Ground and Project CONSULTANTS LTD

FLAT 3, 269 GOLDHURST TERRACE, LONDON, NW6

3EPBasement Impact Assessment: Land Stability and Assessment of Ground Movement

March 2016

Client:

DIG FOR VICTORY LTD

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1. Introduction

Ground and Project Consultants Ltd have been instructed by Dig For Victory Ltd (DFV) to undertake the land stability element of a Basement Impact Assessment, for Flat 3, 269 Goldhurst Terrace, London, NW6 2EP. The property is located in the London Borough of Camden, London in the Swiss Cottage ward, its location is indicated on Figure 1.

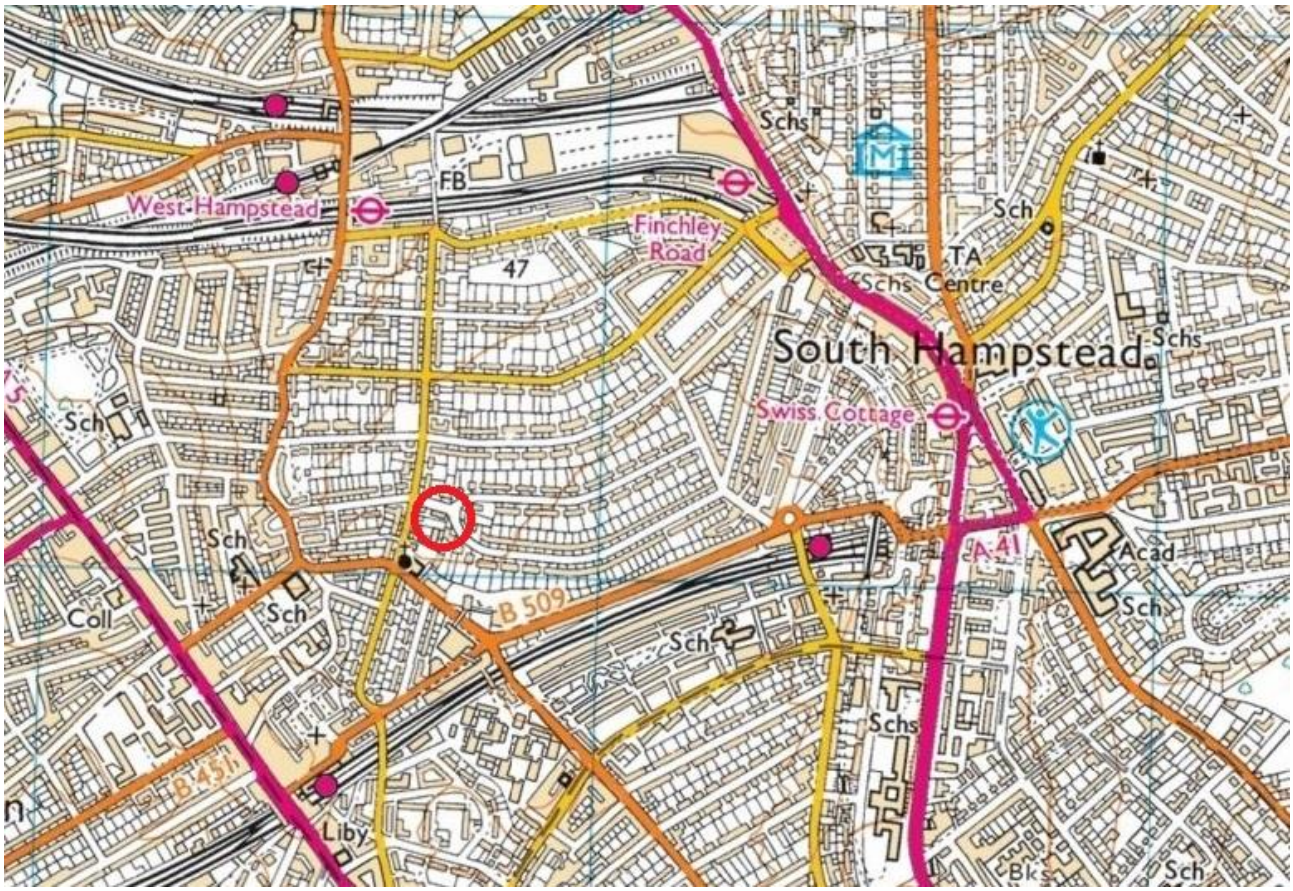

Figure 1: Site Location

2. Scope and Objective

The scope of this report and approach is as follows:

- A review of the existing data supplied by the client has been carried out, including the proposal drawings produced to date, Ground Investigation data, photos of the building and the background data available through London Borough of Camden's website and other freely available data such as BGS geological information and purchased environmental data.
- In line with the London Borough of Camden guidance, CPG4, latest revision:
- In line with the CPG4 guidance:
    - A detailed assessment of the published and encountered geology
    - Development of a ground model including an assessment of geotechnical properties
    - An engineering interpretation including an assessment of slope stability and commentary and assessment regarding ground movements.
- Recommendations for additional work/ monitoring and observation have been provided.
- An Assessment of Ground Movements due to the proposed basement construction has been carried out.

The report has not considered contaminated land aspects of the site.

This report and the work to support it has been carried out by Jon Smithson who is a Director of Ground and Project Consultants Ltd and is a Chartered Geologist (CGeol) with over 30 years' experience.

3. BIA Screening for Slope/Land Stability

A screening exercise has been carried out as per the guidance in Camden's Guidance for Basements, CPG4 as follows:

Question	Answer	Action/ Comment
Question 1: Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approximately 1 in 8)	No. The ground surface at site is relatively level.	None
Question 2: Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg? (approximately 1 in 8)	No. There are no planned significant changes in surface profile.	None
Question 3: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg? (approximately 1 in 8)	No. There are no railway cuttings in the immediate vicinity.	None
Question 4: Is the site within a wider hillside setting in which the general slope is greater than 7degrees? (approximately 1 in 8)	No, the slope in the area is around 1 in 40 (2^{o}) based on Ordnance Survey data. The site is some distance from Hampstead Heath and steeper ground	None
Question 5: Is the London Clay the shallowest strata at the site?	Yes: London Clay is indicated as the shallowest strata on the BGS maps. Head Deposits may be present.	The presence of London Clay close to surface is further discussed in the Impact Assessment.
Question 6: Will any tree/s 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? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	It is understood that there will not be a need to fell trees. However the site sits within South Hampstead conservation area. Trees are present at site.	Further discussed in the Impact Assessment.
Question 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	None known. However London Clay is close to surface.	Further discussed in the Impact Assessment.

Question 8: Is the site within 100m of a watercourse or a potential spring line?	No: Figure 11 of the Arup report indicates a 'Lost River' some distance to the east of the property.	None
Question 9: Is the site within an area of previously worked ground?	None known or suspected.	None
Question 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No. The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The site is not within a source protection zone of a public water supply. However the basement may extend into the water table.	This is further discussed in the Impact Assessment.
Question 11: Is the site within 50m of the Hampstead Heath ponds?	No	None
Question 12: Is the site within 5m of a highway or pedestrian right of way?	Yes	This is further discussed in the Impact Assessment. Health Safety and environmental measures will be required to be integrated into the building contractors methods of working
Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	It is understood that basements are not present in the adjacent neighbouring properties. It is understood that there is a basement in 58 Priory Road.	This is further discussed in the Impact Assessment.
Question 14: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No	None

4. Site Information

4.1 Existing Property and Basement Proposals

The property at 269 Goldhurst Terrace is located on the south side of the road, in between its junctions with Aberdare Gardens and Priory Road. 269 Goldhurst Terrace is a two storey brick built 1960's building. Flat 3 occupies the ground floor. Other flats at 269 Goldhurst Terrace adjoin to the West. The property is around 1.8km North West of Regents Park and around 500m south of

the Jubilee Line, 800m south west of Finchley Road and 600m south west of West Hampstead Stations. Swiss Cottage tube station is about 650m to the east.

The National Grid reference for the property is TQ 25712 84109. The location of the property is provided in Figure 1 above.

There are a number of trees and bushes in the garden and adjacent gardens and on the pavement in front of the property.

It is proposed to extend the property with a 3 wide extension to the west (i.e. towards no.58 Priory Road) and construct a single storey basement beneath the full footprint of the extended property. The basement depth will be around 2.9m. The basement footprint will be approximately 11m by 9m maximum dimensions with a footprint of approximately 85m^2. The descriptions and dimensions above have been estimated from drawings provided by DFV.

4.2 **Topography**

The OS map indicates the property is at around 42m AOD. The ground surface rises gently towards the North West at around 1 in 60 (less than 2^o). There is no significant change in elevation at the property.

4.3 **Geology**

The available geological mapping (Ref 1.) indicates that the site lies on London Clay which typically comprises a stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. The geological map (North London 256) indicates that the property is relatively close to an area of 'propensity' for Head Deposits (stippled area on the map in figure 2), associated with the higher ground of Highgate Hill. Typically these deposits are thin (<2m) and consist of soft, ocherous brown silty clay with blue-grey mottling in places and angular, frost-shattered fragments of flint occur sporadically throughout. The base of the London Clay is likely to occur significant depth below the property. See figure 2 below.

Figure 2: Geology

4.4 Hydrology and Hydrogeology

The OS Map indicates that there are no surface water bodies in the vicinity of the site. The Grand Union Canal forms the northern boundary of Regents Parks some 1.6km to the SE. The Hampstead Ponds are approximately 2.5km to the NE. There are no springs shown on OS mapping. There is a 'lost river' indicated approximately 100m to the northwest.

The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The site is not within a source protection zone of a public water supply. There are no groundwater abstraction licenses within 2 km of the site and no source protection zones within 500 m of the site. (Ref 5. Groundsure Report).

4.5 Other Environmental Data

The Groundsure report for a nearby property gives a wealth of background data on local environmental issues and hazards. (See Appendix A). Some of the key issues relevant to land stability are summarised in the table below:

Local Waste/Landfill sites	There is a waste depot and transfer station 500m to the NE of the property
Drift Deposits	None are indicated on BGS mapping
Made Ground	None are indicated on BGS mapping
Groundwater Abstraction	There is a supply borehole less than 1km to the East
Flood Risk	There is some flood risk at the property. The area is not prone to groundwater flooding. (This is discussed separately in the FRA report)
Shrink/ Swell	There is a moderate Hazard of shrink and swell from the London Clay soils
Landslide	Very Low Risk
Soluble Rocks	Negligible Risk
Compressible Ground	Negligible Risk
Collapsible Ground	Very Low Risk
Running Sand	Very Low Risk
Mining	None recorded

A number of historic OS maps have been obtained, see figures 3-5 below. These show that the property was constructed as infill within the former rear garden of /land associated with 58 Priory Road.

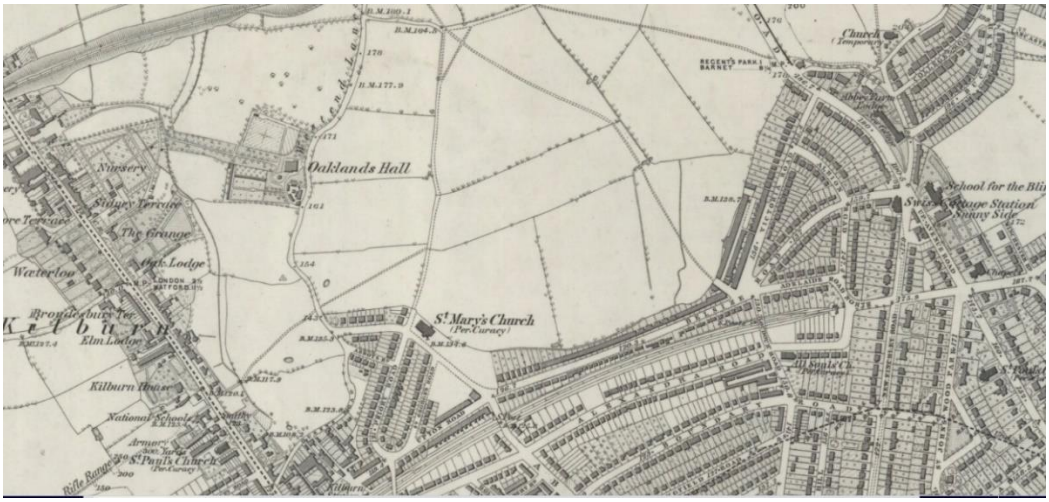

Figure 3: Historic Map 1866

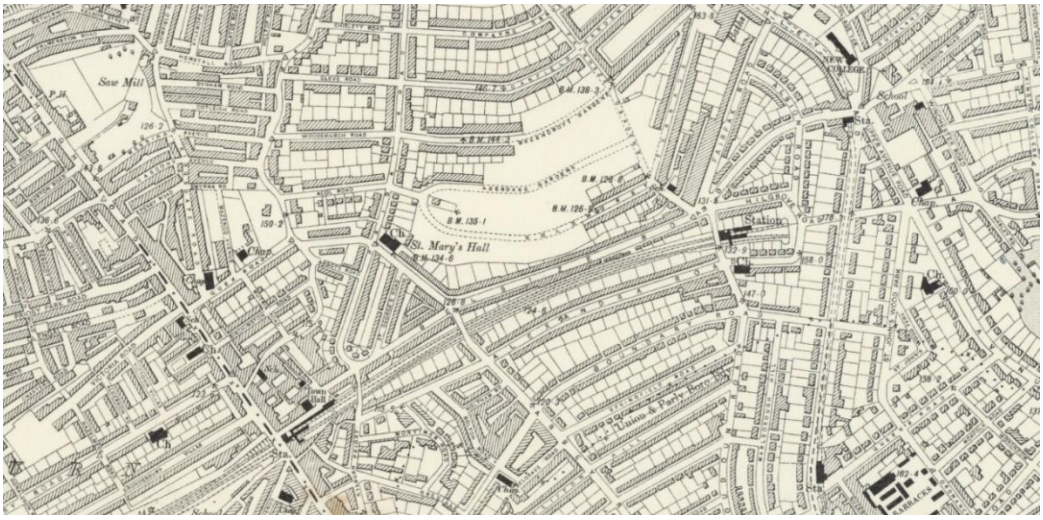

Figure 4: Historic Map 1894

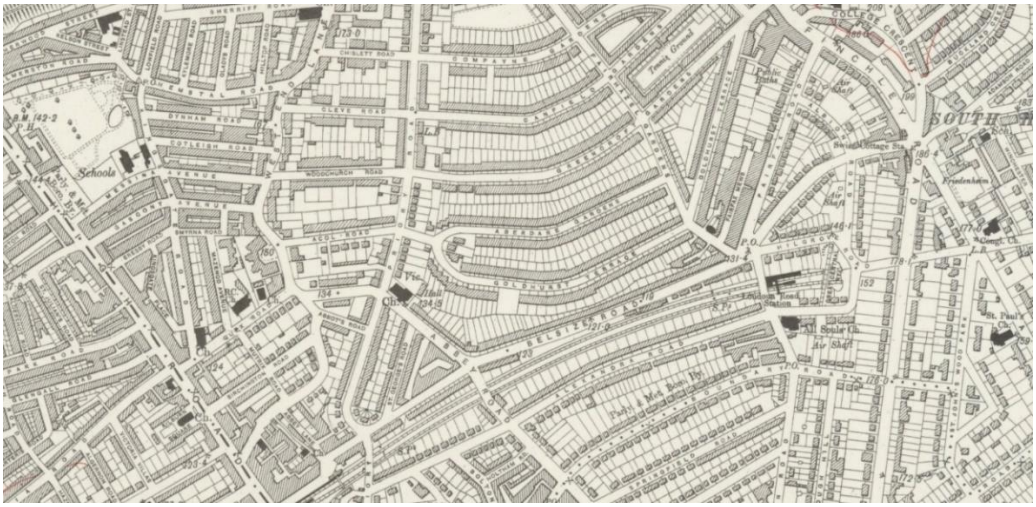

Figure 5: Historic Map 1912

5. Ground Investigation

A ground investigation (GI) has been carried out at the site by Chelmer Site Investigations for Dig For Victory Ltd (DFV) and results of these have been made available by DFV. The GI was carried out in April 2015.

The work comprised one borehole (BH1) to 15.00m bgl drilled using a CFA rig, in the rear garden area of the property. No groundwater monitoring was installed.

Below is a summary derived from the Ground Investigation report. The borehole encountered a thin cover of topsoil/turf, 0.20m thick. Below this the borehole encountered an 'upper' clay deposit described as 'Firm, brown, sandy silty CLAY with fine gravel'. This probably represents the Head Deposit, given the presence of gravel. At 2.5m this passes into a 'Stiff or very stiff, brown, silty CLAY with partings of brown and orange silt and fine sand, claystone nodules and crystals'. This is London Clay.

Groundwater was not encountered during drilling. No roots were noted in the borehole.

Hand shear vane testing was carried out in the clay deposits. In the Head Deposit, these gave undrained shear strength values of 72kN/m^2 increasing to 114kN/m^2. This correlates to the description of firm to stiff becoming stiff. The London Clay had a shear strength exceeding the shear vane's capability of 130kN/m^2 throughout, equating to stiff or very stiff.

Laboratory tests were carried out on the disturbed samples collected from the boreholes. Testing consisted of the following:

9 No. Atterberg Limit test including moisture content determination
3 additional moisture content determination
2 No. Soluble Sulphate, pH and related tests for Concrete Classification on soil samples

Two (2No) of the Atterberg tests were conducted in the Head Deposit. These are consistent with similar values both of water content and atterberg limits as follows:

- Moisture Content 29 to 30%
- Plastic Limit: 23%
- Liquid Limit: 64 to 68%
- Plasticity Index: 42 to 45%
- Liquidity Index 0.17 to 0.16 (decreases with depth)

The Head Deposit is classed as a clay of high plasticity. Seven (7No) Atterberg Limit tests were performed on London Clay. Again these are consistent with narrow ranges of values as follows:

- Moisture Content 27 to 32%
- Plastic Limit: 21 to 27%
- Liquid Limit: 67 to 79%
- Plasticity Index: 44 to 53%
- Liquidity Index 0.04 to 0.18 (decreases with depth)

The minimal variation in liquid, plastic limits and high plasticity index is indicative of London Clay, indicating a clay of high becoming very high plasticity. The water content and liquidity index are reflective of a firm to stiff/stiff clay which correlates reasonably with the shear vane results.

6. Conceptual Ground Model

From the above a conceptual Ground model has been developed and is presented in tabular form below:

Strata	**Typical Description**	**Depth at Property encountered in GI**	**Geotechnical Properties – Tentative Characteristic Values***	**Comments**
Head Deposit	Firm, brown, sandy silty CLAY with fine gravel'	Below topsoil to 2.5m	C' =0 ϕ' = 18^o Cu = 60kN/m^2 **	The undrained shear strength of the Head Deposit should be confirmed prior to construction
London Clay	Stiff, brown, silty CLAY with partings of brown and orange silt and fine sand, claystone nodules and crystals..	2.50 to 15.00m (base not proven).	C' =0 ϕ' = 20^o Cu = 80 increasing to 100kN/m^2 at formation. **	The undrained shear strength of the London Clay should be confirmed prior to construction
Groundwater		Not encountered: Local data available suggests groundwater levels between 1m and 2m bgl		Likely to be present but not found due to low permeability of Head Deposit and London Clay and speed of drilling. May significantly vary seasonally or after prolonged wet or dry periods.

Table 3: Summary of Strata Characteristics

*The determination of parameters is tentative due to the lack of test data.

**Strength should be verified by hand held shear vane/ inspection during ground excavation.

7. Impact Assessment

There are no apparent major issues which should seriously affect the viability of the construction of the new basement. However the assessment of the geological environment of Flat 3, 269 Goldhurst Terrace and the screening exercise indicate some areas for further discussion in this report with suggested mitigation where appropriate.

7.1 **London Clay/Shrink and Swell:** The basement will be founded in London Clay, with Head Deposits above. The soils are of high and very high plasticity and high volume change potential. The basement will be founded at around 2.9m bgl, therefore below any seasonal shrink and swell. The London Clay soils are known for their high levels of soluble sulphate. The concrete mix design should take appropriate account of sulphate levels in accordance with BRE Special Digest 1. The basement structure should be designed to account for swelling pressures.

7.2 **Trees:** Trees are located in the garden and vicinity and the property is within the South Hampstead conservation area. Although roots have not been noted in the ground investigation it is likely that they will be encountered during basement excavation and related excavation works. Care should be taken to minimise root damage during construction works. Should trees be removed there is potential for the soils to swell as a result which may affect this and neighbouring properties and this should be accounted for in design and further assessed as appropriate.

7.3 **Groundwater/Aquifer**: Groundwater was not encountered during the ground investigation. This lack of measurement will not necessarily be representative groundwater presence and levels within the London Clay. The low permeability of the London Clay and Head Deposit coupled with the speed of the drilling process means that any groundwater present in the soils will have not been observed. Typically Groundwater levels in this area have been observed at around 1m below ground level. It is recommended that a design level of ground surface is used, this accounts for seasonal variations and leaks from water supply, etc. Groundwater may be encountered during the works, particularly as seepages through sandy silty layers within the Head Deposit or London Clay or at the base of any Made Ground that may be encountered. (Some Made Ground can be expected particularly associated with past construction activities.) These should be managed carefully to prevent ground loss particularly through loss of fines. Softening of formation due to water ingress is a risk and softened soils should be excavated and replaced where practicable. Consideration should be given to limiting the size and time of face exposures during construction should significant flows be encountered during construction. Baseline and ongoing regular monitoring of the building and its immediate neighbours for settlement and movement/distress is highly recommended during building works and for a short period after completion. It is recommended that ongoing monitoring of groundwater levels is carried out during and up to the end of construction of the basement structure.

7.4 **Lost River:** There is a lost river indicated some distance from site. It is considered that this is unlikely to have an impact on the proposal.

7.5 **Basement Depth**: It is proposed to be construct the basement to a level of approximately 2.9m below the existing ground floor. The property adjoins a neighbouring property and the extended property will be within 5m of no.58 Priory Road. The proposals to construct the basement are understood to be via underpinning at the party wall. Underpinning proposals are understood to involve a 'hit and miss' approach in stages so each 'panel' is separated by 3-5 others from the next open one. It will be important that the building contractor is closely supervised and is experienced in this type of construction. It will be critical to prevent exposed faces from collapse or significant ground loss into the new excavation and temporary face support should be maintained where practicable. It is understood the there are no basements in adjoin/adjacent properties. Most ground movement should occur during wall installation, excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements.

A number of factors will assist in limiting ground movements:

- The speed of propping and support
- Good workmanship
- Ensuring that adequate propping is in place at all times during construction
- Installation of the first (stiff) support quickly and early in the construction sequence.
- Avoidance of ground loss through the gaps between the piles.
- Avoid leaving ground unsupported.
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control dewatering to minimise fines removal and drawdown.

7.6 **Construction near footpath and highway:** The close proximity of the front of the property to the pavement and highway, means that works will be carried out in adjacent to areas of public access. A thorough assessment of risks to the public and the workforce will need to be developed and mitigation measures put in place where risks cannot be eliminated.

8. Assessment of Ground Movement

An assessment of ground movements has been carried out as follows:

- Movements have been assessed for the adjoining and closest properties (Adjoining property at 269 Goldhurst Terrace and 58 Priory Road) which are predicted to arise due to the excavation of the basement. Movements at 56 Priory Road have not been assessed.
- The magnitude of ground movements has been assessed for the excavation in front of the retaining structure.
- Movement due to Wall installation has been discounted at this stage as it is understood that the property will be underpinned, and as such a wall will not be installed into the ground. Rather the 'wall' will be installed into the excavation.
- It is important to note that CIRIA report C580 is written for embedded retaining walls. Therefore movement calculations for the excavation of soil and installation of underpins does not strictly apply to C580. There is no recognised method for calculating ground movements due to underpinned basements so C580 is used as a convenient and recognised approach. However it is recognised that settlements are generally small where care and appropriate measures are taken in construction.

Outline planning drawings developed by AND Designs, OMNIDE and DFV have been reviewed and used to inform this assessment.

The following key assumptions have been made:

- The maximum excavation depth is approximately 2.9m bgl.
- The method of basement construction will be via underpinning using a 'hit and miss' approach.
- A high wall stiffness has been assumed.
- In the permanent case the wall will always be propped at high level.
- The adjoining property (269 Goldhurst Terrace) is attached to the subject property.
- No.58 Priory Road is 4.5m from the property.
- For the purposes of the calculations, the width and height of the subject properties have been estimated to be as follows:
    - 269 Goldhurst Terrace: 8m and 6m respectively.
    - 58 Priory Road: 10m and 12 respectively
- A London Clay soil of at least stiff consistency has been assumed.

From figure 2.11 in C580 the following calculated assessments of ground movements have been developed due the excavation of soils in front of the wall. An excavation depth of 2.9m has been assumed.

No 269 Goldhurst Terrace

Distance from wall* (m)	**0 (Near side)**	**8 (Far side)**	**Max Vertical Movement**
Horizontal Movement (mm)	5	1-2	
Vertical Movement (mm)	1	1	~3mm at 1.8m from the basement

No. 58 Priory Road

Distance from wall*(m)	**4m (Near side)**	**14m (Far side)**	**Max Vertical Movement**
Horizontal Movement (mm)	3	<0.5	
Vertical Movement (mm)	2	<0.5	The near wall of no.58 is also the likely location of maximum vertical movement

This assumes that the wall is propped high and therefore a high stiffness can be assumed when reading from the graphs. It is understood that there will be adequate propping in the temporary case to justify this assumption and in the permanent case the structure will provide adequate support to the retaining walls and act as a high level prop.

There are a number of key points to note in using this assessment:

- Most ground movement will occur during wall installation, excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements.
- The speed of propping and support is key to limiting ground movements
- Good workmanship will contribute to minimising ground movements.
- The assessment assumes the wall is in stiff/competent clay.

- Larger movements will be expected where soft soils are encountered at, above and below formation.

Ground movement can be minimised by adopting a number of measures, including:

- Ensuring that adequate propping is in place at all times during construction
- Installation of the first (stiff) support quickly and early in the construction sequence.
- Avoidance of ground loss through the gaps between the piles.
- Avoid leaving ground unsupported.
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control dewatering to minimise fines removal and drawdown.

It must be noted that the movements are calculated values based on the findings and methods of CIRIA C580. Larger movements may be generated if any one or any combination of the above recommendations and/or assumptions are not heeded or if ground conditions are different to a firm to stiff or stiff London Clay.

In terms of building damage assessment and with reference to Table 2.5 of C580 (after Burland et al, 1977), the 'Description of typical damage' given the *calculated* ground movements is likely to be:

- For adjacent part of no. 269 Goldhurst Terrace: 'Very Slight'
- For no. 58 Priory Road: 'Very Slight'.

Movement will also be experienced by Flat 3 and the Flat above. This has been calculated to be 5mm horizontal and around 1mm vertical, plus the heave as assessed below. Again the actual magnitude of these movements will depend upon a number of factors described above.

Heave

Heave of the ground will occur within the basement due to soil removal and consequent unloading of the soil. Using elastic and consolidation theories, both immediate and longer term heave movements have been calculated for within the basement. These are calculated figures and apply to the centre of the basement. The figures will be significantly lower at the edges and lower still at the corners and estimates are provided. The figures presented represent estimates and are based on a number of assumptions.

Immediate upward (elastic) movements have been calculated at around 6mm. These will be completed upon completion of soil excavation usually within about 7 days.

Longer term soil swelling will also occur. The rate of this longer term swelling will be determined largely by the availability of water and the low permeability of the London Clay. As a result this may take many years to reach full equilibrium. The basement slab will need to be sufficiently stiff to enable it to accommodate the swelling displacements/pressures developed underneath it. The amount of long term swelling has been calculated to be of the order of 6mm for the centre of the excavation with the centre of basement edges and corners having calculated values of the order of 3 to 4mm.

9. Conclusions

The methodology and approach of CPG4 has been followed in developing this BIA with respect to Land stability. It is concluded that with the construction of the new basement at Flat 3 269, Goldhurst Terrace should not have significant impacts on land stability provided that:

- Groundwater inflow, if encountered, is reduced to a minimum and properly controlled such that there is no significant wash out of fine material. Groundwater levels should be monitored before and during construction.
- The retaining wall should be appropriately designed.
- The construction of the basement is carried out by competent and experienced contractors and precautions are taken to maintain the stability of the excavations.
- Care should be taken to minimise the disturbance and damage to trees and their roots. Should tress be removed then an assessment of the potential for swelling of the London Clay and Head Deposit soils should be carried out.
- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate conditions anticipated.
- Monitoring of the structures is carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.

10. References

1. BGS Geological Map Sheet 256.
2. Ordnance Survey Map, Explorer 173, London North
3. Arup: Camden Geological, Hydrogeological and Hydrological Study.
4. AND Design Drawings and Method statements
5. OMNIDE Planning Drawings
6. DFV Method Statements
7. Chelmer Site Investigations: Report Ref FACT /5268 A: 269 Goldhurst Terrace
8. Groundsure EnviroInsight report for Priory Rd, GS-2103155