APPENDIX C: Hydrogeological and Ground Movement Report

Providing Ground Solutions

Pegasus Life Limited

79 Fitzjohn's Avenue, Camden, London

Basement impact assessment

December, 2014

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Reference	CG/18008	Revision 0	Issue Date December 2014

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1. INTRODUCTION

Pegasus Life Limited is proposing the redevelopment of 79 Fitzjohn's Avenue comprising the construction of a double level basement extension on the site. Card Geotechnics Limited (CGL) has been instructed by Symmetrys Limited (the structural engineer for the project) to undertake a Basement Impact Assessment (BIA) for the proposed development to assess the potential impact on surrounding structures and hydrological and hydrogeological features.

Camden Guidance CPG4[1] requires Basement Impact Assessments (BIA) to be undertaken for new basements in the borough and sets out a 5 stage approach:

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

This report is intended to address the screening, scoping and impact assessment processes set out in CPG4 and the Camden geological, hydrogeological, and hydrological study (CGHHS)[2]. It identifies key issues relating to land stability, hydrogeology and hydrology as part of the screening process. A site investigation has already been carried out for the site. As such, the scoping process will comprise a review of this existing site investigation data and other publically available ground investigation data in the immediate area, and its suitability for use in the BIA and the establishment of a conceptual site model.

The report also provides an impact assessment of geotechnical impacts on adjacent structures and the surrounding area based on available site investigation data and structural details. This includes calculations to determine ground movements resulting from the basement excavation, including heave and lateral movements around the basement perimeter.

[1] Camden Planning Guidance, CPG4, Basements and Lightwells, September 2013.
[2] Ove Arup and Partners, Camden geological, hydrogeological, and hydrological study. Guidance for subterranean development, November 2010.

2. SITE CONTEXT

2.1 Site location

The site is located at 79 Fitzjohn's Avenue in the London Borough of Camden and is situated to the southwest of Hampstead Heath. The National Grid reference for the approximate centre of the site is 526446, 185514.

A site location plan is presented in Figure 1.

2.2 Site description

The site is currently occupied by a hotel belonging to the Hyelm Group. The hotel includes two five storey buildings, and is surrounded by planters and hard standing to the north-east and south-east. There is an area of soft landscaping to the west of the hotel.

There are four semi-detached houses with private gardens located approximately 5m to the north-west of the site along Fitzjohn's Avenue. These are numbered 81-87. Fitzjohn's Avenue runs along the north-eastern boundary of the site, and Prince Arthur Road bounds the site to the south-east. Two semi-detached houses are located approximately 25m north-west of the site fronting Ellerdale Road. The properties have private, south facing gardens that abut the site. A line of properties is situated approximately 30m south-east of the site, on the southern side of Prince Arthur Road. A tunnel and train line associated with the West Hampstead Thames Link is located approximately 300m south-east of the site.

The north-eastern and south-eastern site boundaries are occupied by hard standing and planters fronting the pavements of Prince Arthur Road and Fitzjohn's Avenue respectively. The north-western boundary of the site is bounded by a brick wall that separates the site from the properties fronting Fitzjohn's Avenue. The western corner of the site is bounded by fences and hedgerows.

A site layout plan is presented in Figure 2.

2.3 Proposed development

The proposed development comprises the demolition of the existing structure and construction of a six storey complex of buildings with lower ground floor and basement levels. The basement footprint does not extent below the entire footprint of the proposed buildings, and occupies the northern side of the site only.

The basement will be formed at a level of approximately 98mOD and will be cut into the existing slope, with a retained height of around 8m along the north-western site boundary and 4m along the south-western side of the basement.

Proposed development plans and sections are presented in Appendix A.

2.4 Site history

Ordnance Survey maps dating back to 1870 have been reviewed to inform the BIA. The salient points are summarised below.

Mapping from the 1870's indicates that the area was used as agricultural and private land associated with *Mount Farm*. Some farm buildings were present approximately 50m to the north of the site, and there were trees approximately 100m to the south-west. The site was bounded to the east by *Church Place*, to the south by what appeared to be a garden, and to the west by a field. Several small paddocks were located approximately 100m south-west of the site and extended for approximately 200m in that direction. The map indicates two ponds approximately 300m south-west of the site.

The 1895 map indicates that the farm buildings were partially demolished and the farmland was redeveloped. A building occupied the northern end of the site, whilst the southern end was a private garden. Four semi-detached houses were built approximately 5m to the north of the site, and a further two were built approximately 30m to the west. *Prince Arthur Road* was built around this time and bounded the site to the south-east. The road that bounded the north-east of the site was named *Fitzjohn's Avenue*.

There were no significant changes until 1935, when the map indicates a substantial development to the southern end of the site, with the presence of a large building orientated parallel to the existing Prince Arthur Road.

In 1955, the building towards the southern corner of the site was demolished; there was no further significant change noted until 1974, when a new building was built in its place.

Available aerial photographs show that by 1999, both buildings had undergone further development and extension to form one large building, which predominantly occupied the site. A further building had been built in the centre of the site, and hard standing formed a car park between the two buildings. Hard standing and planters were identified along the north-eastern, south-eastern, south-western site boundaries.

No further significant changes were noted between 1999 and present day.

2.5 Bomb damage

The London County Council Bomb Damage Maps 1939-1945 show that there was no recorded bomb damage to any of the buildings within the site area. Therefore the risk of unexploded ordnance (UXO) is considered to be low. A building labelled as *St John's House,* located approximately 260m east of the site, suffered 'total destruction', and four houses located approximately 170m south of the site on *Ellerdale Road* suffered 'damage beyond repair'.

2.6 Topography

The site is located on the south-western side of *Parliament Hill*. The topography of the site slopes towards the west/south-west, decreasing in elevation from 106.39mOD in the eastern corner of the site, to 101.99mOD in the western corner of the site. To the north, the corner of the site is at 105.94mOD, and to the south it is at 102.71mOD. The topography of the site from east to west slopes at approximately 3.7° (1:16 gradient).

The topography is typified by a 'ridge' trending in a north-westerly to south-easterly direction. The area surrounding the site generally slopes up towards the north-east (before slope down on the opposite side of the 'ridge') at an angle of approximately 5° (1:11 gradient) and slopes down towards the south-west at an angle of approximately 3.5° (1:16 gradient).

2.7 Published geology

With reference to the British Geological Survey (BGS) sheet 256[3] for the local area, the site is shown to be underlain by the Bagshot Formation from the surface. No superficial deposits are noted to be in the area of the site. The Bagshot Formation is underlain by the Claygate Member, which is in turn underlain by the London Clay formation, Lambeth Group and the Thanet Sand Formation, with Chalk at depth.

The Bagshot Formation is a predominantly light yellow-brown grey laminated, fine to coarse grained sand. Thin lenses of white sand and 'pipe clay' occur sporadically, increasing in thickness towards the top of the unit. The formation has a basal bed of gravelly coarse grained sand.

The Claygate Member consists of dark grey clays, interbedded with laminated sands and bioturbated silts. Ferruginous concretions and septarian nodules are observed in places.

[3] British Geological Survey. (1994). *North London*. England and Wales Sheet 256. Solid and Drift Geology. 1:50,000 Series.

The London Clay is a very stiff, highly fissured and over consolidated grey blue clay. It typically has a high plasticity, and is finely laminated. It may contain silty or fine grained sandy units, as well as claystone, calcareous and phosphatic nodules, as well as traces of gypsum and pyrite.

2.8 Unpublished geology

Historical BGS borehole records within 500m of the site have been reviewed to place the site within a wider geological context and are summarised in Table 1.

Table 1. Summary of BGS borehole records.

BH record	Approximate Distance (m)	[bearing]	Base of BH (mbgl)	Ground water level (mbgl)	Stratum (depth encountered in mbgl)				
					MG/TS	Possible Head Formation	Bagshot Formation	Claygate Member	London Clay
TQ28NE44 BH1	75	E	9.1	-	GL	-	0.91	5.18	-
TQ28NE44 BH2	75	E	9.1	-	GL	-	0.60	5.36	-
TQ28NE44 BH3	75	E	12.19	-	GL	-	0.79	10.05	-
TQ28NE44 BH4	75	E	6.09	-	GL	-	1.09	1.40	-
TQ28NE95	350	NW	12.67	9.75	GL	0.60	1.82	3.35	5.48
TQ28NE6	430	NE	182.88	-	GL	-	-	-	2.13

The BGS borehole records are in general agreement with the conditions anticipated based on the geological sheet. The Bagshot Formation and Claygate Formation were not recorded in TQ28NE6 and correspond directly to a sharp decline in topography, with the borehole record located on the opposite side of the 'ridge'. This does not correlate with the North Camden Geological Map which indicates that the Claygate Member should be present within the borehole.

Made Ground was recorded in the BGS borehole records, with the thickness varying from site to site, based on the individual site history. No superficial deposits were recorded in the BGS borehole records reviewed.

The top of the London Clay was encountered at approximately 85mOD during a CGL investigation undertaken some 125m to the south of the site.

2.9 Hydrogeology

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

The bedrock has been classified as a Secondary 'A' aquifer, and is classified as a Minor Aquifer High groundwater vulnerability zone. The site is not within a groundwater source protection zone.

2.10 Hydrology

The nearest recorded surface water feature is *Highgate Ponds* located approximately 900m northeast of the site. These are a string of six ponds that correspond with the interface of the Claygate Member and the underlying London Clay.

Existing and historical spring lines are present at the interface of the Claygate Member and the underlying London Clay. These springs have been the source of a number of London's 'lost' rivers, notably the *Fleet*, *Westbourne* and *Tyburn*, most of which are now diverted underground. Several river sources are located to the west and south of the site.

The closest tributary source was situated approximately 300m south of the site. It formerly flowed roughly from the north to south, parallel to the existing *Netherball Gardens*, located approximately 50m to the west of the site. The groundwater is likely to be sourced from springs lines at the interface of the London Clay and Claygate Beds. Given the proximity of this former water course to the site, it is possible that some fluvial reworking of the shallow soils may be present between *Netherball Gardens* and the site.

The next closest tributary was located some 320m to the south-east of the site.

2.11 Flood risk

With reference to Environment Agency mapping, the site is not located within a Flood Risk Zone. Notwithstanding this, and with reference to Figure 15 (Flood Map) of the Arup report, Finchley Road and Frognal (located to the southwest of the site) were flooded in 2002, and *Arkwright Road* (located to the south of the site) was flooded in 1975.

3. SCREENING (STAGE 1)

3.1 Introduction

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

3.2 Subterranean (Groundwater) flow

This section answers questions posed by Figure 1 in CPG4:

Table 2. Responses to Figure 1, CPG4.

Question	Response	Action required
1a. Is the site located directly above an aquifer?	Yes The site is located over a secondary 'A' aquifer corresponding to the Bagshot Formation.	Confirm by investigation and assessment
1b. Will the proposed basement extend beneath the water table surface?	Unknown Unpublished geological records are unclear as to where the groundwater level is.	Confirm by investigation and assessment
2. Is the site within 100m of a watercourse, well or potential spring line?	No The nearest former tributary of the former *River Westbourne* was located approximately 300m to the south of the site.	None
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No The site is not within the catchment of the chain ponds on *Hampstead Heath* which are situated approximately 900m northeast of the site.	None
4. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No Although the proposed structure will extend further than the existing building, the area is already under hardstanding.	None
5. As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS)?	No No significant change is being made to area of hard standing at the surface. Surface water will be discharged to the sewer network through connections.	None

Question	Response	Action required
6. Is the lowest point of the proposed excavation close to, or lower than, the mean water level in any local pond or spring lines?	No Although the spring lines and ponds of *Hampstead Heath* noted to the south and north-east are at a lower elevation than the site.	None

In summary, it is considered that the basement excavation will not affect or be effected by surface water features, specifically the pond chains on *Hampstead Heath*, or local former surface water features. The site is situated above an aquifer, and this should be taken into consideration in the design and construction of the basement.

3.3 Slope/land stability

This section answers questions posed by Figure 2 in CPG4.

Table 3. Responses to Figure 2, CPG4.

Question	Response	Action required
1. Does the site include slopes, natural or man-made, greater than approximately 1:8?	No The general gradient is approximately 1:16	None
2. Will the proposed re-profiling of the landscaping at site change slopes at the property boundary to greater than approximately 1:8?	No	None
3. Does the development neighbour land including railway cuttings and the like with a slope greater than approximately 1:8?	No	None
4. Is the site within a wider hillside setting in which the general slope is greater than approximately 1:8?	No With reference to Figure 16 within the Arup report[2], slope angles are less than 7°.. The topography of the surrounding area generally slopes up towards the north-east a gradient of 1:11 and slopes down towards the south-west at a gradient of 1:16 gradient.	None
5. Is the London Clay the shallowest stratum on site?	No	Confirm by investigation and assessment
6. Will any trees be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	No	None

Question	Response	Action required
7 Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such at the site?	Unknown The shallow soils, particularly the cohesive beds of the Clay Member are likely to susceptible volume change, however, no damage to buildings has been identified.	Impact assessment
8. Is the site within 100m of a watercourse or a potential spring line?	No The nearest former tributary was situated approximately 300m away.	None
9. Is the site within an area of previously worked ground?	No Site history is agricultural and residential.	None
10. Is the site within an aquifer and if so will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No See Table2, Question 1a.	Confirm by investigation and assessment
11. Is the site within 50m of the Hampstead Heath ponds?	No The *Hampstead Heath* ponds are located approximately 900m to the north-east of the site.	None
12. Is the site within 5m of a highway or pedestrian right of way?	Yes The site is bounded to the northeast by *Fitzjohn's Avenue*, and *Prince Arthur Road* to the southeast.	Impact assessment
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes The proposed basement will be deeper than the foundations of the neighbouring property on Fitzjohn's Avenue.	Impact assessment
14. Is the site over (or within the exclusion zone of) any tunnels?	No	None

In summary, there is Bagshot Formation, Claygate Member and London Clay located below the site, and it is anticipated that heave movements/long term settlement will occur during construction and over the long-term. Construction related settlement may also occur as the proposed basement walls are installed. The Bagshot Formation and granular beds of the Claygate Member are susceptible to running sands conditions where groundwater or perched water is present. The London Clay is anticipated at approximately 85mOD.

A basement impact assessment will be undertaken to determine the likely magnitude of ground movements around the basement perimeter. This will include the effects of deflections of retaining walls and associated ground settlement. The results of the ground movement analysis will be used to assess potential damage categories developed in adjacent structures.

3.4 Surface flow and flooding

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

Table 4. Responses to Figure 3, CPG4.

Question	Response	Action required
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No	None
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off), be materially changed from the existing route?	No	None
3. Will the proposed development result in a change in the proportion of hard surfaced/paved external areas?	No	None
4. Will the proposed basement result in a change to the profile of the inflows of surface water being received by adjacent properties or downstream watercourses?	No It is understood that all surface water will be discharged to the sewer network through existing connections and the volumes of surface water run-off from the site are not anticipated in increase significantly.	None
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No The construction of the basement will remove existing Made Ground from this area of the site. As such there will be no degradation in water quality to adjacent properties or downstream water courses.	None
6. Is the site in an area known to be at risk from surface flooding, or is it at risk from flooding because the proposed basement is below the static water level of a nearby surface water feature?	No Arkwright Road and other local roads were flooded previously.	None

In summary, the proposed basement will not result in a change to the area of hard surfaces and therefore there should be no change in volume of surface run-off water, or a material reduction in attenuation characteristics. It is understood that all surface water is discharged to the sewer network through existing connections and the volumes of surface water run-off from the site are not anticipated to change.

With reference to Environment Agency mapping, the site is not located within a Flood Risk Zone. Notwithstanding this, and with reference to Figure 15 (Flood Map) of the Arup report, Finchley Road and Frognal (located to the southwest of the site) were flooded in 2002, and Arkwright Road (located to the south of the site) was flooded in 1975.

3.5 Summary

On the basis of this screening exercise, the basement impact assessment will address the following:

Table 5. Summary of Basement Impact Assessment requirements.

Item	Description
	Subterranean (Groundwater flow)
1.	Confirm the ground conditions and if groundwater is present within the Bagshot Formation/Claygate Beds and, therefore, whether groundwater will be a consideration for the basement design, and if the basement will effect groundwater flows in and around proposed structures within the Secondary A Aquifer.
	Slope stability
2.	Estimate movements associated with construction in Bagshot Formation/Claygate Beds and London Clay, including short and long term heave movements, settlement associated with retaining wall deflections, foundation settlement and ground movements around the basement perimeter.
3.	Impact assessment to determine effect of basement construction on adjacent residential properties and infrastructure.

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

4. SCOPING (STAGE 2)

4.1 Introduction

This section of the report covers the scoping process (Stage 2) of the assessment in accordance with CPG4, which is used to identify potential impacts of the proposed scheme and establish a conceptual site model. The scoping stage also informs the scope of the site investigation.

4.2 Existing Site Investigation

An intrusive investigation was undertaken in August 2014 by Ian Farmer Associates (Ian Farmer) and factual details are presented in Appendix C. The investigation comprised the excavation of three window sampler boreholes (BH1, BH3 & BH4) and two cable percussions boreholes (BH2 and BH5) to depths of between 11mbgl and 20mbgl.

In-situ testing was undertaken and comprised Standard Penetration Tests (SPTs). Groundwater monitoring wells were installed within the boreholes BH2, BH4 and BH5 and the groundwater level was monitored on three occasions.

Three inspection pits were excavated on the north-western site boundary to expose and record the existing foundations. The foundations are likely to be consistent with those of the neighbouring properties and the details have been used with the land stability assessment.

The intrusive investigation is considered to be sufficient to generate the ground model for the development.

5. GROUND AND GROUNDWATER CONDITIONS

5.1 Summary

With reference to the Ian Farmer intrusive investigation, the ground conditions beneath the site generally comprised a limited thickness of Made Ground over interbedded sands and clays, over clay. The summary of ground conditions presented in the Ian Farmer investigation has been reproduced in Table 6 below.

Table 6. Summary of Ian Farmer investigation findings

Stratum	Depth encountered (mbgl)	Thickness (m)
Made Ground/possible Made Ground	0.0	0.25 to 1.8
Bagshot Formation	0.25 to 1.8	6.8 to 14.65
Claygate Member (London Clay Formation	8.5 to 14.9	>11.5 Proven to 20mbgl

Although the Ian Farmer report provides a summary of the ground conditions with strata names, the boreholes records do not. On this basis, the lithostratigraphy has been interpreted by CGL with reference to known regional geology and correlations with previous near-by borehole records. Plots of SPT 'N' versus level and cu versus level are presented in Figure 3 and Figure 4 respectively.

A generalised geological section is presented within the conceptual site model (Figure 5). It is noted that the shallow soils are highly variable, comprising interbedded sands and clays and there is no clear differentiation between the granular Bagshot Formation and interbedded Claygate Member. On this basis, the strata will be considered undifferentiated within the ground movement assessment.

Although not identified as such by Ian Farmer, soils with a description consistent with the London Clay Formation were encountered in borehole BH2 at approximately 86mOD and borehole BH5 at approximately 87.4mOD. The soils are described as stiff, fissured, dark grey, silty, sandy clay.

Groundwater was encountered within the granular soils of the Bagshot Sand/Claygate Member at levels between 94.3mOD and 95.7mOD during three monitoring visits.

5.2 Geotechnical Parameters

Geotechnical design parameters for the ground conditions encountered have been derived based on the soil descriptions and in-situ testing within the available borehole records.

The geotechnical design parameters utilised within the VDISP settlement/heave analysis are outlined in Table 7 below. The presence of sand beds within the Bagshot Formation/Claygate Member will facilitate the movement of water between the clays and sands and as such the soils are expected to behave in the drained condition. This has been allowed for within the settlement/heave analysis.

Table 7. Geotechnical design parameters for heave/settlement analysis

Stratum	**Design level (mOD)**	**Bulk Unit weight γ_b (kN/m^3)**	**Undrained Cohesion c_u (kPa) [c']**	**Friction angle Φ' (°)**	**Young's modulus E_u (MPa) [E']**
Made Ground	Varies	18	20[a] [0]	-	10[b] [7.5]
Bagshot Formation/Claygate Member (cohesive)	Above 98mOD	20	40 [0]	-	24[b] [18][c]
Bagshot Formation/Claygate Member (cohesive)	Below 98mOD	20	50+7.5z[d] [0]	-	25+4.5z[b] [18+3.4z][c]
Probably London Clay Formation	85	20	147+7.5z[d] [5]	-	88+4.5z[b] [66+3.4z][c]

a. Burland, J., Standing, J. and Jardine, F. (2001). Building Response to Tunnelling, CIRIA.
b. Based on 500 Cu for Bagshot Formation/Claygate Beds and 600 Cu for London Clay
c. Based on 0.75E
d. z = depth below design level.

The geotechnical design parameters utilised within the WALLAP retaining wall analysis are outlined in Table 8 below. Owing to the variability of the retained soils, the analysis has been undertaken assuming that the soils act in the drained condition which is considered reasonable as the soils are interbedded sands and clays which are likely to have a reasonably high mass permeability.

Table 8. Geotechnical design parameters for retaining wall analysis

Stratum	Design level (mOD)	Bulk Unit weight γb (kN/m3)	Undrained Cohesion cu (kPa) [c']	Friction angle Φ' (°)	Young's modulus Eu (MPa) [E']
Bagshot Formation/Claygate Member (granular)	Varies	18	-	29[e]	[15]

e. Peck, R.B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967, p.310.

The above values are considered to be moderately conservative and are unfactored (Serviceability Limit State) parameters.

5.3 Conceptual site model

A conceptual site model (CSM) has been developed based on the available data and in accordance with the recommendations of the Arup CGHHS report[2] and is presented diagrammatically in Figure 5.

5.3.1 Critical sections

Two critical sections for analysis have been identified for analysis, their locations are shown on Figure 2.

- Section A-A: from north-west to south-east through adjacent property on *Fitzjohn's Avenue* and north-western basement wall; and
- Section B-B: from north-east to south-west through adjacent property on *Prince Arthur Road* and south-western basement wall.

Section A-A has been analysed to assess the potential for ground movements due to the construction of the basement to cause damage to the neighbouring properties.

With reference to Figure 5, the foundations of the adjacent property on *Prince Arthur Road* (Section B-B) are outside of the zone of influence of the basement (assuming a 45° soil wedge). On this basis, no further assessment for potential ground movements affecting Section B-B is considered necessary.

6. SUBTERRANEAN (GROUNDWATER) FLOW (STAGE 4)

6.1 Introduction

This section addresses outstanding issues raised by the screening process regarding groundwater flow (see Table 2).

Although the Bagshot Formation/Claygate Member is designated a Secondary 'A' Aquifer, groundwater has been recorded at a level below the proposed basement and, on this basis, the proposed basement is not considered impact upon the aquifer.

6.2 Impact on groundwater flow

Groundwater was encountered within the granular soils of the Bagshot Sand/Claygate Member at a level between 94.3mOD and 95.7mOD. It is anticipated that groundwater will be flowing towards the south within the Bagshot Formation/Claygate Member. This is considered to represent an unconfined perched aquifer above the Claygate Member.

Groundwater is likely to be approximately 2m beneath the underside of the proposed lower basement slab.

It is anticipated that groundwater will be able to flow freely beneath and around the basement perimeter within the relatively permeable soils. On this basis, the proposed development is unlikely to have further cumulative impacts on groundwater flow.

6.3 Recommendations for groundwater control

Observations on groundwater should be carefully recorded during excavation and appropriate mitigation strategies put in place prior to the first excavation. Groundwater has been encountered within the granular Bagshot Formation/Claygate Member at a depth below the proposed basement.

Should water bearing sand horizons/lenses be encountered at shallower depths than the proposed basement formation level (i.e. >98mOD), then some limited seepage into excavations may be encountered. Under such conditions, 'running sands' could potentially generate voids beneath adjacent structures and cause collapse of the excavated wall if unsupported. Although such conditions are not anticipated based on the available information, an effective contingency plan for shallow granular soils and/or shallow perched water and running sand conditions should be agreed with the contractor at the time of commencement. This will likely take the form of a temporary shoring system to

prevent collapse and void formation. Such shallow water seepages are likely to be limited in volume and should be readily controlled with a sump pump. Prolonged groundwater lowering by pumping is not anticipated.

Trench sheets, shoring and a pump will need to be available at all times during the works in case of such an event. There should also be preparation to use no fines concrete where appropriate.

7. LAND STABILITY (STAGE 4)

7.1 Introduction

This section provides calculations to assess ground movements that may result from the excavation to sub-basement level of typically 98mOD and how these may affect adjacent structures. It is understood that a contiguous piled wall will be used to retain the excavation.

Ground movements are considered to derive from:

- Piled wall installation: Ground disturbance during pile installation may cause ground settlement;
- Piled wall deflection: Deflection of the piled wall during excavation may cause settlement behind the wall, which could impact the neighbouring property and garden party walls;
- Heave movements: The London Clay is susceptible to short term heave and time dependant swelling on unloading, which will occur as a result of basement excavation, generating upward ground movements; and
- Long term ground movement: The net loading on formation soils will generate ground movement, which could affect adjacent foundations. This takes into account existing stress conditions, additional loads from the new structure and total stress reduction from the excavated soil.

7.2 Ground movements due to piled wall installation

With reference to CIRIA C580[4], vertical and horizontal surface movements due to installation of a contiguous piled wall are generally not reported to exceed 0.04% of the wall depth. The distance to negligible movements is anticipated to be no more than twice the wall depth, or 20m from the wall assuming 10m long piles.

Maximum installation movement (horizontal and vertical) of 4mm have been calculated based on the assumptions above.

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

Notwithstanding this, with good control and assuming a hit and miss construction methodology, in CGLs experience[5] it is possible to limit installation movements to 0.02% of the wall depth.

Should this be achievable, vertical installation movements would reduce to around 2mm.

7.3 Ground movement arising from basement excavation

The calculated unloading due to excavation takes account of the slope from around 106mOD in the north-east to around 102mOD in the south-west of the site and assumes a formation level across the basement of 98mOD. On this basis, the soils at formation level will be subject to stress relief during excavation, as between 4m and 8m of overburden is removed to form the basement and sub-basement levels including up to 0.8m of basement floor slab and heave precautions. This is likely to give rise to a degree of elastic heave over the short term and potential heave or settlement over the longer term as pore pressures recover in the cohesive units of the Bagshot Formation/Claygate Member and the underlying London Clay.

Given the highly variable nature of the Bagshot Formation/Claygate Member, comprising interbedded sands and clays, the analysis has assumed cohesive soils at formation level and below, acting in the drained condition. This is considered to be a conservative, worst-case assessment of potential heave movements. The magnitude of such movements has been assessed using OASYS Limited *VDISP* (***V**ertical **DISP**lacement*) analysis software. *VDISP* assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E') for each stratum input.

The proposed basement development gives rise to a net unloading of the underlying strata both during construction and over the long term. The excavation the proposed basement will unload the soils at the basement formation level by between 80kPa, and 160kPa. These values assume a typical bulk unit weight of 20kN/m^3 for cohesive excavated soils. The combined effects of both the immediate undrained unloading and the long-term drained recovery of pore pressures have been analysed.

The loading information and drawings provided by the structural engineers indicate that the sub-basement slab will be underlain by heave board to accommodate positive vertical displacements of the ground subsequent to unloading, and will be dowelled into piles

[5] Ball et al. (September 2014). *Prediction of party wall movements using CIRIA report C580*. Ground Engineering.

forming the contiguous piled wall. Due to this, no additional net loads are modelled in the long term as structural loads are transmitted to the ground by the piles.

7.3.1 VDISP results

Total heave is predicted to be approximately 45mm, occurring beneath the central region of the proposed basement, reducing to around 7mm around the basement perimeter and 5mm at the nearest foundation of the adjacent property on Fitzjohn's Avenue.

There is potential for up to 3mm to 4mm of undrained heave within the London Clay around at the basement perimeter, reducing to around 2mm to 3mm at the nearest foundation of the adjacent property on Fitzjohn's Avenue.

A contour plot showing the variation of heave across the basement excavation and likely impact on the adjoining property is presented within Figure 6. Full VDISP output can be provided upon request.

7.4 Ground movements due to retaining wall deflections

7.4.1 General

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

7.4.2 WALLAP model assumptions

The WALLAP analysis includes the following assumptions:

1. A contiguous piled wall of 450mm diameter piles will be installed to retain the soil below ground level during excavation of the basement levels;

2. The following adjacent property foundations surcharge loads were provided by the structural engineer for Section A-A:

    a. Boundary wall: 18kN/m have been assumed, applying a bearing pressure of 18kPa assuming a 1m wide foundation;

    b. Nearest building foundation: 90kN/m have been assumed, applying a bearing pressure of 90kPa assuming a 1m wide foundation;

3. Owing to the high variability of the retained soils, comprising interbedded sands and clays, the analysis assumes composite granular soils over the full retained height and embedded depth – this is considered to be a conservative and worst-case assessment of potential deflections.

4. The piled wall will be propped in the temporary condition to provide stability and limit deflections.

An un-propped, cantilever retaining wall may be feasible should the pile diameter be increased.

7.4.3 WALLAP construction sequence

7.4.3.1 Section AA

The following construction sequence was been assumed for the development based on a *bottom-up* construction methodology:

- Install 450mm diameter contiguous piles around perimeter of the basement;
- Excavate basement to 102.5mOD and install temporary prop at 103mOD;
- Excavate basement to 98mOD and install basement floor slab at 98.5mOD;
- Install lower ground floor slab at 103.3mOD and remove temporary prop at 103mOD;

7.4.4 WALLAP results

The WALLAP results for piled wall deflections are summarised in Table 9 below, full WALLAP output is available on request.

Table 9. Pile wall deflection and corresponding ground settlement.

Critical section Reference	Deflection at top of pile (mm)	Maximum deflection (mm)	Level of max. deflection (mOD)
Section A-A	4.0	7.0	98
Section B-B	2.0	9.0	98.5 to 94

Movements should be reviewed once the loading, construction sequence and methodology have been finalised.

7.5 Damage category assessment

The calculated ground movements have been used to assess potential 'damage categories' that may apply to neighbouring properties due to the proposed basement construction. The methodology proposed by Burland and Wroth[6] and later supplemented by the work of Boscardin and Cording[7] has been used, as described in *CIRIA Special Publication 200*[8] and *CIRIA C580*[9].

General damage categories are summarised in Table 10 below:

Table 10. Classification of damage visible to walls (reproduction of Table 2.5, CIRIA C580).

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

For the critical section the impact of short term heave, long term movements and pile wall deflection/installation have been combined to determine the deflection ratio for the adjacent property. The derivation of these parameters is presented graphically in Figure 7 and is based on pile installation movements of 0.04% of the pile length.

Horizontal movements and strains are based on the translation of 0.02% and 0.04% of the pile length to the nearest neighbouring foundations.

[6] 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
[7] Boscardin, M.D., and Cording, E.G., (1989). *Building response to excavation induced settlement*. J Geotech Eng, ASCE, 115 (1); pp 1-21.
[8] 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.
[9] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*

Table 11. Summary of short-term movements and corresponding damage category.

Party Wall Reference		Horizontal movements at neighbouring foundation (mm)	Maximum deflection (mm)	Horizontal Strain Δ/L[b] (%)	Deflection ratio δ_h/L[a] (%)	Damage category
Section AA	0.04%	5.5	2.0	0.0688	0.025	2 –slight
	0.02%	4.4	2.0	0.055	0.025	1 – very slight

1. *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).*
2. *See Box 2.5 (v) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (δh = horizontal movement in metres.*

The predicted damage category imposed on the neighbouring properties due to the proposed basement development and assuming a good standard of workmanship will be marginally 'Category 2' corresponding to slight damage for the adjacent property on Fitzjohn's Avenue, or 'Category 1' corresponding to slight damage if installation movements can be limited to 0.02% of the pile length.

Up to 15mm of heave is anticipated beneath the pavement and carriageway of Fitzjohn's Avenue and Prince Arthur Road and on this basis the proposed basement is unlikely to cause significant damage to these structures.

7.6 Monitoring strategy

The results of the ground movement analysis suggest that with good construction control, damage to adjacent structures generated by the assumed construction methods and sequence are likely to be (within Category 2) 'slight'. To ensure movements do not fall outside of that predicted, it is recommended that a formal monitoring strategy is implemented on site to observe and control ground movements during construction.

The monitoring system should operate broadly in accordance with the 'Observational Method' as defined in CIRIA Report 185[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.

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

8. SURFACE FLOW AND FLOODING (STAGE 4)

It is noted in Section 3.4 of this report that the proposed basement will not significantly alter present surface water conditions as the majority of the site is currently occupied by buildings or hardstanding.

As already identified, the site lies outside any EA designated Flood Zone and the site is not located on a street that flooded in the 1975 and 2002 events.

Surface waters will join the existing drainage infrastructure (via basement pumping if a gravity fed solution is not feasible), with no significant changes in drainage outflows anticipated from the site.

As such the development will have a negligible impact on surface water flow and flooding. In addition, the basement is likely to provide enhanced attenuation given its requirement to be drained in accordance with building.

9. NON-TECHNICAL SUMMARY

9.1 General

The findings of this *Basement Impact Assessment* are informed by ground investigation data, information regarding construction methods provided by the client and assumed construction sequence and detail.

- From the available information, it is considered that the proposed basement construction will have a negligible effect on groundwater, surface water and flooding at this site.

- The construction of the basement will generate ground movements due to a variety of causes including; heave and retaining wall installation and deflection during and after excavation

- Conservative calculations indicate that these will give rise to a damage category marginally within 'Category 2' (slight damage) for the adjacent property on Fitzjohn's Avenue assuming a good standard of workmanship. Limiting pile installation movements to 0.02% would reduce the damage category to within 'Category 1' (very slight damage).

- Observations on groundwater should be carefully recorded during excavation and appropriate mitigation strategies put in place prior to any excavation. Should perched groundwater be encountered within the Bagshot Formation/Claygate Member, a temporary pumping strategy will need to be implemented to allow dry excavations. This could be achieved by the use of, for example, a sump chamber.

- It is recommended that an appropriate monitoring regime is adopted to manage risk and potential damage to the neighbouring structures during construction.

- The analyses reported are based on the information currently available and should be revised if changes are made to the proposed design, loading, construction method or sequence.

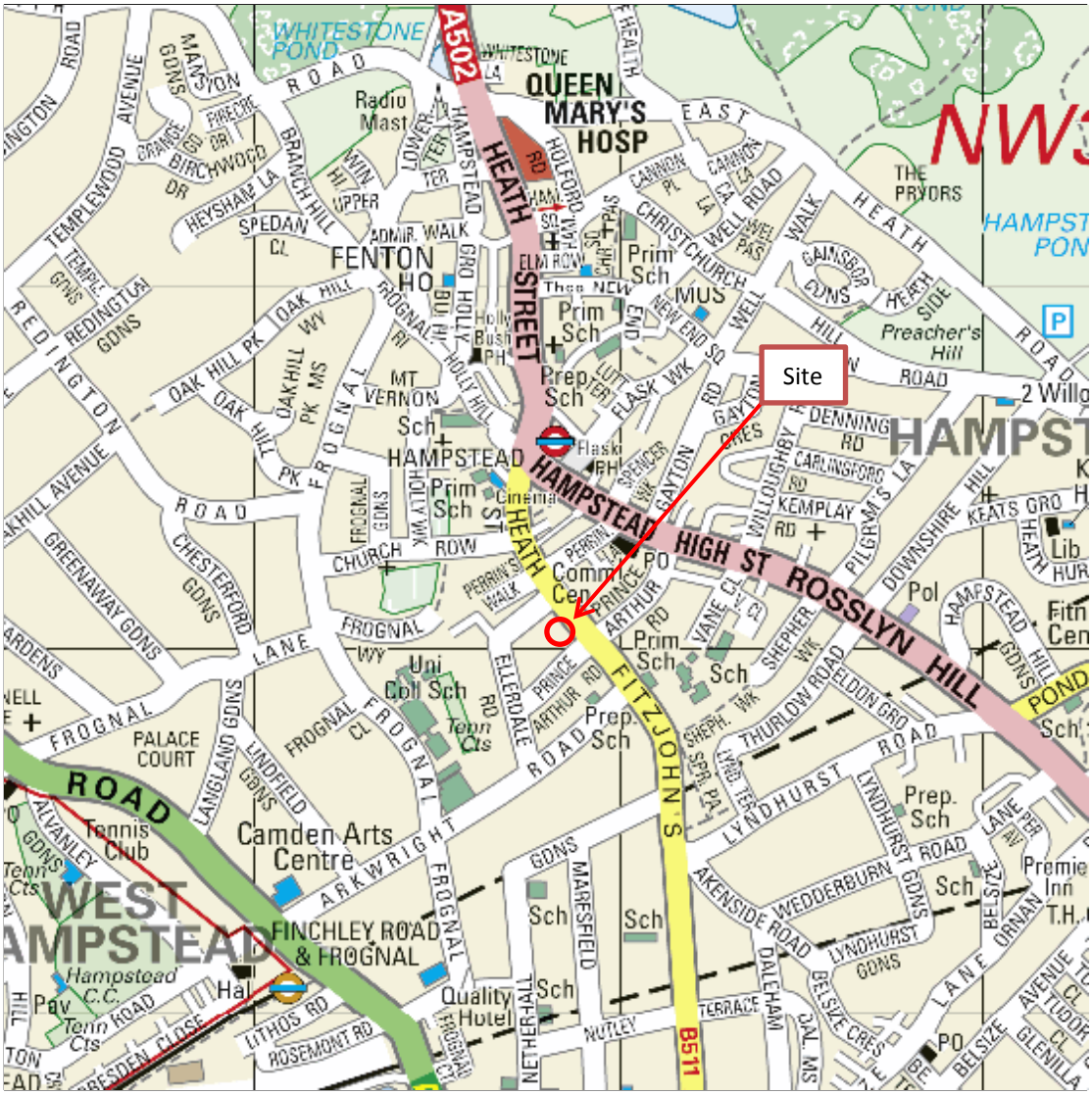
9.2 Cumulative impacts

It is considered that there are no significant cumulative impacts in respect of ground or slope stability due to the proposed development.

The shallow ground conditions beneath the site comprise Made Ground over interbedded sands and clays of the Bagshot Formation/Claygate Member. Groundwater has been encountered within the granular deposits, corresponding to a depth below the basement. Additionally, the contiguous wall will allow groundwater to flow through the wall and beneath basement. On this basis, groundwater is free to flow beneath the proposed and built basements, and it is therefore considered that the proposed development would not contribute further to any cumulative effects.

The proposed development will not materially alter the proportion of hardstanding across the site. It is understood that the existing surface water run-off is currently, and will be discharged to the sewer network through existing connections. On this basis, the development is not considered to contribute to any significant cumulative impact with regard to surface flow or flooding.

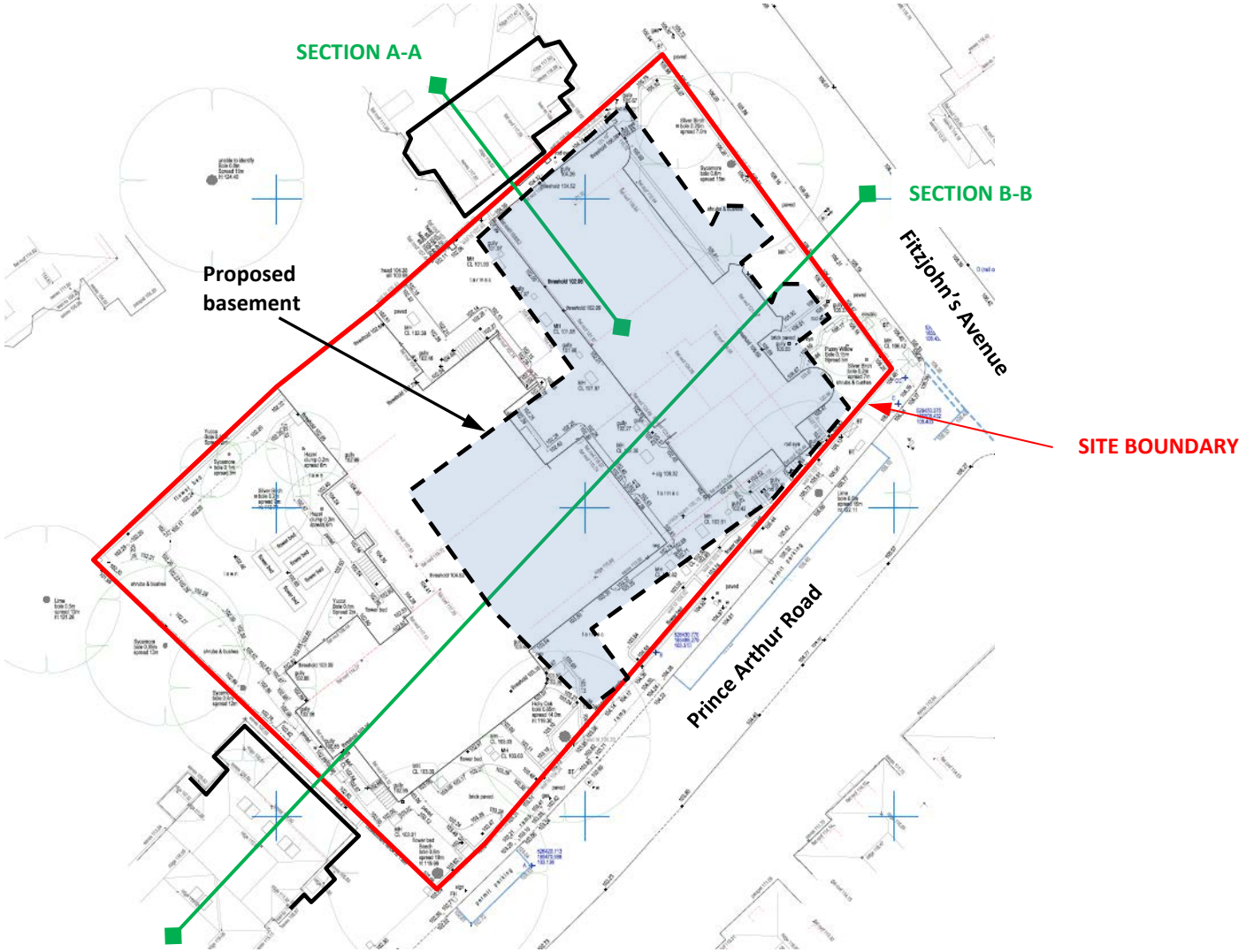
FIGURES



Reproduced from the Ordnance Survey 1:50,000 map with permission of the Controller of Her Majesty's Stationary Office, Crown Copyright.

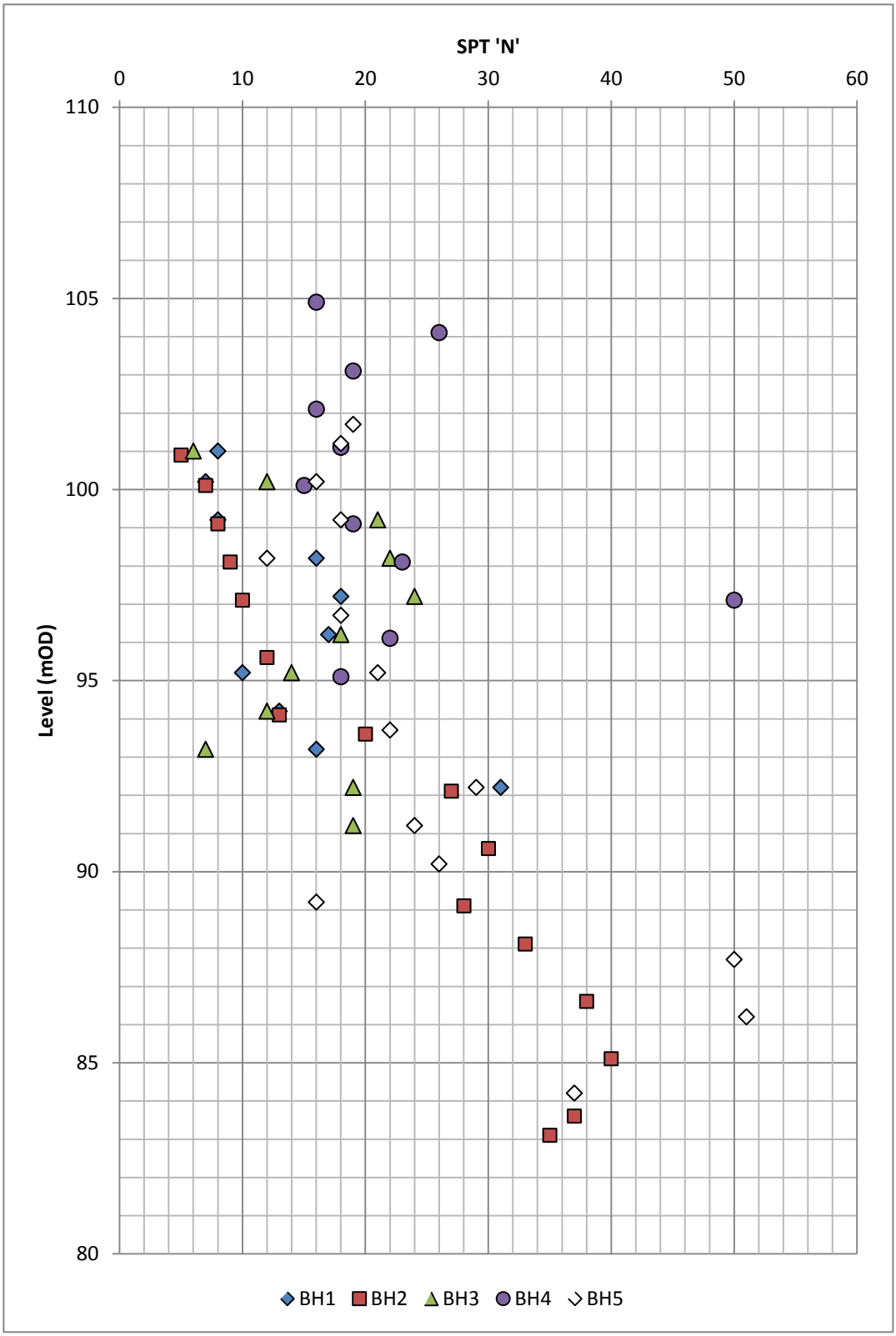
Licence No. 100012585

Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title: **Site location plan**	**Figure 1**

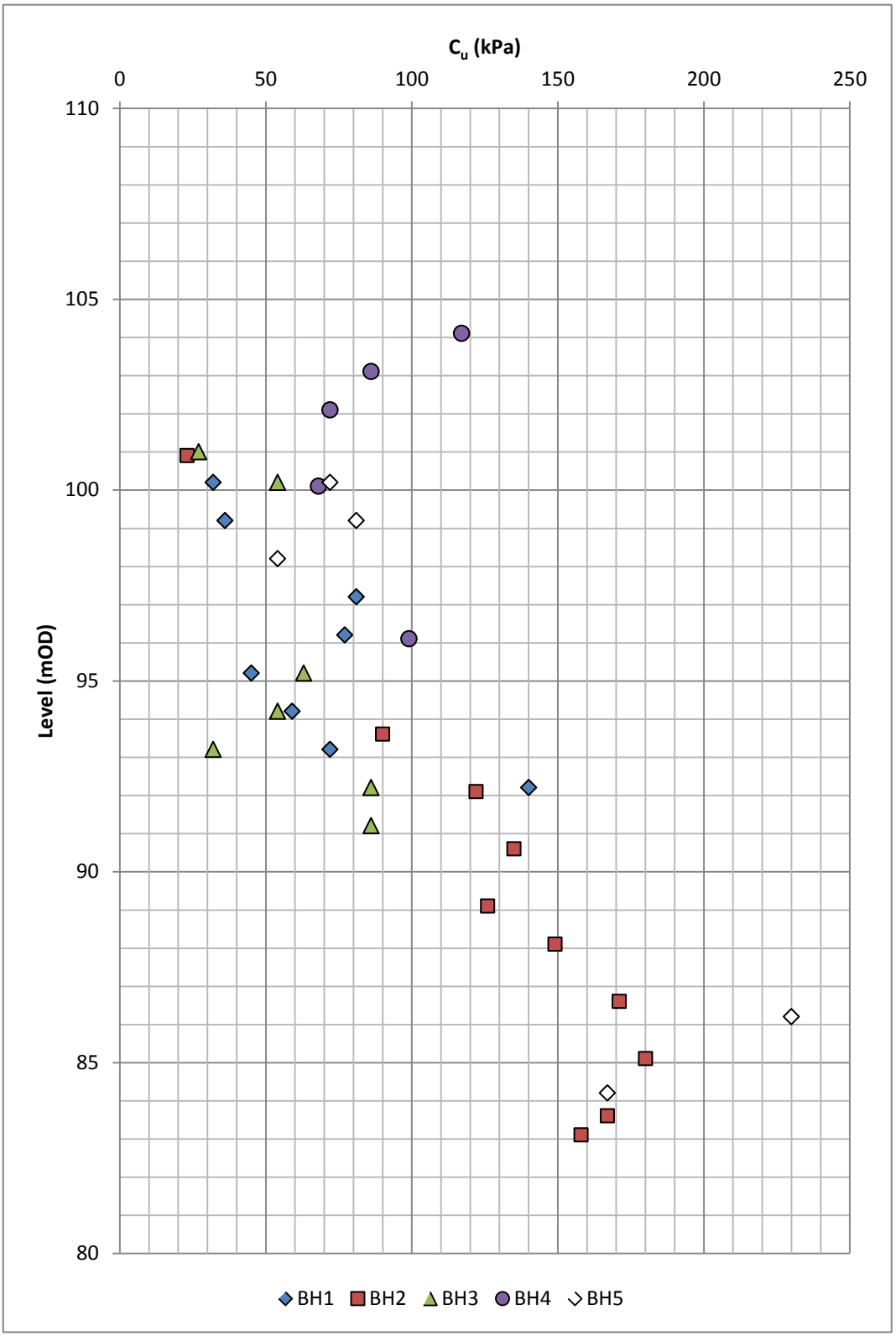


NOT TO SCALE

Client	Project	Job No
Pegasus Life Limited	79 Fitzjohn's Avenue, Camden, London	CG/18008
CGL	Title: Site layout plan	Figure 2

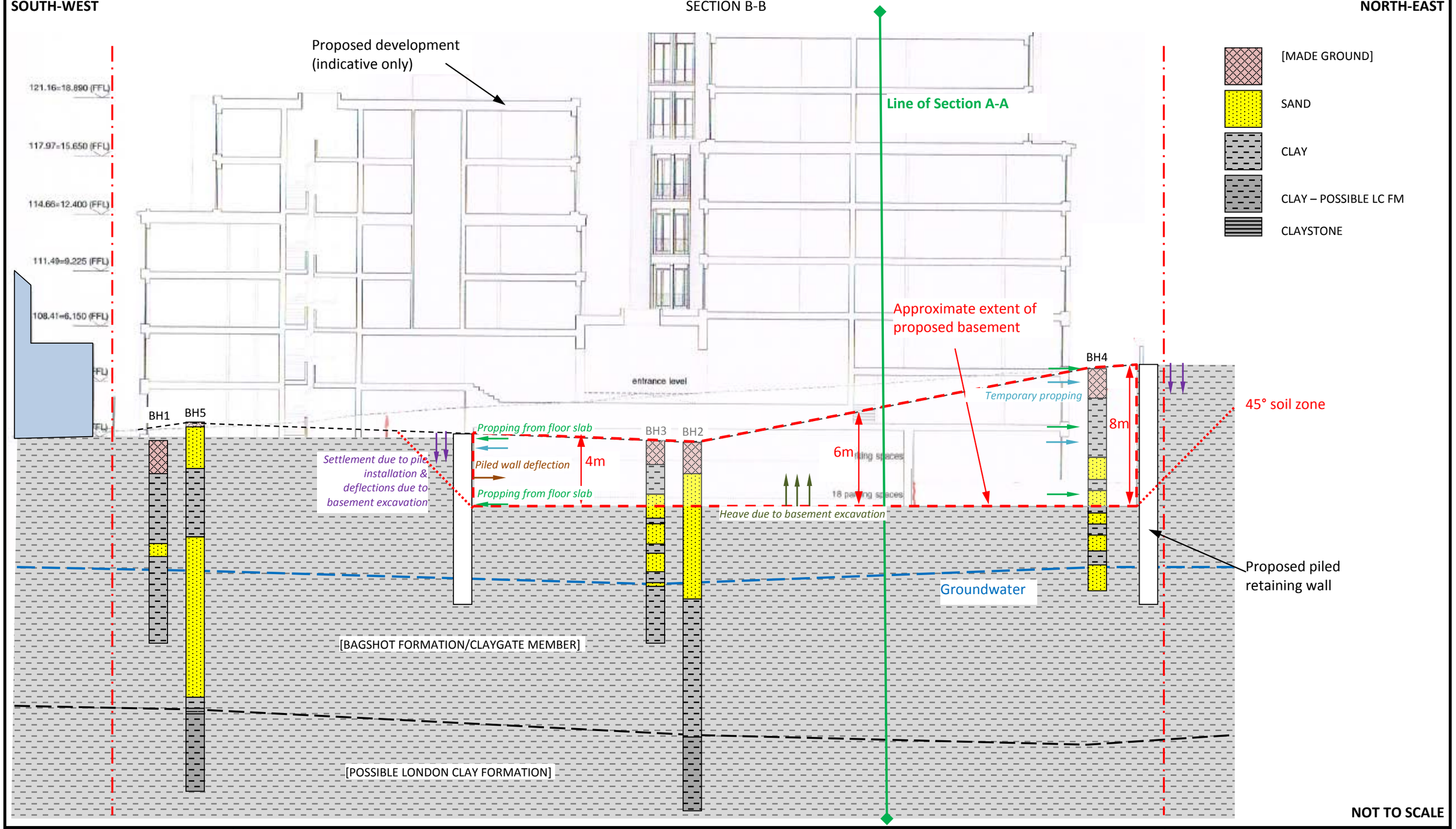


Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title **SPT 'N' versus level**	**Figure 3**



Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title **c_u versus level**	**Figure 4**

SOUTH-WEST SECTION B-B **NORTH-EAST**



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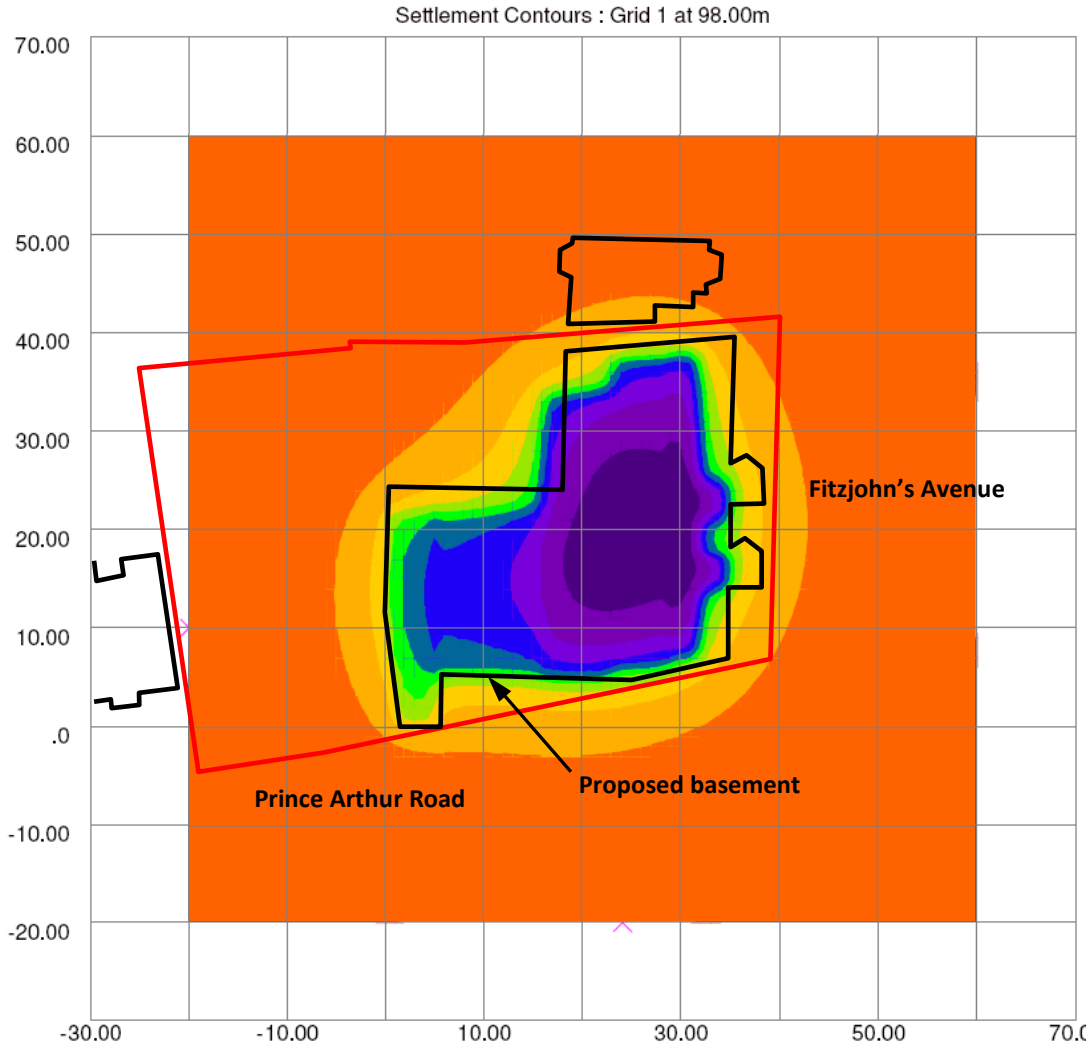
Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title: **Conceptual site model**	**Figure 5**



Ground movements in mm.

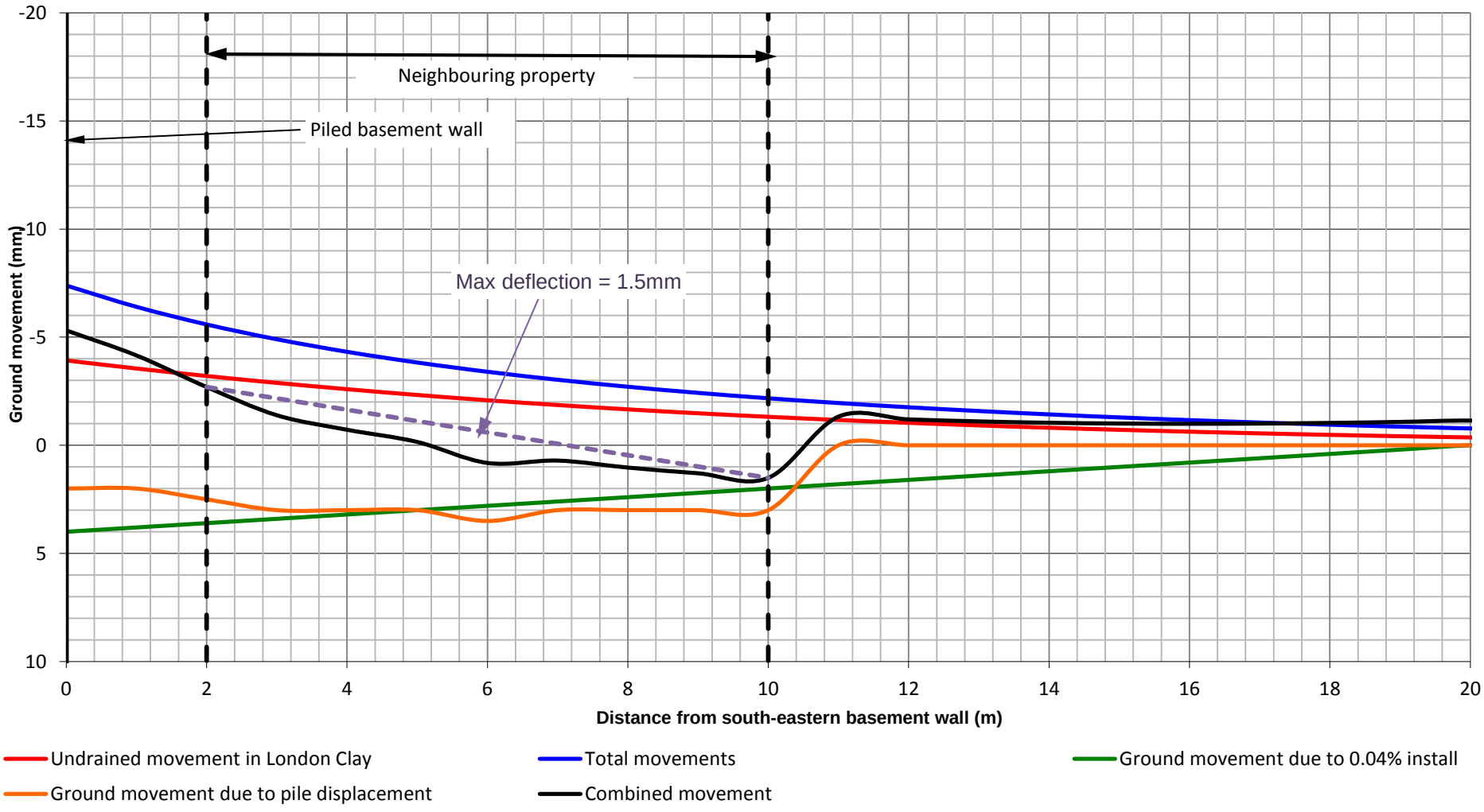
Positive values are settlement, negative values are heave.

Note: the contours are based on an analysis grid at the base of the excavation and should be viewed as indicative for the general distribution of ground movements. Actual movements for the critical section are based on analysis grid lines (see Figure 7).

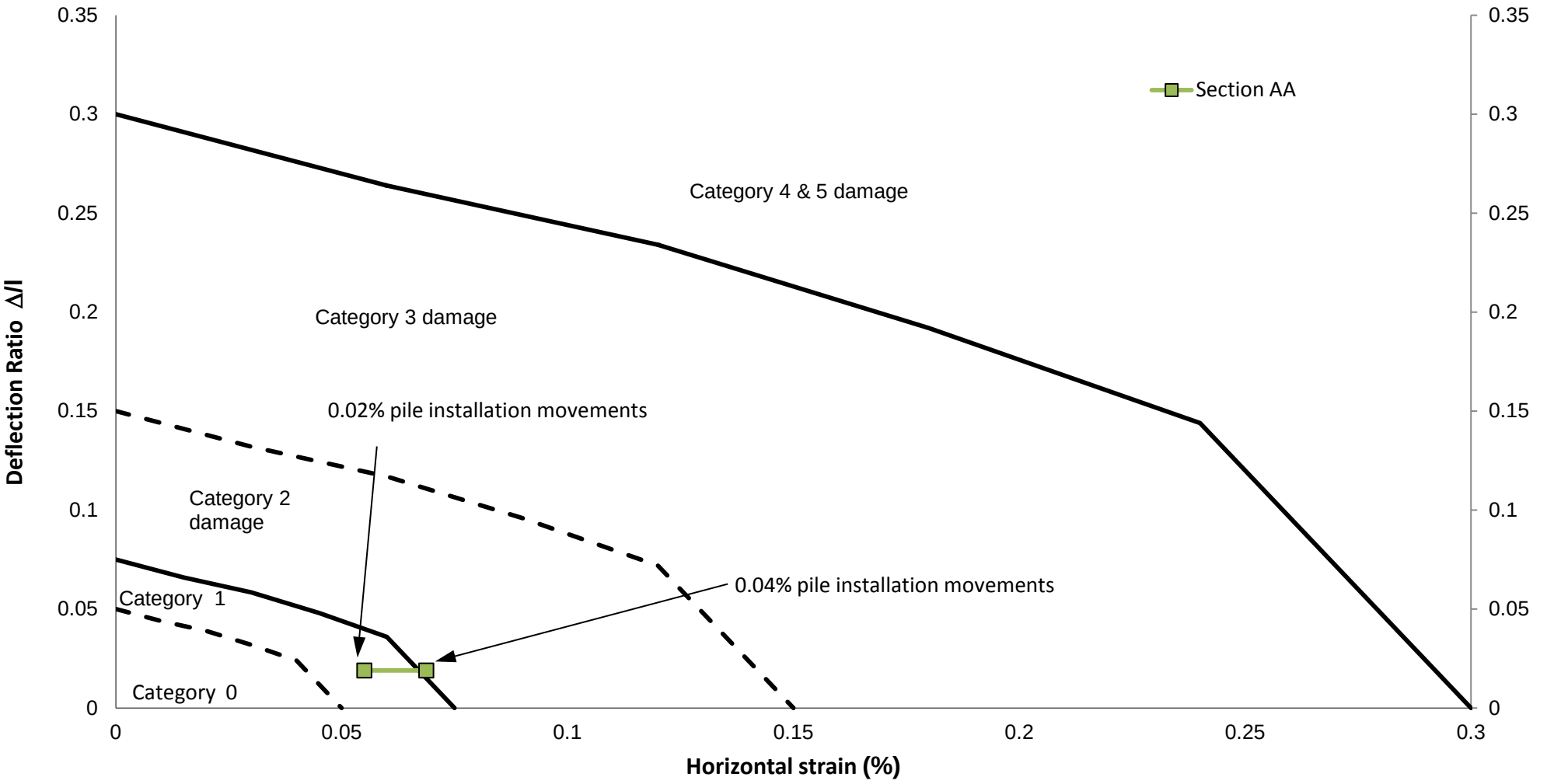
N

NOT TO SCALE

Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title: **Total movement contour plot**	**Figure 6**



Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohns Avenue, Camden, London**	**CG/18008**
CGL	Title **Combined vertical ground movement: Section A-A**	**Figure 7**



Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohns Avenue, Camden, London**	**CG/18008**
CGL	Title: **Building interaction chart**	**Figure 8**

APPENDIX A

Proposed development plans and sections

2
1
1:100 (m)
0
0 1 2

Sergison Bates architects LLP
Proposed basement - car park

Fitzjohns Avenue
Stage C revision

Architects	Date	Scale
Sergison Bates architects 34 Clerkenwell Close London EC1R 0AU United Kingdom Tel +44 (0)20 7255 1564 e-mail studio @sergisonbates.co.uk	16/10/14	1:100@A1 1:200@A3

276/2211c

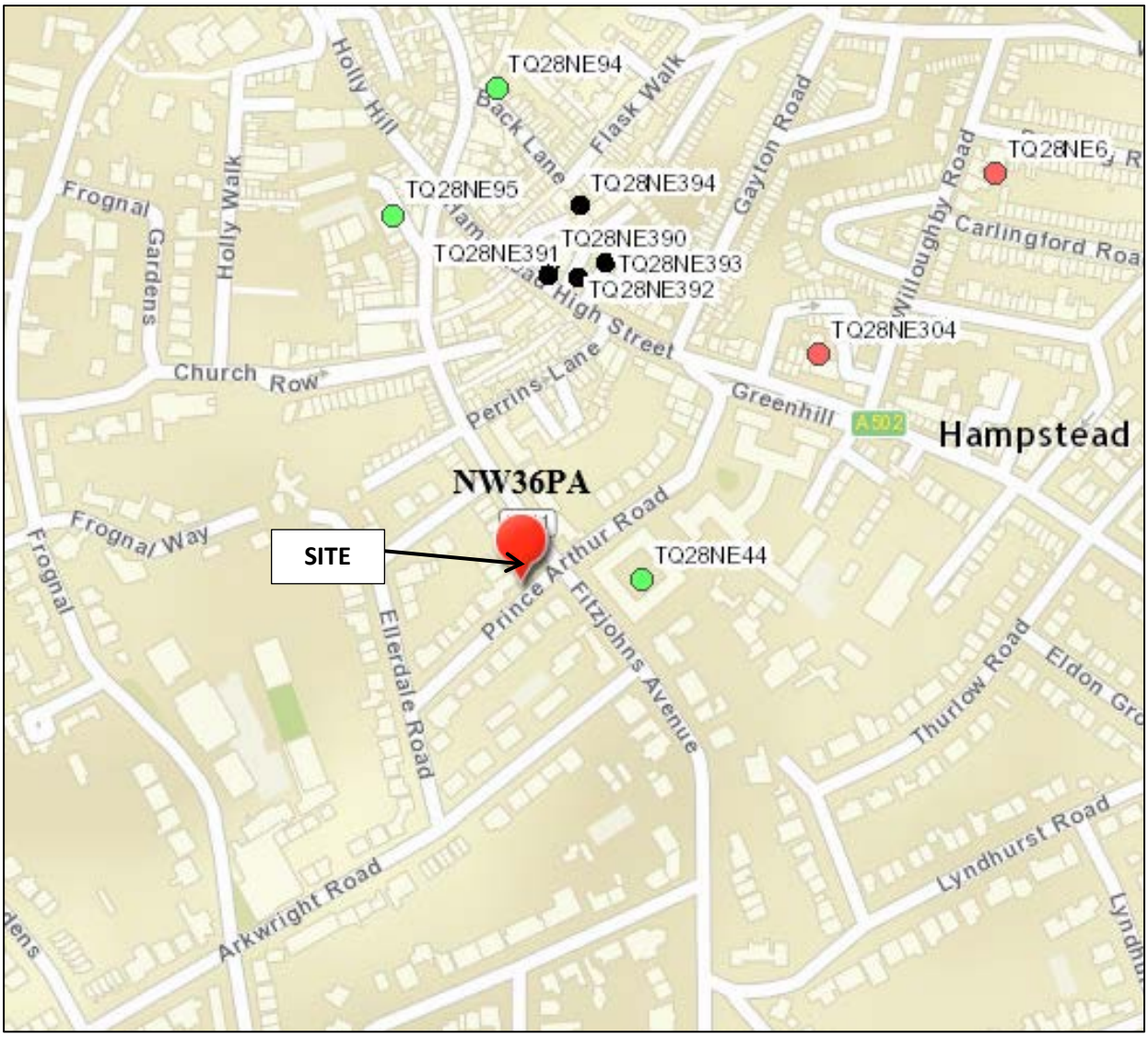
Revision C 12/11/14
General update

Do not scale from this drawing
All dimensions to be verified on site
Limited Liability Partnership Registered in England & Wales
No. OC317501 Registered office as above

Drawing may be scaled for planning purposes

APPENDIX B

BGS borehole records



Reproduced from BGS Geology Viewer of Britain.

N

Client	Project	Job No
Pegasus Life Limited	**79 Fitzjohn's Avenue, Camden, London**	**CG/18008**
CGL	Title **BGS borehole record location plan**	**Appendix B**

GEOLOGICAL SURVEY OF GREAT BRITAIN

RECORD OF SHAFT OR BORE FOR MINERALS

(*For Survey use only*)

6-inch Map Registered No. TQ28NE/6

Name of Shaft or Bore given by Geological Survey:

Name and Number given by owner: Hampstead Brewery

For whom made

Town or Village Hampstead County

Exact site

Attach a tracing from a map, or a sketch-map, if possible.

Purpose for which made Water

Nat. Grid Reference 267685 79

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

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

Made by Date of sinking 1878

Information from Date received

Examined by

SPECIMEN NUMBERS AND ADDITIONAL NOTES

(*For Survey use only*) Geological Classification	DESCRIPTION OF STRATA	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	"London Memoir" Vol II. p. 107 (In Full)			600	

HAMPSTEAD. Brewery. 1878.

Communicated by MR. J. W. GROVER.
315 feet above Ordnance Datum.
Shaft 340 feet, the rest bored. Water rose to 325 feet from the surface.

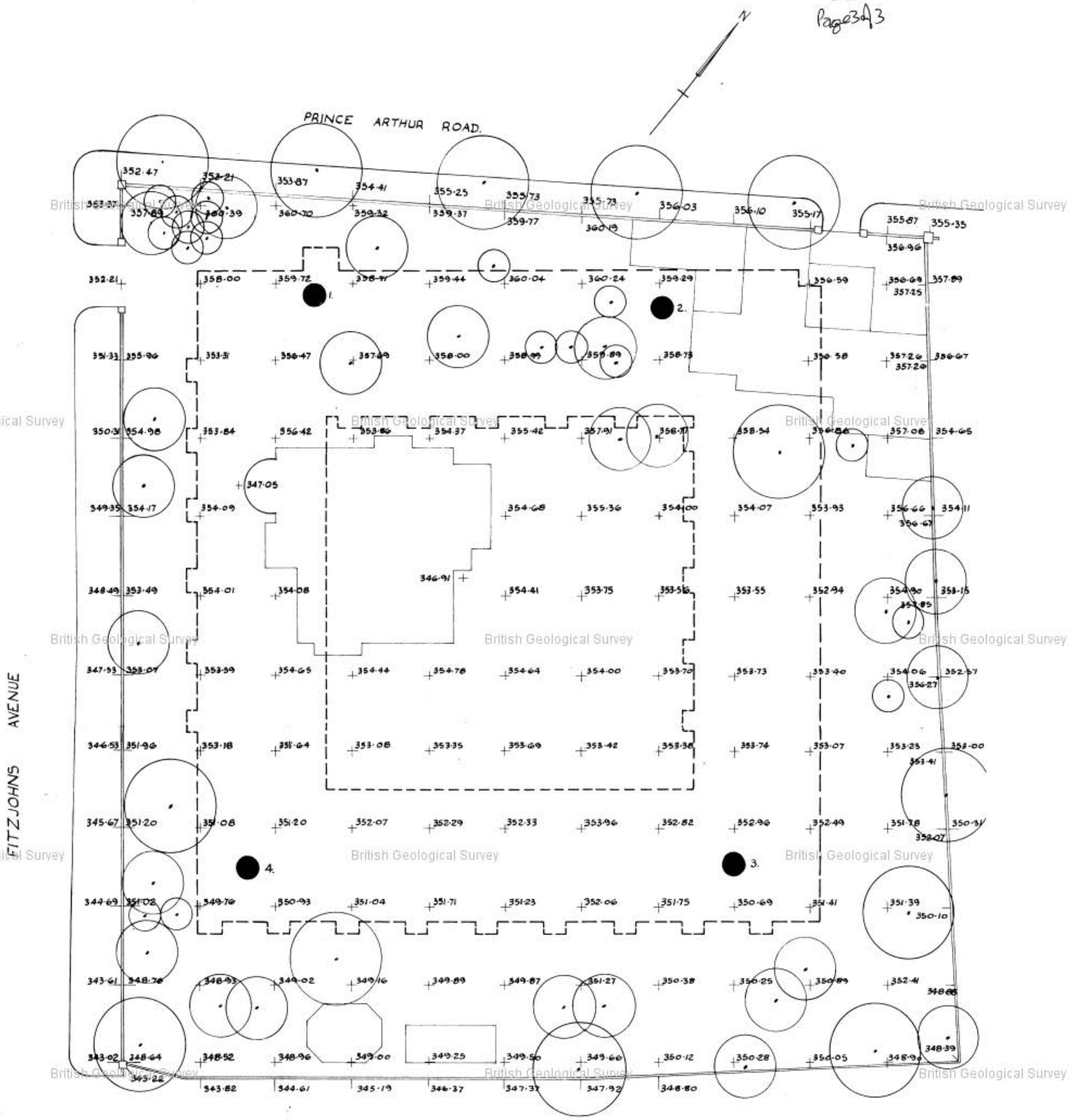
		Thickness.	Depth.
[? Top soil, or made earth]		7 {6}	7
[London Clay, 353 feet.]	Brown clay	33	40
	Clay with shells	40	80
	[? Clay] shells at 90 feet; claystone and calcareous spar (nodules) at 145–147 feet; and also (with shells and iron-pyrites) at 196–206 feet; shells at 223 feet;	about 172	252
	[? Darker clay]	„ 25	277
	[? Clay: shells]	„ 33	310
	[? Rather darker clay]	30	340
	Sandy clay and shells	20	360
[Woolwich and Reading Beds, 53 feet.]	Clay	about 22	382
	Clay, reddish	„ 8	390
	[? Clay, mottled], nodules of iron-pyrites	10	400
	[? Clay, mottled]	about 7	407
	Clay and pebbles	„ 6 {5}	413
[Thanet Sand, 31 feet.]	Clay and sand	„ 18	431
	Grey sand	„ 11 {12}	442
	Flints	„ 2	444
Chalk		156 {155}	600

Perhaps the London Clay should be carried lower. In Spon's "Present Practice of Sinking and Boring Wells," Ed. 2, p. 233 (not seen until the above was in print) it is carried down to 408 feet, which seems too low, and the Thanet Sand is not recognized. There are also some differences of detail from the above. {The figures in these brackets are taken from this book.}

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

British Geological Survey

TQ 28 NE/44
2652.8550
256
Page 343



PLAN.

OUTLINES OF EXISTING BUILDINGS SHEWN THUS. ————————
OUTLINES OF PROPOSED NEW BUILDINGS SHEWN THUS. — — — —

TQ 28 NE/44
2652,8550
256
Page 1 of 3

BOROUGH OF HAMPSTEAD.

CHARLES E. JACOB
A.R.I.B.A.
CHARTERED ARCHITECT

HOUSING ARCHITECT

TELEPHONE: HAMPSTEAD 7171/EXT. 131

Re: [illegible]

YOUR REF. .....

MY REF. MW/PA. P/43

HOUSING ARCHITECT'S DEPARTMENT,
222, HAVERSTOCK HILL,
N.W.3.

11th December, 1963.

Ack by Mr. 12 Dec '63

The Director,
Geological Survey & Museum,
Exhibition Road,
South Kensington, S.W.7.

Dear Sir,

102, Fitzjohn's Avenue. N.W.3.

I refer to Circular No.18/62 from the Ministry of Housing and Local Government and enclose copies of the following documents, for your information, giving details of the trial boreholes that were sunk on this site during July 1963:-

1/1250 O.S.Sheet showing the location of the site
Drawing No.899/4 showing the position of the boreholes on the site.

The following deposits were encountered in the boreholes:-

No.1 Boring	Thickness	Depth below surface.
Topsoil	3'0"	3'0"
Brown fine sand with a little silt and small clay pockets	14'0"	17'0"
Stiff to very stiff laminated grey sandy clay and brown silty fine sand	13'0"	30'0"
Total from surface	30'0"	30'0"

No.2 Boring		
Made ground (sand, ashes, stones etc.)	2'0"	2'0"
Yellow/brown fine sand with a little silt and small clay pockets	15'6"	17'6"
Stiff laminated grey sandy clay and orange/brown silty fine sand	12'6"	30'0"
Total from surface	30'0"	30'0"

/contd:

TQ28NE/44
2652 8550
256.

The Director,
Geological Survey & Museum

Continuation Sheet No.1. Page 2 of 3

No.3 Boring +35.1 OD (+ 106.98 m)

		Thickness	Depth below surface.
	Topsoil	2'6"	2'6"
Bagshot Beds	Stiff laminated grey sandy clay and brown silty fine sand	11'6"	14'0"
	Yellow/brown silty fine sand, clayey at some levels	19'0"	33'0"
Claygate Beds	Coarsely laminated grey sandy clay and orange/brown silty sand	4'0"	37'0"
	Brown silty very fine sand with trace of clay	3'0"	40'0"
	Total from surface	40'0"	40'0"

No.4 Boring +35.0

Made ground (clayey sand, gravel, topsoil, etc.)	3'6"	3'6"
Sandy clay with stones	1'0"	4'6"
Firm to stiff laminated grey sandy clay and silty fine sand	15'6"	20'0"
Total from surface	20'0"	20'0"

Yours faithfully,

G.L. Jacob.

Housing Architect.

Encls:

TQ/28NE/95
2635.857 OF 8

RECORD OF BOREHOLE No: OF 8

HOLLY BUSH VALE,
:HAMPSTEAD HEATH

No. : 431

Boring : Shell + Auger

(started) : 20·5·69

Borehole Dia : 6"

Casing :

Ground Level : 356·863'

Sheet 1 of 2

Water Level	SAMPLES Depth	Type	No.	STRATA Legend	Depth	Thickness	DESCRIPTION OF STRATA
	2·6"	D	1		2:0	2:0	MADE GROUND (Brick Rubble)
	5·0"	U	2		4:0	2:0	Mottled grey, orange brown + light brown firm slightly sandy CLAY
	7·6"	D	3		6·0		Loose dry golden brown fine micaceous SAND
	10·0"	U	4		5:0		(very local soft grey clay pockets)
	12·6"	D	5		11·0	2:0	Light brown silty soft/ firm CLAY + fine orange brown sand.
	15·0"	U	6		13·0	3:0	Firm brown sandy CLAY
	17·6"	D	7		16·0	2:0	Grey silty firm CLAY + fine brown sand.
	20·0"	U	8		18·0		
	22·6"	D	9				Dark grey stiff silty micaceous CLAY, (locally greenish tinge)
	25·6"	U	10				
	27·6"	D	11		23·6		
	30·0	U	12				356 11 345
	32·6"	D	13				
	35·0	U	14				
	37·6"	D	15				
4:0	40:0"	U	16		40·0		

Water first met at 32:0"
Piezometer installed at 40·0"

Foundation Engineering Ltd.

TQ/28NE/95

2635 - 8978. OF.8

RECORD OF BOREHOLE No: OF3

HOLLY BUSH VALE,
: HAMPSTEAD HEATH

: No. : 431

: of Boring : Shell + Auger

Date (started) : 20.5.69

Borehole Dia : 6"

Casing :

Ground Level : 356.863

Sheet 2 of 2

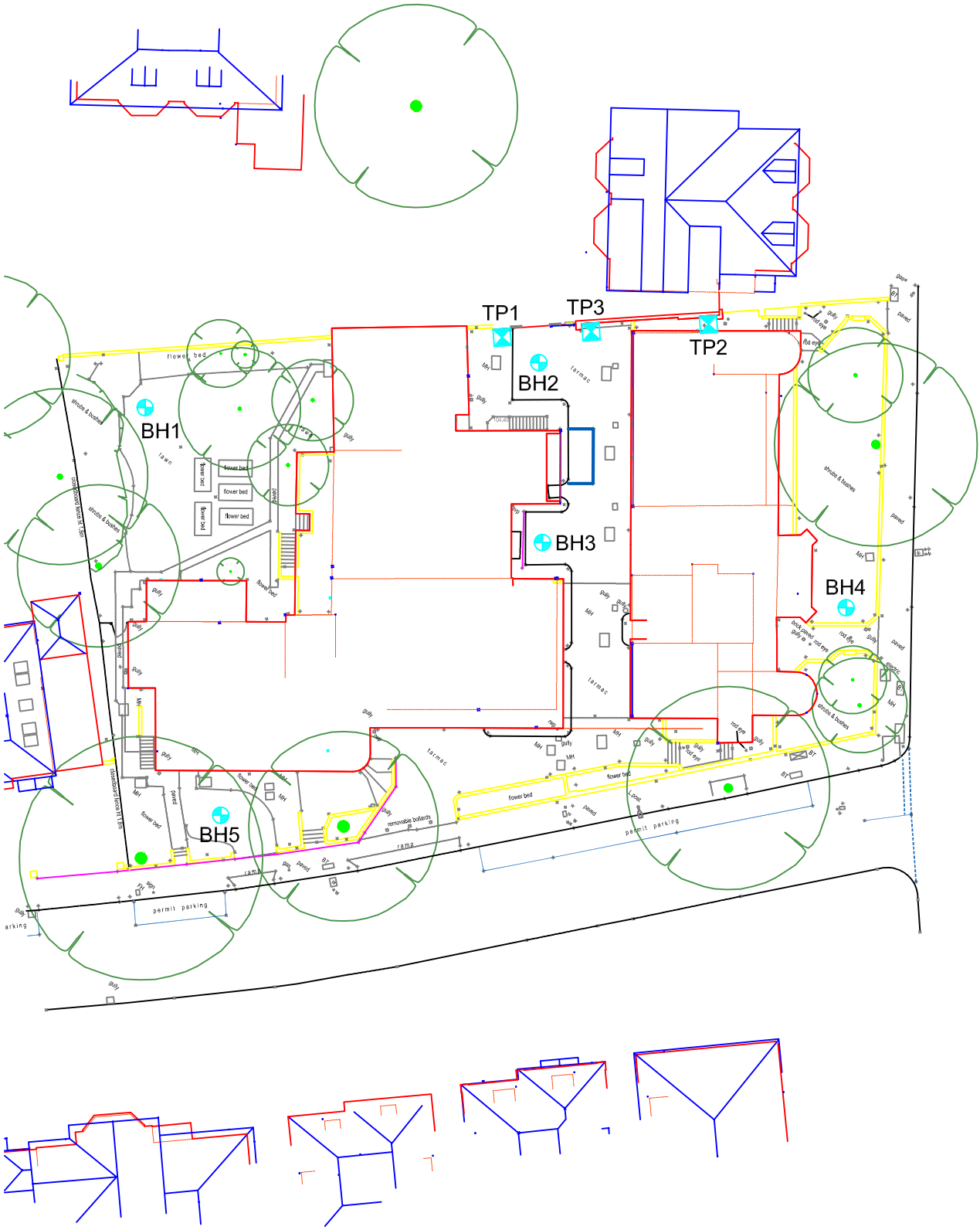
Water Level	SAMPLES			STRATA			DESCRIPTION OF STRATA
	Depth	Type	No.	Legend	Depth	Thickness	
					41.6		as on sheet 1.
					Borehole Complete		

Foundation Engineering Ltd.

British Geological Survey

APPENDIX C

Ian Farmer Associates exploratory hole records



Scale :	N.T.S.
Drawn By :	P.L.E.
Job No:	52247
Fig:	A1.1

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

SITE PLAN

Arthur West House, Fitzjohn's Avenue, Hampstead NW3 6PA.

IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		102.20	Pegasus Life Ltd	52247a
	Location TQ263854	**Dates** 13/08/2014	**Engineer** Gleeds Management Services Ltd	**Sheet** 1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.30	E1				(0.80)	TOPSPOIL. Dark brown slightly gravelly sandy silt with occasional roots, rootlets, brick, concrete, clinker and glass fragments. Gravel is flint.		
				101.40	0.80			
0.90	E2				(0.65)	MADE GROUND. Brown slightly clayey, slightly gravelly silty fine to medium sand with occasional rootlets, organic remains, rare clinker and glass fragments. Becoming claying with depth. Gravel is flint.		
1.20-1.65 1.20	SPT(C) N=8 D3		1,1/2,2,2,2	100.75	1.45			
					(0.35)	MADE GROUND. Firm brown silty fine sandy clay with occasional organic remains, rootlets and rare traces of brick and clinker. Occasional fine to medium flint gravel.		
				100.40	1.80	1.60m to 2.00m; No recovery.		
2.00-2.45 2.00	SPT(C) N=7 D4		1,1/1,1,2,3			Firm brown mottled orange-brown slightly gravelly silty sandy CLAY. Sand is fine. Gravel is fine to coarse well-rounded flint.		
2.50	D5							
3.00-3.45 3.10	SPT(C) N=8 D6		1,1/1,2,2,3		(3.00)			
3.50	D7					3.40m to 4.40m; Soft to firm.		
4.00-4.45 4.00	SPT(C) N=16 D8		2,2/4,4,4,4					
4.50	D9							
				97.40	4.80			
4.90 5.00-5.45	D10 SPT(C) N=18		2,2/3,5,5,5			Firm orange-brown mottled light brown silty sandy CLAY interbedded with slightly clayey, and occasionally clayey, fine SAND.Rare well-rounded flint gravel		
5.30	D11					5.10m to 5.60m; Firm to stiff.		
5.80	D12					5.6m to 6.30m; Medium dense, slightly clayey fine SAND.		
6.00-6.45	SPT(C) N=17		4,5/5,5,4,3					
6.30	D13					Below 6.30m; Occasionally interlaminated orange-brown and brown with lenses of fine sand.		
6.80	D14							
7.00-7.45	SPT(C) N=10		2,2/2,2,3,3 Seepage(1) at 7.10m.					▽1
7.50	D15				(5.50)			
8.00-8.45	SPT(C) N=13		2,3/4,3,3,3 Water strike(2) at 8.20m.					▽2
8.50	D16					8.50m to 9.00m; Firm to stiff.		
9.00-9.45 9.10	SPT N=16 D17		2,3/3,4,4,5			9.00m to 10.00m; 10% recovery.		
10.00-10.45	SPT N=31		3,3/7,7,8,9					

Remarks
Slight seepage at 7.10m.
Groundwater struck at 8.20m.
Difficult drilling below 9.00m due to ingress of groundwater and sand.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.1

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IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		102.20	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ263854	13/08/2014	Gleeds Management Services Ltd	2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.00 10.10	D18 D19					... as previous 10.00m to 11.00m; 10% recovery.		
				91.90	10.30	Stiff dark grey silty CLAY with frequent specks and clusters of iron pyrite crystals.		
					(0.70)			
				91.20	11.00	Complete at 11.00m		

Remarks
Borehole terminated at 11.00m

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.1

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IAN FARMER ASSOCIATES

Site	Borehole Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 12.00m 150mm cased to 18.00m	102.10	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ 264 855	26/08/2014- 29/08/2014	Gleeds Management Services Ltd	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
					102.00	0.10	ASPHALT
						(0.30)	
					101.70	0.40	Reinforced CONCRETE.
0.50	D1						Possible MADE GROUND. Soft brownish grey sandy gravelly clay with occasional pockets of orange-brown fine to medium sand. Gravel is fine to coarse subangular to rounded flint.
						(1.30)	
1.20-1.65	SPT(C) N=5	1.00	DRY	1,0/2,1,1,1			
1.50	B1						
1.70	D2				100.40	1.70	Loose becoming medium dense orange-brown slightly clayey silty fine SAND.
2.00-2.45	SPT N=7	2.00	DRY	1,1/1,2,2,2			
2.00	D3						
3.00-3.45	SPT N=8	3.00	DRY	2,1/2,2,2,2			
3.00	B2						
3.00	D4						
4.00-4.45	SPT N=9	4.00	DRY	2,2/2,3,2,2			
4.00	D5						4.00m to 6.00m; Occasional coarse gravel-sized lumps of bluish grey sandy clay.
5.00-5.45	SPT N=10	5.00	DRY	2,2/3,2,3,2		(6.80)	
5.00	B3						
5.00	D6						
6.00	D7						
6.50-6.95	SPT N=12	6.00	DRY	2,3/3,2,3,4			
6.50	D8						
7.00	B4						
7.50	D9						
8.00-8.45	SPT N=13	8.00	DRY	3,4/3,4,3,3			
8.00	D10						
8.50	D11			Water strike(1) at 8.50m, rose to 8.10m in 20 mins.	93.60	8.50	Stiff, fissured dark grey silty sandy CLAY with occasional specks of iron pyrite and partings of orange-brown silty sand.
8.50-8.95	SPT N=20	8.00	DRY	4,5/5,3,5,7			
9.00	B5						
9.00	D12						
10.00-10.45	SPT N=27	10.00	DRY	6,5/8,5,7,7			

Legend

Water

Instr

▼1

▽1

Remarks
Chiselling from 0.00m to 1.20m for 1 hour.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.2

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IAN FARMER ASSOCIATES

Site	Borehole Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 12.00m 150mm cased to 18.00m	102.10	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ 264 855	26/08/2014- 29/08/2014	Gleeds Management Services Ltd	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
10.00	D13						... as previous
10.50	D14						10.00m to 12.50m; Firm to stiff with occasional bands of dark greenish grey and orange-brown.
11.50-11.95 11.50	SPT N=30 D15	11.00	DRY	4,4/4,7,11,8			
				Water strike(2) at 12.10m, rose to 11.30m in 20 mins.			
12.50	D16						At 12.50m; Recovered as soft to firm with frequent pockets of orange-brown sandy clay.
13.00-13.45 13.00 13.00	SPT N=28 B6 D17	13.00	12.00	5,4/6,6,7,9			
14.00-14.45 14.00	SPT N=33 D18	14.00	11.00	4,4/7,8,8,10		(11.50)	From 14.00m; Firm and grey with greenish and reddish brown banding, and partings of light grey fine sand and silt.
15.00	D19						
15.50-15.95 15.50	SPT N=38 D20	15.00	12.00	6,6/8,9,11,10			
16.00	D21						From 16.00m; No banding.
17.00-17.45 17.00	SPT N=40 D22	17.00	13.00	5,5/11,10,8,11			
18.00	D23						
18.50-18.95	SPT N=37	18.00	13.00	6,6/7,12,10,8			
19.00-19.45 19.00	SPT N=35 D24			8,7/8,9,10,8			
					82.10	20.00	

Legend: Water ▼2 ▽2; Instr

Remarks

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.2

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IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH3

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		102.20	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ264855	14/08/2014	Gleeds Management Services Ltd	1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				102.10	0.10	ASPHALT		
					(0.20)			
				101.90	0.30	Reinfored CONCRETE.		
0.50	E1					MADE GROUND. Yellowish brown fine to coarse gravelly sand with frequent concrete and brick fragments/ cobbles, and occasional clinker, glass and asphalt fragments and flints.		
0.70	D1				(1.00)			
1.00	E2							
1.20-1.65	SPT(C) N=6		0,0/1,1,2,2	100.90	1.30	Firm brown mottled orange-brown silty sandy CLAY. Occasionally very sandy.		
1.40	D2							
1.90	D3							
2.00-2.45	SPT(C) N=12		2,2/3,3,3,3		(1.60)			
2.50	D4					From 2.65m; Firm to stiff.		
				99.30	2.90	Medium dense brown slightly clayey fine SAND.		
3.00-3.45	SPT(C) N=21		5,5/5,6,5,5					
3.00	D5				(1.30)			
3.70	D6							
4.00-4.45	SPT(C) N=22		1,2/4,6,6,6					
				98.00	4.20	Firm orange-brown mottled light brown silty sandy CLAY interbedded with clayey or slightly clayey fine SAND.Rare well-rounded flint gravel.		
4.30	D7					4.50m to 5.60m; Silty clayay fine SAND.		
5.00-5.45	SPT(C) N=24		4,5/6,6,6,6					
5.00	D8							
5.80	D9							
6.00-6.45	SPT(C) N=18		3,3/4,4,4,6			6.10m to 7.10m; Slightly clayey silty fine SAND.		
6.50	D10							
7.00-7.45	SPT(C) N=14		2,2/3,4,3,4					
7.20	D11							
					(6.80)			
			Water strike(1) at 7.70m.			7.70m to 7.90m; Slightly clayey fine SAND.		▽1
8.00-8.45	SPT(C) N=12		2,2/3,2,3,4			8.00m to 9.00m; 75% recovery.		
8.20	D12							
8.80	D13							
9.00-9.45	SPT(C) N=7		2,2/1,2,2,2			9.00m to 10.00m; No Recovery.		
10.00-10.45	SPT(C) N=19		4,4/4,5,5,5					

Remarks
Slight seepage at 3.70m.
Groundwater struck at 7.70m.
Difficult drilling below 8.00m due to ingress of groundwater and sand.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.3

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IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH3

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		102.20	Pegasus Life Ltd	52247a
	Location TQ264855	**Dates** 14/08/2014	**Engineer** Gleeds Management Services Ltd	**Sheet** 2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						... as previous 10.00m to 11.00m; No Recovery.		
11.00-11.45	SPT(C) N=19		3,4/4,4,5,6	91.20	11.00	Complete at 11.45m		

Remarks
Borehole terminated at 11.00m.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.3

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IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH4

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		106.10	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ264855	15/08/2014	Gleeds Management Services Ltd	1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
					(0.40)	TOPSOIL. Dark brownslightly gravelly clayey silty fine to medium sand with occasional roots, rootlets, brick, concrete and clinker fragments.			
0.30	E1			105.70	0.40				
0.80	E2				(0.70)	MADE GROUND. Brown slightly gravelly silty fine sand with occasional rootlets, brick fragments and rare clinker fragments.			
				105.00	1.10				
1.20-1.65	SPT(C) N=16		1,3/4,4,4,4		(0.50)	MADE GROUND. Dense brown mottled orange-brown silty clayey fine sand with occasional brick and clinker fragments. Rare flint pebbles.			
1.20	D3			104.50	1.60				
1.80	D4					Stiff to very stiff, becoming firm with depth, brown mottled orang-brown silty sandy CLAY with frequent decomposing rootlets.			
2.00-2.45	SPT(C) N=26		6,6/5,6,7,8			From 2.00m; Orange-brown mottled grey. Occasionally very sandy with occasional decomposing rootlets.			
2.30	D5								
2.90	D6								
3.00-3.45	SPT(C) N=19		5,5/5,5,4,5		(3.20)				
3.30	D7								
3.80	D8					From 3.70m; Becoming firm with occasional bands of fine sand.			
4.00-4.45	SPT(C) N=16		3,4/3,4,4,5						
4.20	D9								
4.60	D10								
4.80	D11			101.30	4.80				
5.00-5.45	SPT(C) N=18		2,3/4,4,5,5			Medium dense brown slightly silty clayey fine SAND. 5.00m to 5.65m; Very clayey.			
5.20	D12				(1.20)				
5.70	D13								
6.00-6.45	SPT(C) N=15		2,3/3,2,5,5	100.10	6.00	Firm to stiff orange-brown mottled light brown silty sandy CLAY interbedded with slightly clayey, and occasionally clayey, fine SAND.Rare well-rounded flint gravel			
6.20	D14					6.60m to 7.45m; Brown slightly clayey fine SAND.			
6.70	D15								
7.00-7.45	SPT(C) N=19		3,5/6,5,4,4						
7.50	D16					7.45m to 7.80m; Firm very sandy CLAY.			
						7.80m to 8.40m; Brown fine SAND.			
8.00-8.45	SPT(C) N=23		5,6/6,6,5,6						
8.20	D17					8.40m to 9.00m; Firm very sandy CLAY.			
8.60	D18								
9.00-9.45	SPT(C) N=50		8,8/9,11,14,16		(6.00)	9.00m to 9.85m; Brown slightly clayey fine SAND.			
9.50	D19								
10.00-10.45	SPT(C) N=22		2,3/3,4,6,9			9.85m; to 10.60m; Firm orange-brown and			

Remarks
35mm slotted standipipe installed to 11.50m.
Groundwater struck at 10.60m.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.4

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IAN FARMER ASSOCIATES

Site	Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH4

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Percussive Window Sampler		106.10	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ264855	15/08/2014	Gleeds Management Services Ltd	2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
10.00	D20					grey silty sandy CLAY. ... as previous			
10.50	D21		Water strike(1) at 10.60m.			10.60m to 12.00m; Orange-brown slightly clayey, becoming clayey, fine SAND.		∇_1	
10.70	D22								
11.00-11.45	SPT(C) N=18		4,4/4,4,4,4,6						
11.30	D23		Water strike(2) at 11.30m.					∇_2	
11.80	D24								
				94.10	12.00	Complete at 12.00m			

Remarks

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.4

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IAN FARMER ASSOCIATES

Site	Borehole Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH5

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 20.00m	103.20	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ 264 854	20/08/2014-21/08/2014	Gleeds Management Services Ltd	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
					103.05	(0.15) 0.15	Block paving over sand sub base.
					102.95	0.25	MADE GROUND. Dark reddish brown silty sandy medium to coarse subangular granite gravel (Type 1 granular sub base).
0.50	D1					(0.55)	
0.50	E1				102.40	0.80	Brown slightly gravelly silty fine SAND with occasional roots and rootlets.
1.00	D2						Medium dense orange and greyish brown slightly clayey silty fine SAND.
1.00	E2						
1.50-1.95	SPT N=19	1.00	DRY	6/4,5,5,5		(1.70)	
1.50	D3						
2.00-2.45	SPT N=18	2.00	DRY	9/5,4,5,4			
2.00	D4						
					100.70	2.50	Firm orange and yellowish brown mottled grey very sandy silty CLAY with occasional bands and pockets of clayey to very clayer fine SAND.
2.90	D5						
3.00-3.45	SPT N=16	3.00	DRY	6/4,4,4,4			
3.00	D6						
3.50	D7						
4.00-4.45	SPT N=18	4.00	DRY	6/5,5,4,4			
4.00	D8					(3.70)	
4.50	D9						
5.00-5.45	SPT N=12	5.00	DRY	6/3,3,3,3			
5.00	D10						
6.00	D11						
					97.00	6.20	Medium dense brown clayey silty fine SAND.
6.50-6.95	SPT N=18	6.00	DRY	7/4,3,5,6			
6.50	D12						
8.00-8.45	SPT N=21	8.00	DRY	9/5,6,5,5			
8.00	D14						
9.00	D15						
				Moderate(1) at 9.30m, rose to 9.10m in 20 mins.			
9.50-9.95	SPT N=22	9.00	DRY	11/5,6,6,5			

Water: ▼1 ▽1

Remarks
Chiselling from 0.00m to 1.20m for 1 hour.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.5

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IAN FARMER ASSOCIATES

Site	Borehole Number
Arthur West House, 79 Fitzjohn's Avenue, Hampstead NW3 6PA	BH5

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 20.00m	103.20	Pegasus Life Ltd	52247a
	Location	**Dates**	**Engineer**	**Sheet**
	TQ 264 854	20/08/2014-21/08/2014	Gleeds Management Services Ltd	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
10.00	D16						... as previous At 10.00m; Very wet.		▼2	
						(8.70)				
11.00	D17			Moderate(2) at 11.00m, rose to 10.00m in 20 mins.					▽2	
11.00-11.45	SPT N=29	11.00	10.00	10/7,8,6,8						
12.00-12.45 12.00	SPT N=24 D18	12.00	DRY	13/5,7,5,7			From 12.00m; Wet and very clayey with occasional pockets of grey clay.			
13.00-13.45 13.00 13.00	SPT N=26 D19 D20	13.00	DRY	12/7,7,8,4						
14.00-14.45	SPT N=16	14.00	DRY	8/3,5,5,3						
					88.30	14.90	Stiff dark grey silty sandy CLAY.			
15.00	D21					(0.60)				
15.50-15.95	SPT N=50	15.00	DRY	20/25,25	87.70	15.50	CLAYSTONE			
						(0.30)				
					87.40	15.80	Stiff, becoming firm and occasionally fissured, dark grey silty sandy CLAY with occasional specks of iron pyrite.		▼4 ▼3	
16.00	D22									
17.00 17.00	D23 D24			Moderate(3) at 17.00m, rose to 16.10m in 20 mins.			At 17.00m; Soft to Firm, and dark bluish grey.		▽3	
17.00-17.45	SPT N=41	17.00	16.00	15/10,8,11,12						
						(4.20)				
18.00	D25						At 18.00m; Firm, brownish grey and slightly sandy.			
19.00-19.45 19.00	SPT N=37 D26	19.00	16.00	15/9,9,11,8			At 19.00m; Firm bluish grey with brown mottling and sandy.			
				Moderate(4) at 19.50m, rose to 16.00m in 20 mins.					▽4	
					83.20	20.00				

Remarks
Chiselling from 15.50m to 15.80m for 1 hour.

Scale (approx)	Logged By
1:50	BP/DAA

Figure No. A2.5

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APPENDIX D

Load information

FOUNDATION LOAD MORE
15 kN/m DEAD
3 kN/m LIVE

FOUNDATION LOAD MORE
75 kN/m DEAD
15 kN/m LIVE

BOTH PARTY WALL LOADS FOUNDING LEVEL ≈ 104.2m

BASEMENT FLOOR LEVEL = 97.6m

TYPICAL COLUMN LOAD MORE
3200 kN

GIA
773.05 sqm

Sprinklers tank (under the ground)

UKPN staircase 13.60 sqm

Plant 351.87 sqm

Staff staircase 13.32 sqm

Lightwell 11.84 sqm

Lightwell 11.37 sqm

Car park (34 cars) 320.21 sqm

Car park lift 15.50 sqm

Technical room 16.86 sqm

Car park ventilation (6.59 sqm)

LIFT COLUMNS LOAD
800 kN EACH

TYPICAL COLUMN LOAD MORE
2600 kN

TYPICAL COLUMN LOAD MORE
4000 kN

RC COLUMN, ON PILES
TYPICAL LOAD
3600 kN

SUSPENDED RC SLAB ON CELLCORE THROUGHOUT.

RC CONTIGUOUS PILED RETAINING WALL SHOWN THUS,
TYPICAL LOAD 360 kN/m

2
1
1:100 (m)
0
0 1 2

Basement plan - car park
14/11/2014