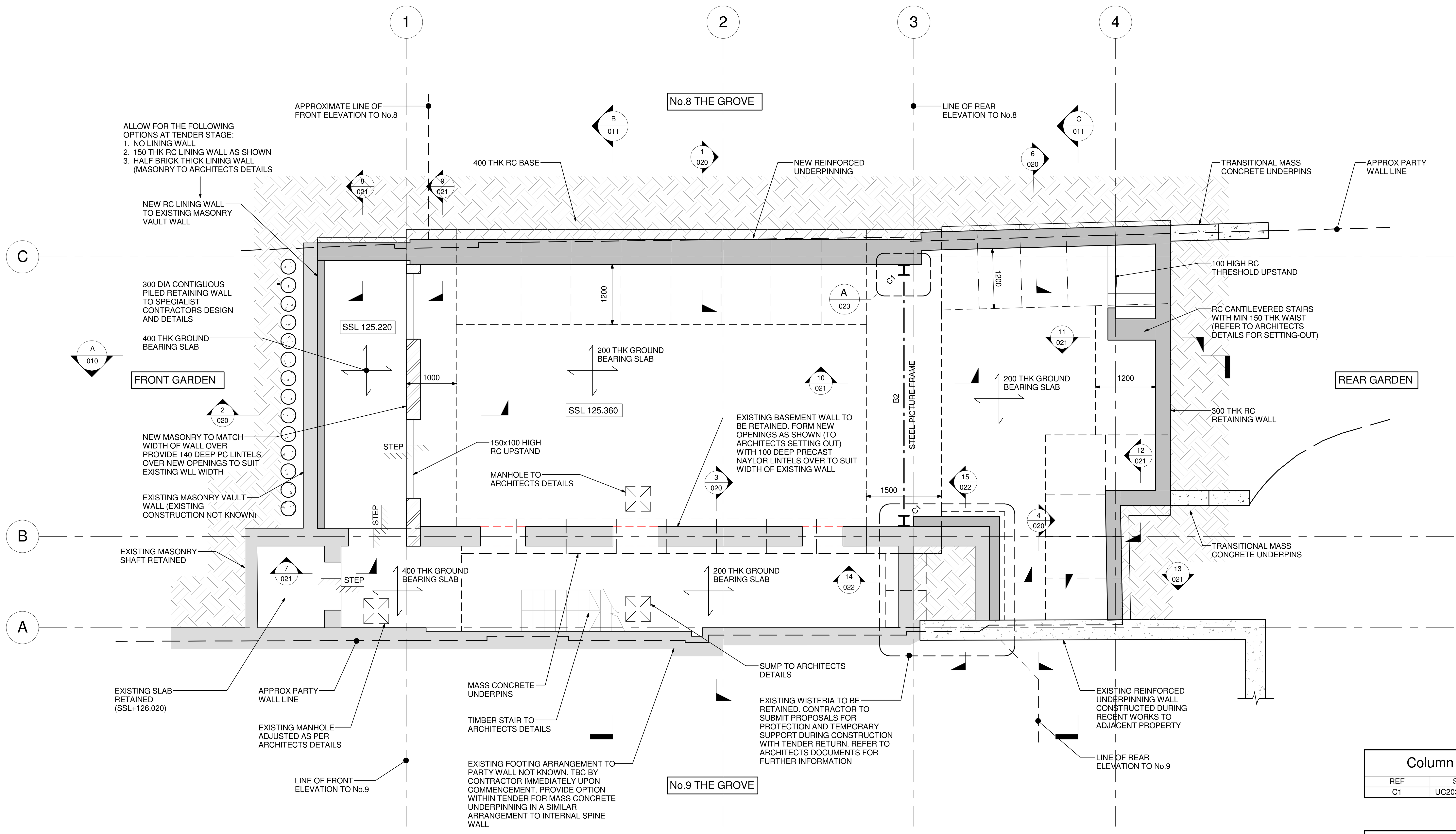
© RICHARD KEEP ARCHITECTS

DRAWN	DATE	JOB NO	DWG	REV
—	05.05.15	140	S1	P
CHECK	SCALE			DATE
—	1:50@A1			

CONTRACTOR TO CHECK ALL DIMENSIONS ON SITE
SPECIFICATION TO TAKE PRECEDENCE OVER DRAWINGS AND DETAILS
DO NOT SCALE

APPENDIX B

Proposed Development Plans



Proposed Basement Plan
Scale 1 : 50

NOTES

1. DO NOT SCALE OUT OF THIS DRAWING
2. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ARCHITECTS AND OTHER CONSULTANTS INFORMATION
3. REFER TO THE ARCHITECT FOR DIMENSIONS AND SETTING OUT FOR ALL NEW OPENINGS etc.
4. ALL AREAS OF DEFECTIVE STRUCTURE FOUND DURING DEMOLITION WORKS ARE TO BE REPORTED TO THE ENGINEER. IF NOT ALREADY ADDRESSED.
5. WHERE POSSIBLE REMEDIAL OR REPLACEMENT WORKS TO BE INSTALLED BEFORE REMOVAL OF EXISTING STRUCTURE - IF IN DOUBT, REFER TO THE ENGINEER
6. FOR GENERAL NOTES REFER TO DRAWING 1290/N/050-051
7. FOR MOVEMENTS AND TOLERANCES REFER TO DRAWING 1290/N/052
8. ALL STRUCTURAL WORKS SHOWN ARE BASED ON VARIOUS ASSUMPTIONS FOLLOWING LIMITED OPENING UP WORKS. FURTHER OPENING UP AND SURVEY WORK IS TO BE UNDERTAKEN IMMEDIATELY UPON COMMENCEMENT OF THE WORKS AS ADVISED BY eHRW, REFER TO GENERAL NOTES SECTION 7.00.
9. REFER TO ARCHITECTS DRAWINGS FOR FULL EXTENT OF DEMOLITION.
10. ALL DIMENSIONS SHOWN ARE SUBJECT TO SITE SURVEY TO BE COMPLETED BY THE CONTRACTOR.
11. REFER TO INFORMATION BY OTHERS FOR LOCATION OF CAST-IN SERVICES, GULLIES, MANHOLES ETC
12. ALL BEAMS BEARING ONTO MASONRY TO HAVE 440x215x100 DEEP MASS CONCRETE PADSTONE UNO.

LEGEND

	DENOTES EXISTING LOADBEARING MASONRY WALLS TO BE RETAINED
	DENOTES NEW LOADBEARING MASONRY WALLS
	DENOTES NEW RC WALLS / UNDERPINNING
	DENOTES DOUBLED JOIST OR FLITCH BEAM LOCATION
	DENOTES EXISTING WALLS TO BE REMOVED
GST	DENOTES GALVANISED METAL WALL STRAPS. REFER TO TYPICAL DETAILS
200	DENOTES 200 THK RC SLAB
RJ1	DENOTES 50x200 C24 JOISTS AT 400crs WITH 18 THK PLYWOOD DECK
RJ2	DENOTES 50x150 C24 JOISTS AT 400crs WITH 18 THK PLYWOOD DECK
P1 -	DENOTES 440x215x100 WIDE MASS CONCRETE PADSTONE
DJ -	DENOTES DOUBLED JOIST WITH M12 BOLTS AT 300crs

Column Schedule

REF	SIZE	GRADE
C1	UC203x203x86	S355

Beam Schedule

REF	SIZE	GRADE
B1	UC203x203x46	S355
B2	UC203x203x86	S355
B3	SHS150x150x8.0	S355

NOTE
REINFORCEMENT DETAILING AND SCHEDULING IS THE RESPONSIBILITY OF THE CONTRACTOR.
REINFORCEMNT SKETCHES WILL BE PROVIDED BY EHRW UPON CONTRACTOR APPOINTMENT.
ALLOW FOR THE FOLLOWING FOR TENDER PURPOSES:
- BASEMENT SLAB - 100kg/m³
- BASEMENT WALLS - 90kg/m³
- GROUND FLOOR SLAB - 125kg/m³

TEMPORARY WORKS NOTE:
THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT HIS OPERATIONS DO NOT IN ANY WAY IMPAIR THE SAFETY OR CONDITION OF THE EXISTING STRUCTURE. HE SHALL PROVIDE ANY TEMPORARY SUPPORTS REQUIRED FOR THIS PURPOSE, AND SHALL CAREFULLY INSPECT THE CONDITION OF THE BUILDING STRUCTURE. HE SHALL PROVIDE ANY TEMPORARY SUPPORTS REQUIRED FOR THIS PURPOSE, AND SHALL CAREFULLY INSPECT THE CONDITION OF THE STRUCTURE BOTH BEFORE AND DURING THE EXECUTION OF THE WORK AND IMMEDIATELY INFORM THE ENGINEER IF HE CONSIDERS THAT ANY MORE STRINGENT PROCEDURE THAN THAT SPECIFIED IS NECESSARY.

1:50 0 1000 2000 3000 4000 5000

Rev	Date	Amendments	By	Chk'd
T1	15.07.15	TENDER ISSUE	DJP	AR
P3	15.06.15	PRE-TENDER COORDINATION ISSUE	DJP	AR
P2	27.05.15	COORDINATION ISSUE	DJP	AR
P1	30.03.15	WORK IN PROGRESS ISSUE	DJP	AR

engineersHRW
London 0207 407 9575 Oxford 01865 251 206 www.ehrw.co.uk

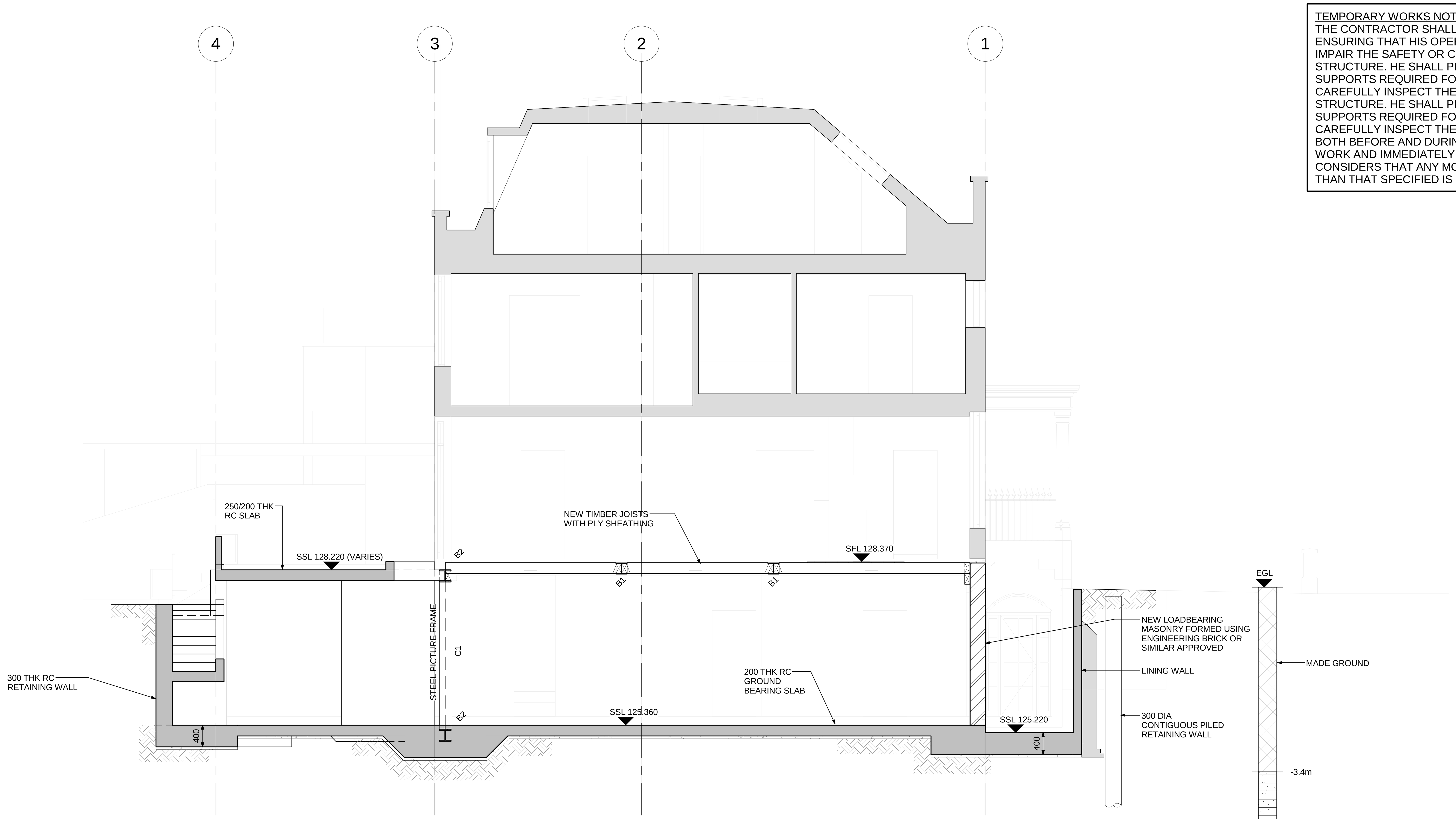
Project:
9A The Grove

Drawing title:
Proposed Basement Plan

Scale at A1:	Drawn by:	Date:	Chk'd by:
1 : 50	DJP	MAR' 2015	AR

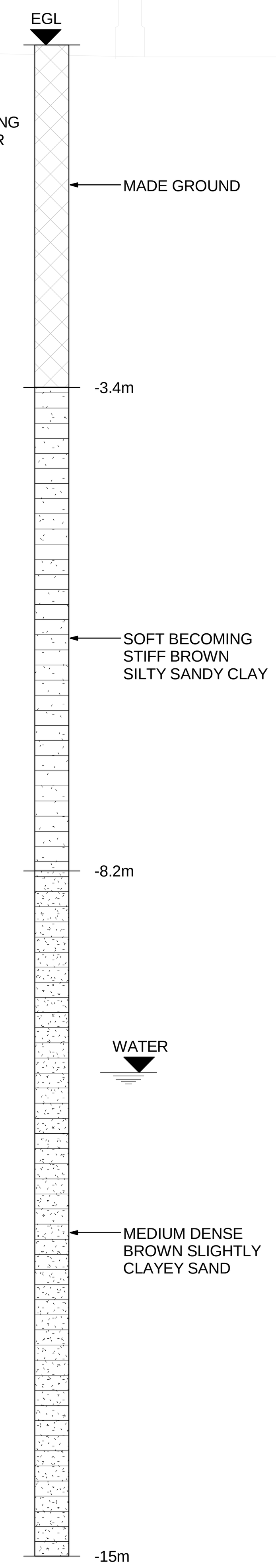
TENDER

Project Number:	Drawing Type:	Drawing No:	Revision:
1290	GA	001	T1



Section A - A

Scale 1 : 50



TEMPORARY WORKS NOTE:
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NOTES

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7. FOR MOVEMENTS AND TOLERANCES REFER TO DRAWING 1290/N/052
8. ALL STRUCTURAL WORKS SHOWN ARE BASED ON VARIOUS ASSUMPTIONS FOLLOWING LIMITED OPENING UP WORKS. FURTHER OPENING UP AND SURVEY WORK IS TO BE UNDERTAKEN IMMEDIATELY UPON COMMENCEMENT OF THE WORKS AS ADVISED BY eHRW, REFER TO GENERAL NOTES SECTION 7.00.
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Column Schedule

REF	SIZE	GRADE
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Beam Schedule

REF	SIZE	GRADE
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Rev	Date	Amendments	By	Chk'd
P3	15.06.15	PRE-TENDER COORDINATION ISSUE	DJP	AR
P2	27.05.15	COORDINATION ISSUE	DJP	AR
P1	30.03.15	WORK IN PROGRESS ISSUE	DJP	AR

engineersHRW

London 0207 407 9575 Oxford 01865 251 206 www.ehrw.co.uk

Project:

9A The Grove

Drawing title:

Proposed Section A-A

Scale at A1:	Drawn by:	Date:	Chk'd by:
As indicated	DJP	MAR' 2015	AR

1:50 0 1000 2000 3000 4000 5000

PRELIMINARY

Project Number:	Drawing Type:	Drawing No:	Revision:
1290	SE	010	P3

APPENDIX C

Ground investigation report

GEA Geotechnical & Environmental Associates	Tyttenhanger House, Coursers Road, St Albans, AL4 0PG	**Site** 9A The Grove, London, N6 6JU	**Borehole Number** BH1

Boring Method	**Casing Diameter**	**Ground Level (mOD)**	**Client**	**Job Number**
Cable Percussion	150 mm to 12.00 m	127.88	Mr Nick Burns	J15047
	Location	**Dates** 13/02/2015	**Engineer** EngineersHRW	**Sheet** 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					127.83	0.05 (0.15)	Block Paving		
					127.68	0.20	Concrete		
0.50	D1					(0.70)	Made Ground (brown silty clayey sand with gravel and brick fragments)		
0.90	D2				126.98	0.90	Made Ground (brown silty sandy clay with gravel brick and ash fragments)		
1.20-1.65 1.20	SPT(C) N=6 D3	1.20	DRY	1,1/1,2,1,2		(0.90)			
1.80	D4				126.08	1.80	Made Ground (brown mottled orange-brown and occasionally grey silty clayey sand with occasional brick fragments)		
2.00-2.45 2.00	SPT N=3 D5	1.50	DRY	1,0/1,0,1,1					
						(1.60)			
2.70	D6								
3.00-3.45 3.00	SPT N=11 D7	1.50	DRY	1,1/2,3,3,3					
					124.48	3.40	Soft becoming stiff brown mottled orange-brown and grey silty sandy CLAY with occasional pockets of orange-brown fine to medium sand and rare fine gravel		
3.70	D8								
4.00-4.45	U9								
4.50	D10								
4.80	D11								
5.00-5.45 5.00	SPT N=15 D12	1.50	DRY	3,3/3,3,4,5					
						(3.85)			
6.00	U13								
6.50	D14								
					120.63	7.25	Medium dense orange-brown clayey fine to medium SAND with layers of orange-brown and grey sandy clay		
7.50-7.95 7.50	SPT N=19 D15	1.50	DRY	2,3/4,4,5,6					
						(0.95)			
					119.68	8.20	Medium dense brown occasionally mottled orange-brown slightly clayey fine to medium SAND		
9.00-9.45 9.00	SPT N=33 D16	1.50	DRY	4,6/6,8,9,10					

Remarks	**Scale (approx)**	**Logged By**
Groundwater monitoring standpipe installed to a depth of 6.00 m.	1:50	AT
	Figure No. J15047.BH1	

GEA Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site 9A The Grove, London, N6 6JU				**Borehole Number** BH1
Boring Method Cable Percussion	**Casing Diameter** 150 mm to 12.00 m	**Ground Level (mOD)** 127.88	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 13/02/2015	**Engineer** EngineersHRW	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
				Seepage(1) at 10.20m, no rise after 20 mins, sealed at 10.50 Mm.			
10.50	D17						
10.50-10.95	SPT N=28	10.50	DRY	4,5/6,7,7,8			
						(6.70)	
12.00-12.45	SPT N=29	12.00	DRY	4,5/6,7,8,8			
12.00	D18						
				Slow Inflow(2) at 12.70m, rose to 12.30m in 20 mins.			
13.50-13.95	SPT N=19	12.00	13.10	3,4/4,4,5,6			
13.50	D19						
14.50	D20						
					112.98	14.90	Stiff grey silty CLAY
					112.88	15.00	Complete at 15.00m

Remarks

Scale (approx)	Logged By
1:50	AT

Figure No. J15047.BH1

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Standard Penetration Test Results

Site : 9A The Grove, London, N6 6JU

Client : Mr Nick Burns

Engineer : EngineersHRW

Job Number J15047

Sheet 1 / 1

Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
BH1	1.20	1.35	1.65	CPT	1	1	1	2	1	2	N=6	
BH1	2.00	2.15	2.45	SPT	1	0	1	0	1	1	N=3	
BH1	3.00	3.15	3.45	SPT	1	1	2	3	3	3	N=11	
BH1	5.00	5.15	5.45	SPT	3	3	3	3	4	5	N=15	
BH1	7.50	7.65	7.95	SPT	2	3	4	4	5	6	N=19	
BH1	9.00	9.15	9.45	SPT	4	6	6	8	9	10	N=33	
BH1	10.50	10.65	10.95	SPT	4	5	6	7	7	8	N=28	
BH1	12.00	12.15	12.45	SPT	4	5	6	7	8	8	N=29	
BH1	13.50	13.65	13.95	SPT	3	4	4	4	5	6	N=19	

GEA Geotechnical & Environmental Associates	Tyttenhanger House Coursers Road St Albans AL4 0PG	**Site** 9A The Grove, London, N6 6JU	**Number** **BH2**

Excavation Method	**Dimensions**	**Ground Level (mOD)**	**Client**	**Job Number**
Drive-in Window Sampler		127.51	Mr Nick Burns	J15047
	Location	**Dates** 19/02/2015	**Engineer** EngineersHRW	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.70)	Made Ground (brown silty sandy clay with gravel and rare brick fragments)		
0.40	D1							
				126.81	0.70 (0.50)	Made Ground (brown silty sandy clay with gravel and abundant brick fragments)		
				126.31	1.20	Made Ground (brick fragments with packets of pale brown sandy clay)		
1.50	D2							
					(2.00)			
				124.31	3.20	Soft pale brown mottled orange-brown sandy CLAY		
3.50	D3				(0.90)			
				123.41	4.10	Pale brown clayey fine to medium SAND		
5.00	D4				(1.90)			
				121.51	6.00	Complete at 6.00m		

Remarks
Groundwater not encountered.
Groundwater monitoring standpipe installed to a depth of 6.00 m.

Scale (approx)	**Logged By**
1:50	AT
Figure No. J15047.BH2	

GEA Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site	Number
9A The Grove, London, N6 6JU	**BH3**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler		127.71	Mr Nick Burns	J15047
	Location	**Dates**	**Engineer**	**Sheet**
		19/02/2015	EngineersHRW	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.40)	Made Ground (dark brown silty sandy clay with gravel and rare brick and concrete fragments)		
0.20	D1							
				127.31	0.40	Made Ground (brown silty sandy clay with gravel, occasional brick and ash fragments and occasional pockets of orange-brown sandy clay)		
0.60	D2				(0.60)			
				126.71	1.00	Made Ground (orange-brown silty very sandy clay with occasional brick and ash fragments)		
					(0.80)			
				125.91	1.80	Firm orange-brown mottled pale brown sandy CLAY		
2.20	D3							
					(2.50)			
3.50	D4							
				123.41	4.30	Pale brown mottled orange-brown clayey fine to coarse SAND		
					(1.70)			
5.20	D5							
				121.71	6.00	Complete at 6.00m		

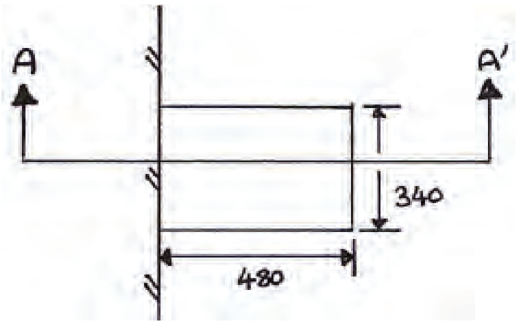
Remarks
Groundwater not encountered.
Groundwater monitoring standpipe installed to a depth of 6.00 m.

Scale (approx)	Logged By
1:50	AT

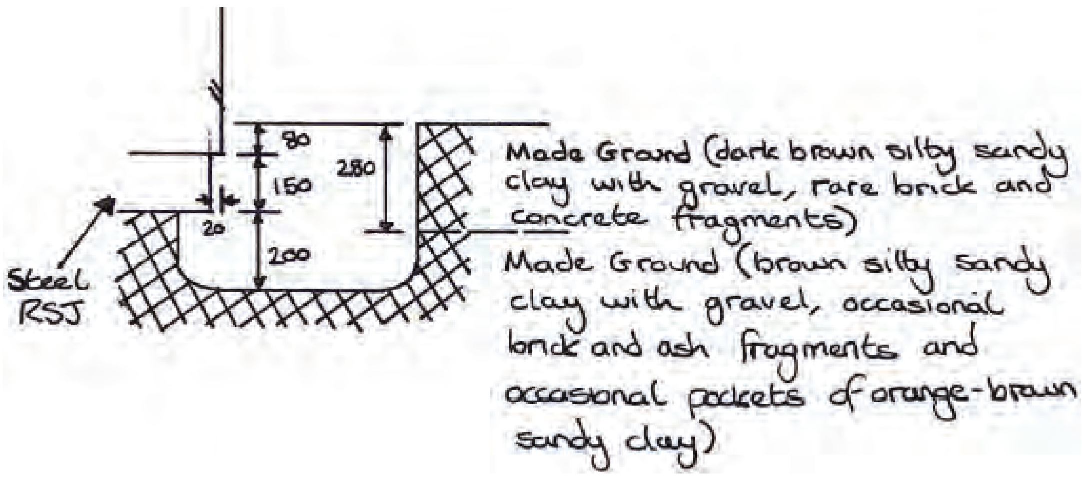
Figure No. J15047.BH3

Geotechnical & Environmental Associates Widbury Barn Widbury Hill Ware Herts SG12 7QE			Site 9A The Grove, London, N6 6JU	Trial Pit Number 1
Excavation Method Manual	Dimensions	Ground Level (mOD)	Client Mr Nick Burns	Job Number J15047
	Location	Dates 19/02/2015	Engineer Engineers HRW	Sheet 1 / 1

Plan: -



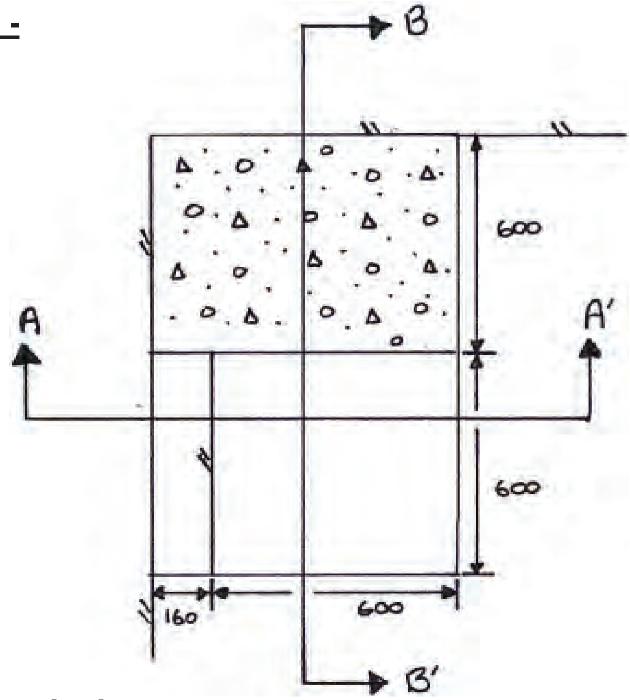
Section A - A: -



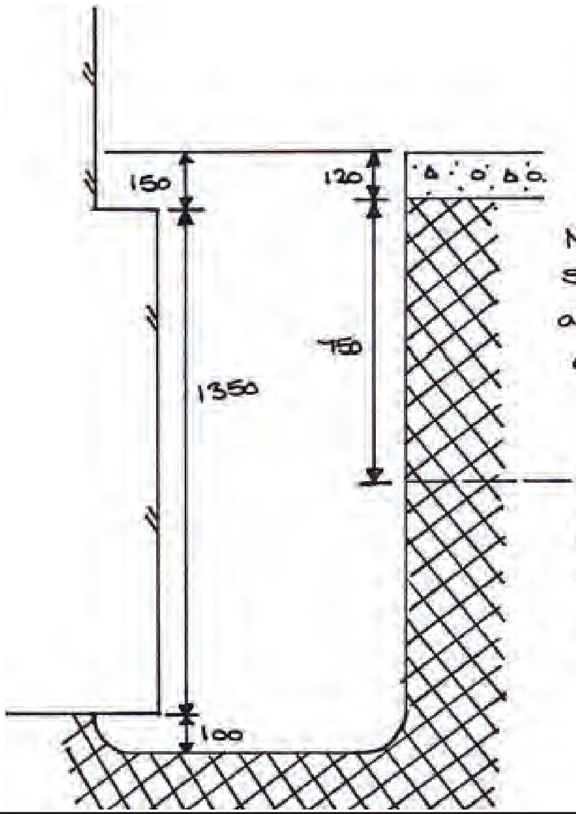
Remarks: All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Scale: 1:20 Logged by: AT

GEA Geotechnical & Environmental Associates, Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE			**Site** 9A The Grove, London, N6 6JU	**Trial Pit Number** 2
Excavation Method Manual	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 19/02/2015	**Engineer** Engineers HRW	**Sheet** 1 / 1

Plan: -



Section A - A: -



Paving over Concrete

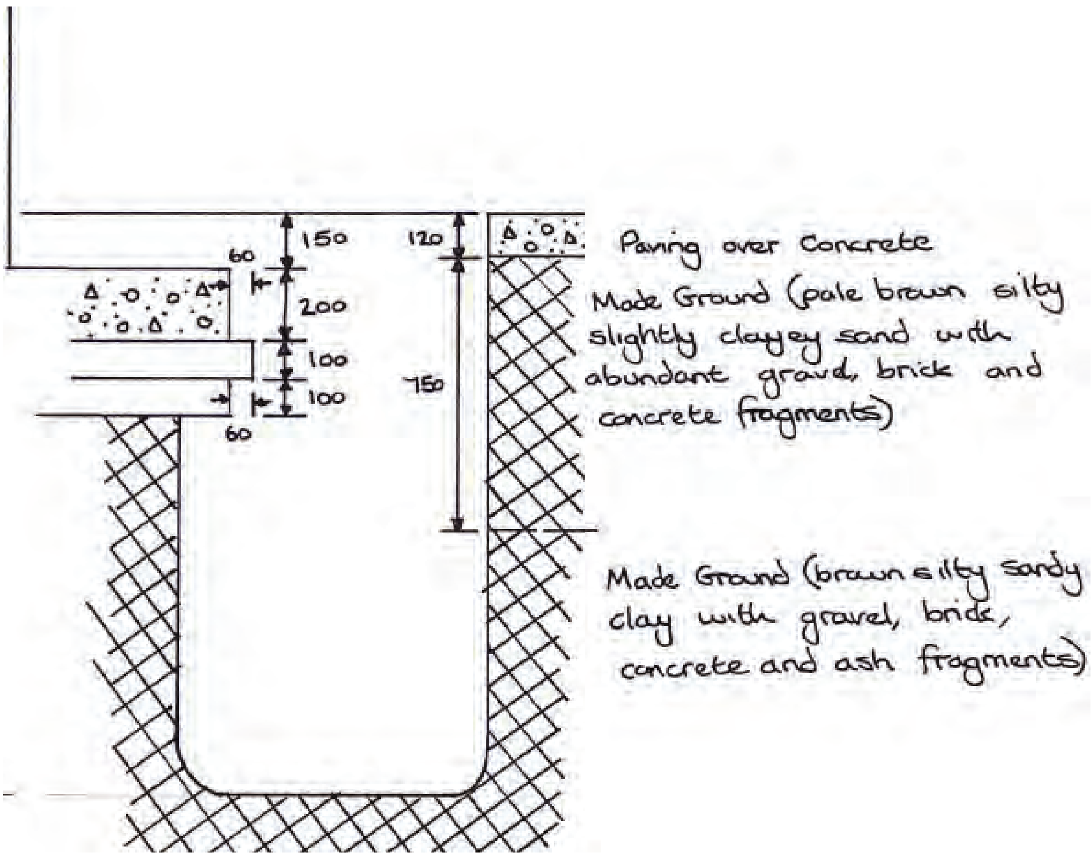
Made Ground (pale brown silty slightly clayey sand with abundant gravel, brick and concrete fragments)

Made Ground (brown silty sandy clay with gravel, brick, concrete and ash fragments)

Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

GEA Geotechnical & Environmental Associates		Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 9A The Grove, London, N6 6JU		**Trial Pit Number** 2
Excavation Method Manual	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Nick Burns		**Job Number** J15047
	Location	**Dates** 19/02/2015	**Engineer** Engineers HRW		**Sheet** 1 / 1

Section B - B': -

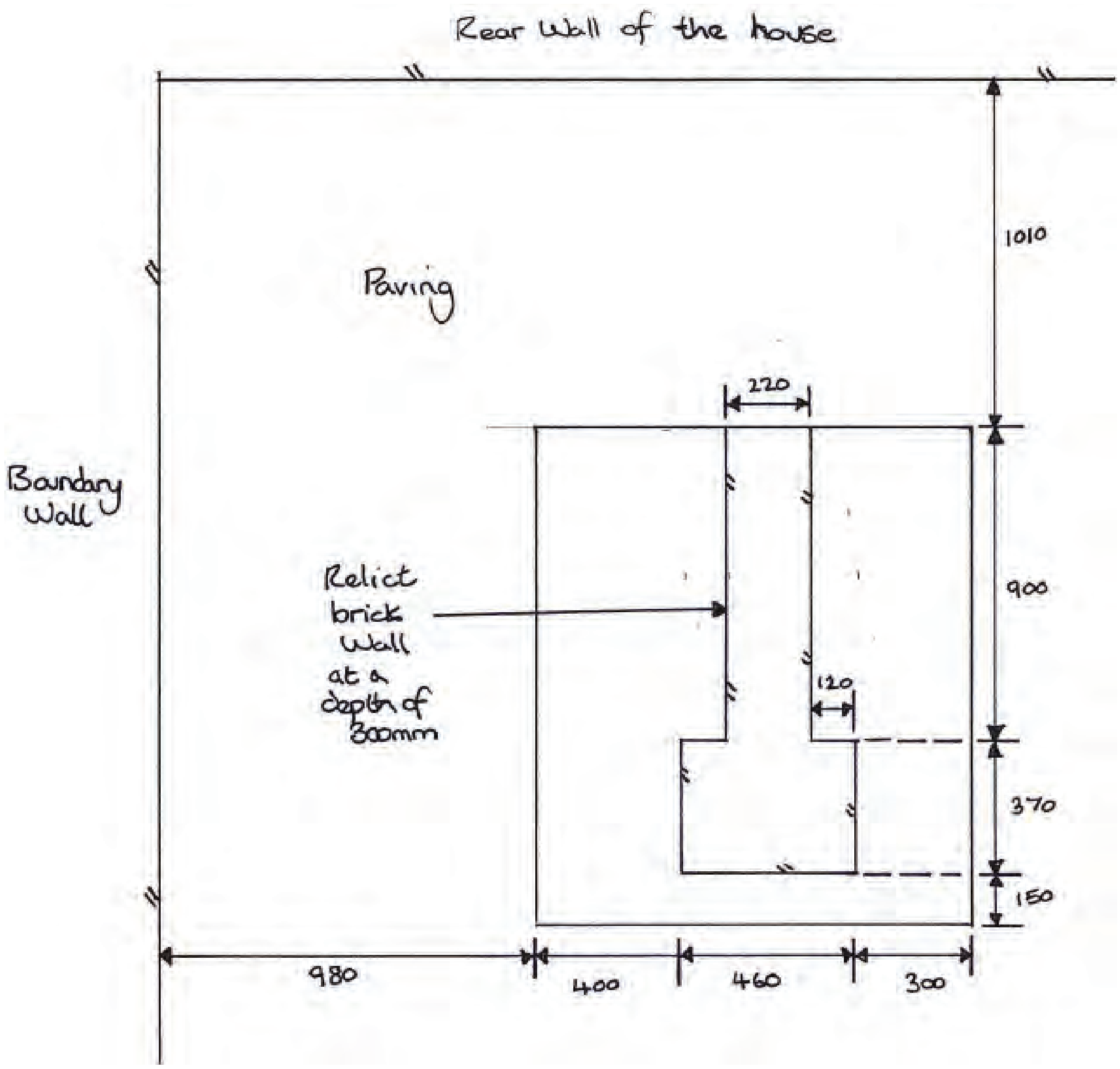


Remarks: All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Scale: 1:20 Logged by: AT

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 9A The Grove, London, N6 6JU	Trial Pit Number 3

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual			Mr Nick Burns	J15047
	Location	**Dates**	**Engineer**	**Sheet**
		19/02/2015	Engineers HRW	1 / 1

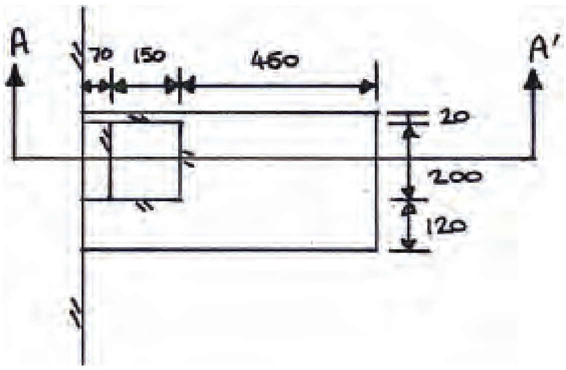
Plan: -



Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

Geotechnical & Environmental Associates — Widbury Barn, Widbury Hill, Ware, Herts SG12 7QE		Site: 9A The Grove, London, N6 6JU	Trial Pit Number: 4
Excavation Method Manual	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 19/02/2015	**Engineer** Engineers HRW	**Sheet** 1 / 1

Plan: -



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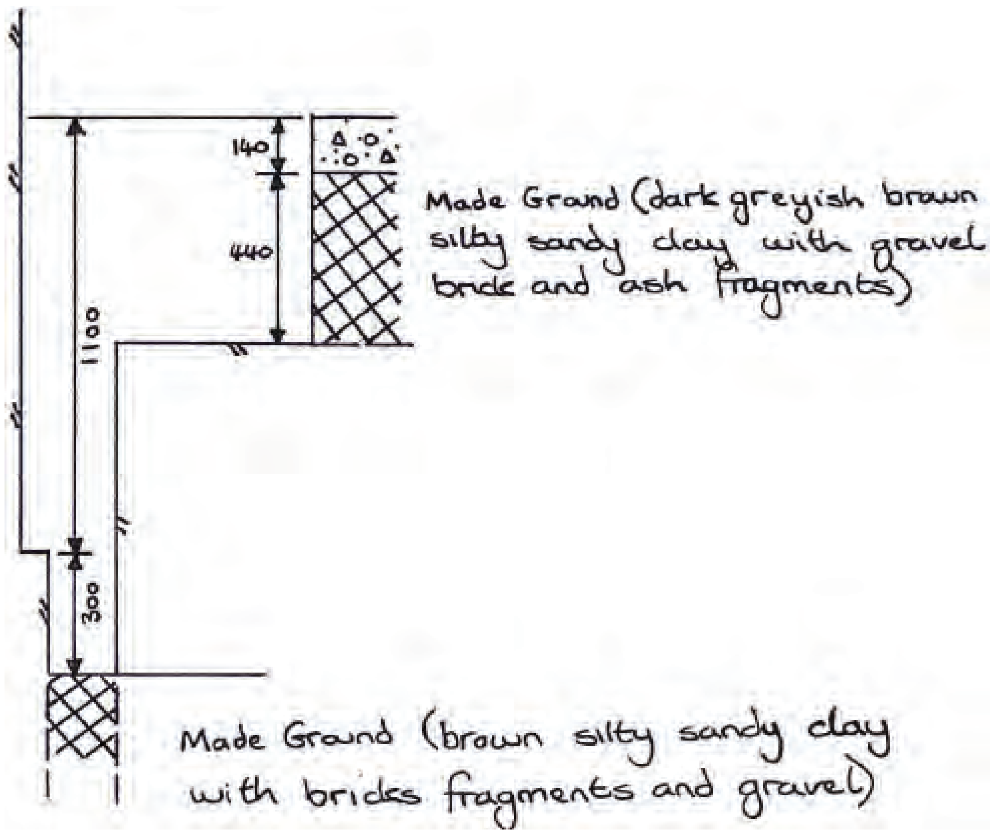
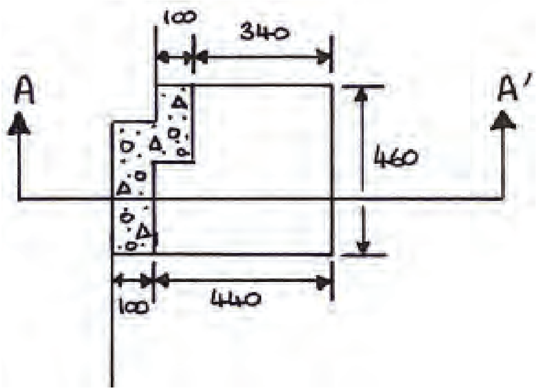


Remarks:	Scale: 1:20
All dimensions in millimetres	
Sides of trial pit remained stable during excavation	Logged by: AT
Groundwater: Not encountered	

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 9A The Grove, London, N6 6JU		**Trial Pit Number** **5**
Excavation Method Manual	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 19/02/2015	**Engineer** Engineers HRW	**Sheet** 1 / 1

Plan: -



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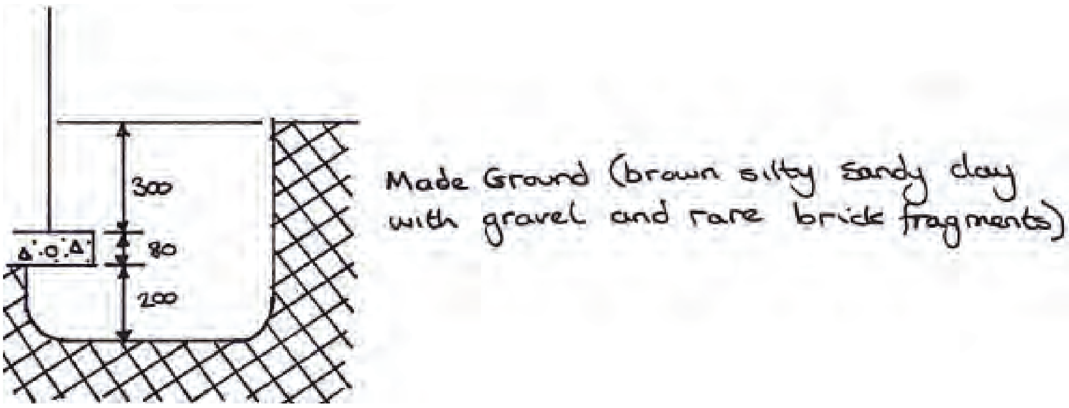
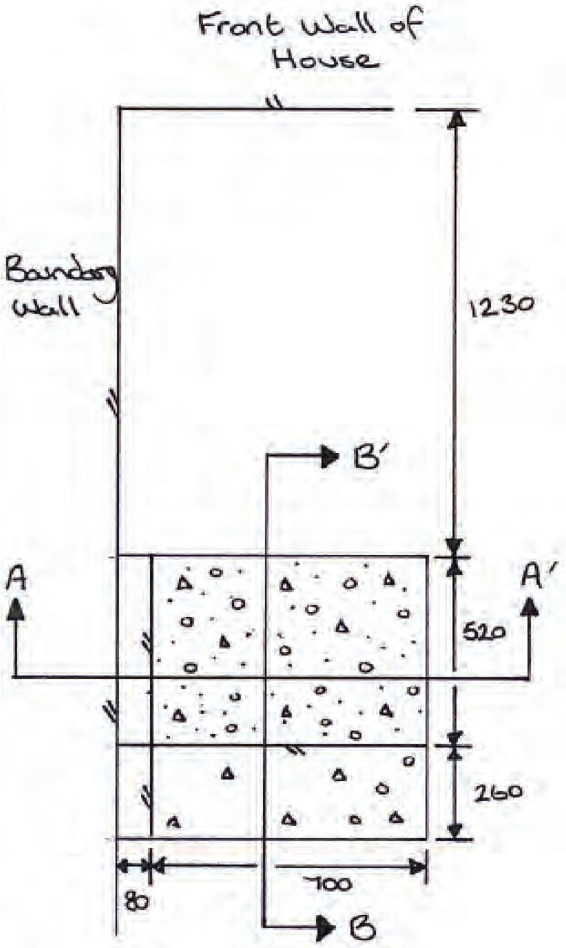


Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

Geotechnical & Environmental Associates		Widbury Barn Widbury Hill Ware Herts SG12 7QE	**Site** 9A The Grove, London, N6 6JU	**Trial Pit Number** **6**
Excavation Method Manual	**Dimensions**	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 19/02/2015	**Engineer** Engineers HRW	**Sheet** 1 / 1

Plan: -



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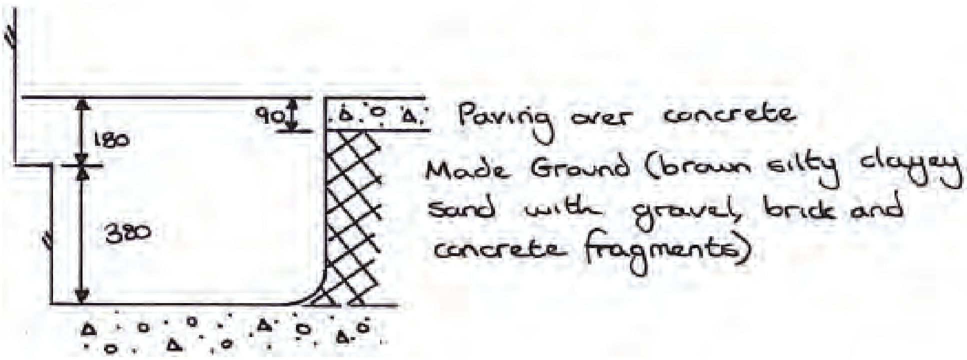
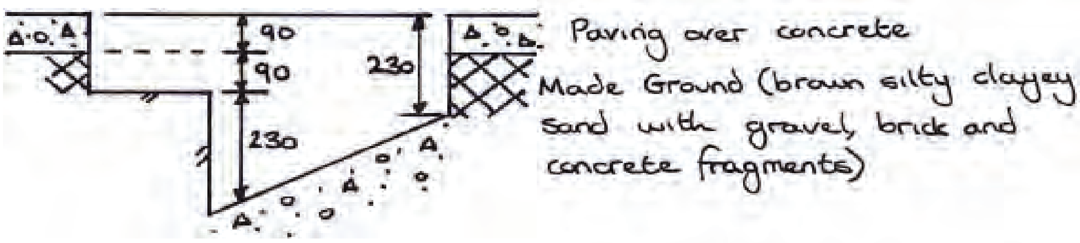


Remarks: All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Scale: 1:20 Logged by: AT

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 9A The Grove, London, N6 6JU		Trial Pit Number 6
Excavation Method Manual	Dimensions	Ground Level (mOD)	Client Mr Nick Burns	Job Number J15047
	Location	Dates 19/02/2015	Engineer Engineers HRW	Sheet 2 / 2

Section B - B': -

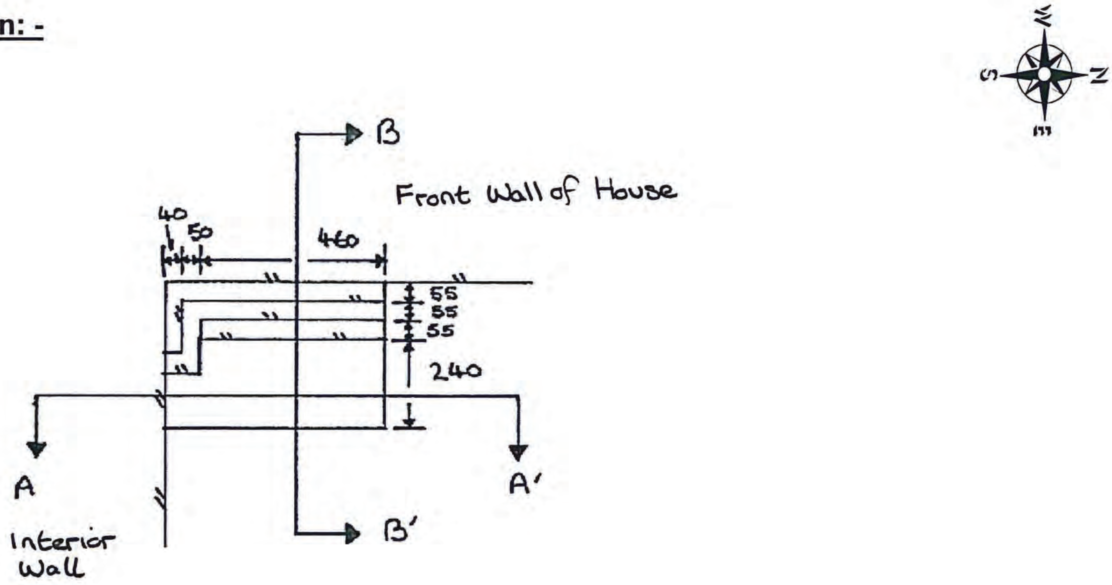


Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 9A The Grove, London, N6 6JU	Trial Pit Number 8

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual	365 x 550 x 610		Mr Nick Burns	J15047
	Location	**Dates**	**Engineer**	**Sheet**
		18/03/2015	Engineers HRW	1 / 2

Plan: -



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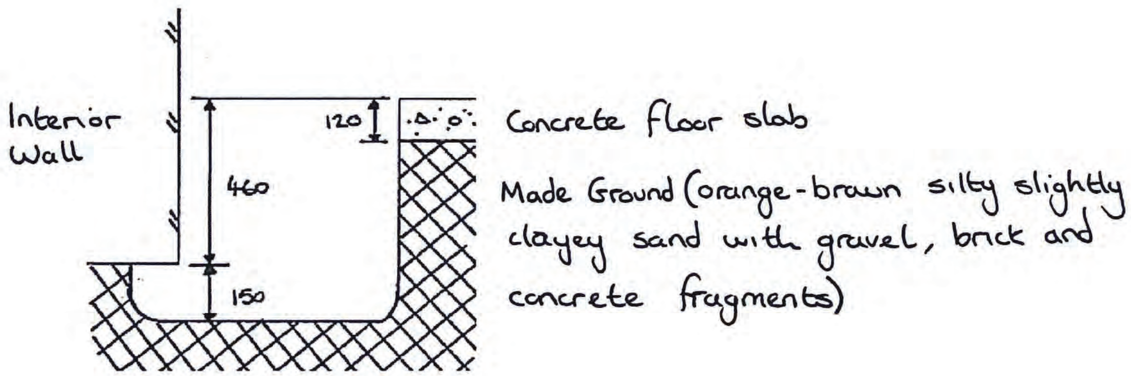
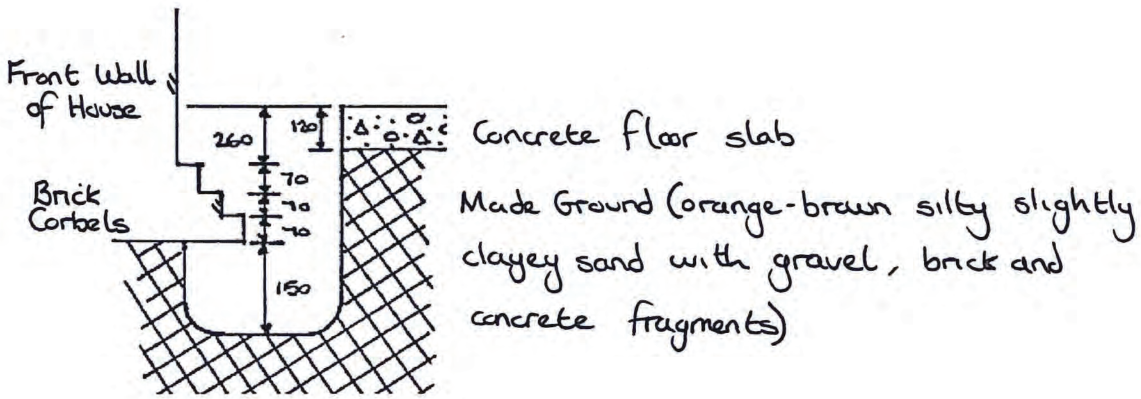


Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 9A The Grove, London, N6 6JU		Trial Pit Number 6
Excavation Method Manual	**Dimensions** 365 x 550 x 610	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 18/03/2015	**Engineer** Engineers HRW	**Sheet** 2 / 2

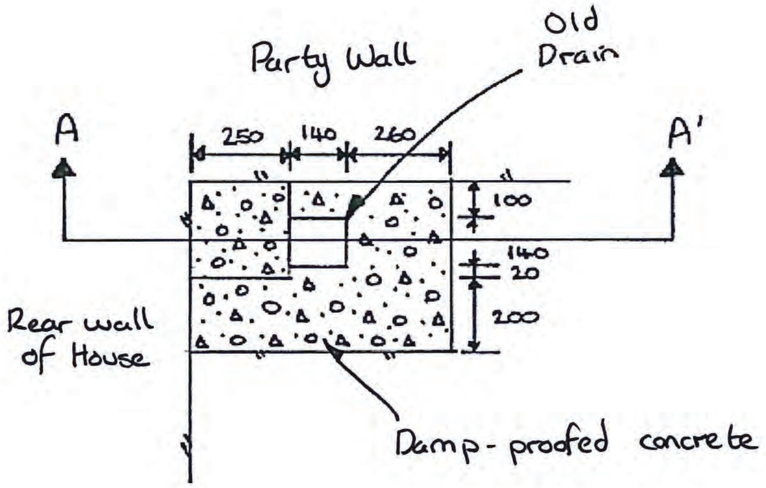
Section B - B': -



Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE		**Site** 9A The Grove, London, N6 6JU	**Trial Pit Number** 9
Excavation Method Manual	**Dimensions** 650 x 460 x 510	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 18/03/2015	**Engineer** Engineers HRW	**Sheet** 1 / 2

Plan: -



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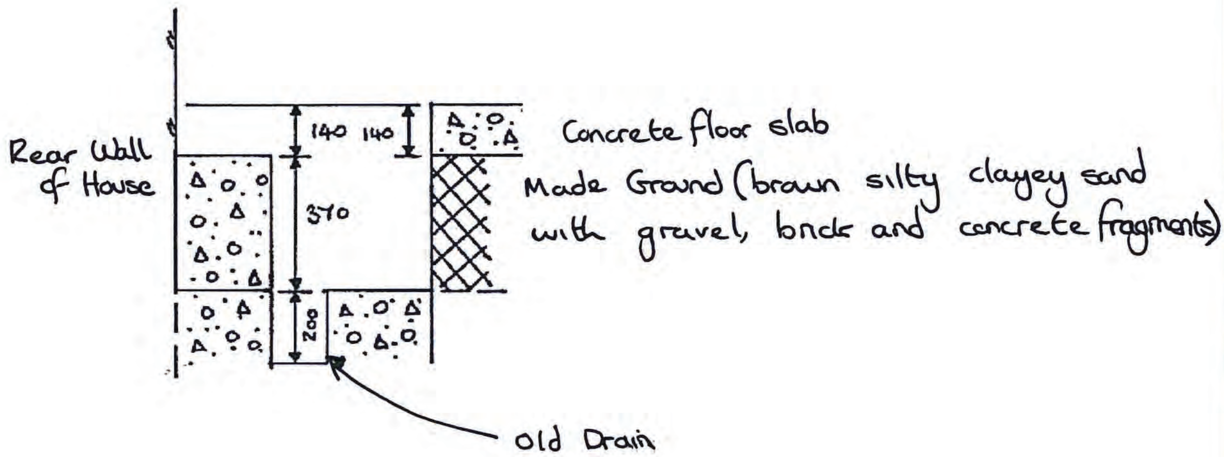
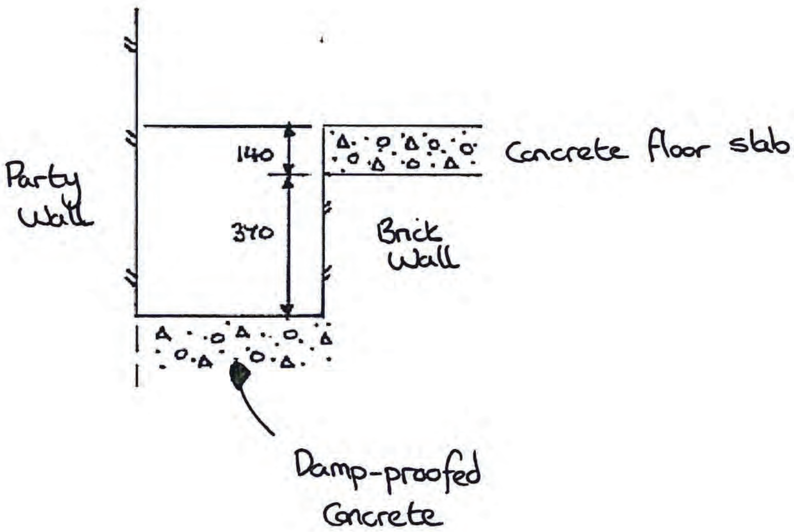


Remarks: All dimensions in millimetres Sides of trial pit remained stable during excavation Groundwater: Not encountered	Scale: 1:20 Logged by: AT

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE	Site 9A The Grove, London, N6 6JU	Trial Pit Number 6

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual	650 x 460 x 510		Mr Nick Burns	J15047
	Location	**Dates**	**Engineer**	**Sheet**
		18/03/2015	Engineers HRW	2 / 2

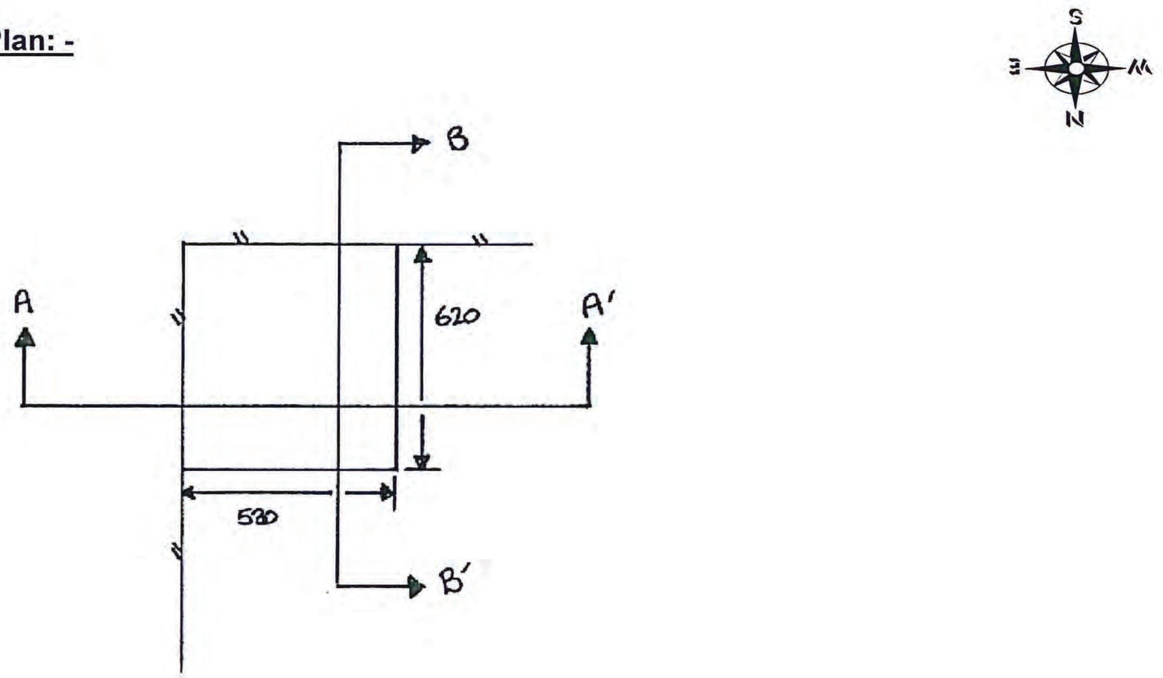
Section B - B': -



Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

GEA Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE		Site 9A The Grove, London, N6 6JU	Trial Pit Number 10
Excavation Method Manual	Dimensions 620 x 530 x 360	Ground Level (mOD)	Client Mr Nick Burns	Job Number J15047
	Location	Dates 18/03/2015	Engineer Engineers HRW	Sheet 1 / 2

Plan: -



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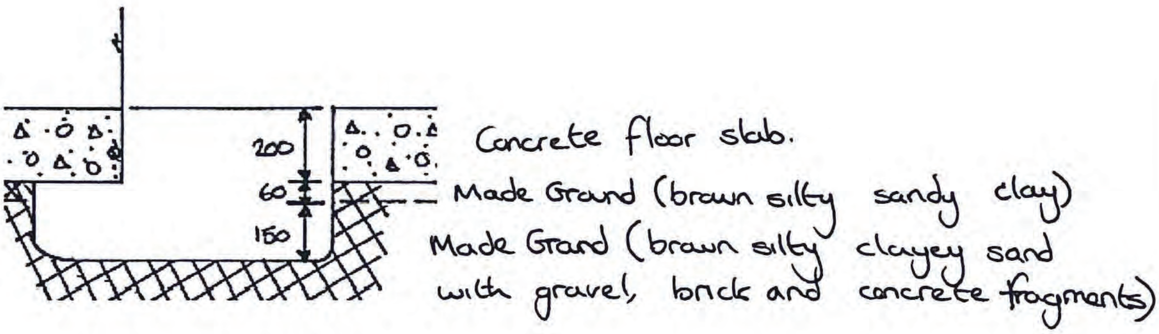
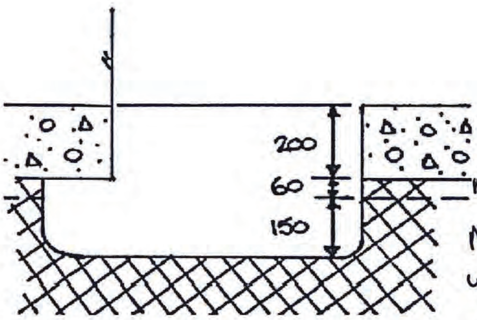


Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

Geotechnical & Environmental Associates	Widbury Barn Widbury Hill Ware Herts SG12 7QE		Site 9A The Grove, London, N6 6JU	Trial Pit Number 10
Excavation Method Manual	**Dimensions** 620 x 530 x 360	**Ground Level (mOD)**	**Client** Mr Nick Burns	**Job Number** J15047
	Location	**Dates** 18/03/2015	**Engineer** Engineers HRW	**Sheet** 2 / 2

Section B - B': -



Concrete floor slab.

Made Ground (brown silty sandy clay)

Made Ground (brown clayey silty sand with gravel, brick and concrete fragments)

Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained stable during excavation	Logged by:
Groundwater: Not encountered	AT

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Site Photographs

Site	9A The Grove, London, N6 6JU	**Job Number** J15047
Client	Mr Nick Burns	**Sheet** 1 / 6
Engineer	Engineers HRW	

View of Trial Pit No 1

View of Trial Pit No 2

View of Trial Pit No 3

View of Trial Pit No 4

Site	9A The Grove, London, N6 6JU	**Job Number**	J15047
Client	Mr Nick Burns	**Sheet**	3 / 6
Engineer	Engineers HRW		

View of Trial Pit No 5

View of Trial Pit No 6

Geotechnical & Environmental Associates

Widbury Barn
Widbury Hill
Ware
Herts SG12 7QE

Site Photographs

Site	9A The Grove, London, N6 6JU	**Job Number** J15047
Client	Mr Nick Burns	**Sheet** 4 / 6
Engineer	Engineers HRW	

View of brick pylon supporting suspended wooden floor

View of brick pylon supporting wooden cross beams

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

Site	9A The Grove, London, N6 6JU	**Job Number** J15047
Client	Mr Nick Burns	**Sheet** 5 / 6
Engineer	Engineers HRW	

View of concrete beams being supported by wooden cross beams, and the formation of the wooden floor

View of Trial Pit No 8

Site	9A The Grove, London, N6 6JU	**Job Number**	J15047
Client	Mr Nick Burns	**Sheet**	6 / 6
Engineer	Engineers HRW		

View of Trial Pit No 9

View of Trial Pit No 10

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	MC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH1	D8	3.70	D	Yellow and orange brown sandy silty CLAY with rare fine gravel	23	44	17	27	98									
BH1	U9	4.00	U	Firm light brown fine sandy CLAY with rare orange staining	27					1.98	1.56	80	141	70				
BH1	D10	4.50	D												6.7	0.04		
BH1	D11	4.80	D	Yellow brown sandy CLAY with rare fine gravel	27	37	17	20	99									
BH1	U13	6.00	U	Firm yellow brown sandy CLAY	18					1.85	1.57	120	44	22				
BH1	D14	6.50	D												7.1	0.03		
BH1	D16	9.00	D	Yellow brown clayey silty fine SAND														Particle Size Distribution
BH1	D19	13.50	D	Yellow brown sandy silty CLAY														Particle Size Distribution
BH2	D3	3.50	D	Orange brown sandy silty CLAY	25	42	20	22	99						7.9	0.54		
BH2	D4	5.00	D	Yellow brown clayey silty fine SAND														Particle Size Distribution
BH3	D3	2.20	D	Orange brown and black fine sandy silty CLAY	25	42	20	22	97									
BH3	D4	3.50	D												8.0	0.05		

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

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
J15047

GEOLABS®

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	MC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH3	D5	5.20	D	Yellow brown clayey silty fine SAND														Particle Size Distribution

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

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

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9A THE GROVE, LONDON, N6 6JU
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BS1377 : Part 2 : Clause 9 : 1990

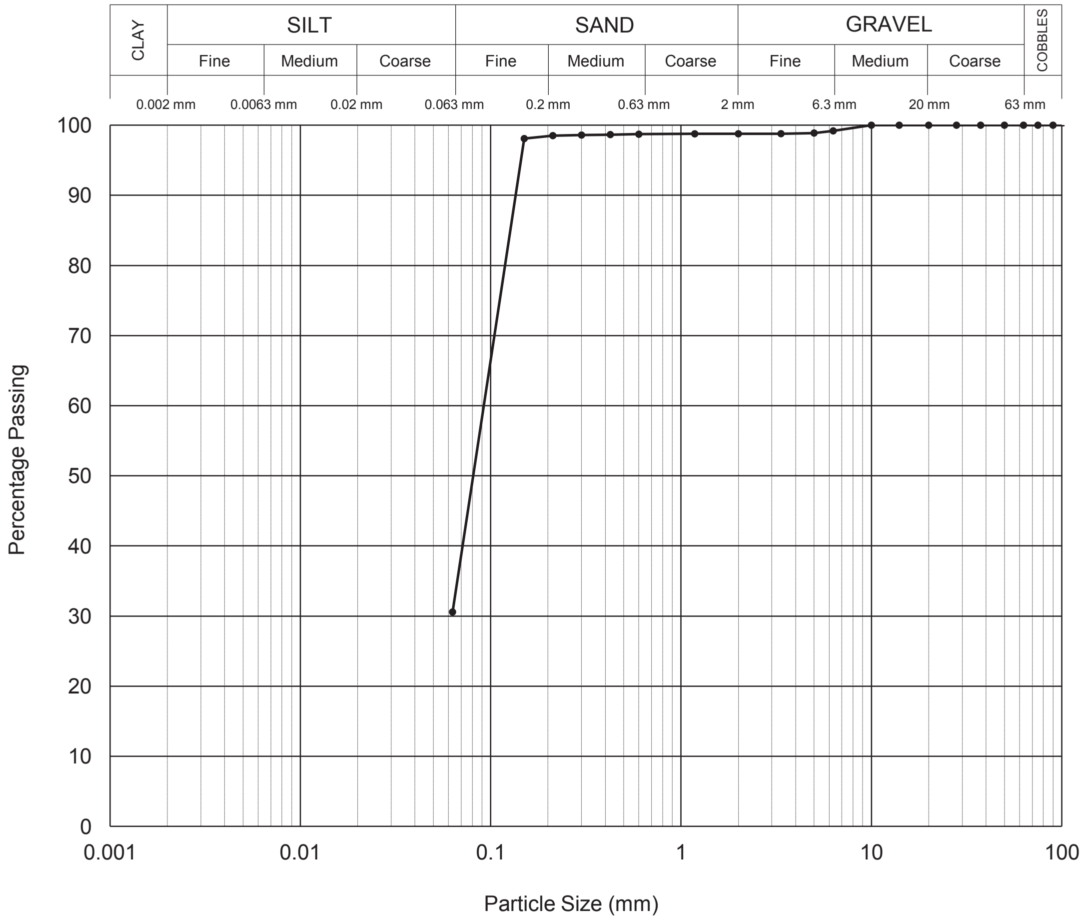
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH1
Sample Ref.	D16
Depth (m):	9.00
Sample Type	D

Description:
Yellow brown clayey silty fine SAND

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	100
10	100
6.3	99
5	99
3.35	99
2	99
1.18	99
0.6	99
0.425	99
0.3	99
0.212	99
0.15	98
0.063	31



Particle Proportions	
Cobbles	0.0 %
Gravel	1.2 %
Sand	68.2 %
Silt & Clay	30.6 %

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
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UKAS TESTING 1982

BS1377 : Part 2 : Clause 9 : 1990

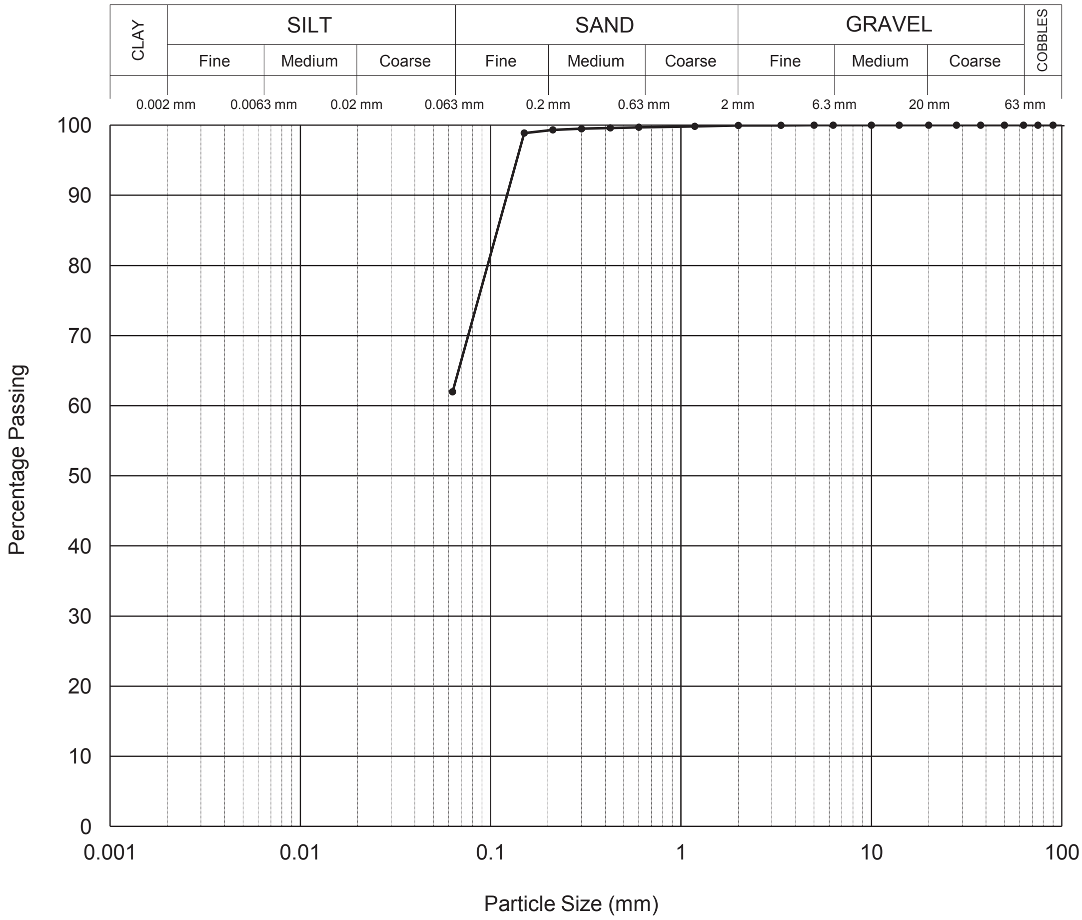
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH1
Sample Ref.	D19
Depth (m):	13.50
Sample Type	D

Description:
Yellow brown sandy silty CLAY

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	100
10	100
6.3	100
5	100
3.35	100
2	100
1.18	100
0.6	100
0.425	100
0.3	99
0.212	99
0.15	99
0.063	62



Particle Proportions	
Cobbles	0.0 %
Gravel	0.0 %
Sand	38.0 %
Silt & Clay	62.0 %

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
J15047

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UKAS TESTING 1982

BS1377 : Part 2 : Clause 9 : 1990

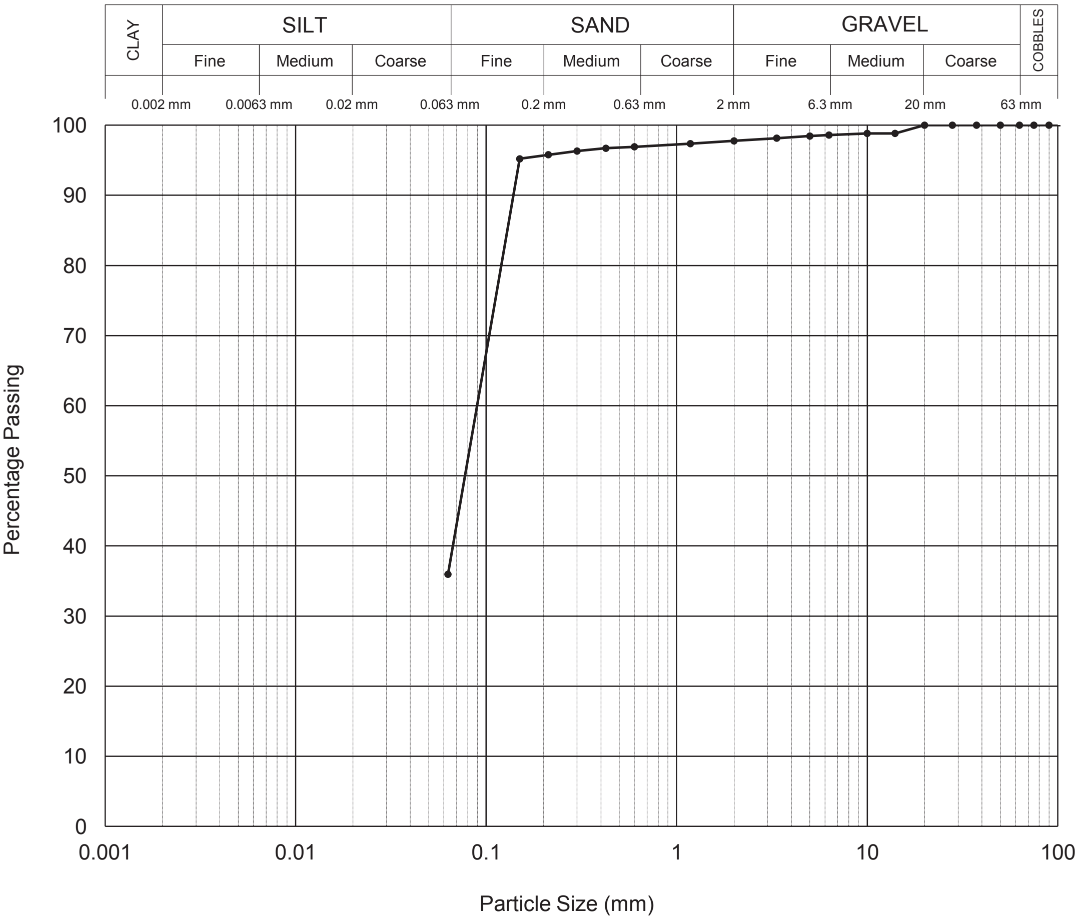
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH2
Sample Ref.	D4
Depth (m):	5.00
Sample Type	D

Description:
Yellow brown clayey silty fine SAND

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	99
10	99
6.3	99
5	98
3.35	98
2	98
1.18	97
0.6	97
0.425	97
0.3	96
0.212	96
0.15	95
0.063	36



Particle Proportions	
Cobbles	0.0 %
Gravel	2.2 %
Sand	61.8 %
Silt & Clay	36.0 %

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
J15047

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UKAS TESTING 1982

BS1377 : Part 2 : Clause 9 : 1990

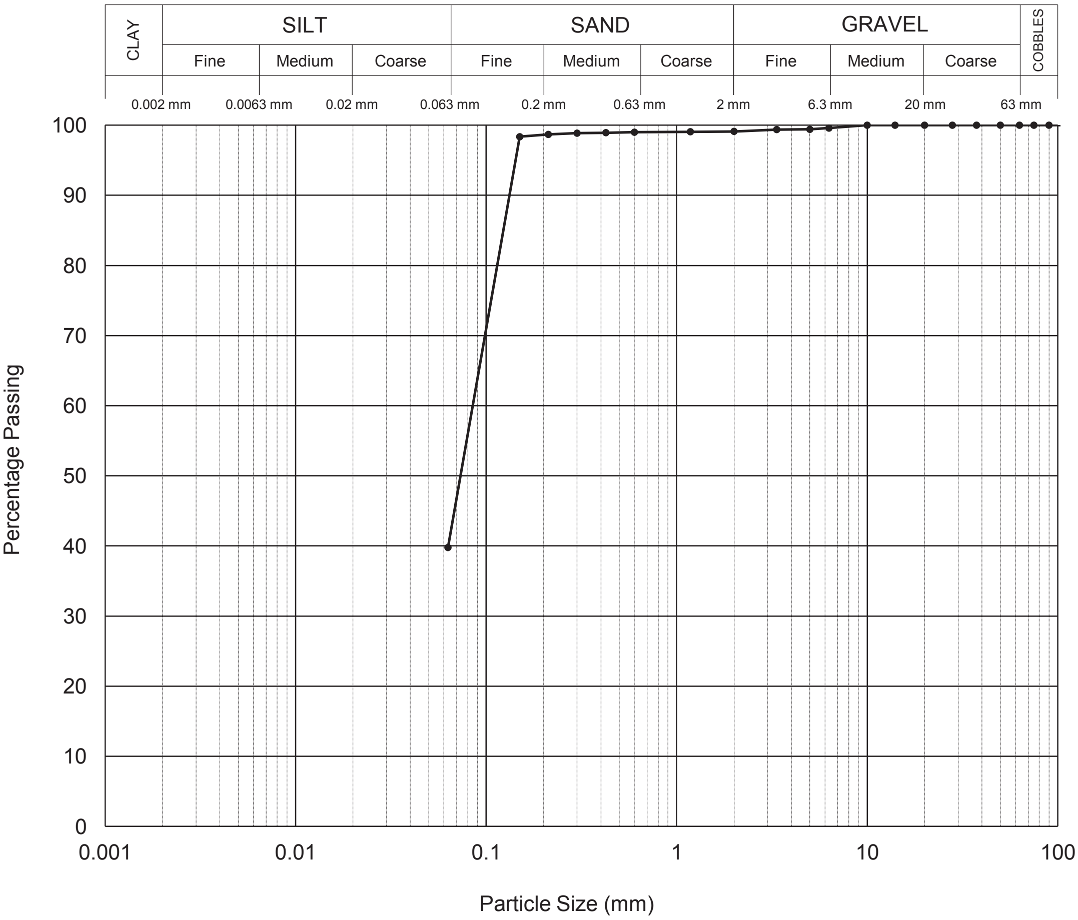
PARTICLE SIZE DISTRIBUTION

BH/TP No:	BH3
Sample Ref.	D5
Depth (m):	5.20
Sample Type	D

Description:
Yellow brown clayey silty fine SAND

BS1377 : Part 2 : Clause 9.2 : 1990 Wet Sieving Method

Sieve	
Sieve (mm)	% pass
200	100
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	100
10	100
6.3	100
5	99
3.35	99
2	99
1.18	99
0.6	99
0.425	99
0.3	99
0.212	99
0.15	98
0.063	40



Particle Proportions	
Cobbles	0.0 %
Gravel	0.9 %
Sand	59.3 %
Silt & Clay	39.8 %

Checked and Approved by

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
J15047

1731 - UUTXL BH1 04.00 U9 U - 22285-112874.xls

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH1
Sample Ref	U9
Depth (m)	4.00
Sample Type	U

Description:

Firm light brown fine sandy CLAY with rare orange staining

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.3
Diameter	(mm)	102.3
Moisture Content	(%)	27
Bulk Density	(Mg/m³)	1.98
Dry Density	(Mg/m³)	1.56
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	1.1
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	80
Strain at failure	(%)	19.9
Maximum Deviator Stress	(kPa)	141
Shear Stress Cu	(kPa)	70

Mode of failure

Orientation of the sample	Vertical
Distance from top of tube mm	90

GL:Version 1.43 - 25/02/2015

Checked and Approved by:

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

9A THE GROVE, LONDON, N6 6JU
J15047

GEOLABS®

UKAS TESTING 1982

BS 1377 : Part 7 : 1990 Clause 8

Quick Undrained Triaxial Compression Test

BH/TP No	BH1
Sample Ref	U13
Depth (m)	6.00
Sample Type	U

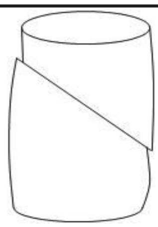
Description:

Firm yellow brown sandy CLAY

Specimen Details

Specimen conditions		Undisturbed
Length	(mm)	201.2
Diameter	(mm)	102.7
Moisture Content	(%)	18
Bulk Density	(Mg/m³)	1.85
Dry Density	(Mg/m³)	1.57
Test Details		
Latex membrane thickness	(mm)	0.3
Membrane correction	(kPa)	0.2
Axial displacement rate	(%/min)	2.0
Cell pressure	(kPa)	120
Strain at failure	(%)	2.5
Maximum Deviator Stress	(kPa)	44
Shear Stress Cu	(kPa)	22

Mode of failure



Orientation of the sample	Vertical
Distance from top of tube mm	50

Checked and Approved by:

S Burke

Senior Technician
13/03/2015

Project Number:

GEO / 22285

Project Name:

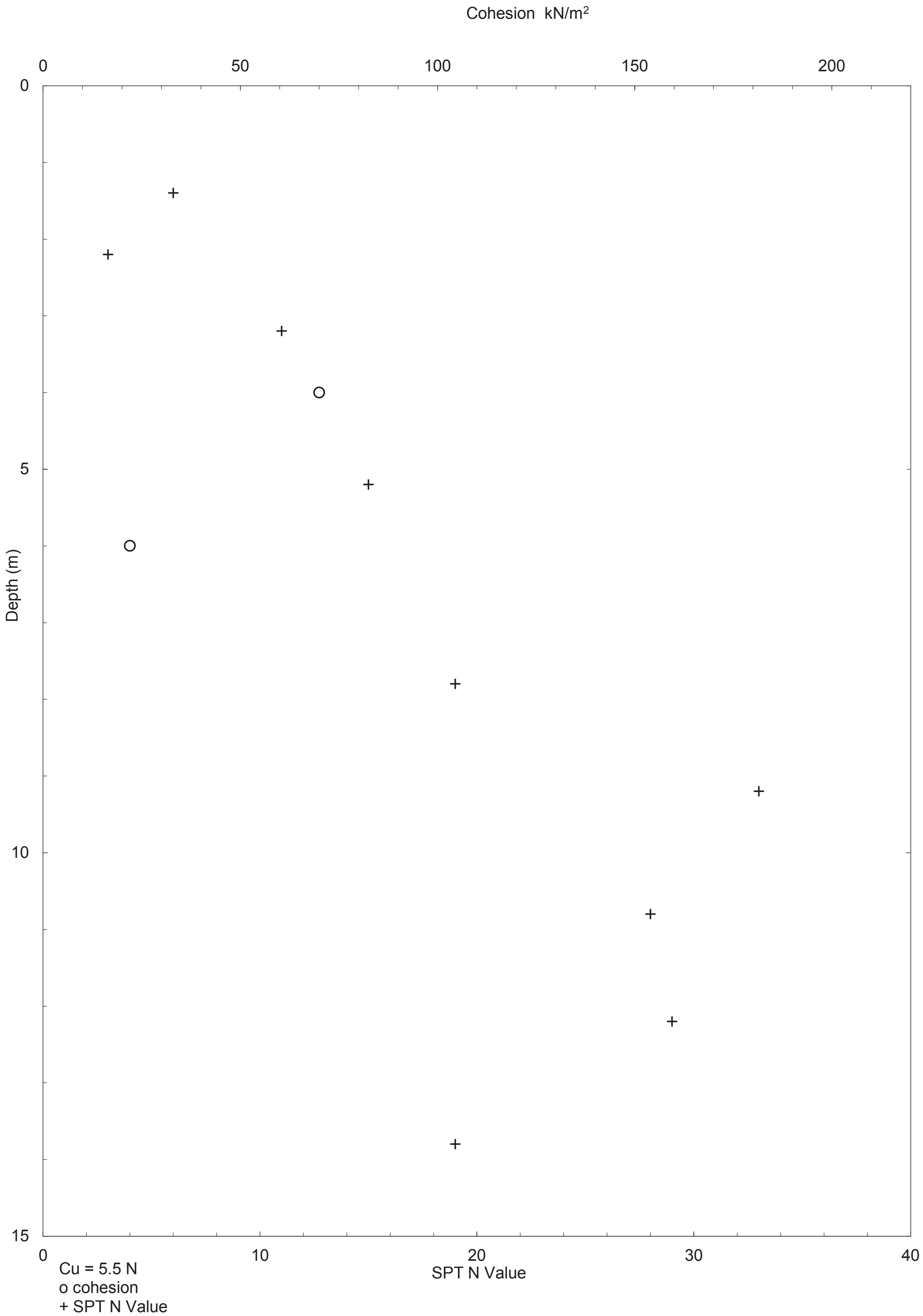
9A THE GROVE, LONDON, N6 6JU
J15047

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
Herts AL4 0PG

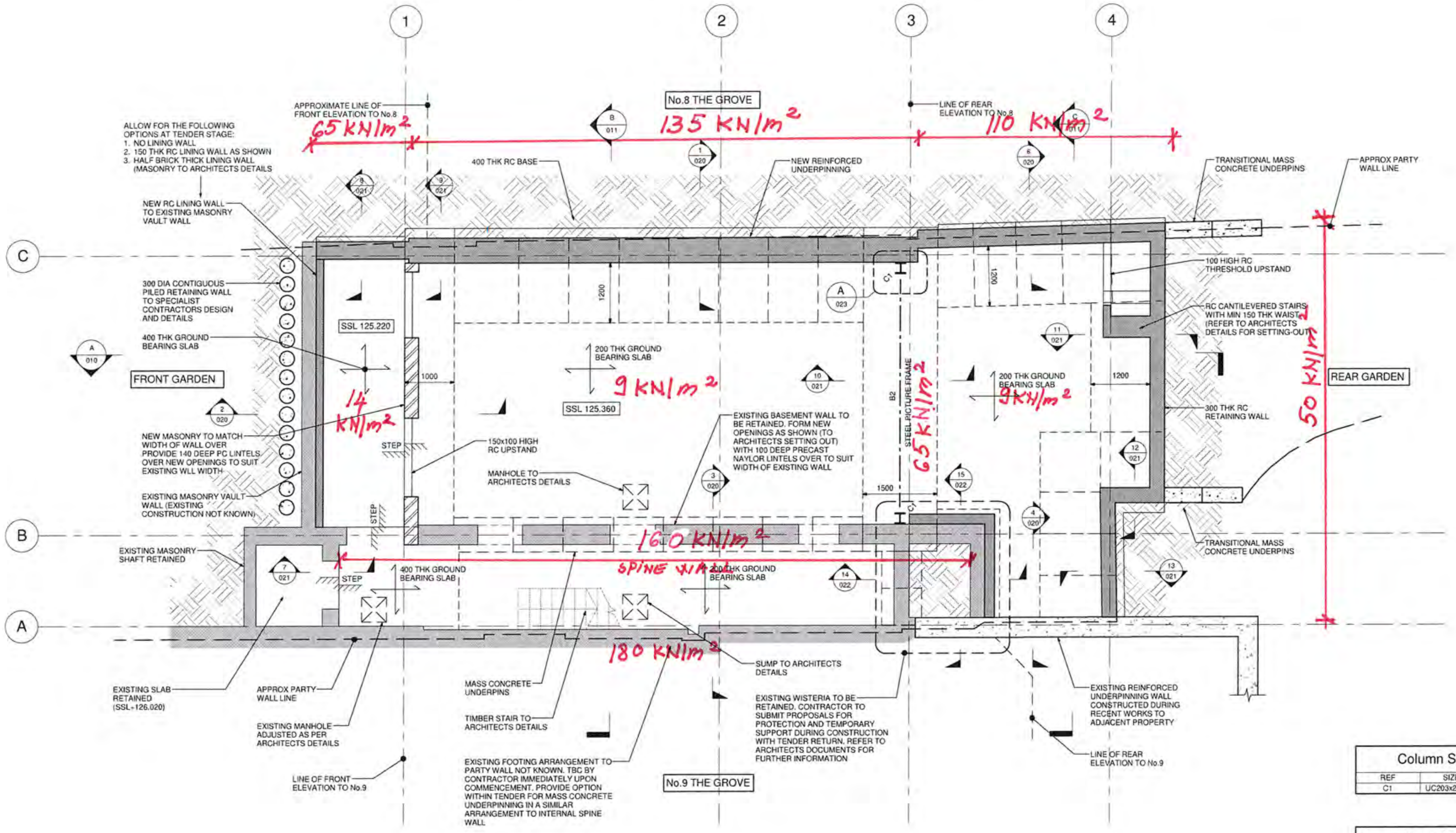
SPT & Cohesion / Depth Graph

Site	9A The Grove, London, N6 6JU	**Job Number**	J15047
Client	Mr Nick Burns	**Sheet**	1 / 1
Engineer	EngineersHRW		



APPENDIX D

Loading Information



Proposed Basement Plan
Scale 1 : 50

NOTES: 1. THE PRESSURES SHOWN AT SPINE WALL AND PARTY WALL TO N°9 LOCATIONS ARE EXISTING PRESSURES (NO EXTRA LOAD ADDED TO THIS WALLS);

2. LOADS FROM N°8 ARE "INCLUDED" IN THE BEARING PRESSURES AT PARTY WALL TO N°8 LOCATION.

eHRW
ISSUED FOR INFO
10.07.2015

Column Schedule

REF	SIZE	GRADE
C1	UC203x203x86	S355

Beam Schedule

REF	SIZE	GRADE
B1	UC203x203x46	S355
B2	UC203x203x86	S355
B3	SHS150x150x8.0	S355

NOTE
REINFORCEMENT DETAILING AND SCHEDULING IS THE RESPONSIBILITY OF THE CONTRACTOR.
REINFORCEMNT SKETCHES WILL BE PROVIDED BY EHRW UPON CONTRACTOR APPOINTMENT.
ALLOW FOR THE FOLLOWING FOR TENDER PURPOSES:
- BASEMENT SLAB - 100kg/m³
- BASEMENT WALLS - 90kg/m³
- GROUND FLOOR SLAB - 125kg/m³

TEMPORARY WORKS NOTE:
THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT HIS OPERATIONS DO NOT IN ANY WAY IMPAIR THE SAFETY OR CONDITION OF THE EXISTING STRUCTURE. HE SHALL PROVIDE ANY TEMPORARY SUPPORTS REQUIRED FOR THIS PURPOSE, AND SHALL CAREFULLY INSPECT THE CONDITION OF THE BUILDING STRUCTURE. HE SHALL PROVIDE ANY TEMPORARY SUPPORTS REQUIRED FOR THIS PURPOSE, AND SHALL CAREFULLY INSPECT THE CONDITION OF THE STRUCTURE BOTH BEFORE AND DURING THE EXECUTION OF THE WORK AND IMMEDIATELY INFORM THE ENGINEER IF HE CONSIDERS THAT ANY MORE STRINGENT PROCEDURE THAN THAT SPECIFIED IS NECESSARY.

1:50 0 1000 2000 3000 4000 5000

NOTES

1. DO NOT SCALE OUT OF THIS DRAWING
2. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ARCHITECTS AND OTHER CONSULTANTS INFORMATION
3. REFER TO THE ARCHITECT FOR DIMENSIONS AND SETTING OUT FOR ALL NEW OPENINGS etc.
4. ALL AREAS OF DEFECTIVE STRUCTURE FOUND DURING DEMOLITION WORKS ARE TO BE REPORTED TO THE ENGINEER. IF NOT ALREADY ADDRESSED.
5. WHERE POSSIBLE REMEDIAL OR REPLACEMENT WORKS TO BE INSTALLED BEFORE REMOVAL OF EXISTING STRUCTURE - IF IN DOUBT, REFER TO THE ENGINEER
6. FOR GENERAL NOTES REFER TO DRAWING 1290/N/050-051
7. FOR MOVEMENTS AND TOLERANCES REFER TO DRAWING 1290/N/052
8. ALL STRUCTURAL WORKS SHOWN ARE BASED ON VARIOUS ASSUMPTIONS FOLLOWING LIMITED OPENING UP WORKS. FURTHER OPENING UP AND SURVEY WORK IS TO BE UNDERTAKEN IMMEDIATELY UPON COMMENCEMENT OF THE WORKS AS ADVISED BY eHRW, REFER TO GENERAL NOTES SECTION 7.00.
9. REFER TO ARCHITECTS DRAWINGS FOR FULL EXTENT OF DEMOLITION
10. ALL DIMENSIONS SHOWN ARE SUBJECT TO SITE SURVEY TO BE COMPLETED BY THE CONTRACTOR.
11. REFER TO INFORMATION BY OTHERS FOR LOCATION OF CAST-IN SERVICES, GULLIES, MANHOLES ETC
12. ALL BEAMS BEARING ONTO MASONRY TO HAVE 440x215x100 DEEP MASS CONCRETE PADSTONE UNO.

LEGEND

- DENOTES EXISTING LOADBEARING MASONRY WALLS TO BE RETAINED
- DENOTES NEW LOADBEARING MASONRY WALLS
- DENOTES NEW RC WALLS / UNDERPINNING
- DENOTES DOUBLED JOIST OR FLITCH BEAM LOCATION
- DENOTES EXISTING WALLS TO BE REMOVED
- GST DENOTES GALVANISED METAL WALL STRAPS. REFER TO TYPICAL DETAILS
- 200 DENOTES 200 THK RC SLAB
- RJ1 DENOTES 50x200 C24 JOISTS AT 400crs WITH 18 THK PLYWOOD DECK
- RJ2 DENOTES 50x150 C24 JOISTS AT 400crs WITH 18 THK PLYWOOD DECK
- P1 - DENOTES 440x215x100 WIDE MASS CONCRETE PADSTONE
- DJ - DENOTES DOUBLED JOIST WITH M12 BOLTS AT 300crs

Rev	Date	Amendments	By	Chkd
P3	15.06.15	PRE-TENDER COORDINATION ISSUE	DJP	AR
P2	27.05.15	COORDINATION ISSUE	DJP	AR
P1	30.03.15	WORK IN PROGRESS ISSUE	DJP	AR

engineersHRW
London 0207 407 9575 Oxford 01865 251 206 www.ehrw.co.uk

Project
9A The Grove

Drawing title
Proposed Basement Plan

Scale at A1	Drawn by	Date	Chkd by
As indicated	DJP	MAR' 2015	AR

PRELIMINARY

Project Number	Drawing Type	Drawing No	Revision
1290	GA	001	P3

APPENDIX E

WALLAP Analysis Output

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Soil types: Passive side
1	128.00	1 Granular Made Ground	1 Granular Made Ground
2	124.80	3 Bagshot Clay	3 Bagshot Clay
3	121.00	4 Bagshot Sand	4 Bagshot Sand

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	17.00a	0	0.531	NC	0.311	4.085	
	Made Ground	19.00b	(2500)		(0.250)	(0.000)	(0.000)	
2	Not defined							
3	Bagshot	18.00	50000	1.000	OC	1.000	1.000	50.00u
	Clay				(0.490)	(2.389)	(2.390)	
4	Bagshot	19.00a	46000	0.455	OC	0.252	5.545	
	Sand	21.00b			(0.250)	(0.000)	(0.000)	
5	Bagshot Cl-	18.00	41600	0.561	OC	0.343	3.524	0.0d
	ay Drained				(0.250)	(1.348)	(5.175)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	Ka: Soil friction angle	Ka: Wall adhesion coeff.	Ka: Back-fill angle	Kp: Soil friction angle	Kp: Wall adhesion coeff.	Kp: Back-fill angle
1	Granular Made Ground	28.00	0.636	0.00	28.00	0.636	0.00
2	Not defined						
3	Bagshot Clay	0.00	0.500	0.00	0.00	0.500	0.00
4	Bagshot Sand	33.00	0.581	0.00	33.00	0.581	0.00
5	Bagshot Clay Drained	26.00	0.561	0.00	26.00	0.561	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	118.00	118.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 121.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 1.3200E-03 m4/m run
E.I = 36960 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	Not defined							
2	125.00	2.00	0.017800	2.100E+08	2.00	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	Far edge	Equiv. soil type	Partial factor/ Category
1	128.00	0.00(A)	6.00	5.00	15.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 128.00
2	Change EI of wall to 25872 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Excavate to elevation 125.00 on PASSIVE side
4	Install strut or anchor no.2 at elevation 125.00
5	Change properties of soil type 3 to soil type 5 Ko pressures will not be reset
6	Change EI of wall to 18480 kN.m2/m run Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

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) = 12.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 6.00 m

Width of excavation on active side of wall = 5.00 m
Width of excavation on passive side of wall = 5.00 m

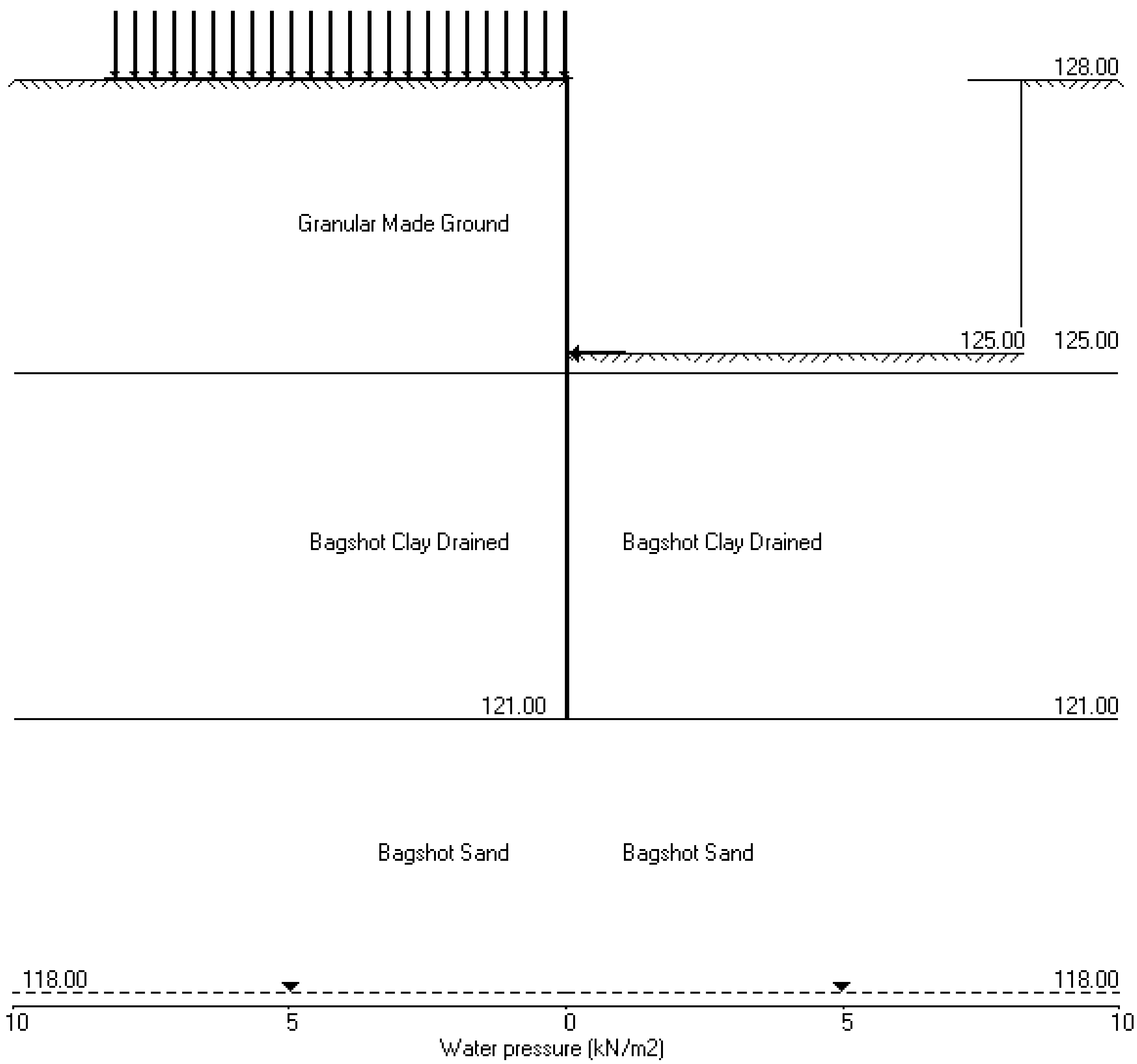
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 5.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 128.00	No	No	No
2	Change EI of wall to 25872kN.m2/m run	No	No	No
3	Excav. to elev. 125.00 on PASSIVE side	No	No	No
4	Install strut no.2 at elev. 125.00	No	No	No
5	Change soil type 3 to soil type 5	No	No	No
6	Change EI of wall to 18480kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

```
CARD GEOTECHNICS LIMITED                                     | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R49          | Job No. CG18545
                             Licensed from GEOSOLVE          | Made by :   ANK
Data filename/Run ID: CG18545 Wall - SLS                     |
9A The Grove                                                 | Date:27-08-2015
Basement Impact Assessment - SLS                             | Checked :
-----------------------------------------------------------------------------
                                                  Units: kN,m
```

Stage No.6   Change EI of wall to 18480kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 125.00 on PASSIVE side

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. = 121.00: Factor of Safety	FoS for toe elev. = 121.00: Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Toe elev. for FoS = 1.000: Wall Penetr -ation
3	128.00	125.00	Cant.	1.857	121.80	122.86	2.14

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 6.00m
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 20.00 from wall
Passive side 5.00 from wall

*** Wall displacements reset to zero at stage 2

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	EI of wall kN.m2/m
1	128.00	6.70	0.014	3.86E-03	0.0	-0.0		25872
2	127.60	6.77	0.013	3.86E-03	2.7	0.6		25872
3	127.20	8.85	0.011	3.86E-03	5.8	2.3		25872
4	126.80	10.88	0.009	3.85E-03	9.8	5.4		25872
5	126.40	12.86	0.008	3.80E-03	14.5	10.3		25872
6	126.00	14.79	0.006	3.69E-03	20.0	17.2		25872
7	125.60	16.69	0.005	3.49E-03	26.3	26.4		25872
8	125.30	18.10	0.004	3.25E-03	31.6	35.1		25872
9	125.00	21.39	0.003	2.93E-03	37.5	45.5		25872
10	124.80	10.65	0.002	2.65E-03	40.7	53.4		25872
		-106.90	0.002	2.65E-03	40.7	53.4		
11	124.40	-104.29	0.002	1.95E-03	-1.6	64.5		25872
12	124.00	-37.89	0.001	1.22E-03	-30.0	55.5		25872
13	123.60	0.87	0.001	6.46E-04	-37.4	40.5		25872
14	123.30	16.06	0.000	3.34E-04	-34.9	29.3		25872
15	123.00	22.87	0.000	1.19E-04	-29.0	19.6		25872
16	122.70	24.07	0.000	-1.47E-05	-22.0	11.9		25872
17	122.40	21.85	0.000	-8.91E-05	-15.1	6.3		25872
18	122.00	16.17	0.000	-1.30E-04	-7.5	2.0		25872
19	121.60	9.31	0.000	-1.39E-04	-2.4	0.3		25872
20	121.30	3.98	0.000	-1.38E-04	-0.4	-0.0		25872
21	121.00	-1.35	0.000	-1.38E-04	0.0	-0.0		---

(continued)

Stage No.3 Excavate to elevation 125.00 on PASSIVE side

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	128.00	0.00	15.00	4.66	61.28	6.70	6.70	71.1
2	127.60	0.00	21.78	6.77	88.99	6.77	6.77a	427
3	127.20	0.00	28.47	8.85	116.32	8.85	8.85a	854
4	126.80	0.00	35.01	10.88	143.03	10.88	10.88a	1280
5	126.40	0.00	41.38	12.86	169.06	12.86	12.86a	1707
6	126.00	0.00	47.61	14.79	194.48	14.79	14.79a	2134
7	125.60	0.00	53.72	16.69	219.47	16.69	16.69a	2561
8	125.30	0.00	58.27	18.10	238.03	18.10	18.10a	2881
9	125.00	0.00	62.79	19.51	256.50	21.39	21.39	3201
10	124.80	0.00	65.80	20.44	268.80	24.54	24.54	3414
		Total>	65.80	16.00m	185.30	16.00	16.00a	27715
11	124.40	Total>	63.45	18.00m	182.95	18.95	18.95	27715
12	124.00	Total>	78.67	20.00m	198.17	47.09	47.09	27715
13	123.60	Total>	85.16	22.00m	204.65	66.46	66.46	27715
14	123.30	Total>	90.05	23.50m	209.54	76.60	76.60	27715
15	123.00	Total>	94.96	25.00m	214.46	84.09	84.09	27715
16	122.70	Total>	99.91	26.50m	219.40	89.81	89.81	27715
17	122.40	Total>	104.87	28.00m	224.37	94.47	94.47	27715
18	122.00	Total>	111.54	30.00m	231.04	99.86	99.86	27715
19	121.60	Total>	118.25	32.00m	237.75	104.92	104.92	27715
20	121.30	Total>	123.31	33.50m	242.81	108.68	108.68	27715
21	121.00	Total>	128.39	35.00m	247.89	112.47	112.47	27715

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	128.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	127.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	127.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	126.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	126.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	126.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	125.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	125.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	80.8
10	124.80	0.00	3.40	1.06	13.90	13.90	13.90p	485
		Total>	3.40	1.00m	122.90	122.90	122.90p	63848
11	124.40	Total>	10.64	3.00m	130.13	123.24	123.24	63848
12	124.00	Total>	17.97	5.00m	137.46	84.98	84.98	63848
13	123.60	Total>	25.43	7.00m	144.93	65.60	65.60	63848
14	123.30	Total>	31.15	8.50m	150.64	60.54	60.54	63848
15	123.00	Total>	36.96	10.00m	156.46	61.22	61.22	63848
16	122.70	Total>	42.87	11.50m	162.37	65.74	65.74	63848
17	122.40	Total>	48.88	13.00m	168.38	72.63	72.63	63848
18	122.00	Total>	57.02	15.00m	176.52	83.69	83.69	63848
19	121.60	Total>	65.29	17.00m	184.79	95.61	95.61	63848
20	121.30	Total>	71.56	18.50m	191.06	104.70	104.70	63848
21	121.00	Total>	77.87	20.00m	197.37	113.82	113.82	63848

Note: 16.00a Soil pressure at active limit
122.90p Soil pressure at passive limit

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CARD GEOTECHNICS LIMITED                                    | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R49         | Job No. CG18545
                             Licensed from GEOSOLVE         | Made by :   ANK
Data filename/Run ID: CG18545 Wall - SLS                    |
9A The Grove                                                | Date:27-08-2015
Basement Impact Assessment - SLS                            | Checked :
-----------------------------------------------------------------------------
                                                   Units: kN,m
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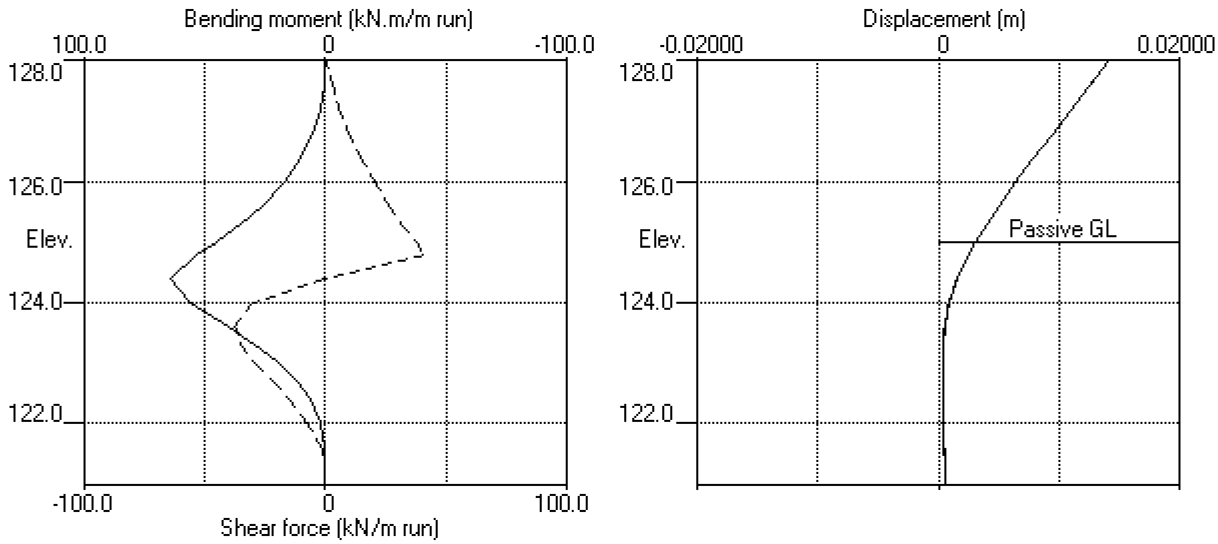
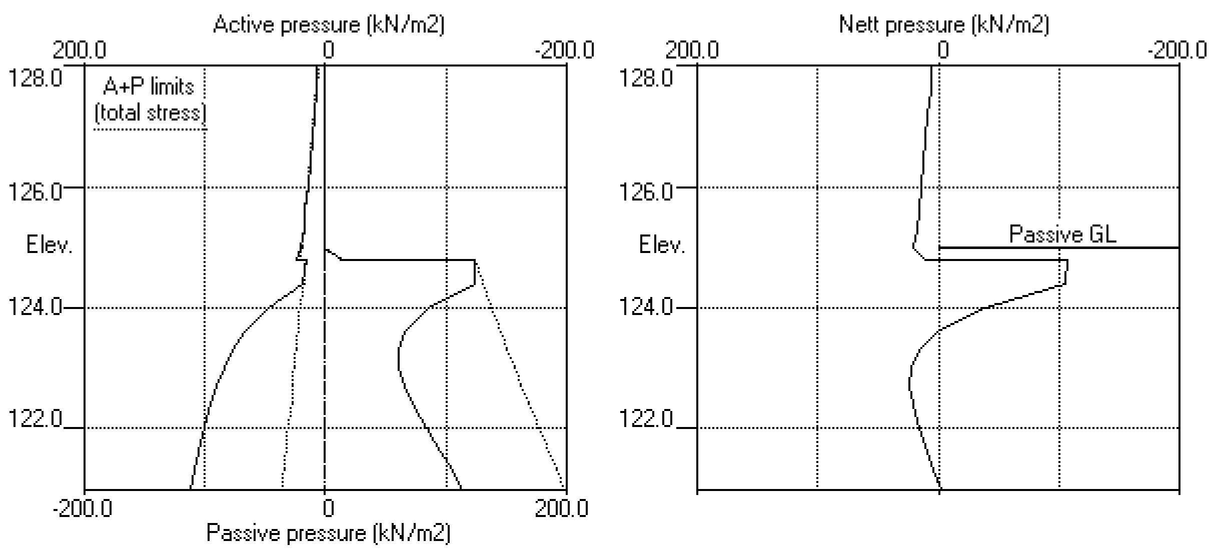
Stage No.3 Excav. to elev. 125.00 on PASSIVE side



Stage No.3 Excav. to elev. 125.00 on PASSIVE side



Units: kN,m

Stage No. 5 Change properties of soil type 3 to soil type 5
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 121.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
5	128.00	125.00	125.00	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 6.00m
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 20.00 from wall
Passive side 5.00 from wall

*** Wall displacements reset to zero at stage 2

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	EI of wall kN.m2/m
1	128.00	6.79	0.013	3.46E-03	0.0	-0.0		25872
2	127.60	7.27	0.011	3.46E-03	2.8	0.6		25872
3	127.20	9.71	0.010	3.46E-03	6.2	2.4		25872
4	126.80	11.94	0.009	3.44E-03	10.5	5.8		25872
5	126.40	13.96	0.007	3.39E-03	15.7	11.0		25872
6	126.00	15.77	0.006	3.26E-03	21.7	18.5		25872
7	125.60	17.36	0.005	3.04E-03	28.3	28.4		25872
8	125.30	18.41	0.004	2.77E-03	33.7	37.7		25872
9	125.00	21.23	0.003	2.41E-03	39.6	48.8	50.6	25872
		21.23	0.003	2.41E-03	-11.0	48.8		
10	124.80	10.16	0.003	2.14E-03	-7.9	47.0		25872
		10.55	0.003	2.14E-03	-7.9	47.0		
11	124.40	-12.75	0.002	1.63E-03	-8.3	47.4		25872
12	124.00	-22.73	0.001	1.14E-03	-15.4	41.2		25872
13	123.60	-13.38	0.001	7.40E-04	-22.6	32.6		25872
14	123.30	3.22	0.001	4.97E-04	-24.1	25.2		25872
15	123.00	11.97	0.001	3.14E-04	-21.9	18.1		25872
16	122.70	15.31	0.001	1.87E-04	-17.8	12.1		25872
17	122.40	15.22	0.001	1.05E-04	-13.2	7.4		25872
18	122.00	12.20	0.000	4.57E-05	-7.7	3.3		25872
19	121.60	7.72	0.000	2.00E-05	-3.7	1.2		25872
20	121.30	4.40	0.000	1.28E-05	-1.9	0.4		25872
21	121.00	8.25	0.000	1.09E-05	0.0	-0.0		---

At elev. 125.00 Strut force = 101.2 kN/strut = 50.6 kN/m run

(continued)

Stage No.5 Change properties of soil type 3 to soil type 5
Ko pressures will not be reset

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	128.00	0.00	15.00	4.66	61.28	6.79	6.79	79.3
2	127.60	0.00	21.78	6.77	88.99	7.27	7.27	476
3	127.20	0.00	28.47	8.85	116.32	9.71	9.71	951
4	126.80	0.00	35.01	10.88	143.03	11.94	11.94	1427
5	126.40	0.00	41.38	12.86	169.06	13.96	13.96	1903
6	126.00	0.00	47.61	14.79	194.48	15.77	15.77	2379
7	125.60	0.00	53.72	16.69	219.47	17.36	17.36	2854
8	125.30	0.00	58.27	18.10	238.03	18.41	18.41	3211
9	125.00	0.00	62.79	19.51	256.50	21.23	21.23	2886
10	124.80	0.00	65.80	20.44	268.80	24.06	24.06	3078
		0.00	65.80	22.54	231.89	22.54	22.54a	16008
11	124.40	0.00	72.23	24.74	254.54	24.74	24.74a	16008
12	124.00	0.00	78.67	26.95	277.26	40.59	40.59	16008
13	123.60	0.00	85.16	29.17	300.11	60.06	60.06	16008
14	123.30	0.00	90.05	30.85	317.34	70.83	70.83	16008
15	123.00	0.00	94.96	32.53	334.67	79.19	79.19	16008
16	122.70	0.00	99.91	34.22	352.09	85.88	85.88	16008
17	122.40	0.00	104.38	35.76	367.87	91.50	91.50	16008
18	122.00	0.00	111.54	38.21	393.09	98.07	98.07	16008
19	121.60	0.00	118.25	40.51	416.73	104.20	104.20	16008
20	121.30	0.00	123.31	42.24	434.57	108.88	108.88	97565
21	121.00	0.00	128.39	43.98	452.47	117.06	117.06	97565

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	128.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	127.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	127.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	126.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	126.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	126.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	125.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	125.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	39.3
10	124.80	0.00	3.40	1.06	13.90	13.90	13.90p	236
		0.00	3.40	1.17	11.99	11.99	11.99p	19604
11	124.40	0.00	10.64	3.64	37.49	37.49	37.49p	19604
12	124.00	0.00	17.97	6.15	63.31	63.31	63.31p	19604
13	123.60	0.00	25.43	8.71	89.63	73.44	73.44	19604
14	123.30	0.00	31.15	10.67	109.76	67.61	67.61	19604
15	123.00	0.00	36.96	12.66	130.25	67.22	67.22	19604
16	122.70	0.00	42.87	14.69	151.09	70.57	70.57	19604
17	122.40	0.00	48.88	16.74	172.26	76.27	76.27	19604
18	122.00	0.00	57.02	19.53	200.96	85.88	85.88	19604
19	121.60	0.00	65.29	22.37	230.10	96.48	96.48	19604
20	121.30	0.00	71.56	24.51	252.19	104.48	104.48	106214
21	121.00	0.00	77.87	26.67	274.43	108.82	108.82	106214

(continued)

Stage No.5 Change properties of soil type 3 to soil type 5
Ko pressures will not be reset

Note: 24.74a Soil pressure at active limit
63.31p Soil pressure at passive limit

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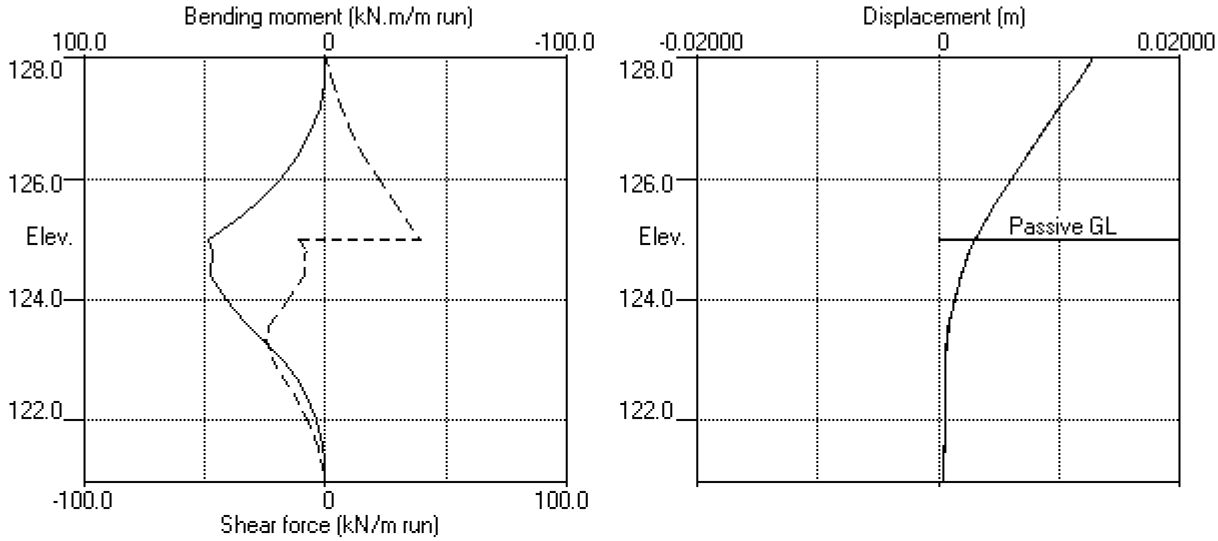
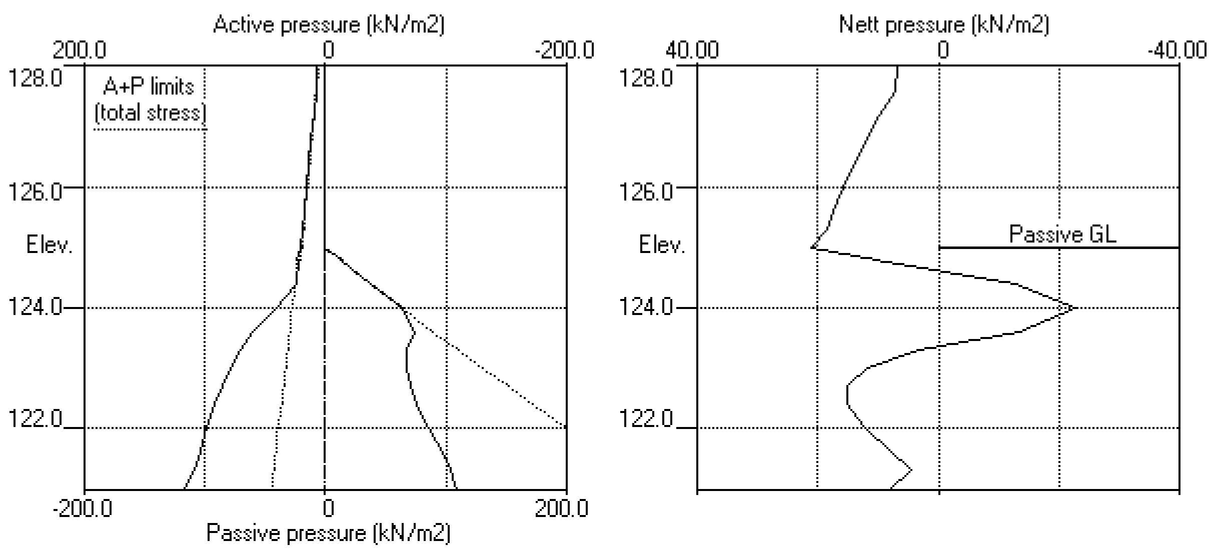
CARD GEOTECHNICS LIMITED                                          | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R49               | Job No. CG18545
                             Licensed from GEOSOLVE               | Made by :   ANK
Data filename/Run ID: CG18545 Wall - SLS                          |
9A The Grove                                                      | Date:27-08-2015
Basement Impact Assessment - SLS                                  | Checked :
-----------------------------------------------------------------------------
                                                          Units: kN,m
```

Stage No.5 Change soil type 3 to soil type 5



Stage No.5 Change soil type 3 to soil type 5



Units: kN,m

Stage No. 6 Change EI of wall to 18480 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 121.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
6	128.00	125.00	125.00	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 6.00m
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 20.00 from wall
Passive side 5.00 from wall

*** Wall displacements reset to zero at stage 2

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	EI of wall kN.m2/m
1	128.00	6.68	0.014	3.96E-03	0.0	-0.0		18480
2	127.60	6.77	0.013	3.96E-03	2.7	0.4		18480
3	127.20	8.85	0.011	3.96E-03	5.8	1.9		18480
4	126.80	10.88	0.009	3.94E-03	9.8	4.6		18480
5	126.40	12.86	0.008	3.87E-03	14.5	9.1		18480
6	126.00	14.82	0.006	3.72E-03	20.0	15.7		18480
7	125.60	16.75	0.005	3.44E-03	26.4	24.7		18480
8	125.30	18.10	0.004	3.11E-03	31.6	33.2		18480
9	125.00	21.23	0.003	2.65E-03	37.5	43.4	51.6	18480
		21.23	0.003	2.65E-03	-14.1	43.4		
10	124.80	10.32	0.003	2.32E-03	-10.9	40.9		18480
		12.28	0.003	2.32E-03	-10.9	40.9		
11	124.40	-9.01	0.002	1.69E-03	-10.3	40.4		18480
12	124.00	-18.63	0.001	1.13E-03	-15.8	34.3		18480
13	123.60	-10.02	0.001	6.76E-04	-21.5	26.5		18480
14	123.30	5.65	0.001	4.18E-04	-22.2	19.9		18480
15	123.00	13.37	0.001	2.35E-04	-19.3	13.8		18480
16	122.70	15.75	0.001	1.18E-04	-15.0	8.8		18480
17	122.40	14.73	0.001	5.01E-05	-10.4	5.1		18480
18	122.00	10.66	0.000	7.18E-06	-5.3	2.1		18480
19	121.60	5.45	0.000	-8.32E-06	-2.1	0.7		18480
20	121.30	1.68	0.001	-1.29E-05	-1.0	0.3		18480
21	121.00	5.09	0.001	-1.45E-05	0.0	-0.0		---

At elev. 125.00 Strut force = 103.1 kN/strut = 51.6 kN/m run

(continued)

Stage No.6 Change EI of wall to 18480 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

ACTIVE side

Node no.	Y coord	Water press. kN/m2	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	128.00	0.00	15.00	4.66	61.28	6.68	6.68	84.5
2	127.60	0.00	21.78	6.77	88.99	6.77	6.77a	507
3	127.20	0.00	28.47	8.85	116.32	8.85	8.85a	1014
4	126.80	0.00	35.01	10.88	143.03	10.88	10.88a	1522
5	126.40	0.00	41.38	12.86	169.06	12.86	12.86a	2029
6	126.00	0.00	47.61	14.79	194.48	14.82	14.82	2536
7	125.60	0.00	53.72	16.69	219.47	16.75	16.75	3043
8	125.30	0.00	58.27	18.10	238.03	18.10	18.10a	3424
9	125.00	0.00	62.79	19.51	256.50	21.23	21.23	3804
10	124.80	0.00	65.80	20.44	268.80	24.21	24.21	3764
		0.00	65.80	22.54	231.89	23.33	23.33	19572
11	124.40	0.00	72.23	24.74	254.54	26.45	26.45	19572
12	124.00	0.00	78.67	26.95	277.26	42.46	42.46	19572
13	123.60	0.00	85.16	29.17	300.11	61.59	61.59	19572
14	123.30	0.00	90.05	30.85	317.34	71.94	71.94	19572
15	123.00	0.00	94.96	32.53	334.67	79.83	79.83	19572
16	122.70	0.00	99.91	34.22	352.09	86.08	86.08	19572
17	122.40	0.00	104.38	35.76	367.87	91.27	91.27	26053
18	122.00	0.00	111.54	38.21	393.09	97.36	97.36	26053
19	121.60	0.00	118.25	40.51	416.73	103.15	103.15	26053
20	121.30	0.00	123.31	42.24	434.57	107.62	107.62	26053
21	121.00	0.00	128.39	43.98	452.47	115.60	115.60	26053

PASSIVE side

Node no.	Y coord	Water press. kN/m2	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	128.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	127.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	127.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	126.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	126.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	126.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	125.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	125.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	6812
10	124.80	0.00	3.40	1.06	13.90	13.88	13.88	280
		0.00	3.40	1.17	11.99	11.05	11.05	23268
11	124.40	0.00	10.64	3.64	37.49	35.46	35.46	23268
12	124.00	0.00	17.97	6.15	63.31	61.09	61.09	23268
13	123.60	0.00	25.43	8.71	89.63	71.62	71.62	23268
14	123.30	0.00	31.15	10.67	109.76	66.29	66.29	23268
15	123.00	0.00	36.96	12.66	130.25	66.46	66.46	23268
16	122.70	0.00	42.87	14.69	151.09	70.33	70.33	23268
17	122.40	0.00	48.88	16.74	172.26	76.54	76.54	30094
18	122.00	0.00	57.02	19.53	200.96	86.70	86.70	30094
19	121.60	0.00	65.29	22.37	230.10	97.70	97.70	30094
20	121.30	0.00	71.56	24.51	252.19	105.94	105.94	30094
21	121.00	0.00	77.87	26.67	274.43	110.51	110.51	30094

(continued)

```
Stage No.6   Change EI of wall to 18480 kN.m2/m run
              Yield moment not defined
              Allow wall to relax with new modulus value
Note:     18.10a  Soil pressure at active limit
         123.45p  Soil pressure at passive limit
```

```
CARD GEOTECHNICS LIMITED                                         | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R49              | Job No. CG18545
                             Licensed from GEOSOLVE              | Made by :   ANK
Data filename/Run ID: CG18545 Wall - SLS                         |
9A The Grove                                                     | Date:27-08-2015
Basement Impact Assessment - SLS                                 | Checked :
-----------------------------------------------------------------------------
                                                    Units: kN,m
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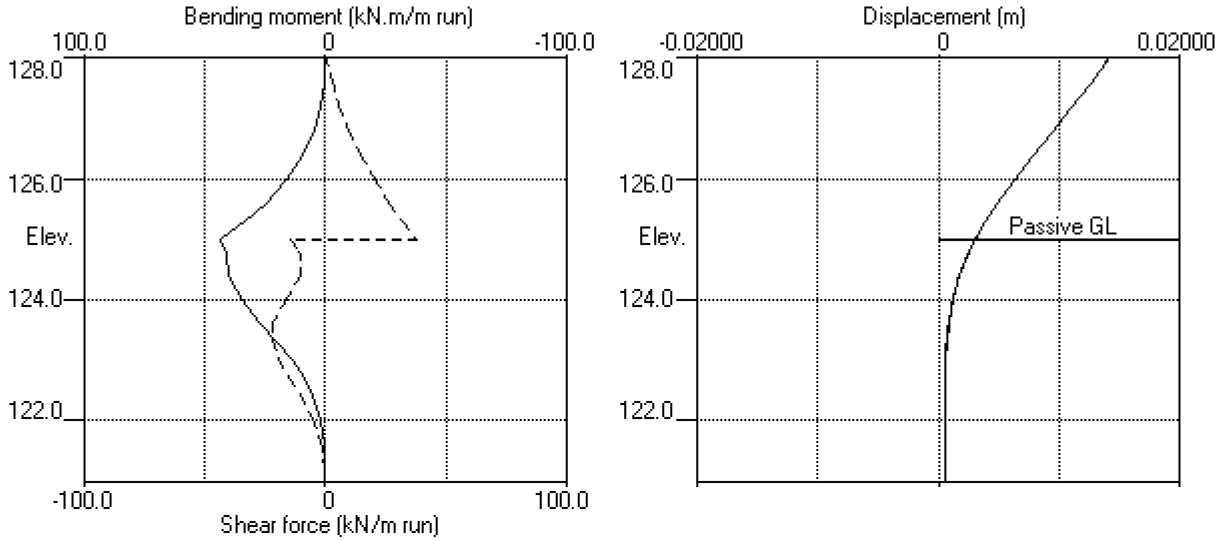
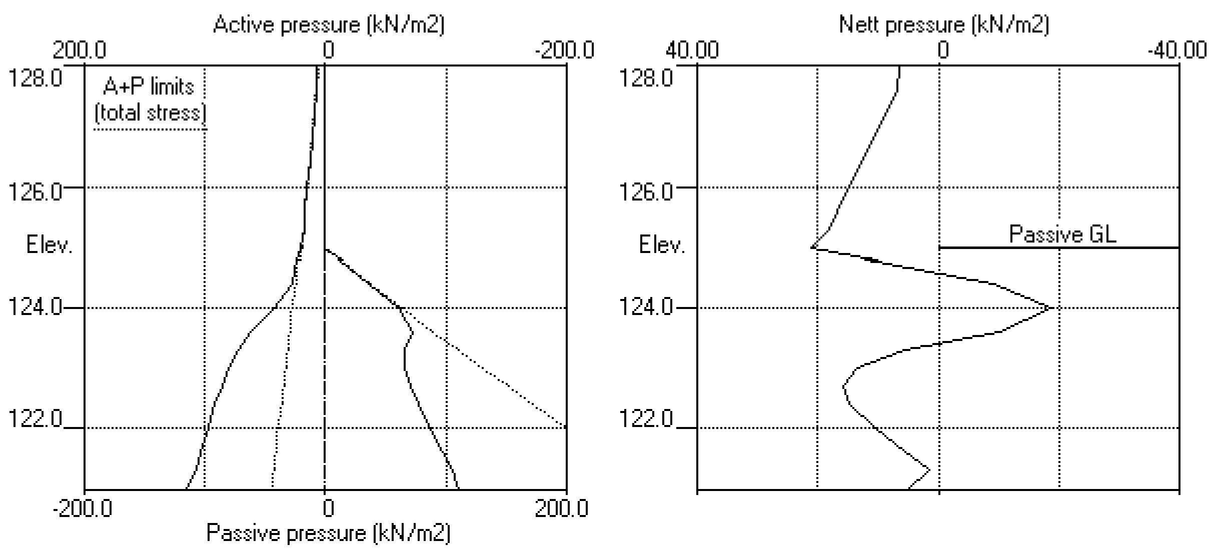
Stage No.6 Change EI of wall to 18480kN.m2/m run



Stage No.6 Change EI of wall to 18480kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				FoS for toe elev. = 121.00		Toe elev. for FoS = 1.000	
Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation
1	128.00	128.00	Cant.	Conditions not suitable for FoS calc.			
2	128.00	128.00		No analysis at this stage			
3	128.00	125.00	Cant.	1.857	121.80	122.86	2.14
4	128.00	125.00		No analysis at this stage			
5	128.00	125.00	125.00	Conditions not suitable for FoS calc.			
6	128.00	125.00	125.00	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 = 6.00m
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 20.00 from wall
Passive side 5.00 from wall

Bending moment, shear force and displacement envelopes

Node	Y	Displacement		Bending moment		Shear force	
no.	coord	maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	128.00	0.014	0.000	0.0	-0.0	0.0	0.0
2	127.60	0.013	0.000	0.6	0.0	2.8	0.0
3	127.20	0.011	0.000	2.4	0.0	6.2	0.0
4	126.80	0.009	0.000	5.8	0.0	10.5	0.0
5	126.40	0.008	0.000	11.0	0.0	15.7	0.0
6	126.00	0.006	0.000	18.5	0.0	21.7	0.0
7	125.60	0.005	0.000	28.4	0.0	28.3	0.0
8	125.30	0.004	0.000	37.7	0.0	33.7	0.0
9	125.00	0.003	0.000	48.8	0.0	39.6	-14.1
10	124.80	0.003	0.000	53.4	0.0	40.7	-10.9
11	124.40	0.002	0.000	64.5	0.0	0.0	-10.3
12	124.00	0.001	0.000	55.5	0.0	0.0	-30.0
13	123.60	0.001	0.000	40.5	0.0	0.0	-37.4
14	123.30	0.001	0.000	29.3	0.0	0.0	-34.9
15	123.00	0.001	0.000	19.6	0.0	0.0	-29.0
16	122.70	0.001	0.000	12.1	0.0	0.0	-22.0
17	122.40	0.001	0.000	7.4	0.0	0.0	-15.1
18	122.00	0.000	0.000	3.3	0.0	0.0	-7.7
19	121.60	0.000	0.000	1.2	0.0	0.0	-3.7
20	121.30	0.001	0.000	0.4	-0.0	0.0	-1.9
21	121.00	0.001	0.000	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment				Shear force			
no.	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	14.0	124.40	-0.0	128.00	5.6	124.80	-7.2	123.60
2	No calculation at this stage							
3	64.5	124.40	-0.0	121.30	40.7	124.80	-37.4	123.60
4	No calculation at this stage							
5	48.8	125.00	-0.0	128.00	39.6	125.00	-24.1	123.30
6	43.4	125.00	-0.0	128.00	37.5	125.00	-22.2	123.30

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.004	128.00	0.000	128.00	Apply surcharge no.1 at elev. 128.00
2	Wall displacements reset to zero				Change EI of wall to 25872kN.m2/m run
3	0.014	128.00	0.000	128.00	Excav. to elev. 125.00 on PASSIVE side
4	No calculation at this stage				Install strut no.2 at elev. 125.00
5	0.013	128.00	0.000	128.00	Change soil type 3 to soil type 5
6	0.014	128.00	0.000	128.00	Change EI of wall to 18480kN.m2/m run

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 2 at elev. 125.00 kN/m run	kN/strut
5	50.60	101.20
6	51.56	103.11

```
CARD GEOTECHNICS LIMITED                                           | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R49                | Job No. CG18545
                             Licensed from GEOSOLVE                | Made by :   ANK
Data filename/Run ID: CG18545 Wall - SLS                           |
9A The Grove                                                       | Date:27-08-2015
Basement Impact Assessment - SLS                                   | Checked :
-----------------------------------------------------------------------------
                                                                  Units: kN,m
```

Bending moment, shear force, displacement envelopes